DEPARTMENT OF THE INTERIOR
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MINERAL RESOURCES
OF THE
UNITED STATES

CALENDAR YEAR
1913

Part II—NONMETALS

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MINERAL RESOURCES OF THE UNITED STATES FOR 1913—PART II.

MICA.

By Douglas B. Sterrett.

INTRODUCTION.

The term mica indicates a group of minerals having similar physical properties and related chemical structure. The physical properties characteristic of these minerals are monoclinic crystallization—the crystals being approximately hexagonal or orthorhombic in shape—and very perfect basal cleavage. The micas considered in this report are characterized by great flexibility and elasticity of the cleavage sheets. Some other species of mica cleave into brittle or inelastic sheets. Chemically, micas are silicates of aluminum and potassium containing varying amounts of magnesium and iron; some varieties contain also sodium, lithium, and other elements.

Of the several varieties of mica only two are available for commercial use on a large scale because of their physical properties. These are muscovite, or potash mica, and phlogopite, or magnesia mica. Lepidolite, or lithia mica, has been used in some quantity as a source of lithia. Muscovite is the most common variety. It is generally lighter in color than phlogopite, ranging from colorless in thin sheets to amber yellow, green, brownish red or "rum," and ruby red in sheets over one-sixteenth of an inch thick. Phlogopite is generally darker colored than muscovite, ranging from amber yellow to dark brown, even in rather thin sheets. Muscovite is the only variety of mica mined in the United States, no phlogopite deposits of commercial value having been found.

Some of the properties which render mica valuable are its occurrence in large crystals which can be split into thin sheets of various sizes, its transparency, flexibility, elasticity, nonconductivity of heat and electricity, and the brilliancy of its cleavage faces. Mica occurs in crystals ranging from small size up to several feet across. Crystals 2 feet in diameter are not unusual and those 10 or 12 inches across are common. This combination of properties is not found in any other natural or artificial product. Mica is sometimes called isinglass when used in stoves and lamp chimneys, but it should not be confused with the original isinglass, a gelatinous material obtained from certain fish.

The apparent approach to hexagonal or orthorhombic symmetry in mica is indicated by the nearly hexagonal and rhombic outlines often observed in the prisms, by the percussion and pressure figures, and by "ruled" and "A" mica.

Mica is of widespread occurrence in the rocks of the earth's surface, either as small grains or scales distributed through various types of rocks, or as larger crystals in distinctive types of rocks. Only the distribution of those deposits which contain mica of sufficient size to be of economic value will be noted here.

The principal mica-producing countries of the world at present are India, the United States, Canada, German East Africa, and Brazil. Small productions have been reported from South Africa, Ceylon, Norway, China, Japan, Argentina, and South Australia. Deposits of probable value are reported from other countries as New Zealand, West Australia, and the Philippine Islands.

In the United States the production of mica comes from a number of States, of which only a few are regular producers, the others having a more or less intermittent output. North Carolina has led in production for years, and the output from the following States has varied in importance: New Hampshire, South Dakota, Idaho, New Mexico, Colorado, Virginia, South Carolina, Alabama, and Georgia. Small outputs of mica from deposits which promise to be of future value have been reported from Wyoming, Utah, Nevada, Arizona, California, Washington, Maine, Connecticut, New York, Pennsylvania, and Maryland. The distribution of the mica-bearing rocks in these States may be better understood after a discussion of the geologic occurrence of mica, for mica deposits rarely occur outside of areas of old or metamorphic rocks.

GENERAL GEOLOGY.

Most of the mica deposits of the United States occur in regions of highly metamorphic rocks such as mica, garnet, kyanite, fibrolite, staurolite, hornblende, and granite gneisses and schists. A few deposits have been found in less altered granites or other igneous rocks. The highly metamorphic gneisses and schists are considered to be of pre-Cambrian age in most places; in some places the ages have not been determined.

Deposits of muscovite mica of commercial value are confined to pegmatite. This rock is quite variable in composition, but in its more normal phases is composed of feldspar and quartz, with or without mica and other minerals. It is therefore allied to granite in composition and has been called "giant granite." The texture grades from that of ordinary granite to masses in which the individual grains or minerals measure many feet across, and these variations may occur in the same deposit.

Orthoclase and microcline are the most common varieties of feldspar found in pegmatite. In many places, however, a variety of plagioclase, either albite or oligoclase, makes up part or all of the feldspar component. The feldspar occurs in masses and rough crystals, some of which may be several feet thick.

Quartz occurs in several ways in pegmatite, either intermixed with feldspar and mica in granitic texture, graphically intergrown with feldspar, or segregated out into large separate masses. In the latter case the quartz may form sheets or veins in the interior or along the walls, or it may occur in irregularly shaped bodies through the pegmatite. The quartz in these segregations is massive and generally granular, though locally showing rough crystallization.

The mica occurs in various positions in the pegmatite and no definite rule can be laid down as to where it may be expected to be found in different deposits. In these pegmatites in which quartz segregations are prominent the mica is generally richest near the quartz. In some deposits the mica follows one or the other wall, and in others it may be either regularly or irregularly distributed through the pegmatite. The mica crystals or blocks are generally rough and range in size from a fraction of an inch to several feet across.

Pegmatites occur in irregular masses, sheets, lenses, and stocks or chimneys, which range in size from small deposits to those many yards in thickness and length. These masses cut the country rock in various ways, either conformably with its bedding or at various angles to it. Some pegmatites are conformable with the bedding of the inclosing gneisses or schists through part of their extent and cut across it in other places. Some pegmatites fork or branch out from larger masses into two or more sheets. Inclusions of the wall rock or "horses" are common, and these may be in the form of sheets, lying parallel with the walls of the pegmatite, or of irregular masses occupying random positions through it.

MINING AND TREATMENT.

The occurrence of mica in deposits of such irregular nature as described renders its mining problematical. At a few deposits the pegmatite is in sheetlike bodies, which are not badly warped and are persistent for some distance. If the mica content is not too variable ordinary methods of mining can be applied to such deposits; that is, mining by regular shafts, adits or tunnels, drifts, and stopes; if the mica content varies much, stopes and other workings become more irregular. Where the pegmatite forks, rolls, is folded, pinches, or bulges out into large masses, the mining methods necessarily become more irregular. Such deposits lead to the type of mining called "ground hogging" or "gophering," in which the workings are very irregular, and waste rock is left to accumulate because difficult to remove through the small tunnels and openings.

If the pegmatite occurs in large masses rich enough to be worked for mica, regular quarry methods may be used. This is common in the New England mica mines, where open quarry work with derricks and incline tracks are used to remove ore and waste.

Much mica is mined each year in the United States from deposits operated in a small way without steam engines, pumps, or power drills. Hand power or, at most, horse power is used in such places to hoist mica, waste, and water from the workings, and drilling is done by hand. Tracks with mine cars may or may not be used.

As a general rule it is best to open a mica prospect by cuts, shafts, or tunnels in the pegmatite along the streak or deposit of mica and also in other positions that appear favorable until it has been determined that mica is present in paying quantities. Then only is it safe to develop by vertical shafts to one side of the vein or by long crosscut tunnels from lower levels on a hillside. Few prospects give evidence on the surface that they will warrant extensive development or large outlay in mining equipment.

In mining care is necessary to avoid drilling through good crystals of mica. Miners using either hand or power drills can generally tell by its clogging when the drill is in mica. In blasting only small charges of dynamite should be used around a pocket of mica, and black powder is even better, if it can be used.

Mica as it is obtained from the mine consists of rough crystals and blocks ranging from small size to several feet across. These crystals have to be treated before the mica is ready for the trade by cobbing, splitting, rough trimming, sorting, cutting into patterns, building up into large composite sheets, or grinding. In many places these operations are carried out in two or three different plants, but some of the better equipped companies prepare the mica for the trade in one conveniently located plant, either at the mine or elsewhere.

The rough mica crystals are cobbed and cleaned of adhering quartz, feldspar, or dirt, by rapping with hammers. They are then split with splitting knives or wedges into plates of about one-sixteenth of an inch or less in thickness. The rough edges are cut off these plates by knives held at an angle to the cleavage, and the mica is graded for size and quality. The graded mica is then ready for further splitting and trimming into patterns desired by the trade. Small sheets may be left with rough edges and used for punching into mica disks, washers, and other forms. "Thin splittings" are made from small mica. In making these the edges of the plates are ground on a bevel and these edges are pressed against a flat surface to open the cleavage. The mica is then "thin split" into sheets one five-hundredth of an inch or less in thickness by means of a thin-bladed knife. This work is generally done by girls as "piece work." The "thin splittings" are built up into mica board and flexible mica sheets. Mica board is built up either with or without tissue paper from several layers of thin splittings coated with shellac; it is made up into large sheets 2 by 3 feet square and is then subjected to great pressure under hydraulic presses. The sheets are heated during the pressing and are then baked to dry the shellac. The required thickness is obtained after baking by sanding and milling machines. Mica board can be cut or punched and treated like sheet mica.

Trimming mica into forms and patterns desired by the trade is accomplished by large shears and punches operated either by hand or by power. If shears are used, the mica is cut into the desired form around a templet of wood, metal, or composition laid against the mica. Mica punching machines are supplied with various dies to punch disks, washers, and other shapes.

The rough small mica and the waste from trimming sheet mica are ground. Two processes, wet grinding and dry grinding, are employed according to the uses to which the mica is to be put. Several methods of accomplishing each are used but most of them are held secret. In the wet-grinding process the following method has been used in some mills: Soft wood beaters with heavy spikes projecting from them are revolved in wooden tubs or vats containing scrap mica and water. The spikes beat and tear the mica into small scales forming a mush in the tubs. After the proper amount of grinding this mush is removed and spread over cloth-covered drying tables supplied with steam pipes below. When dry, the mica is removed in cakes or lumps, is beaten apart in disintegrators or pulverizers, and is then sent through bolters for sizing.

In dry grinding, the Raymond pulverizer or other type of pulverizing machinery is used in many places, and the mica is broken and torn up by beaters revolving at high speed in a chamber. The ground product is conveyed by air draft to bolters for sizing. One No. 0 Raymond pulverizer will supply two Barnard & Leas bolting machines.

USES.

The physical properties enumerated above render mica especially adaptable to many requirements in the industrial world, both as sheet mica and as ground mica. The largest use of sheet mica is in the manufacture of electrical apparatus and machinery, but a quantity is used in the glazing trade for stoves, gas-lamp chimneys, lamp shades, etc. Only clear mica of good grade and with perfect cleavage is used in the glazing trade.

In the manufacture of electrical apparatus and machinery mica is used in sheets of various sizes and shapes down to washers and disks for places in which a noninflammable insulating material is necessary. Thus properly trimmed sheets are used between the commutator segments of direct-current motors and dynamos, for tubes, sheets, and other forms in transformers, and for washers and rings around many bolts and screws requiring insulation. Large disks and washers are used in every arc light, and smaller ones in the sockets of incandescent lamps. Flexible mica-covered cloth and tape find varied uses in many pieces of electrical apparatus.

Ground mica is used in largely increasing quantities for the decoration of wall paper, for the manufacture of lubricants, fancy paints, rubber goods, molded mica, roofing papers, and as covering for steam pipes. Finely ground mica is applied to wall paper to furnish luster and brightness. For this purpose wet-ground mica is the most satisfactory because, it is claimed, the scales are cleaner and flatter than in the dry-ground product. Ground mica mixed with oil forms a good lubricant for axles and other bearings, and quantities are used for this purpose. For fancy and brocade paints ground mica is mixed with various pigments and serves the purpose of metallic paints. Many rubber goods contain finely ground mica used as an adulterant and to furnish certain qualities desired in the rubber. Ground mica mixed with shellac or plaster is used in the form of "molded mica" for insulation of trolley wire and for similar supports. Tar and other roofing papers are coated with coarse flakes or "bran" mica to prevent sticking when they are rolled for shipment. Bran mica and coarser grades furnish good fireproof and heat-retaining coverings for steam pipes and boilers when mixed with other materials.

Mica with a rich golden-bronze color and luster has been obtained by certain processes of calcining biotite found near Hecla, Chaffee County, Colo. Specimens of this mica and of the calcined product were kindly supplied by Mr. W. W. Kirby, of Denver, Colo. The mine product consists of a hydrated biotite resembling a chlorite. It is greenish black with rather dull luster. On heating it expands or exfoliates greatly and assumes various shades of silver to golden-bronze color, with metallic luster, according to treatment. Mr. Kirby is investigating the possibilities of this promising product for decorative and other purposes.

A new mica product called "micarta" is reported to have been developed by the Westinghouse Electric & Manufacturing Co.,[1] of Pittsburgh, Pa. It is intended to take the place of hard fiber, glass, porcelain, hard rubber, built-up mica board, rawhide, and molded compounds for use in commutators, bushings, brush-holder insulation, noiseless gear blanks, conduits for wiring, spools for spark coil and magnet windings, wireless-coil separators, and water-meter disks. Micarta is a tan-colored, hard, homogeneous material that can be sawed, milled, turned, and threaded. Thin sheets can be punched, and it is claimed that it will not warp, expand, or shrink beyond very small limits.

Two grades of "micarta" are made, one known as "bakelite micarta," which is infusible and will resist heat to a point where carbonization of some of the ingredients takes place. This variety is insoluble in nearly all ordinary solvents, such as alcohol, benzine, turpentine, and weak acid and alkali solutions.

PRODUCTION.

The total value of the mica produced in the United States in 1913 was $436,060. The production came from 11 States—North Carolina, New Hampshire, Idaho, New Mexico, South Dakota, South Carolina, Alabama, Virginia, Pennsylvania, Colorado, and New York, named in the order of the value of their output. Of these States no production was reported from Alabama, Virginia, and Pennsylvania in 1912. The value of the production of mica in 1913 exceeded by $104,164 that of 1912 and was the largest ever reported.

The production of sheet mica as reported to the Survey amounted to 1,700,677 pounds, valued at $353,517, as compared with 845,483 pounds, valued at $282,823, in 1912. The production of scrap mica in 1913 amounted to 5,322 short tons, valued at $82,543, as compared with 3,226 short tons, valued at $49,073, in 1912.

The figures given for sheet mica include both rough trimmed and cut or manufactured mica. Some of the producers manufacture their own mica and furnish figures for their product; others either sell in the rough or after first splitting and grading. It is impossible to separate the different classes of mica from the returns made by the producers, and the figures therefore include varying proportions of rough, graded, and trimmed mica. The output of rough trimmed or graded mica amounted to over 3,000,000 pounds, and the waste from the manufacture of this material is represented in the scrap mica.

The value of the production of mica in North Carolina in 1913 was $267,913, as compared with $256,549 in 1912. The production reported consisted of 803,462 pounds of sheet mica, valued at $230,674, and 2,729 tons of scrap mica, valued at $37,239. The production of sheet mica in 1913 exceeded that of 1912 by 313,863 pounds in quantity and $10,800 in value, and the excess of scrap mica was 237 tons in quantity and $564 in value.

In New Hampshire the total production of mica in 1913 was valued at $79,671, as compared with $37,338 in 1912. The output was

[1] Manufacturers' Record, Aug. 14, 1913.

reported as 731,478 pounds of sheet mica, valued at $65,765, and 692 tons of scrap mica, valued at $13,906. The value of the production of mica in South Dakota and Virginia amounted to $12,609 and $5,150, respectively. The production from the other States was reported by only one or two producers in each State and is therefore not given separately.

The production of mica in the United States since 1880 is shown in the following table:

Production of mica in the United States, 1880–1913.

Year.	Rough trimmed and cut mica.		Scrap mica.		Total value.
	Quantity.	Value.	Quantity.	Value.	
	Pounds.		*Short tons.*		
1880	81,669	$127,825			$127,825
1881	100,000	250,000			250,000
1882	100,000	250,000			250,000
1883	114,000	285,000			285,000
1884	147,410	368,525			368,525
1885	92,000	161,000			161,000
1886	40,000	70,000			70,000
1887	70,000	142,250			142,256
1888	48,000	70,000			70,000
1889	49,500	50,000			50,000
1890	60,000	75,000			75,000
1891	75,000	100,000			100,000
1892	75,000	100,000			100,000
1893	51,111		156		88,929
1894	35,943		191		52,388
1895	44,325		148		55,831
1896	49,156	65,441	222	$1,750	67,191
1897	82,676	80,774	740	14,452	95,226
1898	129,520	103,534	3,999	27,564	131,098
1899	108,570	70,587	1,505	50,878	121,465
1900	456,283	92,758	5,497	55,202	147,960
1901	360,060	98,859	2,171	19,719	118,578
1902	373,266	83,843	1,400	35,006	118,849
1903	619,600	118,088	1,659	25,040	143,128
1904	668,358	109,462	1,096	10,854	120,316
1905	924,875	160,732	1,126	17,856	178,588
1906	1,423,100	252,248	1,489	22,742	274,990
1907	1,060,182	349,311	3,025	42,800	392,111
1908	972,964	234,021	2,417	33,904	267,925
1909	1,809,582	234,482	4,090	46,047	280,529
1910	2,476,190	283,832	4,065	53,265	337,097
1911	1,887,201	310,254	3,512	45,550	355,804
1912	845,483	282,823	3,226	49,073	331,896
1913	1,700,677	353,517	5,322	82,543	436,060

PRICES.

The average price of sheet mica in the United States during 1913, as deduced from the total production, was 20.8 cents a pound, as compared with 33.4 cents a pound in 1912 and 16.4 cents in 1911. The average price of sheet mica in North Carolina was 28.8 cents a pound as compared with 44.9 cents a pound in 1912; in New Hampshire the average price was 8.8 cents a pound, as compared with 10.4 cents in 1912; in New Mexico it was 42.8 cents a pound; in South Dakota, 11.5 cents; in South Carolina, 11.4 cents; in Virginia, nearly $1 a pound. The average price of scrap mica in 1913, as deduced from the total production, was $15.51 a short ton, as compared with $15.21 in 1911; in North Carolina the price was $13.64; in New Hampshire, $20.09; in New Mexico, $15.26; in South Dakota, $17.60.

The following table shows the prices by the pound offered in North Carolina during part of 1913 for rough knife-trimmed mica, sorted to cut the sizes indicated:

Price of mica in North Carolina in 1913, by grades.

Size.	Grades Nos. 1 and 2.	Spotted or slightly clay stained.	Black "specked," heavily clay stained.
Punch mica	$0.035	$0.035	$0.03
1½ by 2 inches	.12	.07	....
2 by 2 inches	.30	.15	.07
2 by 3 inches	.70	.30	.25
3 by 3 inches	1.15	.70	.40
3 by 4 inches	1.35	1.00	.70
4 vy 6 inches	2.25	1.60	1.25
6 by 8 inches	4.00	2.25	1.60
8 by 10 inches	6.00	3.00	2.25

IMPORTS.

The imports for consumption of unmanufactured and trimmed sheet mica into the United States during 1913, as reported by the Bureau of Foreign and Domestic Commerce of the Department of Commerce, were valued at $943,018, compared with $748,973 in 1912. The quantity of imports was recorded for the first three quarters of the year only, during which time it amounted to 1,839,584 pounds, valued at $740,466. Ground mica to the value of $4,765 was imported during 1913, compared with $6,611 in 1912.

The quantity and value of mica imported for consumption into the United States annually from 1905 to 1913, inclusive, are shown in the following table:

Mica imported and entered for consumption in the United States, 1905–1913, in pounds.

Year.	Unmanufactured.		Cut or trimmed.		Total.	
	Quantity.	Value.	Quantity.	Value.	Quantity.	Value.
1905	1,506,382	$352,475	88,188	$51,281	1,594,570	$403,756
1906	2,984,719	983,981	82,019	58,627	3,066,738	1,042,608
1907	2,226,460	848,098	112,230	77,161	2,338,690	925,259
1908	497,332	224,456	51,041	41,602	548,373	266,058
1909	1,678,482	533,218	168,169	85,595	1,846,651	618,813
1910	1,424,618	460,694	536,905	263,831	1,961,523	724,525
1911	1,087,644	346,477	241,124	155,686	1,328,768	502,163
1912	1,900,500	649,236	88,632	99,737	1,989,132	748,973
1913	(a)	751,092	(a)	191,926	(a)	943,018

[a] Quantity not reported

CANADA.

The production of mica in Canada[1] during 1913 was valued at $170,112, as compared with $143,796 in 1912 (revised figures). The exports of mica from Canada during 1913 amounted to 817,152 pounds, valued at $240,775, as compared with 895,338 pounds, valued at $334,054, in 1912.

INDIA.

Figures for the output of mica in India in 1913 are not yet available. In 1912 the production reported to the Government[2] amounted to 43,835 hundredweight, valued at £97,286 ($473,442), as compared with 33,896 hundredweight, valued at £70,552 ($343,341) in 1911. The value of the exports in 1912 amounted to £284,290 ($1,383,497), as compared with £188,642 ($918,026), in 1911.

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[1] Preliminary report on the mineral production of Canada in 1913, Canada Dept. Mines.
[2] India Geol. Survey Records, vol. 43, pt. 2, p. 91, 1913.

FUEL BRIQUETTING.

By Edward W. Parker.

INTRODUCTION.

The fuel-briquetting industry in the United States in 1913 was characterized by a net decrease of two in the number of operating plants and a decrease of 17 per cent in the quantity, but an increase of 5.8 per cent in the value of the manufactured product. If the future of this infant relative of the coal-mining industry is to be judged by the record in 1913, the judgment should be based on the increase in value rather than on the fewer plants and decreased tonnage. Briquetted fuel in the United States is essentially a domestic fuel, for which there was a slackened demand during the year, owing to the exceptional mildness of the winter of 1912–13 and of November and December, 1913. In consequence the consumption of briquets, like that of raw fuel for domestic purposes, was less in 1913 than in either 1911 or 1912. An exception to the general trend is to be noted on the Pacific coast, where there was an increase of one (from 3 to 4) in the number of operating plants and a production in 1913 exactly double that of 1912, with a gain in value of somewhat larger proportion. Three plants in the Eastern and Central States that made briquets in 1912 were out of commission in 1913. One of these, at Murphysboro, Ill., was destroyed by fire in the early part of 1912 and probably will not be rebuilt. One of the other inactive establishments had been built by the Rhode Island Coal Co., at Portsmouth, R. I., and with the failure of the coal-mining enterprise became useless. The third idle plant was one of small capacity and output, operating on peat at Fertile, Iowa. The inactivity of all three of these plants had little influence on the total production in 1913.

Of the 17 active plants in 1913, 8 in the Eastern States produced 62,244 short tons, valued at $240,643, compared with 107,181 tons, valued at $370,841, from 9 plants in 1912; 5 in the Central States produced 73,287 tons, valued at $360,408, compared with 7 plants producing 89,714 tons, valued at $400,624 in 1912; and 4 plants on the Pacific coast produced 46,328 tons, valued at $406,276, against 23,169 tons, valued at $180,796, by 3 plants in 1912. It will be observed that in each geographic division the average value per ton was higher in 1913 than in 1912, although in the Eastern and Central States the production fell off. The explanation for the higher values in the face of decreased demand appears to lie in the general enhancement of values of all industrial products in 1913, in which higher cost of manufacture was a factor. In the production of briquets in 1913, 7 plants used anthracite culm or fines; 1 used semianthracite; 1 semianthracite and bituminous slack mixed in proportions of 3 to 1; 1 used anthracite culm and bituminous slack, principally the former; 5 used bituminous or semibituminous slack; and 2 used carbon residue from gas works making gas from petroleum. Eight plants used coal-tar pitch for binder, 1 used asphaltic pitch, 1 used water-gas pitch, and 5 used mixed binders, the composition of which was not divulged. No additional binder is required in the briquetting of the carbon residue from oil-gas works. The two plants designed for the purpose of utilizing coke breeze, one at Point Breeze, Philadelphia, and the other at Detroit, Mich., have not been operated during the last two years, the abrasive action of the coke on the molds and machinery being too destructive for commercial success in these attempts to utilize an unmerchantable product of the coke ovens.

PRODUCTION.

The total quantity of manufactured fuel in the form of briquets, eggettes, coalettes, boulets, etc., all considered in this report under the general head of "briquets," amounted in 1913 to 181,859 short tons, valued at $1,007,327, compared with 220,064 tons, valued at $952,261, in 1912. Distributed by Eastern, Central, and Pacific coast divisions, this production in the two years was as follows:

Production of briquets in 1912 and 1913, by groups of States, in short tons.

	1912			1913		
	Number of plants.	Quantity.	Value.	Number of plants.	Quantity.	Value.
Eastern States:						
Maryland	1			1		
New Jersey	1			1		
New York	2			2		
Pennsylvania	3			3		
Rhode Island	1					
Virginia	1			1		
	9	107,181	$370,841	8	62,244	$240,643
Central States:						
Illinois	1					
Indiana	1			1		
Iowa	1					
Michigan	1			1		
Missouri	1			1		
Wisconsin	2			2		
	7	89,714	400,624	5	73,287	360,408
Pacific Coast States:						
California	2			2		
Oregon				1		
Washington	1			1		
	3	23,169	180,796	4	46,328	406,276
Total	19	220,064	952,261	17	181,859	1,007,327

In the six years 1907–1909 and 1911–1913 the production has been as follows:

Production of briquets in the United States in 1907, 1908, 1909, 1911, 1912, and 1913, in short tons.

Year.	Quantity.	Value.
1907	66,524	$258,426
1908	90,358	323,057
1909	139,661	452,697
1911	218,443	808,721
1912	220,064	952,261
1913	181,859	1,007,327

In order to meet with popular favor in this country briquets must be of convenient shape for shoveling and for permitting air to circulate in the fire box. They must be of sizes suitable for the purposes they are intended to serve and must possess sufficient cohesion to resist fracture and abrasion under rough handling. Some of the briquets manufactured in European countries, particularly in Germany, are made very large, for easy stowage in bunkers of steamships and tenders of locomotives, and are not adapted for use in this country. They must be handled and stowed by hand and must be broken up before they are shoveled into the fire. The high cost of labor in this country prohibits such handling.

The briquets which appear to meet with favor in the Eastern States are of the boulet type, pillow or egg shaped, and about the size of anthracite nut. Those that are practically smokeless, as they should be, make an ideal fuel for the open grate or kitchen range, holding their shape until entirely consumed and then falling, when stirred, into a pulverulent clinkerless ash. In the Central and Pacific Coast States the popular type of briquetted fuel appears to be the larger size, about that of egg coal, for which the raw materials available seem to be best adapted.

RAW MATERIALS.

It may be well again to call attention to the enormous quantities of raw material available for the manufacture of briquets and obtainable at little cost, though most of what follows is a repetition of what has been said in previous reports. The most desirable material for producing a smokeless product is anthracite culm, of which a plentiful supply still remains in the anthracite region of Pennsylvania and more is produced daily in the mining operations. It is not too much to believe or to hope that in the near future the small sizes of anthracite, such as buckwheat and smaller, which are now sold for making steam in competition with bituminous coal and at prices below the actual cost of production, will become more valuable as raw material for the briquet manufacturer. The output of these small sizes produced by crushing the large coal to obtain the domestic grades (egg, stove, and nut) exceeds 20,000,000 long tons annually, exclusive of 3,000,000 to 4,000,000 tons that are annually recovered from the culm banks by washeries. The present revenue from this product will not exceed $30,000,000. Washery and small-size coal is worth from 50 cents to $1.50 a ton, the price depending on the size. As briquetted fuel it should be worth as much as stove or egg coal, or from $3 to $4 a ton. The cost of briquetting is from $1 to $1.25 a ton. The uniform size of the briquets makes them highly desirable as a domestic fuel; besides, they are completely consumed, and if properly made they do not produce that bugbear to the housekeeper—clinkers. One objection raised to the use of briquets is that they will compete with the prepared sizes of anthracite. From the viewpoint of the consumer the objection lacks logic, and it seems equally illogical from the viewpoint of the producer when the apparent profit obtainable on the briquetted product is considered.

Slack from noncoking bituminous, subbituminous, and semianthracite coals is another cheap and abundant raw material. It is obtainable in all the coal-mining regions of the Middle West, where at many places it is now wasted or almost given away. Slack piles have sometimes been burned to prevent their cumbering the ground and more frequently have ignited spontaneously and devoured themselves. The quantities now used in the manufacture of briquets represents but a drop in the bucket of available material.

The vast and almost untouched areas of lignite in North Dakota and Texas contain enormous supplies of fuel that European experience has taught is well adapted to briquetting and that is much more usable in that form than in the raw state. The school of mines of the North Dakota University, under the direction of Prof. E. J. Babcock, has been making some interesting and valuable experiments in briquetting lignite and has already attained excellent results.

The large areas of peat beds in the United States are also available as a source of raw material. They are generally remote from the coal fields, and the briquetted fuel from peat, if properly prepared, makes an excellent substitute for coal. The peat now produced in the United States is used for stable litter, fertilizer, etc. None is used raw for fuel.

BINDERS.

As already stated, more than half of the briquetting establishments use coal-tar pitch as a binder, and if asphaltic and gas-tar pitch are added the binders of this type are used in two-thirds of the briquetting plants in which binders are employed. The five establishments using binders other than pitch employ mixtures whose constituents are principally of vegetable origin. Inorganic binders, such as cement and lime, have not given satisfactory results, for although they may be efficient in cementing qualities they have the serious objection of increasing the ash and of adding nothing to the combustible matter of the fuel. Binders of organic material, however, such as pitches from coal tar, gas tar, or asphalt or mixtures of vegetable origin, contribute combustible matter and do not increase the percentage of ash. A binder to produce an entirely satisfactory briquet should not materially add to the emission of smoke, particularly in communities where smokeless anthracite is customary, as a tendency to smoke creates a prejudice against the use of briquets.

BRIQUETTING PLANTS IN THE UNITED STATES IN 1912.

EASTERN STATES.

American Coal Boulet Co., Phoenix Mines, Md.—This plant, built in 1911, uses bituminous coal with a binder of secret character.

Eggette Coal Co., Trenton, N. J.—Plant began operations in 1912, using anthracite culm and patented binder, and produces a domestic briquet of about nut size. The capacity of the plant was considerably increased during 1913.

Coal Boulet Co., New York, N. Y.—Plant began operations in 1910, using anthracite coal and secret binder, and produces nut-size, egg-shaped briquets.

Robert Devillers, Brooklyn, N. Y.—Plant began operations in 1907, using anthracite culm and coal-tar pitch; was closed in August, 1913, because of the expiration of lease, and removal of machinery to Staten Island is contemplated. Regular product is a boulet weighing 2 ounces. During the time the plant was in operation in 1913 it briquetted experimentally about 300 tons of Texas and North Dakota lignite.

American Coalette Co., Philadelphia, Pa.—One of two new plants which began operations in 1913. Uses anthracite culm and patented binder.

Lehigh Coal & Navigation Co., Lansford, Pa.—Plant originally built in 1909, destroyed by fire in the same year, and reconstructed in August, 1911. Uses anthracite culm and coal-tar pitch and produces egg-shaped "boulets" about the size of anthracite nut, weighing 1½ ounces.

Scranton Anthracite Briquette Co., Dickson City, Pa.—In continuous operation since 1907, using anthracite culm and coal-tar pitch. Manufactures an egg-shaped briquet of egg or furnace and nut sizes, weighing 5 ounces and 1 ounce, respectively.

Virginia Coal Briquetting Co. (Inc.), Richmond, Va.—Began operations in November, 1912. Uses semianthracite from Pulaski, Va., with Hite patented binder. Makes pillow-shaped boulets, weighing 2 ounces.

CENTRAL STATES.

Indianapolis Pressed Fuel Co., Indianapolis, Ind.—Plant rebuilt in 1912, original establishment having been destroyed by fire in 1911. Uses principally bituminous coal slack with coal-tar pitch. Was operated to a considerable extent in 1913 on experimental and demonstration work, including tests with coke breeze and residue from water-gas plants. The briquet is cylindrical in shape and about the size of egg coal.

Detroit Coalette Fuel Co., Detroit, Mich.—Began operations in 1909, using slack coal from Pocahontas, Va., and coal-tar pitch. Produces cylindrical "coalettes" of egg or furnace size, weighing 11½ ounces.

Standard Briquette Fuel Co., Kansas City, Mo.—Began operations in 1909, using Arkansas semianthracite with coal-tar pitch. Produces a cylindrical "coalette" of egg or furnace size, weighing about 11 ounces.

Berwind Fuel Co., Superior, Wis.—Began operations in 1912, using Pocahontas semibituminous slack with coal-tar pitch. Produces a cylindrical "coalette" of egg size, weighing 12½ ounces. This is the largest plant in the United States.

Stott Briquet Co., Superior, Wis.—Began operations in 1909, using a mixture of anthracite culm and bituminous slack with coal-tar pitch. Produces a briquet in pillow form, of about range or stove size.

PACIFIC COAST STATES.

Los Angeles Gas & Electric Corporation, Los Angeles, Cal.—Began operations in 1905, using carbon residue from oil-gas manufacture, without binder. Produces a "coalette" of egg or furnace size, weighing about 10 ounces.

Western Fuel Co., Oakland, Cal.—Plant has been in operation since 1907, using screenings principally of Welsh anthracite from coal yards, with asphaltic pitch. Produces a cylindrical briquet of egg size.

Portland Gas & Coke Co., Portland, Oreg.—This is one of two companies which began operations in 1913. Like the Los Angeles Gas & Electric Corporation, this company uses the carbon residue from oil-gas works without any additional binder, the moisture and the volatile matter of the carbon residue having sufficient cementing qualities. The product is cylindrical in shape and averages 9 ounces in weight.

United Collieries Co., Seattle, Wash.—Plant constructed in 1911, using bituminous coal slack from Vancouver Island, British Columbia, with mixed binder. Makes eggette, weighing 4½ ounces.

SAND-LIME BRICK.

By Jefferson Middleton.

INTRODUCTION.

The sand-lime brick industry has been established in the United States since 1901, when the first plant was started at Michigan City, Ind. Since that time it has passed through the various stages of a new industry. In the beginning it suffered severely from the "boomer," on whose glittering promises to make brick for a few dollars a thousand that would sell in competition with high-grade face clay brick plants were established for the manufacture of sand-lime brick, without regard to market, transportation facilities, or even a supply of suitable material. Some plants constructed under these conditions never even attempted to market their product. Then came the natural reaction when the number of the plants and the value of the product decreased even more rapidly than commercial conditions would have seemed to warrant. Since that stage, within the last few years, the industry seems to have become firmly established and is now showing a reasonable growth.

In common with most new building materials, sand-lime brick has had to overcome prejudice in the minds of some architects and builders. This prejudice was sometimes justified by the poor brick resulting from ignorance or lack of technical skill. The plants making this poor material have either gone out of business or have improved their product, so that to-day at many places sand-lime brick is successfully meeting the competition of clay building brick.

The condition of the sand-lime brick industry in the United States in 1913 was on the whole encouraging. The number of active operators reporting decreased, and four States that reported production for 1912, dropped out of the list of producers in 1913. On the other hand, the quantity of brick reported and its value increased, and the average value also of output per plant increased from $16,905 in 1912 to $18,211 in 1913. When this material was first produced in the United States, it was thought that many applications of it would be made, such as wall coping, ornamental pieces for garden and lawn, window sills, trimmings, lintels, columns, and capitals. None of these have been made extensively, although some attempts were made to produce them. The tendency has been, however, to eliminate these special forms and uses and to make only building brick. For 1913 only the production of building brick was reported to the Survey.

The sand-lime brick industry showed progress in 1913 over 1912. In 1913 the value of the output reported attained its maximum, $1,238,325, or $12,556 more than in 1907, the year of maximum value prior to 1913. Compared with 1912, this was an increase of $38,102, or 3.17 per cent. In 1912 the value of sand-lime brick products increased over 1911, $302,559, or 33.71 per cent. The average value of output per active plant in 1907 was $13,040; in 1913 the average per plant was $18,211. Of the 24 States reporting production in

1913, 15 showed increase and 9 decrease. The increase was not confined to any one section of the country; the decrease was principally in the smaller producing States.

PRODUCTION.

The following table shows the production of sand-lime brick in the United States from 1903 to 1913, inclusive:

Value of production of sand-lime brick in the United States, 1903–1913.

Year.	Number of operating firms reporting.	Value of product.	Year.	Number of operating firms reporting.	Value of product.
1903	16	$155,040	1909	74	$1,150,580
1904	57	463,128	1910	76	1,169,153
1905	84	972,064	1911	66	897,664
1906	87	1,170,005	1912	71	1,200,223
1907	94	1,225,769	1913	68	1,238,325
1908	87	1,029,699			

This table shows that the value of sand-lime brick marketed and the number of operating plants reporting rose rapidly until 1907. In 1908 there was a decrease, in common with other industries. In 1909 and 1910 there were slight increases. In 1911 the lowest value was reached ($897,664) since 1904. In 1912 and 1913 there were gains in value, the total for 1913 being the maximum, though the number of active firms reporting was 3 less than in 1912.

The domestic production of sand-lime brick in 1912 and 1913 by States and kinds is shown in the following tables:

Production of sand-lime brick in the United States in 1912, by States and kinds.

State.	Number of operating firms reporting.	Common brick.		Front brick.		Miscellaneous (value).[a]	Total value.
		Quantity (thousands).	Value.	Quantity (thousands).	Value.		
California	5	1,511	$12,635	1,395	$20,875	([b])	$33,860
Colorado, Montana, and Washington	4	1,622	9,732	585	9,915		19,647
Connecticut, District of Columbia, Maryland, and Massachusetts	5	6,478	57,020	3,755	30,209	([b])	92,659
Florida	5	16,216	110,436	([b])	([b])		121,378
Georgia, Kentucky, Mississippi, and Ohio	4	10,463	61,294	([b])	([b])		63,878
Idaho	3	1,668	19,677	([b])	([b])	([b])	25,121
Indiana	3	12,056	59,929				59,929
Iowa, Kansas, Nebraska, North Dakota, Oklahoma, and Texas	8	11,684	90,265				96,450
Michigan	11	48,129	307,106	([b])	([b])		316,732
Minnesota	4	19,232	109,765	262	3,020		112,785
New Jersey	4	760	4,940	([b])	([b])		6,924
New York	5	19,858	123,500	([b])	([b])		128,700
Pennsylvania	3	6,365	36,970				36,970
South Dakota	3	1,780	14,395				14,395
Wisconsin	4	10,498	70,265	([b])	([b])		70,795
Other States[c]				4,224	42,375	$5,900	([d])
Total	71	168,320	1,087,929	10,221	106,394	5,900	1,200,223
Average price per M			6.46		10.41		

[a] Including blocks and trimmings and fancy brick.
[b] Included in "Other States."
[c] Includes all products made by less than three producers in one State to prevent disclosing individual operations.
[d] The total of "Other States" is distributed among the States to which it belongs in order that they may be fully represented in the totals.

Production of sand-lime brick in the United States in 1913, by States and kinds.

State.	Number of active firms reporting.	Common brick.		Front brick.		Total value.
		Quantity (thousands).	Value.	Quantity (thousands).	Value.	
California	5	1,237	$8,414	[a] 2,267	[a] $30,425	$38,839
Colorado, Iowa, and Nebraska	4	1,336	10,260	288	3,458	13,718
Florida	4	12,621	72,665	750	7,014	79,679
Idaho	3	1,234	13,839	[a] 99	[a] 2,640	16,479
Indiana	4	12,091	58,150	40	400	58,550
Kansas, Oklahoma, and Texas	4	7,418	66,940	300	3,421	70,361
Massachusetts	3	5,315	34,348	[a] 607	[a] 7,801	42,149
Michigan	12	49,373	315,882	692	5,363	321,245
Minnesota	4	23,293	127,794	120	1,370	129,164
New Jersey	4	415	2,115	1,706	13,642	15,757
New York	5	21,251	133,303	330	2,710	136,013
North Dakota and South Dakota	3	3,942	30,364			30,364
Pennsylvania	3	11,984	73,674			73,674
Wisconsin	4	12,302	75,130	222	2,434	77,564
Other States [b]	6	14,540	95,524	[a] 3,886	[a] 39,245	134,769
Total	68	178,352	1,118,402	11,307	119,923	1,238,325
Average price per M			6.27		10.61	

[a] Includes fancy brick.
[b] Includes the District of Columbia, Georgia, Kentucky, Ohio, and Washington.

These tables show that the value of the output in 1913 increased $38,102, or 3.17 per cent. The number of States in which production was reported in 1913 was 24, a decrease of 4 from 1912—Connecticut, Maryland, Mississippi, and Montana dropping out as producers. In order to avoid disclosing individual operations, it has been necessary to group the output of certain States together. Michigan continued to be the leading State, the value of its product constituting 25.94 per cent of the total value of all sand-lime brick in 1913, and 26.39 per cent of the total in 1912. New York was second in 1913, as in 1912, reporting 10.98 per cent in 1913 and 10.72 per cent in 1912. Minnesota regained third place, from which it was displaced by Florida in 1912, and Florida was fourth.

Of the States for which totals are given, 8—California, Massachusetts, Michigan, Minnesota, New Jersey, New York, Pennsylvania, and Wisconsin—showed increase in 1913 and 3—Florida, Idaho, and Indiana—showed decrease. None of these changes were very great, the largest gain being in Pennsylvania—$36,704, or 99.28 per cent. The largest proportionate gain was in Massachusetts—nearly 150 per cent. The largest decrease was in Florida—$41,699, or 34.35 per cent.

Michigan had the largest number (12) of operating firms reporting in 1913, an increase of 1 over 1912. California and New York each had 5 operating firms reporting in 1913, the same number as in 1912. No other State had as many as 5 producers in 1913.

The average price per thousand for common sand-lime brick was $6.27 in 1913, as compared with $6.46 in 1912 and with $6.09 in 1911; for front brick it was $10.61 in 1913, as against $10.41 in 1912 and $9.53 in 1911. In 1913 common brick represented 90.32 per cent of the value of all products and front and fancy brick 9.68 per cent. In 1912 common brick constituted 90.64 per cent of the total value and front brick 8.86 per cent.

SAND-LIME BRICK INDUSTRY BY STATES.

California.—Five plants in California marketed products in 1913. Conditions, on the whole, were better than in 1912, and the value of the sand-lime brick reported increased $4,979, or 14.7 per cent.

Colorado.—Only 1 company reported from Colorado in 1913. Building conditions were extremely dull and the plant was idle, but sales were made from the stock on hand at the beginning of the year.

District of Columbia.—There is only 1 sand-lime brick company in the District of Columbia. Business was very much better than in 1912, owing possibly to the exhaustion of some of the clay deposits of the District.

Florida.—Florida was fourth in the value of sand-lime brick in 1913 and third in 1912. The number of operators reporting for 1913 was 4, a decrease of 1. Business conditions were, on the whole, not so good as in 1912, and the value of the product decreased $41,699, the largest decrease in any State. Operators of 2 plants in Florida failed to report to the Survey for 1913.

Georgia.—Two companies reported from Georgia in 1913; one was active and the other was idle. Conditions were poor compared with 1192, and the value of the product showed a decrease in 1913.

Idaho.—Three plants reported sales of sand-lime brick in Idaho in 1913, the same number as in 1912. Business conditions were poor compared with 1912, and the value of the product decreased $8,642, or 34.4 per cent.

Indiana.—Four plants were active in Indiana in 1913, an increase of 1 over 1912. Business conditions were not very good, and notwithstanding the increase in the number of operators reporting, the total value of the product showed a small decrease—$1,379, or 2.3 per cent.

Iowa.—There were 2 plants in Iowa at the beginning of 1913, but 1 of them ceased operations during the year. A new plant was under construction during the latter part of the year. The value of the output fell off markedly in this State in 1913.

Kansas.—Only 1 plant was in operation in Kansas in 1913. Business conditions were not good, but the value of the product was about the same as in 1912.

Kentucky.—There is only 1 sand-lime brick plant in Kentucky. The conditions of the industry were not good in Kentucky in 1913.

Massachusetts.—In Massachusetts 3 plants were active in 1913, an increase of 1 over 1912, and 1 was building. The value of the production in this State showed the largest proportionate increase in 1913. The demand was good, and the prospects for 1914 are encouraging.

Michigan.—Michigan has been the leading State in number of plants and in value of production of sand-lime brick since the beginning of the industry in this country, with the exception of one year, 1906. Twelve plants reported production for 1913. Two new plants began operations during the year, and 1 went out of business, a net gain of 1 over 1912. The gain in value of output, however, was only $4,513, or 1.42 per cent. Michigan's product in 1913 was valued at more than twice as much as that of the second State, New York, and constituted, as in 1912, over 25 per cent of the total value. The principal producing locality was Wayne County, in which Detroit is located. The other producing counties were Genesee, Houghton, Huron, Jackson, Kalamazoo, Kent, Manistee, Menominee, Oakland, and Saginaw.

Minnesota.—Four plants were in operation in Minnesota in 1913, and 1 was building. Business conditions were good and the production increased in value $16,379, or 14.52 per cent. Minnesota was third among the States in the value of sand-lime brick in 1913; in 1912 it was fourth.

Nebraska.—Two active operators reported from this State for 1913, an increase of 1 over 1912. The output showed an increase in value in 1913 over 1912, though as 1 plant was operated only a portion of the year the increase was not very large.

New Jersey.—Four plants were active in New Jersey in 1913, the same number as for 1912. The value of the product, however, showed a large proportionate increase—127.57 per cent.

New York.—New York was the second State in value of sand-lime brick in 1913, as for some years past, and reported a product valued at $136,013, an increase of $7,313, or 5.68 per cent, over 1912. Five active operators reported for 1913, the same number as for 1912. One new plant had not begun operations at the close of the year, and 4 plants reported no sales. Business conditions were good generally, with an increasing demand for this class of brick. The active plants were located in Erie, Monroe, Onondaga, Suffolk, and Warren counties.

North Dakota.—There is but 1 plant in this State, located in McHenry County. Business conditions were better in 1913 than in 1912, and the value of the product showed a considerable increase.

Ohio.—Ohio, the leading State in the clay-working industries, had but 1 active sand-lime brick plant in 1913, located in Montgomery County. Business conditions were better in 1913 than in 1912, and notwithstanding the loss of time caused by the Dayton flood this company reported a large increase in business in 1913.

Oklahoma.—One active plant reported from Oklahoma for 1913, as in 1912, and business conditions were reported about the same as in 1912.

Pennsylvania.—Pennsylvania was the sixth State in value of sand-lime brick in 1913, and showed a large increase in value of output—$36,704, or 99.28 per cent. There were one idle and three active operators in the State. The active plants were located in Dauphin, Lackawanna, and Lebanon counties.

South Dakota.—The 2 active plants in South Dakota reported much better business conditions in 1913 than in 1912. There was 1 idle plant in the State, and a new one that expected to begin operations in the spring of 1914. The value of the output showed a good increase over that of 1912.

Texas.—Two active operators reported from Texas in 1913, and 1 plant was building. Business conditions were about the same as in 1912.

Washington.—There were 2 active plants in Washington in 1913, an increase of 1, and 1 idle plant. One of the active plants, located in Island County, is new. Business conditions were reported to be about the same in 1913 as in 1912, though the value of the sand-lime brick produced increased considerably.

Wisconsin.—Wisconsin was the fifth State in the value of the sand-lime brick output in 1913. The value increased $6,769, or 9.56 per cent, over 1912. The 4 plants in this State, all of which were active in 1913, are located in Columbia, Dane, Milwaukee, and Washington counties. Business conditions were better than in 1912.

LITERATURE.

The literature in English on the sand-lime brick industry is very meager, though the Illinois State Geological Survey [1] published a list of 61 papers on the subject. The great majority of these are foreign, mostly German. The following list is taken principally from the Illinois Survey publication:

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[1] Parr, S. W., and Ernest, T. R., A study of sand-lime brick; Illinois State Geol. Survey Bull. 18, 83 pp., 1912.

SULPHUR, PYRITE, AND SULPHURIC ACID.

By W. C. Phalen.

SULPHUR.

PRODUCTION.

The marketed production of sulphur in the United States in 1913 was 311,590 long tons, valued at $5,479,849. As compared with the quantity of sulphur marketed in 1912, which was 303,472 long tons, valued at $5,256,422, this is an increase of 8,118 long tons in quantity and of $223,427 in value. Unsold sulphur stocked at the mines is not included in the above figures nor in the table of production given below. By reference to a subsequent page of this report it will be observed that the output of Sicilian sulphur amounted to 351,752 metric tons (346,213 long tons) for the year ending July 31, 1913. If the quantity of sulphur mined is considered, the United States now occupies the leading position among the sulphur-producing countries of the world.

The production of sulphur in the United States since 1880 is given in the following table:

Production of sulphur in the United States, 1880–1913.

Year.	Quantity.	Value.	Year.	Quantity.	Value.
	Long tons.			*Long tons.*	
1880	536	$21,000	1897	2,031	$45,590
1881	536	21,000	1898	1,071	32,960
1882	536	21,000	1899	4,313	107,500
1883	893	27,000	1900	3,147	88,100
1884	446	12,000	1901	[a] 241,691	1,257,879
1885	638	17,875	1902	[a] 207,874	947,089
1886	2,232	75,000	1903	[a] 233,127	1,109,818
1887	2,679	100,000	1904	127,292	2,663,760
1888	....	....	1905	181,677	3,706,560
1889	402	7,850	1906	294,153	5,096,678
1890	....	....	1907	[b] 293,106	5,142,850
1891	1,071	39,600	1908	[b] 369,444	6,668,215
1892	2,400	80,640	1909	[b] 239,312	4,432,066
1893	1,071	42,000	1910	[b] 255,534	4,605,112
1894	446	20,000	1911	[b] 265,664	4,787,049
1895	1,607	42,000	1912	[b] 303,472	5,256,422
1896	4,696	87,200	1913	[b] 311,590	5,479,849

[a] Includes the production of pyrite. [b] Marketed production.

In 1913 three States produced sulphur, namely, Louisiana, Texas, and Wyoming. The production of these three States can not be given separately, as individual output can not be disclosed. Louisiana, of course, led in the sulphur industry in the United States. Texas ranked second, but production in this State has just begun. The production in Wyoming was small.

In the following pages are given descriptions of the sulphur-mining operations in Texas and Wyoming and notes on certain desulphurizing processes which are of especial interest in connection with the smelter-gas problem. Notes are also given on certain phases of the sulphur situation in Sicily, together with brief descriptions of the rather recently developed sulphur deposits on White Island, Bay of Plenty, New Zealand.

IMPORTS.

The table of imports of sulphur for consumption shows that 22,605 long tons, valued at $448,564, were imported in 1913. This includes imports of all varieties of sulphur—crude, refined, flowers of sulphur, and other grades not specifically mentioned. In the second table following, the imports of crude sulphur alone are given by countries. This table shows that the crude sulphur imported came practically from two countries, Italy (Sicily) and Japan. The Italian product is entered at Atlantic ports, chiefly New York; the Japanese product is entered at the Pacific ports, San Francisco and Los Angeles, Cal.; and Willamette and Portland, Oreg.; and at Hawaii.

Sulphur imported and entered for consumption in the United States for the calendar years 1909–1913, by kinds, in long tons.

Year.	Crude.		Flowers of sulphur.		Refined.		All other.[a]		Total.	
	Quantity.	Value.	Quantity.	Value.	Quantity.	Value.	Quantity.	Value.	Quantity.	Value.
1909	28,800	$492,962	770	$23,084	966	$26,021	53	$7,565	30,589	$549,632
1910	28,656	496,073	1,024	30,180	1,106	25,869	47	6,489	30,833	558,611
1911	24,200	434,796	3,891	83,491	985	24,906	68	9,643	29,144	552,836
1912	26,885	494,778	1,311	39,126	1,665	40,933	66	9,137	29,927	583,974
1913	15,122	286,209	5,899	115,574	1,234	29,091	350	17,690	22,605	448,564

[a] Includes sulphur lac and other grades not otherwise provided for, but not pyrite.

Statement, by countries and by customs districts, showing the imports into the United States of crude sulphur or brimstone each calendar year, 1911–1913, in long tons.

Countries whence exported and customs districts through which imported.	1911		1912		1913	
	Quantity.	Value.	Quantity.	Value.	Quantity.	Value.
COUNTRY.						
Canada					98	$2,372
United Kingdom	11	$248			101	2,905
Italy	8,031	156,157	2,348	$46,003	125	3,046
Japan	16,185	279,991	24,505	447,946	14,317	269,730
Other countries	23	329	32	829		3
Total	24,250	436,725	26,885	494,778	14,641	278,056
CUSTOMS DISTRICTS.						
Baltimore, Md	1,500	28,209				
Boston and Charlestown, Mass	20	480			15	343
New York, N. Y	6,531	127,948	1,359	29,387	140	3,809
Los Angeles, Cal	700	11,330	850	13,757	1	42
San Francisco, Cal	9,664	85,928	15,984	280,010	5,110	86,146
Willamette and Portland, Oreg	4,661	19,274	7,646	149,612	6,802	128,709
Hawaii	1,100	161,720	1,000	20,916	523	8,923
All other	74	1,836	46	1,096	2,050	50,084
Total	24,250	436,725	26,885	494,778	14,641	278,056

EXPORTS.

In 1911 the United States exported 28,103 long tons of sulphur, valued at $545,420. In 1912 the exports amounted to 57,736 long tons, valued at $1,076,414. In 1913, the exports were 89,221 long tons, valued at $1,599,761. The excess of exports over imports for 1913 amounted to 66,616 long tons and the balance of trade in favor of the United States was $1,151,197.

OCCURRENCE AND INDUSTRY.

TEXAS.

BRYAN HEIGHTS.

The actual mining of sulphur in Texas began in November, 1912, near Bryan Heights at the mouth of Brazos River, Brazoria County. During 1913 progress was more or less intermittent, owing to delays and adjustments incident to the commencement of an important mining operation of this character. There was, however, a substantial output of sulphur reported for the year, and the statement seems to be justified that Texas is about to take a place among the important sulphur-producing districts of the world.

Bryan Heights[1] is well located for the production and exploitation of the sulphur there occurring. It is only a short distance from the Gulf coast and about 3 miles from the harbor of Brazos River, where the town of Freeport will be established. The general location is about 40 miles southwest of Galveston and about 60 miles south of Houston, two of the most important cities of eastern Texas. One of the unique features of the locality is that mining operations will be conducted practically on the coast itself. The general plans of the syndicate of financiers in charge of the operations contemplate a port city of ultimate importance located on the west side of Brazos River near its mouth—a natural landlocked harbor—also the necessary railroad and steamship facilities, together with a bank, hotel, and other civic improvements of a substantial character. These will help to constitute the city called Freeport.

The transportation facilities at the Texas mine are ample. The field is located a short distance from the projected inland waterway which will provide a new transportation route from Galveston to Matagorda Bay. A railroad is now under construction from the mine to Freeport, which will give the Freeport Sulphur Co. a shipping point with ample wharfage facilities within 3 miles of the deposit.

Oil is the fuel used for heating the water needed in the process of mining the sulphur. There is no expense of rail haul on this oil, which will be supplied, it is understood, from the oil fields in the Tampico district, Mexico, across the Gulf from Freeport, and which has water transportation from Tampico to the distributing tanks of the company at Freeport. From these tanks the oil is pumped direct to the plant at Bryan Heights, thus providing a plentiful supply of fuel at the lowest possible cost.

Other industries which may locate at Freeport in the future will also be able to avail themselves of this supply of cheap fuel.

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[1] This description is based on the article by A. W. Davis, Min. Sci., August, 1913, pp. 99–102.

The occurrence of sulphur at Bryan Heights is in one of the structural domes characteristic of the Mississippi embayment. When these domes were drilled for oil in both Louisiana and Texas other mineral products were found in them, including gas, salt, sulphur, and gypsum. Little attention was paid to any of these products except the oil and gas until the Frasch process for the extraction of sulphur was put into successful operation in Calcasieu Parish, La., by the Union Sulphur Co. Then these mounds at once attracted attention as a source of sulphur. The area underlain by valuable sulphur deposits in the Texas locality has been proved to be large.

The process of mining used in Texas has already been fully described in these reports.[1] The sulphur is melted underground by means of superheated water and is then pumped or forced to the surface by an air lift. Sulphur recovered in this way requires the installation of a water-heating plant of great size, as large quantities of both heat and water are consumed. It is reported that one well will use an average of 1,000 barrels of fuel oil a day.

The large quantity of water required in the boilers and for the superheaters is provided by means of deep wells located 1½ miles from the plant. The water is forced to the surface by air, the pressure being furnished by an air compressor. The wells deliver more than 2,000,000 gallons of water a day to an artificial storage reservoir built adjacent to the plant and having a capacity at the 11-foot stage of 23,000,000 gallons and at the 12-foot stage of 33,000,000 gallons.

The heating plant at the Texas mine consists at present of one unit capable of developing the equivalent of 6,000 steam horsepower. Little steam, however, is used as power; except a very small quantity for the auxiliary machinery, it is applied to heating the water used in melting the sulphur. The initial plant as installed at the Bryan Heights mine consists of four 750-horsepower boilers, with a capacity of 100 per cent overload, that deliver steam at 100 pounds pressure to 2 heaters, in which water is heated to 387° F. The capacity of these boilers provides for the heating of 2,000 gallons of water a minute at this temperature. They are said to be the largest individual units in the South. Heaters are also used to feed water to the boiler. The equipment of the plant also contains a battery of twelve 10 by 6 by 12 duplex plunger pumps used in pumping water to the heaters and delivering it to the sulphur formation.

The water which is forced into the formation has a temperature of 337° F. at the ground, although sulphur melts at 239°. This heated water, which goes into the well, runs off into the cavities in the formation and does not return to the surface. After the hot water is forced into the ground for a number of hours a pool of molten sulphur forms at the bottom of the well. This accumulation is pumped to surface by an air lift.

Practice shows that when sulphur has been pumped from a well and a small percentage of water becomes mixed with it, the sulphur congeals to dust on reaching the surface. The water coming to the surface minutely commingled with the sulphur is relieved of pressure and necessarily cools to 212° F. very quickly, a temperature consider-

[1] U. S. Geol. Survey Mineral Resources, 1907, pt. 2, p. 674, 1908; idem, 1909, pt. 2, p. 686, 1911; idem, 1911, pt. 2, pp. 940-941, 1912.

ably lower than the melting point of sulphur. This tendency to cooling produces the dust mentioned above. When sulphur comes to the surface as dust, technically known as "blowing," it is known to the operators at the well that the accumulation of sulphur has been obtained. However, after a good well has been under steam a number of days, the pumping may be so regulated that a constant production can be obtained until the well becomes exhausted. This may not occur, however, for a year or more.

The hot water is forced into the formation during the entire time that the sulphur is being removed. The introduction of hot water and the removal of the sulphur is accomplished at the well by the use of a number of concentric pipes, the water passing downward between the outside pipes and the sulphur upward between the inside pipes.

The molten sulphur from the well is collected in huge plank bins whose capacities run into the hundreds of tons. When it is desired to ship the sulphur, the planking is removed and the sulphur, which hardens shortly after it reaches the surface, is broken up into pieces convenient to handle and is loaded into freight cars or on steamers as the case may be.[1]

Late reports in 1913 are to the effect that the Freeport Sulphur Co. is planning to build additions to its plant that will double the output of sulphur at Bryan Heights. The experience gained in operating the initial plant during 1913 indicates that the entire field should be rapidly developed. The original plant was built with provisions for additional units, and the proposed new installations comprise—a mining unit of fireproof construction with boilers to produce 8,000 horsepower; the remodeling of the old plant and the installation of additional pumps and compressors; the construction of mechanical loading devices both at the mine and at the steamship pier; the location of the 3-mile canal to extend from Brazos River to the mine at Bryan Heights; the erection of a pumping station at the river to pump water into the canal; the building of a water-treating plant at the mines to prepare the water for use in the boilers and heaters.

WYOMING.

The following notes on the operations of the Northwest Sulphur Co. at the southeast end of Cedar Mountain, Park County, Wyo., are by D. F. Hewett, of the United States Geological Survey.

The Northwest Sulphur Co. operates deposits of sulphur at the southeast end of Cedar Mountian in sec. 15, T. 52 N., R. 102 W., Park County, Wyo. They lie about 2 miles due south of those described by Woodruff [2] and about 4 miles southwest of the town of Cody.

Sulphur-bearing material is mined from three open cuts and from them is hauled by wagon 2,000 feet east to the refining plant. The largest and most eastern open cut is 100 feet long, 30 feet wide, and 15 feet deep. The open cut follows the north face of a low ridge composed of beds of dense gray sandstone, which probably are a portion of the Tensleep sandstone and at this point strike S. 65° W. and dip 10° SE. The sandstone is composed of clear quartz sand and is highly indurated. It is broken by numerous joints, of which a system extending approximately north and dipping 70° west predominates.

Sulphur occurs as an incrustation on blocks of sandstone in a very irregular zone, which is only locally controlled by the joints, but such material is low grade and is not

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[1] Davis, A. W., op. cit.
[2] Woodruff, E. G., Sulphur deposits at Cody, Wyo.: U. S. Geol. Survey Bull. 340, pp. 451–456, 1908.

used as a source of sulphur. The material that is richest in sulphur is the surface débris or wash, which adjoins the sandstone ridge on the north. This débris is composed of angular fragments of sandstone and chert and round pebbles of andesite and is clearly of local origin. In places it probably contains as much as 40 per cent sulphur. The total thickness of débris is not exposed in the open cut, but it can scarcely exceed 25 feet. The material as mined probably contains from 15 to 25 per cent of sulphur.

A second pit lies about 800 feet west of the first. It is 85 feet long, 25 feet wide, and has a maximum depth of 12 feet. The pit has not disclosed the bedrock sandstone. Sulphur incrusts fragments of sandstone along highly irregular zones, but the superficial layer of débris is barren. The third pit, 200 feet south of the second, is 80 feet long, 35 feet wide, and 30 feet deep at the inner end. Bedrock is not exposed, and sulphur occurs sporadically in the surface débris.

Travertine and similar hot springs deposits such as are found near the deposits which were operated along Shoshone River are absent in the vicinity of these deposits. It is probable that the sulphur was deposited in its present position by the decomposition of hydrogen sulphide gas through oxidation. Water may accompany this gas in its ascent along fractures and may escape at lower levels to join the waters of Sage Creek, half a mile north.

The extent of the sulphur-bearing material can only be determined by exploration, as it is covered for the most part by a thin layer of barren material, but it is very doubtful that sulphur will be found as a persistent deposit between the several open cuts.

At the refining plant the sulphur-bearing rock is drawn into perforated steel cars which are run in groups of 3 into a retort. Steam is supplied from two 16-foot boilers, and the liquid sulphur is drawn into wooden tanks, where it is allowed to solidify. The sulphur is broken, crushed to pass through a 20-mesh sieve, and sacked for shipment.

FOREIGN SULPHUR INDUSTRY.

SULPHUR OUTPUT AND EXPORTS FROM SICILY.[1]

According to the official report of the Consorzio Obbligatorio per l'Industria Solfifera Siciliana, of Palermo (Compulsory Sicilian Sulphur Combine), for the seventh working year, from August 1, 1912, to July 31, 1913, the total production of sulphur in Sicily was 351,752 metric tons, as compared with 366,457 tons in 1911–12 and with 391,908 tons in 1910–11. These figures show a gradual decrease during the last two working years, the production declining 25,451 tons in 1911–12 as compared with that of 1910–11, and 14,705 tons in 1912–13 as compared with that of 1911–12.

The failure to reach a normal production of 400,000 tons, as was anticipated, or at least the production of the working year 1910–11, which was 391,908 tons, is again attributed to the general conditions pointed out in a previous report from this consulate and to the closing in 1913 of 7 mines in addition to the 16 closed in 1912. Among the general conditions affecting the industry are the destruction by explosion of one of the more important mines which had previously produced an average of about 30,000 metric tons a year; the failure to discover new deposits of sulphur during the last decade; the continual deepening of almost all the existing mines, with consequent increased cost of mining; the working out and inundation of a number of mines; the lack of labor and its increased cost due to continuous emigration; and, finally, the law of June 30, 1910, which restricted the granting of sulphur-mining concessions. All these causes lead to the belief that the annual output of Sicilian sulphur in the future will not exceed 400,000 metric tons.

The total sales of sulphur during 1912–13, including sales for future delivery, amounted to 497,246 metric tons, compared with 603,255

[1] U. S. Consul Hernando de Soto, Palermo, Italy, Daily Cons. and Trade Repts., Feb. 5, 1914, pp. 470–471.

tons in 1911–12 and 816,818 tons in 1910–11. On July 31, 1913, there remained to be delivered on sales made 589,477 metric tons, of which 249,783 tons were booked for delivery during 1913–14 and 339,694 tons during the following years.

The total exports declined from 447,638 metric tons in 1911–12 to 434,473 tons in 1912–13, as is shown by the following table:

Exports of Sicilian sulphur.

Country.	1911–12	1912–13	Country.	1911–12	1912–13
	Metric tons.	*Metric tons.*		*Metric tons.*	*Metric. tons.*
United States	7,125	1,792	Greece	14,762	14,606
Africa	13,327	16,175	Netherlands	12,625	12,518
Australia	12,648	13,944	Norway	3,738	9,016
Austria	37,265	34,543	Portugal	14,185	14,758
Belgium	12,152	12,399	Russia	22,838	27,358
British Indies	4,928	5,342	Southern Italy	78,954	82,348
Canada	16	376	Spain	6,952	7,036
Central America and South America	7,440	7,624	Sweden	25,339	28,771
Denmark	836	305	Turkey	834	5,186
France	112,897	79,927	Other countries	9,144	7,818
Germany	28,869	35,091	Total	447,638	434,473
Great Britain and Malta	20,764	17,540			

The most striking decline was in the exports to France, which was always considered the best customer and which took 32,970 tons less in 1913 than in the preceding year. This decline, the Consorzio believes, is due to the establishment by the Union Sulphur Co. of large refineries in France. On the other hand, the exports to Germany increased by 6,222 tons, to Norway by 5,278 tons, to Russia by 4,520 tons, to Turkey by 4,352 tons, to Sweden by 3,422 tons, which in part counterbalanced the smaller purchases by France. The exports to the United States further declined from 7,125 in 1912 to 1,792 tons in 1913.

The stock on hand on July 31, 1913, amounted to 354,169 metric tons (against 444,381 tons on July 31, 1912), of which 250,548 tons were deposited in the warehouses at Porto Empedocle, 90,001 tons at Palermo, 69,611 tons at Licata, and 3,395 tons at Termini Imerese in this consular district.

In its annual review the Government monopoly (the Consorzio) calls attention to the fact that the Union Sulphur Co. has also extended its activity over other European markets by erecting large storehouses in Harburg, near Hamburg, Germany, and by purchasing lands near Rotterdam in Holland, upon which warehouses, sulphur refineries, and grinding mills are in course of construction. It is also pointed out that the Union Sulphur Co. proposes to establish its headquarters in Rotterdam for the distribution of American sulphur in Europe and that it has added two large steamers to its fleet to carry its products across the Atlantic. The review continues:

Against this rather discomforting news it is to be hoped that the steady increase in consumption of sulphur and the limited production in Sicily will permit the coexistence of the two most important sulphur producers in the world's market without prejudice to the progress of the Sicilian sulphur interests.

The decline in the exports of Sicilian sulphur should not be regarded as indicating a smaller demand for sulphur. This falling off is chiefly due to the loss, in part, of the French market, from which, however, it should not be inferred that the actual consumption is declining. In fact, Russia, Germany, and Scandinavia considerably increased their purchases.

The general apprehensions that the foreign competition is liable to seriously damage the Silician sulphur industry should be dismissed for the following reasons:

First. That the Freeport Sulphur Co., which began operations in 1911 in exploiting the sulphur deposits in Texas, failed to obtain the results it had anticipated, due chiefly to considerable technical difficulties.

Second. That Japan has not increased its exports, which is evidenced by the increasing demand for sulphur from the Pacific markets.

Third. That the rumors of large sulphur deposits on White Island, in Oceania, have not been confirmed.

Fourth. That the sulphur deposits in Spain are completely exhausted.

Fifth. That no definite information has been received announcing the alleged increase of sulphur production in Mexico.

NEW ZEALAND.

In April, 1912, work began on the deposits of sulphur on White Island, New Zealand. White Island has an area of approximately 600 acres and is located in the Bay of Plenty, on the coast of the North Island of New Zealand, about 30 miles from the mainland.

The island has somewhat the shape of a horseshoe. About 150 to 200 acres are fairly flat, a part of this flat area being occupied by a lake. This flat portion is open to the sea on one side, except for a hill near the center of the opening. The rim around the rest of its edge attains a height of 900 feet. Thus the topography indicates an old crater. Back of the lake is a boiling spring, a further indication of former volcanism. The island is situated also on one of the lines of weakness which strike transversely across North Island through the Hot Lakes district and the pumice zone. This volcanic activity extending seaward 30 miles and possibly more found a vent in what is now White Island. From the cumulative evidence given above, the sulphur is considered to be of volcanic origin.

In the flat portion of the island between the lake and the sea, both brimstone and flowers of sulphur are found. Between 6,000 and 7,000 tons of this sulphur were found in such shape as to be easily extracted. A boiling spring back of the lake is also producing sulphur, and though the exact quantity obtainable from this source is not closely determinable, estimates place it at several tons an hour. It is, moreover, of good grade, being about 94 per cent pure. Sulphur has also been found in the bottom of the lake, the drainage of which has exposed supplies of nearly pure material that were formerly unsuspected.

At the time of the last report[1] there were about 4,000 tons of raw material on the dump, which ran from 60 to 70 per cent sulphur, and 700 to 800 tons which was so pure as to need no refining.

The company operating the deposits has erected several small houses and has laid tracks to handle the mined material easily and cheaply. The refining operations are conducted in a battery of three retorts, each with a capacity of 4 tons an hour. The process is very simple. The material is wheeled from dump to retorts, and the sulphur is melted in the latter by means of superheated steam. The liquid sulphur runs out into troughs. The gypsum remaining is saved, and it is hoped it may be disposed of later at a profit.[2]

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[1] Eng. Min. Jour., vol. 96, pp. 815–817, 1913.

[2] Eng. and Min. Jour., vol. 96, pp. 815–818, 1913; see also ibid., vol. 94, p. 1238, 1912, and Australian Min. Standard, Feb. 6, 1913, p. 115.

DESULPHURIZING PROCESSES.

THIOGEN PROCESS.[1]

The Thiogen process has for its object the reduction of oxides of sulphur present in the gases given off by blast furnaces, reverberatories, and roasters, to elementary sulphur in such condition that most of it may be removed from the furnace gases before they are discharged into the atmosphere. In the process of S. W. Young this reduction is accomplished by fuel oil. When sulphur dioxide (SO_2) and a hydrocarbon of the ethylene series are heated together the reaction which ensues is approximately as follows: $3SO_2 + CH_2 = 3S + 2CO_2 + 2H_2O$. According to Young[2] this reaction is slow and incomplete and the use of some intermediate reagent has been found necessary. From the chemical point of view the sulphide of any sufficiently basic metal will do, but calcium sulphide, by virtue of certain physical properties, has been found to possess advantages. The reaction between sulphur dioxide and calcium sulphide may be represented as follows: $2CaS + 3SO_2 = 2CaSO_3 + 3S$. This reaction takes place in the dry state rapidly at a temperature of 100° C., but in the presence of water it takes place at ordinary temperatures.

If the mixture of sulphite and sulphur be heated, the free sulphur distils off and the residual calcium sulphite may be reduced at a moderate red heat by hydrocarbon oil, whereby the calcium sulphide is regenerated. The reduction is difficult except in the presence of small quantities of iron compounds; but when these are present the reduction takes place rapidly at a low heat, and the full reduction value of the hydrocarbon oil is realized. The reaction involved is as follows: $2CaSO_3 + 2CH_2 = 2CaS + 2CO_2 + 2H_2O$.

In practice if a mixture of sulphur dioxide and hydrocarbon vapor pass together over a mixture of calcium sulphite and calcium sulphide, the reactions given above take place simultaneously; that is, a portion of the sulphite is attacked by hydrocarbon and reduced to sulphide, which is in turn attacked by sulphur dioxide and reconverted into sulphite, and so on. Thus, the mixture of sulphite and sulphide behaves like a contact material.

Experiments having in view the placing of the process on a commercial basis, have been carried on for several months in the plant of the Penn Mining Co., at Campo Seco, Calaveras County, Cal. Many difficulties were encountered during the early stages of the process, but these were overcome one by one. The general scheme of operation is as follows:

> The roaster gases pass first through a dust settler, which leaves them fairly clean, small amounts of dust seeming to produce no deleterious effect for a considerable time. From the dust chamber the gas is passed to the fore chamber, where a certain amount of oil is introduced; thence the gas goes to the contact chamber, where additional oil is introduced. The relative amounts introduced at these places are adjusted by the temperature conditions which establish themselves in the contact chambers, the total amount being that necessary to burn out oxygen and reduce sulphur dioxide. The contact material is made from plaster of Paris, which is mixed with water containing a small amount of iron salts, allowed to set, and then broken into lumps. The issuing gases containing free sulphur pass to a cooling and condensing apparatus, where the sulphur deposits. Up to the present time practically no attention has been paid to the matter of condensation, other matters claiming all

[1] Young, S. W., Eng. and Min. Jour., vol. 95, pp. 369–370, 1913. [2] Young, S. W., loc. cit.

the time and knowledge of the experimenters. Sulphur has, however, been condensed several times on a small scale, but in a purely incidental way. Ordinarily it has been allowed to escape directly from the contact chamber at high temperature, under which conditions it reburns to sulphur dioxide.

The chief chemical difficulties met with have had to do with the "poisoning" of the contact material. Three causes may lead to this result: (1) If an excessive quantity of flue dust enters the contact chamber the contact mass soon becomes coated with it and its activity declines rapidly. To remedy this difficulty the flue dust is reduced to a minimum, small amounts, as stated above, having but little effect. (2) High temperatures also destroy the activity of the contact material. (3) The third source of trouble lies in foreign substances. The action of these substances is not clearly understood and is to be investigated further, as opportunity offers.

The plant has been run for periods of 10 to 12 days upon the same charge of contact material without loss of activity, during which time any degree of reduction desired could be obtained. During these runs no difficulty has been encountered in producing exit gases with practically no sulphur dioxide. Though all the problems are not yet settled, it is the opinion of those in charge of the work that those remaining present no serious obstacles to the ultimate success of the process.

HALL SULPHUR PROCESS.[1]

It was reported during 1913 that the First National Copper Co. is to undertake experiments on a working scale at its smelter at Coram, Cal., on the Hall process for desulphurizing smelter gases. The Hall sulphur process, named from William A. Hall, who devised it, is essentially a "controlled oxidation" process and—

> is based on the principle of removing the fixed sulphur atom of a sulphide by distillation and without permitting any considerable portion of the sulphur thus discharged to pass into any combined forms such as sulphur dioxide or sulphur trioxide.

The sulphur in the ore is removed therefrom in the elementary condition, and when the furnace operation is properly adjusted there is substantially no discharge from the furnace of combined sulphur, either as sulphur dioxide (SO_2), sulphur trioxide (SO_3), hydrogen sulphide (H_2S), or carbon oxysulphide (COS).

Many tests and demonstrations of the process have been made in France, England, and America under the direction of several metallurgical engineers and chemists. Analyses of the gases discharged have also been made. Such analyses have been made over continuous runs of several hours, and the total amount of sulphur in any gaseous condition has been found to average under 0.25 per cent by volume without any admixture of extraneous air. A set of analyses made by A. L. Walker and C. F. Chandler on the gases issuing is as follows:

Analyses of gases discharged in Hall sulphur process.

	Percentage SO_2.
First hour	0.025
Second hour	.028
Third hour	.023

[1] Hall, Wm. A., Eng. and Min. Jour., vol. 96, pp. 35-36, 1913. Liddell, D. M., Eng. and Min. Jour., vol. 96, p. 50, 1913; also Min. and Sci. Press, p. 2, July 5, 1913.

During this time the amount of hydrogen sulphide evolved is too small to be analytically determined.

In this demonstration the rate of decomposition was equivalent to that in treating 50 tons of ore per day in an 18-foot 6-hearth McDougall furnace, when roasting said ore from 40.5 per cent sulphur to 3.5 per cent sulphur. The rate of decomposition in the Hall process when conducted in multiple-hearth furnaces appears to be from 100 to 125 pounds of ore per square foot of hearth area per 24 hours, which makes it compare favorably with the capacity obtained in the best conducted roasting furnace. The action will be even more rapid if the desulphurization is not carried down to so sweet a roast and if the operation is stopped at a point where there is from 7 to 9 per cent total sulphur remaining, sufficient for matte formation. The cinder discharged is in excellent condition, comparing favorably with the best obtained in the roasting process.

The distillation of the sulphur is accomplished by direct application to the ore of a burning gas flame of slightly reducing or non-oxidizing character, accompanied by sufficient water, either in the shape of water of formation (from the combustion of hydrogen) or of small quantities of extraneous water in the form of steam. The water, from whatever source derived, is decomposed by the hot ore, the nascent oxygen going to the metal and the nascent hydrogen combining with any free oxygen that may enter the furnace through the atomizer through which the gases are admitted. There is thus created a sort of cycle of decomposition and of formation of water.

When the burners on the furnace are properly adjusted, the discharge of hydrogen appears to be in the form of water vapor; that is, complete balances are easily maintained, whereby there is substantially neither sulphur dioxide nor hydrogen sulphide in the discharge, the tests being made on samples taken within a distance of 6 inches from the furnace.

A great variety of ores has been experimented with, including pyrite, pyrrhotite, copper concentrates, crude blende, zinc concentrates, and chemically pure sulphide of iron. The action appears to be the same in all ores, the amount of sulphur produced, of course, depending on the amount originally present. To prove that the "fixed" atom is removed by distillation, the furnace has been operated on chemically pure sulphide of iron (FeS), which contains no "free" atom of sulphur. Only yellow-sulphur vapor was obtained, there being no sulphur dioxide or hydrogen sulphide in the discharge gases. Tests made abroad to determine the completeness of the desulphurization process show less than 1 per cent of sulphur in the residual cinder.

The analyses of the cinder when sulphide of iron has been used show it to be a mixture of the iron oxides Fe_2O_3 and Fe_3O_4. The oxidation of the metal after any "feeble" sulphur atom has been removed is due to the nascent oxygen from the decomposed water, it apparently being proved that nascent oxygen has a much greater affinity for the metal that decomposed the water than it has for the sulphur.

If producer gas is used for fuel, a larger amount of extraneous water is found necessary than when a gas is used that is high in hydrogen, such as water gas, and particularly oil gas. Gasified fuel oil appears to be an ideal fuel, as it contains substantially no nitrogen and has extremely high thermal values. When high-grade fuel oil is used there is a much smaller volume of fumes to be handled in the subsequent sulphur extractions. Where a gas is used that is high in carbon monoxide, a certain amount of carbon oxysulphide is formed, as carbon monoxide has a greater affinity for sulphur at elevated temperatures, but it has been found that when carbon oxysulphide and water vapor pass to a lower temperature—for example, less than 400° C.—there is a reaction resulting in the formation of hydrogen sulphide and carbon dioxide.

The temperature maintained in the furnace must be slightly above 700° C., as that is about the distillation point of the sulphur of a metallic sulphide, and it must be maintained below 900° C., the fusing point. The latitude of 200° C. gives a considerable range of safety in the operation.

The fumes coming from the smelter are of a heavy yellow appearance with no appreciable odor other than that of hot sulphur vapor. The sulphur is extracted from these fumes by simply washing. When the fumes are agitated with water the atmosphere is almost instantly clarified, the sulphur settling to the bottom of the apparatus. Any well-known gas-washing apparatus is considered to be adapted for the purpose, and tests have already been made with a few of them. The fumes have also been run through the Cottrell electric dust collector, which completely precipitated the sulphur. The solids precipitated by washing the fumes have been analyzed, and have been found to run from 98 to 99½ per cent sulphur, the impurities being fine dust or lead or zinc sulphides. The refined sulphur has been found to be more than 99½ per cent soluble in carbon bisulphide.

So far the process has been developed chiefly with the view of its attachment to multiple-hearth roasters, but it is understood that promising experiments have been made with reference to its attachment to blast furnaces.

The cost of producing sulphur by this method in American smelting works is calculated at from $3 to $5 per ton of crude sulphur derived.

PYRITE.

PRODUCTION.

The production of pyrite in the United States in 1913 amounted to 341,338 long tons, valued at $1,286,084. As compared with the production and value of pyrite in 1912 this is a reduction of 9,590 long tons in quantity and of $48,175 in value. Though the figures of production were less in 1913 than in 1912, nevertheless the industry can not be regarded as having gone backward, for when viewed for the last four years the average production will be found to be greatly in excess of what it was in 1910 and 1911.

The following table gives the production of pyrite by States during the last three years:

Production of pyrite in the United States, 1911–1913, by States, in long tons.

State.	1911			1912			1913		
	Quantity.	Value.	Average price per ton.	Quantity.	Value.	Average price per ton.	Quantity.	Value.	Average price per ton.
California	48,415	$182,787	$3.78	61,812	$201,453	$3.26	70,536	$218,525	$3.10
Georgia	(a)	(a)	(a)	(a)	(a)	(a)	11,110	55,094	4.96
Illinois	17,441	47,020	2.70	27,008	62,980	2.33	11,246	31,966	2.84
Indiana	(a)	(a)	(a)	1,462	5,684	3.89	1,242	3,115	2.51
Ohio	6,471	18,017	2.78	14,487	43,853	3.03	13,622	34,998	2.57
Virginia	150,800	558,494	3.70	162,478	621,219	3.82	148,259	587,041	3.96
Wisconsin	12,893	50,025	3.88	17,898	70,518	3.94	25,328	94,727	3.74
Other States [b]	65,438	308,527	4.71	65,783	328,552	4.99	59,995	260,618	4.34
Total	301,458	1,164,871	3.86	350,928	1,334,259	3.80	341,338	1,286,084	3.77

[a] Included in "Other States."
[b] 1911, Georgia, Indiana, Massachusetts, Missouri, New York, Oklahoma, and Pennsylvania; 1912, Georgia, Missouri, New York, and Pennsylvania; 1913, Missouri and New York.

The production of pyrite in the United States since 1882 is given in the following table:

Production of pyrite in the United States, 1882–1913, in long tons.

Year.	Quantity.	Value.	Year.	Quantity.	Value.
1882	12,000	$72,000	1898	193,364	$593,801
1883	25,000	137,500	1899	174,734	543,249
1884	35,000	175,000	1900	204,615	749,991
1885	49,000	220,500	1901	[a] 241,691	1,257,879
1886	55,000	220,000	1902	[a] 207,874	947,089
1887	52,000	210,000	1903	[a] 233,127	1,109,818
1888	54,331	167,658	1904	207,081	814,808
1889	93,705	202,119	1905	253,000	938,492
1890	99,854	273,745	1906	261,422	931,305
1891	106,536	338,880	1907	247,387	794,949
1892	109,788	305,191	1908	222,598	857,113
1893	75,777	256,552	1909	247,070	1,028,157
1894	105,940	363,134	1910	241,612	977,978
1895	99,549	322,845	1911	301,458	1,164,871
1896	115,483	320,163	1912	350,928	1,334,259
1897	143,201	391,541	1913	341,338	1,286,084

[a] Includes production of natural sulphur.

IMPORTS.

The pyrite imported into the United States in 1913 amounted to 850,592 long tons, valued at $3,611,137. As compared with 1912, this is a decrease in 1913 of 120,193 long tons in quantity and of $230,546 in value. Foreign pyrite is the controlling factor in the domestic market, the domestic production being insufficient to supply the demand.

The imported pyrite comes chiefly from Spain, in which country the principal deposits occur, though part of them are located in Portugal. The Huelva deposits are the most important. They occur in the Spanish Province of Huelva and the Portuguese Province of Alemtejo, between Rio Tinto and San Domingo, in a zone about 120 miles long and from 12 to 20 miles wide. The famous San Domingo, La Zarza, and Tharsis mines lie near the middle of this zone.

The ore in the Spanish deposits is compact, finely crystalline, and often banded or stratified. The color varies from a silver white in the San Telmo ores to a rich golden in the Granada. These colors depend on the relative percentages of iron, copper, and other metals present. Vogt estimates the entire area of the Huelva pyrite deposits as half a million square meters and the total mass of the deposit, omitting depletion through erosion and mining, as one billion metric tons.

The imported Spanish ore is admirably suited for the purpose of making sulphuric acid. The ores are of the compact, massive varieties and are of high grade, rarely falling under 47 per cent sulphur and reaching as high as 51 per cent. For export the ore is broken into uniform pieces about 2½ inches in average diameter, and in this form it is sold as "furnace size" ore. Generally there is a maximum guaranty of 5 per cent "fines" or material under one-quarter inch mesh. This uniform size and weight enables the ore to be handled more easily and burned more efficiently, and its additional cost is outweighed by the fact that no breaking and rehandling are necessary at the factory. In addition to the furnace size ore, there is also quite a large quantity of lump ore imported, varying in size from that of a pea up to masses weighing 100 to 200 pounds. The lump ore is initially cheaper per ton, but before it can be burned it has to be broken by sledges to furnace size. The labor and cost involved in this operation are considerable, and a large quantity of "fines" is formed which can not be used in lump burners but must be sold for use in "fines" burners. Besides the imports of lump and furnace size ores, there is also imported a fine ore about the size of a pea for use in "fines" burners.

The ores are sold on a unit basis—that is, at a certain price for every per cent or fraction thereof of available sulphur. These prices fluctuate, depending on the demand, output, chartering of boats, etc. From the best information obtainable, the water rate from Spain to Atlantic ports is somewhat over $2 a ton, and wharfage is about 45 cents a ton exclusive of the land freight rate. Spanish pyrite is at present quoted at 13 cents per unit f. o. b. for furnace size ore. The fine ore of the same grade is usually quoted at 1 to 2 cents less per unit than the furnace size. The final cost of the furnace size is less than that of lump ore of the same grade or even of higher grade, because added to the actual cost, plus freight charges, including water, rail, wharfage, etc., is the cost of breaking the lump at the factory, which is about 50 cents a ton. For this extra expense of breaking the company selling the ore usually allows about 30 cents a ton. But in addition to this added trouble and expense there are considerable fines formed which have to be disposed of at 2 cents less per unit than they cost. There are still some factories that buy lump ore and break it to furnace size at the works.[1]

The imports of pyrite for consumption for the last five years are given in the following table:

Imports for consumption of pyrite containing not more than 3.5 per cent of copper, 1909–1913, in long tons.

Year.	Quantity.	Value.	Year.	Quantity.	Value.
1909	688,843	$2,428,580	1912	970,785	$3,841,683
1910	803,551	2,748,647	1913	850,592	3,611,137
1911	1,006,310	3,788,803			

WORLD'S PRODUCTION OF PYRITE.

In the following table is given the world's production of pyrite and the quantity of pure sulphur which it is supposed to replace in the market, estimated on the assumption that the pyrite averages 45 per cent in sulphur.

Wherever possible, the figures have been taken from the official Government publication of the country concerned. Where this was not possible the figures have been taken from the British Blue Book, known as Mines and Quarries, London. In the table below, the British Blue Book has been used for all countries with the exception

[1] From paper read by W. C. Dumas before the Georgia section of the Am. Chem. Society: Am. Fertilizer, vol. 36, No. 6, pp. 21–23. See also Beck, R., The nature of ore deposits, translated by W. H. Weed, vol. 2, pp. 483–485, 1905.

of Canada, Belgium, the German Empire, Italy, and the United States.

Production of iron pyrite in principal producing countries and quantity of sulphur displaced, 1908–1913, in long tons.

Country.	1908	1909	1910	1911	1912	1913
North America:						
Canada	a 42,264	b 57,718	48,098	73,809	72,791	204,296
United States	222,598	247,070	241,612	301,458	350,928	341,338
Europe:						
Belgium	351	211	211	120	146	(c)
Bosnia and Herzegovina	10,238	7,151	56	3,069	(c)	(c)
France	280,233	268,918	246,488	273,565	(c)	(c)
German Empire	216,000	195,560	212,311	214,034	(c)	(c)
Greece	6,759	14,506	32,767	35,390	(c)	(c)
Hungary	97,268	97,412	91,008	95,231	(c)	(c)
Italy	a 129,647	a 130,152	133,492	143,823	244,697	(c)
Norway	a 264,891	a 278,352	a 324,457	a 363,243	(c)	(c)
Portugal	d 104,270	d 268,108	289,119	d 272,869	(c)	(c)
Russia	57,760	45,323	(c)	(c)	(c)	(c)
Servia	32,211	21,286	36,255	(e)	(c)	(c)
Spain	f 259,308	f 254,853	f 289,551	f 339,448	(c)	(c)
Sweden	29,103	15,850	25,044	29,622	(c)	(c)
Turkey	g 57,707	g 77,402	h 148,130	h 104,823	(c)	(c)
United Kingdom	9,448	8,429	9,380	10,114	10,522	(c)
Asia:						
Japan	33,334	21,170	78,421	72,585	(c)	(c)
Oceania:						
Australia	....	....	2,916	2,496	(c)	(c)
Total	1,853,390	2,009,471	2,209,316	2,335,699	....	....
Sulphur displaced i	834,026	904,262	994,192	1,051,065	....	....

a Cupreous iron pyrites.
b Includes cupreous iron pyrites.
c Statistics not available.
d 1908: Composed of cupreous iron pyrites, 80,135 long tons, and sulphur ore, 24,136 long tons; 1909: Composed of cupreous iron pyrites, 194,861 long tons, and sulphur ore, 73,247 long tons; 1911: Composed of cupreous iron pyrites, 9,595 long tons, and sulphur ore, 263,274 long tons.
e Quantity not stated. Value, $54,101.
f Also 2,938,759 long tons in 1908, 2,908,715 long tons in 1909, 3,180,530 long tons in 1910, and 3,232,465 long tons in 1911, designated as "copper ore and cupreous iron pyrites.'
g 1908: Year ending March, 1908; 1909: Year ending March, 1909.
h Exported from Stratoni.
i Based on estimated 45 per cent of sulphur content.

PYRITE INDUSTRY BY STATES.

CALIFORNIA.

California ranked third among the States in the production of pyrite in 1913. The output was 70,536 long tons, valued at $218,525, an increase as compared with the preceding year, when it amounted to 61,812 long tons, valued at $201,453. California pyrite is reported from near Oakland and Leona Heights, Alameda County, and from Keswick, Shasta County. Some of the California pyrite is used by the companies producing it in the manufacture of sulphuric acid.

GEORGIA.

There was a substantial increase in the quantity of pyrite produced in Georgia in 1913, the output nearly doubling as compared with that of 1912. The pyrite mined came from Bremen, near the line between Carroll and Haralson counties, and from Villa Rica, Carroll County. M. K. Phillips operated at the former place and the Sulphur Mining & Railroad Co., the most important operator in the State, at the latter. The Franklin Pyrite & Power Co., of Creighton, Cherokee

County, reported in 1912 as doing considerable improvement work, also reported a small output for 1913.

ILLINOIS.

Illinois in 1913 ranked seventh among the States in the production of pyrite. During the two preceding years this State had ranked fourth in this industry, but the output for 1913 fell off markedly, amounting to less than half that of 1912. This is not due to any marked decrease in the number of companies producing this mineral, but to the decrease in individual production.

The pyrite is produced as a by-product in coal mining in Vermilion and Madison counties, the headquarters of the industry being at Catlin, Danville, and Oakwood, Vermilion County, and Glen Carbon, Madison County. Some of the coal mines operated only a part of the year, which accounts for part, at least, of the reduction in output.

INDIANA.

The production of pyrite in Indiana in 1913 was not so great as in 1912. As in Illinois, the pyrite is obtained as a by-product in the mining of coal, the principal headquarters of the industry being at Terre Haute, Vigo County.

MISSOURI.

The production of pyrite in Missouri in 1913 was made chiefly by the Rolla Mining Co., near Rolla, the shipping point for the ore being Cabeen, on the St. Louis & San Francisco Railroad. The material, which runs about 40 per cent sulphur on the dry basis, as mined, is used in the manufacture of sulphuric acid at East St. Louis, Ill. A small part of the Missouri production in 1913 is reported as having been obtained in coal mining. This pyrite came from Vandalia, Audrain County. No pyrite was reported from Leslie, Franklin County.

NEW YORK.

Northern New York, between the Adirondack Mountains and St. Lawrence River is a foothill country with hard granites and gneisses making up the hills, and limestones and soft schists constituting the flats and lowlands. The sedimentary rocks of this region have been highly metamorphosed and the original character of some of the outcropping masses can be told only with great difficulty, if at all. In general, the highly metamorphosed crystalline rocks strike northeast and southwest, parallel to St. Lawrence River. They dip northwest. The basement rock of the region is gneiss. Overlying this comes the Grenville series, made up of crystalline limestones, gneisses, and schists of Algonkian (?) age with which most of the mineral deposits are associated. These rocks are intruded by masses of granite which no doubt played an important rôle in the formation of the deposits. To the north and west of the pre-Cambrian deposits, and occurring also as occasional patches within the area of the older formations, are found Cambrian (Potsdam) sandstones.

One of the important mineral deposits of this region is pyrite, found in occasional places in a belt extending from near Antwerp on the southwest, through Gouverneur, De Kalb, and Hermon townships on the northeast, a distance of over 40 miles. The pyrite occurs both en masse or in segregated deposits and disseminated, giving rise by its oxidation to the familiar rusty schists and gneisses of the region. The segregations are large and are of importance, constituting the workable deposits of the region. They are variable in shape, in length, and in thickness, but in general, they conform to the structure of the inclosing rock.

During the year 1913 two pyrite mines were worked in this region. One of these was operated by the St. Lawrence Pyrites Co., at Stellaville, on a branch railroad running between Hermon and De Kalb Junction. The second mine, sometimes known as the Cole mine, from its location on the farm of J. Frank Cole, was operated by W. J. Bulger, jr. The latter mine is 4 miles northeast of Gouverneur, and is most conveniently reached from that place.

The St. Lawrence Pyrites Co., controlled by Ladenberg, Thalmann & Co., of New York, has been producing pyrites for some years, and ranks as one of the four principal companies in the United States. Its mines, better known as Stella mines, include 2 shafts on parallel deposits, 1,600 feet apart. The northwest shaft, known as the Stella, is not at present operated. At this mine, the ore body, averaging 10 feet thick, extends 1,100 feet along the strike and has been worked 900 feet down the dip of 20° to 30°; considerable pyrrhotite occurs in the ore. The Anna shaft, where present mining is in progress, is on a parallel lens about 1,000 feet in the footwall of the Stella mine; the ore averages 20 feet thick and has been followed 250 feet down at 45° dip and 1,200 feet along the strike. The walls are not sharply defined and the merchantable ore fades gradually into rusty gneiss. Following the general rule of the entire district, the deposits strike northeast and dip to the northwest.

The ore carries from 15 to 40 per cent sulphur, with an average of about 21 per cent. Practically all the mine output is concentrated; though a rather low-grade ore, it is free from arsenic and injurious impurities. The ore is put through a jaw crusher at the shaft house, from which it falls into bins and is loaded into railroad cars. The cars convey it to the mill, situated near the Stella shaft on a small creek. At the mill it is put through a gyratory crusher, trommels, and 3 sets of rolls, and is concentrated in two 25-foot Hancock jigs; the tails from the Hancock jigs are treated in Harz jigs, and the fines are concentrated on 10 Wilfley tables and 1 Deister table, the latter treating the slimes. During the winter the concentrates are dried to prevent freezing in a Ruggles-Coles cylindrical drier. This consists of a nearly horizontal cylinder with another cylinder inside, the concentrates being passed between the two. The hot gases enter the inner cylinder at the end, where the concentrates are wettest, and return between the cylinders, where they come in actual contact with the material. The mill was designed for 500 tons capacity per 24 hours, which is sometimes exceeded, and reduces the mine's output about one-half in weight, sending out concentrates running about 44 per cent in sulphur. The product is sold to sulphuric-acid manufacturers and to some extent to paper mills in the East; on account of the proximity of St. Lawrence River (about 20 miles by rail), some of the material is transferred to boats at Ogdensburg and shipped up the Lakes. Trouble has been encountered from protests of residents because of pollution of the creek by mill tailings; to obviate this, a circular concrete settling tank has been constructed near the mill and housed in, the plan being to use the same water over again with only small additions from the creek. * * *

The Cole mine, near Gouverneur, is a small mine, partly an open cut; only a depth of about 60 feet has been reached. The ore is shipped crude, the shipments averaging 30 per cent sulphur. One of the former lessees operated a small mill, later torn down by the St. Lawrence Pyrites Co., which held the lease at one time. The mine has recently been pumped out, after several years of idleness, by the Hinckley Fiber Co., which uses the output in its paper mill at Hinckley, N. Y., for making sulphurous acid to be used in a sulphite pulp process. The ore appears to lie in two parallel bodies separated by 15 feet of siliceous rock; the lower ore body was first worked as an open pit, and later through an inclined shaft. The upper ore body has been worked a little through a raise from the lower stope. The dip appears to be to the northwest and the strike northeast.[1]

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[1] McDonald, P. B., Mining in northern New York: Eng. and Min. Jour., vol. 95, No. 14, pp. 689-692, Apr. 5, 1913.

OHIO.

The production of pyrite in Ohio in 1913 was less than in 1912. Pyrite in Ohio is obtained as a by-product in coal mining and is often referred to by the miners as sulphur. The by-product pyrite in Ohio mines comes from Stark, Jefferson, and Tuscarawas counties, and at least 10 communities are headquarters of the industry.

VIRGINIA.

Though the production of pyrite in Virginia was less in 1913 than in 1912, the State still ranked first in the production of this mineral. The pyrite came from the Cabin Branch Mining Co., Dumfries, Prince William County., from the Arminius Chemical Co., and the Sulphur Mining & Railroad Co., near Mineral, Louisa County, and from the Pulaski Mining Co., Monarat, Carroll County.

The holdings of the United States Fidelity & Guaranty Co., near Mineral, Louisa County, were stated in this report for 1912 to have been sold to a new corporation organized in the spring of 1913 under the laws of Virginia and known as the Boyd-Smith Mines (Inc.). Development work was done at this mine during the year.

At the Gossan Mine of the Pulaski Mining Co., located at Monarat, Carroll County, in southwestern Virginia, the ore mined is pyrrhotite. This is shipped to the Pulaski works of the General Chemical Co., where it is crushed and roasted and used in the manufacture of sulphuric acid. The residue is nodulized and smelted for iron in a neighboring blast furnace.

WISCONSIN.

The production of pyrite (marcasite) in southwestern Wisconsin and northwestern Illinois is given in this report as from the State first mentioned, both for the reason that nearly all the production comes from Wisconsin and for the additional reason that it is impossible to differentiate the production of the two States. This latter condition is due to the fact that low-grade blende containing marcasite and originating in both States is shipped to separating plants in both Wisconsin and Illinois, after which it is impossible to correctly credit the original State quotas. Part of this pyrite is obtained in connection with the zinc ores mined in the southwestern part of Wisconsin in what is usually known as the Wisconsin or Upper Mississippi Valley zinc district, which includes also Illinois and Iowa.

This pyrite (marcasite) comes chiefly from the Linden, Platteville, Cuba City, and Benton districts, in Wisconsin, but a small quantity comes also from the Galena district of Illinois. The zinc sulphide and the iron sulphide from both States are separated by the Linden Zinc Co. at Linden, the Empire Roaster at Platteville, the National Zinc Separating Co. at Cuba City, the Wisconsin Separating Co. at Benton, in Wisconsin, and by the Joplin Separating Co. at Galena, in Illinois.

The greater part of the marcasite credited to Wisconsin is, however, not obtained by any process of separation, but is sold as mined. This marcasite is produced at the Wilkinson mine, operated by the Vinegar Hill Zinc Co., in the Benton district, Wisconsin.

The production from this district greatly increased in 1913 as compared with 1912, the increase amounting to more than 40 per cent.

Much of the pyrite from this region is high grade and averages 45 per cent sulphur.

UTILIZATION OF PYRITE RESIDUES.

In 1913, 3,538,980 short tons of sulphuric acid of 50° Baumé, valued at $22,366,482, were made in the United States. Of this production, 790,296 short tons, valued at $4,346,272, represents by-product acid, that is, acid made in connection with copper and zinc smelting. The difference, amounting to 2,748,684 tons, valued at $18,020,210, represents acid made from both domestic and imported pyrite. This acid is used in various ways, such as in the manufacture of superphosphates and explosives, in the refining of crude oil, and in making a host of chemical substances enumerated on a subsequent page.

Practically all the last-mentioned quantity of acid is made from pyrite, marcasite, or pyrrhotite, the different sulphides of iron, which are roasted in various types of roasting furnaces, the product, sulphur dioxide, being subsequently oxidized and treated with water vapor or steam to form the final product.

Pyrite contains 53.4 per cent sulphur and 46.6 per cent iron. Pyrrhotite, the other important iron sulphide and the mineral used at Pulaski, Va., contains usually from 38.4 to 39.6 per cent sulphur and from 60.4 to 61.6 per cent iron. Though the commercial pyrite now placed on the market does not contain the theoretical percentages of sulphur and iron given above, the figures approach near enough to the theoretical to make them of very practical interest. The average in sulphur content of the pyrite shipped from the Virginia pyrite mines ranges from 43 to 45 per cent. The following analyses show the general character of the Louisa County (Va.) pyrite; the fourth analysis being that of pyrrhotite from the southwestern part of the same State:

Composition of Virginia pyrite and pyrrhotite.

	1	2	3	4
Sulphur (S)	48.02	50.00	49.27	34.06
Iron (Fe)	42.01	43.00	43.62	53.15
Iron oxide (Fe_2O_3)	1.93			
Silica (SiO_2)	7.60			2.99
Insoluble		6.02	4.23	
Sulphur trioxide (SO_3)	.44			
Copper (Cu)	None.			[a].866
Arsenic (As)	None.			
Zinc (Zn)			.38	
Lime (CaO)			1.32	
Magnesia (MgO)			1.32	
Manganese				.306

[a] Copper.

The residual material, after the sulphur is removed by burning, as will be observed from the analyses given above and from the domestic production of pyrite plus the imports, is large in quantity and for the most part constitutes the equivalent of a good grade of iron ore. Most of the calcined residue contains approximately 2 per cent of sulphur, and some contains enough copper to make its removal profitable either by leaching or by other means. The material which is sometimes called "blue billy" resembles a reddish-brown iron ore, and except for its comparatively high sulphur content, its occasional copper content, and its finely divided condition, would pass for an ordinary red iron ore.

The problem, before utilizing the iron residues in the furnace, is to get rid of the comparatively large amount of sulphur which remains in the "blue billy" after as much sulphur as possible has been burned away as sulphur dioxide in the manufacture of the acid. This sulphur content is ordinarily much too high to permit the direct use of the residue in the manufacture of pig iron. The claim that many acid plants burn pyrite until the sulphur amounts to only 0.5 to 1 per cent is scarcely ever realized in practice and the pyrite cinder on the market contains, as a rule, 2 per cent or more of sulphur. "Blue billy" is therefore regarded as an undesirable iron ore and consequently brings a low price. Still another objection is the finely divided condition in which it comes from the acid factory, making it especially unsatisfactory where heavy blasts are used. This objection does not obtain where lump pyrite is used in the manufacture of acid, but here again such pyrite is apt to contain a larger content of sulphur than the fines.

During recent years several attempts or installations have been reported using one process or another for desulphurizing these residues and smelting them for iron. With the eventual depletion of our iron ore reserves (although far removed), it seems quite probable that this tendency will increase and that in time pyrite cinder will not be wasted, as has been so long the case, but will constitute an important source of iron. A few of these installations have been described in this chapter in previous years.

At the mines of the Pulaski Mining Co. in southwestern Virginia the procedure which obtained a few years ago, and which is presumably still in use, is as follows: The pyrrhotite is dead roasted; sulphuric acid is made, and the resulting cinder is used as part of the charge in an iron blast furnace. The ore is mined from open cuts; it is crushed and then conveyed to Herreshoff roasters. The cinder from these roasters is then clinkered in a 100-foot rotary cement kiln into which powdered coal is blown at the end opposite the feed. The pyrite cinder when fed to the kiln contains from 4 to 7 per cent sulphur; after going through the clinking process the sulphur content is reduced to 0.05 per cent. The cinder is sold to the Pulaski Iron Co., whose furnace is only a short distance away.

At the plant of the Pyrites Co. (Ltd.), which is engaged in the manufacture of sulphuric acid from Rio Tinto pyrite, there has just been put into operation a 150-ton Dwight-Lloyd sintering machine for sintering the cinder. About 8 per cent of coke dust is mixed with the cinder; the cost of the operation is considerably less than in nodulizing in kilns, the sulphur being reduced from 2 to 0.04 per cent. There is a tendency at present to use copper-bearing steel for rails for railway service, and if the use of steel containing copper should increase it is not at all improbable that the burning of copper-bearing pyrite for the manufacture of sulphuric acid, nodulizing the residue, and smelting in the blast furnace to yield a copper-bearing pig iron will become an important phase of future practice.[1]

[1] Min. and Sci. Press, July 26, 1913, p. 153.

SULPHURIC-ACID INDUSTRY IN THE UNITED STATES.

INTRODUCTORY NOTE.

The year 1913 is the third for which statistics of sulphuric acid have been collected by the United States Geological Survey. As stated in the report for 1911, the first year during which such statistics were published, one of the reasons for adding the subject of sulphuric acid to the chapter on sulphur and pyrite is because it is a commodity so extensively used in the manufacture of other chemicals that it has come to be regarded as a criterion or gage of the activity of the country in chemical manufactures in general. Another reason of recent importance since the beginning of the manufacture of by-product acid in the copper and zinc smelting industry is that through sulphuric acid is offered the only means of expressing the value of the sulphur in those sulphides now used in making by-product acid—that sulphur which formerly went to waste in the air in the form of sulphur dioxide and sulphur trioxide.

GENERAL USES.

Sulphuric acid is probably used in a greater variety of ways in the chemical arts than is any other substance. According to Lunge[1] the principal applications of the acid are as follows:

1. *In a more or less dilute state (say from 144° Twad. downward).*—For making sulphate of soda (salt cake) and hydrochloric acid, and therefore ultimately for soda ash, bleaching powder, soap, glass, and innumerable other products. Further, for superphosphates and other artificial manures. These two applications probably consume nine-tenths of all the sulphuric acid produced. Further applications are for preparing sulphurous, nitric, phosphoric, hydrofluoric, boric, carbonic, chromic, oxalic, tartaric, citric, acetic, and stearic acids; in preparing phosphorus, iodine, bromine, the sulphates of potassium, ammonium, barium (blanc fixe), calcium (pearl-hardening); especially also for precipitating baryta or lime as sulphates for chemical processes; sulphates of magnesium, aluminum, iron, zinc, copper, mercury (as intermediate stage for calomel and corrosive sublimate); in the metallurgy of copper, cobalt, nickel, platinum, silver; for cleaning (pickling) sheet iron to be tinned or galvanized; for cleaning copper, silver, etc.; for manufacturing potassium bichromate; for working galvanic cells, such as are used in telegraphy, in electroplating, etc.; for manufacturing ordinary ether and the composite ethers; for making or purifying many organic coloring matters, especially in the oxidizing mixture of potassium bichromate and sulphuric acid; for parchment paper; for purifying many mineral oils, and sometimes coal gas; for manufacturing starch, sirup, and sugar; for the saccharification of corn; for neutralizing the alkaline reaction of fermenting liquors, such as molasses; for effervescent drinks; for preparing tallow previously to melting it; for recovering the fatty acids from soapsuds; for destroying vegetable fibers in mixed fabrics; generally, in dyeing, calico printing, tanning, as a chemical reagent in innumerable cases; in medicine against lead poisoning, and in many other cases.
2. *In a concentrated state.*—For manufacturing the fatty acids by distillation; purifying colza oil; for purifying benzene, petroleum, paraffin oil, and other mineral oils; for drying air, especially for laboratory purposes, but also for drying gases for manufacturing processes (for this, weaker acid also, of 140° Twad., can be used); for the production of ice by the rapid evaporation of water in a vacuum; for refining gold and silver, desilvering copper, etc.; for making organo-sulphonic acids; manufacturing indigo; preparing many nitro compounds and nitric ethers, especially in manufacturing nitroglycerin, pyroxylin, nitrobenzene, picric acid, and so forth.
3. *As Nordhausen fuming oil of vitriol (anhydride).*—For manufacturing certain organo-sulphonic acids (in the manufacture of alizarin, eosin, indigo, etc.); for purifying ozokerite; for making shoe blacking; for bringing ordinary concentrated acid up to the highest strength as required in the manufacture of pyroxylin; and for other purposes.

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[1] Manufacture of sulphuric acid and alkali, vol. 1, pt. 2, pp. 1169–1170, ed. 1903.

The most important of the classes of manufacture enumerated above, so far as the consumption of the acid is involved, are in (1) the manufacture of fertilizer; (2) the refining of petroleum products; (3) the iron, steel and coke industries; (4) the manufacture of nitrocellulose, nitroglycerin, celluloid, etc.; and (5) in general metallurgical and chemical practice.

PRODUCTION.

The statistics of sulphuric acid have previously been collected at each census, beginning with the census of 1870; and at the censuses of 1889, 1899, and 1904, the quantity and value of each of the important grades were ascertained. The statistics of production in the tables which follow for the years prior to 1911 have been taken from the census reports for 1899 and 1904.[1]

In the production reported to the Survey for 1911, 1912, and 1913 all sulphuric acid is given regardless of whether it was sold as such or consumed in the factories where it was made. It is well known that nearly all the sulphuric acid made at fertilizer works is there consumed in the manufacture of superphosphates, that in factories where explosives are manufactured the sulphuric acid is combined with nitric acid and is used in making nitroglycerin and guncotton, and that, finally, in petroleum refineries much of the acid is consumed in refining the crude oil. In the earlier census reports the sulphuric acid consumed in establishments where manufactured and that produced by establishments engaged primarily in the manufacture of other products was listed separately, which is not done in the Survey's figures for 1911, 1912 and 1913, except in the case of the sulphuric acid manufactured at smelters as a by-product.

Sulphuric acid is produced in several grades: (1) 50° Baumé acid, also known as chamber acid, containing an average of 50.76 per cent SO_3, or 62.18 per cent H_2SO_4; (2) 60° Baumé acid, containing an average of 63.41 per cent SO_3, or 77.67 per cent H_2SO_4; (3) 66° Baumé acid, known as oil of vitriol, containing approximately 76 per cent SO_3, or approximately 93.19 per cent H_2SO_4. Higher strengths of acid usually contain SO_3 dissolved in sulphuric acid; for example, pyrosulphuric acid and fuming or Nordhausen acid. Oleum is a grade which contains 30 to 60 per cent of free SO_3, or a total of 87 to 92 per cent of free and combined SO_3. It is essentially a solution of SO_3 dissolved in sulphuric acid.[2]

The production of sulphuric acid published by the Survey represents bona fide returns from producers, and the figures in the following tables are not estimates. For this reason the figures may be either equal to or less than the actual production. It is obvious that they can not exceed it so long as the returns are correct.

In the following table the quantity, value, and price per ton are given of the three main grades of acid, and also similar data for other strengths of acid combined. With the exception of the quantity of acid indicated in the footnote the output is also expressed in terms of 50° Baumé acid for the sake of comparison.

[1] Census of manufactures, 1905, Bull. 92, pp. 15 and following, 1907.
[2] Molinari, Ettore, General and industrial chemistry, p. 274, 1912.

Production of sulphuric acid in the United States in 1899, 1904, 1909, 1911, 1912, and 1913, by grades, in short tons.

Grade.	1899			1904		
	Quantity.	Value.	Price per ton.	Quantity.	Value.	Price per ton.
50° Baumé	953,439	$7,965,832	$8.35	1,169,141	$8,314,646	$7.11
60° Baumé	17,012	246,284	14.47	48,688	581,523	11.94
66° Baumé	382,279	6,035,069	15.78	411,165	5,917,699	14.38
Other grades				[b] 13,268	361,018	27.20
Total	1,352,730	14,247,185		1,642,262	15,174,886	
Total reduced to 50° Baumé acid	[a] 1,548,123		9.20	[c] 1,869,437		

Grade.	1909			1911		
	Quantity.	Value.	Price per ton.	Quantity.	Value.	Price per ton.
50° Baumé	1,624,178	$8,494,451	$5.23	1,026,896	$5,447,958	$5.31
60° Baumé	186,900	1,089,350	5.78	421,165	2,624,042	6.23
66° Baumé	558,078	6,719,259	12.04	751,541	9,176,297	12.21
Other grades	[b] 31,349	476,135	15.18	[e] 10,728	121,575	11.33
Total	2,400,505	16,779 195		2,210,330	17,369,872	7.86
Total reduced to 50° Baumé acid	[d] 2,748,527			[e] 2,688,456	[e] 17,313,822	6.44

Grade.	1912			1913		
	Quantity.	Value.	Price per ton.	Quantity.	Value.	Price per ton.
50° Baumé	1,047,483	$5,378,411	$5.13	1,643,318	$9,212,917	$5.61
60° Baumé	451,172	2,727,764	6.05	509,929	3,202,528	6.28
66° Baumé	774,772	9,360,630	12.08	797,104	9,282,432	11.65
Other grades	66,166	871,214	13.17	63,158	986,659	15.62
Total	2,339,593	18,338,019	7.84	3,013,509	22,684,526	7.53
Total reduced to 50° Baumé acid	[f] 2,876,000	[f] 17,572,837	6.11	[g] 3,538,980	[g] 22,366,482	6.32

[a] Includes 764,355 tons, with an assigned value of $7,032,066, consumed in establishments where manufactured; and also sulphuric acid produced by establishments engaged primarily in the manufacture of other products.
[b] Reported as oleum by the census.
[c] Includes 968,445 tons, with an assigned value of $7,232,675, consumed in establishments where manufactured; and also sulphuric acid produced by establishments engaged primarily in the manufacture of other products.
[d] Includes 1,271,535 tons, with an assigned value of $6,694,436 consumed in establishments where manufactured; and also sulphuric acid produced by establishments engaged primarily in the manufacture of other products.
[e] Exclusive of acids of strength greater than 66° Baumé.
[f] Exclusive of electrolyte and acids of strength greater than 66° Baumé.
[g] Exclusive of 22,947 short tons of fuming acid, not convertible, valued at $318,044.

NOTES ON SULPHURIC ACID FIGURES.

The pyrite imported for consumption during the calendar year 1913 (which must not be confused with the total imports for that year), amounted to 850,592 long tons, according to the Bureau of Foreign and Domestic Commerce. If to this figure of imports the domestic production of pyrite given in a preceding table, namely, 341,338 long tons, be added there results a total available for 1913 of 1,191,930 long tons of pyrite. On the basis of an average content in this pyrite of 45 per cent available sulphur and on the basis of a yield of 50° acid amounting to 4.7 times the available sulphur, there would result from the total pyrite indicated above 2,520,934 long tons, corresponding to 2,823,446 short tons, of acid from pyrite alone. In the tables already given the total output of 50° acid produced in 1913 is given as 3,538,980 short tons. Of this total, the quantity of by-product acid manufactured in connection with copper and zinc smelting operations amounted to 790,296 short tons. The difference, namely, 2,748,684 short tons, represents the actual quantity of acid made, based on actual returns from the producers themselves. The latter figures appear to indicate that not all of the pyrite produced and imported was consumed, for it will be observed that the calculated and the actual results differ by 74,762 tons, or approximately 2 per cent, based on the total acid production. If the acid excluded from the grand total, as indicated in the footnote to the first table, be added to the production, the small discrepancy would be correspondingly reduced.

There are certain factors in the situation which are not indicated in these calculations. In the first place, the total quantity of imported pyrite reported by the producers as used in the manufacture of sulphuric acid in 1913 was not the imports as furnished by the Bureau of Foreign and Domestic Commerce, but a very much larger quantity, including what is reported to the Survey by acid makers as foreign copper-bearing pyrite. Also the quantity of domestic pyrite reported as used in the manufacture of acid is not nearly so great, apparently, as the output of pyrite represented in the table giving the domestic production of this mineral. Another complicating factor in the sulphuric acid calculation is the fact that an important quantity of sulphur (nearly all domestic), which in 1913 amounted to more than 16,000 long tons, is used in making acid. It may be added in this place that the sulphuric acid figures of the Survey for previous years have always included the acid that has been made from sulphur. The remaining sulphide ore that is utilized in the manufacture of sulphuric acid is made up of domestic copper-bearing pyrite and domestic gold and silver bearing pyrite not used in the preparation of by-product acid and which presumably, either entirely or for the most part, is reported to the Survey as pyrite. The total quantity of such copper, gold, and silver bearing pyrite when added to the pyrite reported as being utilized in the manufacture of acid does not bring the total up to the total pyrite figures reported independently to the Survey. If the sum of these different items reported directly to the Survey by the sulphuric acid manufacturers are taken, and the factors indicated above are used, the production of acid calculated should be theoretically the same as that actually reported. Such calculation has been made by the writer and was found to differ by about 1 per cent from the actual returns, a difference considered to be within the limit of error.

Theoretically, as indicated, the production of domestic pyrite added to the imports should furnish a base on which to calculate the quantity of acid made in a given year. This collective figure should afford an index of the acid industry based on it. There are, however, certain elements of uncertainty involved in such calculations. For example, in addition to the points already enumerated, it is more than probable that a certain part of the stock of one year may hold over and be used the next year. During a period of several years, however, this element of uncertainty would be practically negligible, its importance diminishing inversely as the length of time. Another variable factor is the percentage of sulphur that is actually burned, which depends not alone on the original quantity of sulphur present, but also on the physical condition of the ore, the type of furnace used, the efficiency of manipulation, and perhaps on other conditions. It is obvious, therefore, from the large number of uncertain factors involved that estimates or calculations, though very interesting, have only a limited value. The Survey has therefore published in the past only actual returns from producers and since the work on sulphuric acid was inaugurated three years ago it has endeavored to get into closer touch with all the producers of this commodity. It is believed that during 1913, this has been practically accomplished and that the figures for that year are very close to the truth. The cordial spirit of cooperation evinced by the producers in the past has been highly appreciated and this opportunity is taken to acknowledge it.

PRODUCTION OF SULPHURIC ACID FROM SMELTER GASES.

In the following table is given the quantity of sulphuric acid recovered from the gases from smelters throughout the United States. By comparison with the preceding table it will be observed that this is approximately 22 per cent of the total sulphuric acid produced in the United States[1] during the year 1913. The figures given in the table, however, do not include acid manufactured from copper-bearing Spanish pyrite.

Production of sulphuric acid from copper and zinc smelters in 1911, 1912, and 1913, in short tons.[a]

[Reduced to 60° Baumé acid.

Source.	1911			1912		
	Quantity.	Value.	Price per ton.	Quantity.	Value.	Price per ton.
Copper smelters	207,657	$1,056,185	$5.09	[b] 321,156	[b] $1,985,704	[b] $6.18
Zinc smelters	230,643	1,677,511	7.27	[b] 292,917	[b] 2,255,237	[b] 7.70
Total	438,300	2,733,696	6.24	[b] 614,073	[b] 4,240,941	[b] 6.91
Total acid reduced to 50° Baumé	547,875			[c] 764,237		

Source.	1913		
	Quantity.	Value.	Price per ton.
Copper smelters	336,019	$2,205,627	$6.56
Zinc smelters	296,218	2,140,645	7.23
Total	632,237	4,346,272	6.87
Total acid reduced to 50° Baumé	790,296		

[a] The acid reported to the Survey includes that of 50°, 53°, 60°, and 66° Baumé strengths, and a small quantity of electrolyte and oleum. All strengths, with the exception of the electrolyte, have been reduced to both 50° and 60° Baumé, as given in the table.
[b] Inclusive of a small quantity of electrolyte.
[c] Exclusive of a small quantity of electrolyte.

[1] Percentages based on the total 50° acid, namely, 3,538,980 tons.

MINERAL PAINTS.

By James M. Hill.

INTRODUCTION.

As in the reports of the last few years, the mineral paints treated in this chapter are divided into three groups—(1) natural mineral pigments, (2) pigments made directly from ores, and (3) chemically manufactured pigments. Of the three classes the first two are included in the Survey's annual summary of the mineral production of the United States, as they are thought to represent values of crude material taken directly from the earth or material which at most has passed through simple or merely preliminary treatment. The chemically prepared pigments are not included in that statement of production because the quantity and value of the original minerals included in most of these pigments have been reported elsewhere, so that the publication of the statistics of the manufactured products would result in duplication.

Group 1, or natural mineral pigments, comprises ocher, umber, sienna, hematite, siderite, limonite, and ground slate and shale. The principal bases of metallic paints and mortar colors are the three ores of iron—hematite, siderite, and limonite. Many other minerals or mineral products are used in the paint trade, such as asbestos and products derived from it, aluminum, asphalt, barytes, clay, graphite, gypsum, magnesite, mica, pyrite, quicksilver, shells, silica, talc, and tripoli, and many by-products; but these are not considered here, since most of them are reported elsewhere in Mineral Resources, and for some of them statistics are not available.

Group 2, pigments made directly from ores, comprises zinc oxide, leaded zinc oxide, sublimed white lead, and sublimed blue lead. The last two are also known to the trade as basic sulphates of lead.

Group 3, the chemically manufactured pigments, comprises the chemical products—basic carbonate white lead, litharge, red lead, orange mineral, lithopone, and Venetian red.

The total quantity and value of pigments sold during 1913 and considered in this report were less than in 1912. There was a slight increase in the production of the natural mineral pigments, but in both the other classes there was a marked decrease in output. The output of the pigments made directly from ores fell off 8.4 per cent and the production of pigments made chemically decreased about 3.7 per cent.

The following table shows the total marketed production of the three groups of pigments for the last two years:

Quantity and value of mineral paints sold in 1912 and 1913, in short tons.

	1912		1913	
	Quantity.	Value.	Quantity.	Value.
Natural mineral pigments	74,657	$561,693	75,595	$522,410
Pigments made directly from ores	106,497	9,507,895	97,573	9,020,896
Chemically manufactured pigments	228,135	26,356,232	219,644	25,123,167
Total	409,289	36,425,820	392,812	34,666,473

Since the publication of the 1912 report there have been no new publications giving the results of the paint tests which are being carried on in various parts of the country. The last published reports are contained in Bulletins 34, 35, and 36 of the Scientific Section of the Paint Manufacturers' Association of the United States.

NATURAL MINERAL PIGMENTS.

MARKETED PRODUCTION.

The marketed production of the natural mineral pigments in the United States in 1913, as reported to the Survey, amounted to 75,595 short tons, valued at $522,410. Compared with 1912 this was an increase of 938 short tons, or slightly more than 1 per cent. The value of these pigments in 1913 decreased $39,283, or nearly 7 per cent. There was an increased output of ocher, metallic paint, and ground slate and shale. The production of umber and sienna decreased by 29 short tons. The greatest decrease was in the output of mortar colors. This is in part accounted for by the fact that some material heretofore classed as mortar colors is now included with the output of metallic paint. The output of slate and shale in 1913 showed a gain of 822 short tons over that of 1912; ocher gained 2,309 short tons; metallic paint 1,751 short tons; but mortar colors decreased by 3,915 short tons. The table given below shows the prices per ton at the point of production of the different mineral paints. The market price of all the pigments, except ocher, shows a slight decrease from the average prices received in 1912. The marked decrease in the price of metallic paint from $6.40 a ton in 1912 to $5.69 in 1913 and of mortar colors from $9.45 in 1912 to $6.62 in 1913 is partly due to the fact that the price paid for crude iron ore extensively used in the manufacture of these products was low, being not greatly in excess of the prices paid for iron ore used in the manufacture of pig iron.

Average price per short ton of natural mineral pigments, 1910–1913.

	1910	1911	1912	1913
Ocher	$9.60	$9.35	$9.78	$9.90
Umber and sienna	26.31	26.09	27.30	26.79
Metallic paint [a]	6.28	7.08	6.40	5.69
Mortar color	10.82	9.66	9.45	6.62
Slate and shale	5.81	6.39	5.79	5.55

[a] Includes crude iron ore sold for paint, which accounts in part for the low value per ton.

The following table gives the marketed production and value of the natural pigments during the last four years:

Marketed production of natural mineral pigments, 1910-1913, in short tons.

Pigment.	1910		1911		1912		1913	
	Quantity.	Value.	Quantity.	Value.	Quantity.	Value.	Quantity.	Value.
Ocher	11,711	$112,445	11,703	$109,465	15,269	$149,289	17,578	$173,944
Umber } Sienna }	1,015	26,700	1,005	26,225	805	21,975	776	20,790
Metallic paint	29,422	184,869	25,599	181,163	28,347	181,352	30,098	171,264
Mortar colors	9,960	107,780	7,922	76,517	9,272	87,595	5,357	35,443
Slate and shale, ground	16,515	96,001	16,510	105,451	20,964	121,482	21,786	120,969
Total	68,623	527,795	62,739	498,821	74,657	561,693	75,595	522,410

This table represents approximately the output of natural mineral pigments; the figures are the best obtainable under present conditions. With increasing appreciation of the value of impartial Government statistics it is hoped that the cooperation of all of the producers of these products with the Survey will eventually be complete.

The natural pigments are used for the most part by the manufacturers of linoleum and ready-mixed paints; some, of course, reach the market in dry ground form. The market for natural paint materials is, therefore, limited, and is believed to a certain extent to be dominated by a group of large producers whose plants are so situated that they practically cover the United States. The margin of profit in mining, preparing, and marketing the natural mineral pigments is not great, and it seems that a large and efficient organization is necessary in most cases to make a success of the business. There are probably hundreds if not thousands of deposits of the natural mineral pigments which have not been worked and which probably never will pay to work until there is a marked increase in the demand for the products.

OCHER.

MARKETED PRODUCTION.

The quantity of ocher sold in 1913 was 17,578 short tons, valued at $173,944, compared with 15,269 short tons, valued at $149,289, in 1912, an increase of 2,309 short tons in quantity and of $24,655 in value. The average price per ton in 1912 was $9.78 and in 1913 it was $9.90, an increase of 12 cents a ton.

The following table gives the quantity of ocher sold by States from 1910 to 1913, inclusive:

Marketed production of ocher, 1910-1913, by States, in short tons.

State.	1910		1911		1912		1913	
	Quantity.	Value.	Quantity.	Value.	Quantity.	Value.	Quantity.	Value.
California	118	$1,730	(a)	(a)	(a)	(a)	(a)	(a)
Georgia	7,011	70,388	7,395	$69,447	10,107	$101,790	11,420	$123,090
Pennsylvania	3,642	32,254	3,013	28,101	3,300	28,950	3,935	32,175
Vermont	609	5,935	(a)	(a)	531	6,346	(a)	(a)
Other States [b]	331	2,138	1,295	11,917	1,331	12,203	2,223	18,679
Total	11,711	112,445	11,703	109,465	15,269	149,289	17,578	173,944

[a] Included in "Other States."

[b] Includes, 1910: Iowa, Kentucky, Oregon, and Tennessee; 1911: California, Iowa, Vermont, and Virginia; 1912: California, Iowa, and Virginia; 1913: Alabama, California, Iowa, Vermont, and Virginia.

IMPORTS.

In the following table are given the imports of ocher for the last five years:

Imports of ocher, 1909–1913, in pounds.

Year.	Crude.		Dry.		Ground in oil or water.		Total.	
	Quantity.	Value.	Quantity.	Value.	Quantity.	Value.	Quantity.	Value.
1909	340,593	$3,501	13,337,310	$106,224	17,847	$939	13,695,750	$110,664
1910	181,176	2,055	11,849,921	129,308	10,213	483	12,041,310	131,846
1911	128,328	1,870	11,090,798	108,205	15,406	857	11,234,532	110,932
1912	160,117	1,884	15,863,678	145,699	14,069	723	16,037,864	148,306
1913	[a] 321,671	3,282	[a] 12,126,238	104,212	[a] 13,068	770	16,697,098	143,720

[a] Figures for Jan. 1 to Oct. 3, inclusive, 1913; since Oct. 4, under the new tariff, the figures for crude, dry, and ground in oil or water are given together by the Bureau of Foreign and Domestic Commerce. Total figures are correct for the year.

The imports of crude and dry ocher and ocher ground in oil or water amounted in all to 16,697,098 pounds, or approximately 8,349 tons, in 1913. The imports of crude and dry ocher for the first three quarters of the year amounted to 6,224 tons, valued at $107,494. This was about 35 per cent of the domestic production reported, which is supposed to be in these two forms. The value of the imported crude and dry ocher was less than that of the domestic output by $66,450.

NOTES ON OCHER.

Ocher is a hydrated ferric oxide permeating a clay base. It has a specific gravity of about 3.5 and a decidedly golden-yellow color. As viewed under the microscope and with a considerable enlargement the particles composing ocher appear flocculent and uniform. Good grades should contain 20 per cent or more of iron oxide, though there is a wide variation in the iron content of the material sold as ocher. Ferruginous shale is often ground and the product marketed as ocher, but unless the material is actually an ocher, as defined above, such product is classed under slate and shale in this chapter.

In 1913 ocher was produced in Georgia, Pennsylvania, Virginia, Alabama, California, Iowa, and Vermont, the States being named in the order of their producing importance. The Georgia output, practically all of which came from the vicinity of Cartersville, Bartow County, was 65 per cent of the total production of the United States. Mines located in Berks, Northampton, and Lehigh counties, Pa., produced a little over 22 per cent of the ocher mined in the country. In Virginia the production was as usual from Page and Pulaski counties. Alabama reentered the class of ocher producers, a new mine being opened in Clarke County. The ocher mines of Stanislaus and Calaveras counties, Cal., were worked to a limited extent, and it seems possible, according to trade reports, that the deposits near Michigan Bar, Sacramento County, may be reopened.

Ocherous clays and true ocher are not unusual in most parts of the country. The Survey is constantly in receipt of samples of yellow material, some of which would undoubtedly make good paints, but many of which are certainly not salable for use as pigments. During the year promising deposits have been newly opened in Utah, California, and Wisconsin, and several samples have been received from new workings in the old Virginia field.

OCHER IN CANADA.

According to a recent report issued by the department of mines[1] of Canada, the ochers are commercially mined in the Provinces of Quebec and Ontario, and deposits are found in many parts of Canada. The chief producing localities in the Province of Quebec are near Three Rivers and in Nicolet County. In Ontario the deposits of the Algoma district and those in Nassagaweya Township and Halton County are the most important; the deposits of Colchester County also have been worked to a small extent.

UMBER AND SIENNA.

MARKETED PRODUCTION.

The total quantity of umber and sienna sold in the United States in 1913 as reported to the Survey was 776 short tons, valued at $20,790, a decrease of 29 tons in quantity and of $1,185 in value, as compared with the production of 1912. The average price of umber and sienna per ton in 1913 was $26.79, as compared with $27.30 in 1912 and with $26.09 in 1911.

In the following table is given the marketed production of umber and sienna in the United States for the period 1909–1913:

Marketed production of umber and sienna, 1909–1913, in short tons.

Year.	Quantity.	Value.
1909	1,276	$33,472
1910	1,015	26,700
1911	1,005	26,225
1912	805	21,975
1913	776	20,790

IMPORTS.

In the following table are given the imports of umber and sienna for the last five years:

Imports for consumption of umber, 1909–1913, in pounds.

Year.	Dry.		Ground in oil or water.		Total.	
	Quantity.	Value.	Quantity.	Value.	Quantity.	Value.
1909	3,104,037	$26,125	4,953	$256	3,108,990	$26,381
1910	3,994,286	28,819	11,813	734	4,006,099	29,553
1911	3,163,614	22,025	751	87	3,164,365	22,115
1912	4,857,706	31,408	3,179	218	4,860,885	31,626
1913	[a] 4,537,505	31,476	[a] 6,042	374	5,236,489	36,771

[a] Figures for Jan. 1 to Oct. 3, inclusive; since Oct. 4, under the new tariff, the figures for dry and ground in oil or water are given together by the Bureau of Foreign and Domestic Commerce. Total figures are correct for the year.

[1] Economic minerals and mining industry of Canada: Canada Dept. Mines, Mines Branch, Ottawa, pp. 49–50, 1913.

Imports for consumption of sienna, 1909–1913, in pounds.

Year.	Dry.		Ground in oil or water.		Total.	
	Quantity.	Value.	Quantity.	Value.	Quantity.	Value.
1909	2,402,901	$32,913	6,114	$421	2,409,015	$33,334
1910	3,048,203	46,866	6,233	453	3,054,436	47,319
1911	2,845,938	36,296	14,039	923	2,859,977	37,219
1912	3,056,064	45,354	6,021	440	3,062,085	45,794
1913	[a] 2,367,963	34,793	[a] 2,502	92	3,273,217	48,535

[a] Figures for Jan. 1 to Oct. 3, inclusive; since Oct. 4, under the new tariff, the figures for dry and ground in oil or water are given together by the Bureau of Foreign and Domestic Commerce. Total figures are correct for the year.

The imports to October 3, 1913, as given in the tables are expressed in pounds. The quantity of dry umber imported in 1913 amounted to a little less than 2,268 short tons, considerably more than the domestic production of umber and sienna combined. The imports of dry sienna amounted to 1,184 short tons, making the total for both products 3,452 short tons, or 2,676 tons in excess of the domestic output. The value of the imported dry ground umber and sienna in 1913 was $66,269, or more than three times as much as that of the domestic production reported for the year.

NOTES ON UMBER AND SIENNA.

Umber consists of iron and aluminum silicates, containing varying quantities of manganese oxide, which influence its color accordingly. The raw variety is drab, but becomes reddish brown on burning. A marked percentage of large-sized particles is present in this pigment. The calcined material is referred to as burnt umber. The only State reporting a production of this pigment to the Survey in 1913 was Pennsylvania.

Sienna is composed essentially of silicates of iron and aluminum with less manganese oxide than umber and is of a lighter color. Large particles are present in the raw sienna, but burnt sienna is fine grained. According to some authorities, sienna and umber owe their color to the manganese oxide. Sienna and umber are used principally as pigments in the manufacture of ready-mixed paints and linoleum. Sienna was produced in Pennsylvania and California in 1913.

Umber has been mined at three localities in Pennsylvania, namely, Quaker Hill, Northampton County; Doylestown, Bucks County; and Bethel, Berks County. This limitation is strange in view of the fact that most of the Pennsylvania ochers carry manganese oxide. Apparently in most of the deposits the quantity of this oxide is too small to give the material the necessary color. The Pennsylvania umbers are always closely associated with deposits of ocher, and the origin, method of mining, and preparation of the material for market are similar to those of the yellow pigment.

It would seem that the United States could produce all the sienna needed for consumption, but the foreign pigments have always been considered superior to the domestic in color. The Survey has within the last year received a number of samples of exceptionally good siennas from deposits in Colusa County, Cal., Cherokee County, Ala., and Campbell County, Va.

A possible source of these pigments was suggested by the examination of certain oxidized gold ores obtained from Blaine County, Idaho. These ores are manganese-bearing limonitic material carrying free gold. After crushing and the removal of the gold by amalgamation, the tailings, if milled and settled, could be utilized for pigments. The samples obtained when roasted produce a good sienna brown equal to any of the standards, either foreign or domestic, in the Survey collection.

PRODUCTION IN PRINCIPAL COUNTRIES.

The following table gives the output of ocher and umber in certain of the principal producing countries from 1908 to 1912, inclusive, as far as statistics are available:

Production of ocher and umber in principal producing countries, 1908–1912, in short tons.

Year.	United States.		United Kingdom.		France.		German Empire (Bavaria and Saxony).	
	Quantity.	Value.	Quantity.[a]	Value.	Quantity.[b]	Value.	Quantity.	Value.
1908	15,266	$152,319	17,244	$69,012	36,442	$457,072	1,938	$7,443
1909	13,064	138,553	18,271	73,873	36,971	419,321	2,554	5,859
1910	12,211	123,145	18,497	74,832	36,232	428,238	3,038	6,404
1911	12,178	118,590	16,335	66,827	38,075	313,276	3,434	10,324
1912	15,644	156,589	15,621	66,481	(c)	(c)	[d] 7,595	13,518

Year.	Canada.		Belgium.		Spain.		Cyprus.	
	Quantity.[b]	Value.	Quantity.[b]	Value.	Quantity.[b]	Value.	Quantity.[e]	Value.
1908	4,746	$30,440	496	$1,655	441	$749	2,524	$9,621
1909	3,940	28,093	771	1,351	461	813	3,781	20,011
1910	4,813	33,185	661	1,158	837	1,442	3,441	15,748
1911	3,622	28,333	595	965	686	1,200	4,221	15,850
1912	7,654	32,410	716	1,592	(c)	(c)	(c)	(c)

[a] Includes oxides of iron and manganese used as pigments, lubricants, etc.
[b] Reported as ocher only.
[c] Figures not available.
[d] Production of Bavaria only figures for Saxony not yet available.
[e] Umber exports.

METALLIC PAINT.

MARKETED PRODUCTION.

The marketed production of metallic paint reported to the Survey in 1913 was 30,098 short tons, valued at $171,264, as compared with 28,347 short tons, valued at $181,352 in 1912. The effort is being made to put the production as nearly as possible on the basis of the material entering into metallic paint and to credit it to the individual State in which it was originally mined and first placed on the market. The production of metallic paints is reported from some States mainly in terms of the dry ground product, the average price per ton of which is considerably greater than of the crude ore produced in the same States and sold as such to the paint mills. The maximum price, that of ground paint in Pennsylvania, was $12.77, which shows that a large part of the production averages considerably below that figure, such portion being material that comes on the market originally in the form of unground iron ore. The price of the crude ore sold in that condition apparently varies between $1.16 and $2.88 a ton. The higher average value for metallic paint is probably to be explained by the fact that the large producers operate théir own mines and the material is marketed by them in the ground form.

The following table gives the marketed production of metallic paint from 1910 to 1913, inclusive:

Marketed production of metallic paint, 1910–1913, by States, in short tons.

State.	1910		1911		1912		1913	
	Quantity.	Value.	Quantity.	Value.	Quantity.	Value.	Quantity.	Value.
Maryland	(a)	(a)	(a)	(a)	562	$1,930	(b)	(b)
New York	c 11,085	$32,208	c 7,993	$28,569	c 10,951	29,547	c 14,949	$34,041
Pennsylvania	8,063	91,714	7,676	100,837	8,970	107,499	8,312	106,172
Tennessee	a 3,907	26,680	a 3,282	25,381	(b)	(b)	(b)	(b)
Wisconsin	c 2,057	14,916	c 2,048	11,258	c 2,106	9,953	c 2,144	11,584
Other States d	4,310	19,351	4,600	15,118	5,758	32,423	4,693	19,467
Total	29,422	184,869	25,599	181,163	28,347	181,352	30,098	171,264

a Maryland is included in Tennessee.
b Included in "Other States."
c Principally crude iron ore sold for paint.
d Includes, 1910: California, Georgia, Michigan, Missouri, Washingtom; 1911: Georgia, Michigan, Missouri, Virginia, Washington; 1912: Michigan, Missouri, Tennessee, Virginia, Washington; 1913: California, Georgia, Maryland, Michigan, Tennessee, Virginia, Washington.

NOTES ON METALLIC PAINT.

Metallic paint consists chiefly of red and brown iron oxides, produced either by grinding natural iron oxides, anhydrous or hydrated, or by roasting natural iron carbonate. The beds of Clinton hematite in New York, Tennessee, and Georgia, the red hematite of the Lake Superior region in northern Michigan, and the gray siderite found near Lehigh Gap, Pa., are the chief sources of the raw-ore supply. Several secondary materials are used to an important extent in the manufacture of metallic paint. Blast-furnace dust, a grayish-brown mixture of oxide of iron and coke that is collected at many furnaces, particularly in the Pittsburgh, Pa., district, yields on grinding a seal-brown powder. In the manufacture of sulphuric acid from pyrite large quantities of "blue billy," a purplish oxide of iron, is produced that is sometimes ground to form a pigment which, unless carefully prepared, is said to be unsatisfactory for structural iron paints, as it may contain free sulphur or sulphuric acid. In 1913 1,425 short tons of metallic paint from pyrite cinder were produced, which sold for $21,608, or $15.16 a ton. This product has not been included under natural pigments. Another by-product that has been utilized as a metallic paint is the residue left after extracting aluminum salts from bauxite. This residue, resembling a ferruginous clay and containing in the neighborhood of 54.25 per cent ferric oxide (Fe_2O_3), produces a brick-red material when roasted in a rotary kiln. This pigment is apt to retain appreciable quantities of soluble aluminum salts, which can hardly be considered as desirable ingredients in paints. Ferrous sulphate or copperas is roasted with lime or gypsum and sold as metallic paint. Differences in the conditions surrounding the roasting produce different shades of iron oxide, called by various names. as Indian red and purple oxide.

The metallic paints as considered here are, therefore, both browns and reds. Commercially the browns are known as metallic brown and certain of the reds as Indian red. All the paints made from by-product substances can not strictly be classed in group 1, but as a rule the production of these materials is not reported to the Survey.

Metallic paints, both natural and artificial, if of good grade, are practically inert to the ordinary atmospheric agencies. They are extensively used for painting structural ironwork and by railroads for box-car colors.

MORTAR COLORS.

MARKETED PRODUCTION.

The marketed production of mortar colors reported to the Survey in 1913 was 5,357 short tons, valued at $35,443, a decrease of 3,915 tons in quantity and of $52,152 in value as compared with 1912. This apparent great decrease in the output and value of mortar colors in 1913 is partly explained by the fact that heretofore a large amount of the iron-oxide ores have been reported as ground for mortar colors. Since the Survey is striving to give accurate statistics, it was thought best, upon the discovery of this condition, to include such iron oxide with the metallic paint figures rather than under mortar colors. It was found to be impossible to revise the figures of production for previous years, but it is hoped that in the future the producers of this class of material will aid the Survey in its endeavors to express correctly the output of the various natural mineral paint materials.

It is questionable whether figures for mortar colors should be included as a separate item of production, since a large part of the material sold under that name should probably be included with metallic paint or ground slate and shale. The material is used for tinting mortar, cement, and concrete, and the colors are usually of the various shades of red, brown, purple, blue, and black. The average price per ton for mortar colors was $6.62 in 1913, as compared with $9.45 in 1912. The material entered the market first in the dry ground condition, for which the prices are given.

In the following table is given the production of mortar colors from 1910 to 1913, inclusive:

Marketed production of mortar colors, 1910–1913, by States, in short tons.

State.	1910		1911		1912		1913	
	Quantity.	Value.	Quantity.	Value.	Quantity.	Value.	Quantity.	Value.
New York	5,200	$50,000	2,518	$24,723	3,309	$29,969	5,357	$35,443
Pennsylvania	2,711	33,752	3,248	30,442	2,550	24,857		
Other States [a]	2,049	24,028	2,156	21,352	3,413	32,769		
Total	9,960	107,780	7,922	76,517	9,272	87,595	5,357	35,443

[a] Includes—1910: Maryland, Ohio, and Tennessee; 1911, 1912, and 1913: Maryland and Tennessee.

SLATE AND SHALE.

MARKETED PRODUCTION.

The quantity of slate and shale ground for paints and fillers in 1913 was 21,786 short tons, valued at $120,969, an increase of 822 short tons in quantity, but a decrease of $513 in value, as compared with 1912. The average price of the material in 1911 was $6.39 a ton; in 1912 it was $5.79; and it was further reduced to $5.55 in 1913.

The following table gives the production of slate and shale ground for pigment during the last five years:

Quantity and value of slate and shale, ground for pigment, 1909-1913, in short tons.

Year.	Quantity.	Value.
1909	14,944	$98,176
1910	16,515	96,001
1911	16,510	105,451
1912	20,964	121,482
1913	21,786	120,969

NOTES ON SLATE AND SHALE.

Slate and shale for use in pigments and as fillers in the manufacture of oilcloth and linoleum were produced in 1913 in Pennsylvania, New York, New Jersey, Indiana, and Georgia, named in the order of their producing importance.

Pennsylvania in 1913 produced over 93 per cent of the paint slate and shale output of the United States. In this State the shales used in the paint trade may be divided into three classes—black, yellow, and red shales. Black shales, sold under the name "mineral black," are widely distributed throughout the State. In many places the material has been dug for use in paint. The refuse about slate quarries and the culm from anthracite coal mines have also been shipped to paint factories. Black shale is used to some extent in paint for buildings, but chiefly in the manufacture of a black filler for ironwork. Yellow shales occur in many places throughout the State. In a number of places these shales, after grinding, have been utilized in the manufacture of paint. Their principal use, however, is in the manufacture of oilcloth and linoleum. They are considerably lighter in color than the ochers and contain a much lower percentage of hydrous iron oxide, though they are usually called ochers. Red shales in many places in the State have been employed in the manufacture of paint.

A company has recently been formed to grind the black shales occurring near Brigham City, Utah, which were supposed to contain graphite. The samples sent to the Survey do not contain appreciable amounts of graphite, but are in reality carbonaceous shales.

WHITING.

Whiting was produced in Kentucky and Missouri in 1913. As only two companies producing ground whiting reported to the Survey, the statistics of production can not be given. It is doubtful if whiting should be included in the production of mineral paints, for it seems probable that only a small part of the output is actually used as a pigment.

Whiting is prepared by grinding various forms of white limestone and calcite. Some whiting, prepared artificially, is finer grained and a little lighter in weight than the natural whiting. It is used largely in the manufacture of putty, in distemper work, and in small quantities in ready-mixed paints.

A deposit of calcite from which whiting is made, occurring on the south side of Kentucky River about 8 miles from the town of Harrodsburg, Ky., appears to be in the form of a vein varying from 3 to 9 feet in width. Some samples of good-grade, fine-grained calcareous material suitable for the manufacture of whiting were received by the Survey from Uvalde County, Tex., and from Salt Lake County, Utah.

A company recently formed is marketing a very fine-grained rhyolitic tuff found in large deposits in Los Angeles County, Cal. It is said to make a good calcimine and to be suitable in the manufacture of rubber and as a filler for light-colored linoleums.

PIGMENTS MADE DIRECTLY FROM ORES.

PIGMENTS AND ORES.

The pigments here discussed are zinc oxide, leaded zinc oxide, sublimed white lead or "basic lead sulphate," and sublimed blue lead or "blue fume."

The white pigments having zinc for a base, either wholly or in part, are zinc oxide and leaded zinc oxide. No zinc lead has been produced in this country for a number of years. In the United States these pigments are usually made directly from the franklinite ores of New Jersey and the zinc and lead ores of the Mississippi Valley and of certain of the Western States.

In the upper Mississippi Valley lead and zinc region the zinc carbonate ore, smithsonite, locally known as "drybone," has been used almost altogether for pigment manufacture by the Mineral Point Zinc Co., but the sulphide ores of lead and zinc have also been used. In the Joplin region the mixed silicate and carbonate ores of zinc have been used for zinc-pigment manufacture. Zinc carbonate ore from New Mexico and southern Nevada and mixed sulphide ores of lead and zinc from these and various other Western States have also been extensively used in making zinc and zinc-lead pigments. Zinc carbonate ores imported from Mexico have also been used in the manufacture of zinc pigments. During 1913 zinc oxide and leaded zinc made directly from ores were reported from Pennsylvania, Wisconsin, Virginia, and Kansas.

The pigments containing lead known under the copyrighted name of "sublimed white and blue lead," or as basic lead sulphate and blue fume, are produced by the direct sublimation of lead ores largely derived from the Mississippi Valley deposits.

MARKETED PRODUCTION.

In order to conceal individual returns, the statistics of production of zinc oxide, leaded zinc, and of white lead and blue lead produced by sublimation have to be combined as in the last two years. The total quantity of material marketed amounted to 97,573 short tons, valued at $9,020,896. As compared with the production of 1912 this was a decrease of 8,924 tons, or about 8 per cent, in quantity and of $466,999, or about 5 per cent, in value.

The following table gives the production and value of pigments made directly from ores during the last four years:

Marketed production of pigments made directly from ores, 1910–1913, in short tons.

Pigment.	1910		1911		1912		1913	
	Quantity.	Value.	Quantity.	Value.	Quantity.	Value.	Quantity.	Value.
Sublimed blue lead ("blue fume"); Sublimed white lead ("basic lead sulphate"); Leaded zinc oxide	16,681	$1,613,859	80,611	$7,343,762	106,497	$9,507,895	97,573	$9,020,896
Zinc oxide	58,481	5,238,945						
Total	75,162	6,852,804	80,611	7,343,762	106,497	9,507,895	97,573	9,020,896

IMPORTS OF ZINC OXIDE.

The following table gives the imports of zinc oxide into the United States during the last five years:

Imports for consumption of zinc oxide, 1909–1913, in pounds.

Year.	Dry.		In oil.		Total.	
	Quantity.	Value.	Quantity.	Value.	Quantity.	Value.
1909	6,119,328	$342,999	535,024	$54,085	6,654,352	$397,084
1910	6,137,362	365,701	393,248	30,874	6,530,610	396,573
1911	5,012,308	316,972	548,708	40,494	5,561,016	357,466
1912	5,350,515	342,985	524,542	43,168	5,875,057	386,153
1913	6,580,944	410,493	284,150	23,663	6,865,094	434,156

ZINC OXIDE.

Zinc oxide is the most important of the zinc pigments. It is a white powder consisting, when chemically pure, of 80.34 per cent zinc and 19.66 per cent oxygen. When examined under the microscope, the fineness and structure of the particles composing this pigment are clearly evident. On account of its stability, whiteness, opaque nature, and slight tendency to chalk, it is invaluable as a pigment for use as a constituent in a combination formula. Its extreme hardness renders it less resistant to temperature changes when used alone. Zinc oxide is manufactured by two processes, one known as the American and the other as the French process.

The ores from which zinc oxide is made are the franklinite ore of New Jersey, the sulphide ores of the Mississippi Valley, and the sulphide, carbonate, and silicate ores of Colorado, New Mexico, and Nevada. The plants which produced zinc oxide in 1913 were the New Jersey Zinc Co. of Pennsylvania, with plants located at Palmerton and Freemansburg, Pa.; the Mineral Point Zinc Co., located at Mineral Point, Wis.; and the Bertha Mineral Co., located at Austinville, Va. The Ozark Smelting & Mining Co. produced no zinc oxide at its Coffeyville plant, and its Joplin plant is being dismantled. The

Western Zinc Mining & Reduction Co. is building a 50-ton Wetherill plant at Leadville, Colo., to treat zinc carbonate ores. This plant will operate in 1914 and its capacity may be increased to 250 tons daily.

LEADED ZINC OXIDE.

Leaded zinc oxides are pigments consisting of zinc oxide and lead sulphate. They are made with definite percentages of lead sulphate, usually ranging from 6 to 20 per cent, according to the purpose for which they are to be used. These oxides are produced from western zinc ores that carry a certain proportion of lead sulphide. In fineness they are similar to zinc oxide but are not quite so white. Leaded zinc pigment is manufactured at the Coffeyville plant of the Ozark Smelting & Mining Co., and by the Mineral Point Zinc Co., Mineral Point, Wis.

No zinc-lead pigment was produced in the United States during 1913, according to reports received by the Survey.

SUBLIMED WHITE LEAD AND SUBLIMED BLUE LEAD.

Sublimed white lead or "basic lead sulphate" is made directly from the lead sulphide ore, galena. It is manufactured from ore produced in the Joplin, Mo., district or from any other soft (non-argentiferous) lead ore. Cleaned galena ore ground to a powder and charged with carbon into a furnace is volatilized, and in the presence of air the lead sulphide is oxidized to a basic lead sulphate, while some free sulphur dioxide is formed. This product is cooled by being drawn by suction through a long series of pipes, goosenecks, and settling chambers, and then is collected in bag houses. This material finds use not only in mixed paints, but in the manufacture of putty and rubber. The basic lead sulphate is thought to be composed of two molecules of lead sulphate ($PbSO_4$) linked to one of lead oxide (PbO). It contains approximately[1] 77 per cent of lead sulphate, 17 per cent of lead oxide, and 6 per cent of zinc oxide. Notable properties of this pigment are its great fineness, the uniform size of its particles, and its relative chemical stability. It has a snow-white color and is very opaque, but since it is extremely fine and of amorphous texture it requires blending with coarser pigments to give it "tooth."

In the sublimation of galena a peculiar bluish-gray compound of lead is formed, which is known commercially as sublimed blue lead or "blue fume." Analyses have shown the presence in it of about 2 per cent carbon, 4.5 to 5 per cent lead sulphide, 1 to 2.5 per cent zinc oxide, 0.36 to 1.44 per cent lead sulphite, 50 to 53 per cent lead sulphate, and 37.5 to 41.3 per cent lead oxide. It is used in the same industries as the white lead produced by sublimation.

Two firms manufacture these products in the United States. The Picher Lead Co., of Joplin, Mo., was for years the sole producer and registered the trade-mark "sublimed white lead." The St. Louis Smelting & Refining Co., whose plant is located at Collinsville, Ill., produces a similar pigment sold under the name "basic lead sulphate."

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[1] Schaeffer, John A., The lead contents in sublimed white lead: Paint, Oil, and Drug Rev., vol. 57, pp. 17-18, Apr. 29, 1914.

CHEMICALLY MANUFACTURED PIGMENTS.

MARKETED PRODUCTION.

The chemically manufactured pigments treated in this report include basic carbonate white lead, both dry and in oil, red lead, litharge, and orange mineral among the lead pigments, and lithopone and Venetian red. The last two pigments contain no lead, but are chemically precipitated pigments, the process of whose manufacture will be given later.

The marketed production of chemically manufactured pigments in 1913 amounted to 219,644 short tons, valued at $25,123,167. This is a decrease from the production in 1912 of 8,491 tons in quantity and of $1,233,065 in value.

The following table shows the marketed production and value of chemically prepared pigments during the last four years:

Marketed production of chemically manufactured pigments, 1910–1913, in short tons.

Pigment.	1910		1911		1912		1913	
	Quantity.	Value.	Quantity.	Value.	Quantity	Value.	Quantity.	Value.
Basic carbonate white lead:								
In oil	111,573	$15,027,993	106,778	$14,699,339	120,591	$16,041,100	118,430	$15,603,431
Dry	32,237	3,378,622	25,834	2,693,902	26,242	2,642,361	24,196	2,508,788
Red lead	[a] 19,801	2,448,684	[a] 19,540	2,345,320	[a] 21,120	2,571,702	[a] 17,635	2,127,976
Litharge	23,742	2,686,159	25,190	2,773,196	29,111	3,194,194	23,093	2,524,707
Orange mineral	[b] 676	111,773	[b] 766	119,370	[b] 545	88,245	[b] 434	71,625
Lithopone	12,655	916,512	16,866	1,243,108	24,220	1,702,119	29,685	2,170,445
Venetian red	6,312	113,980	5,773	106,009	6,306	116,511	6,171	116,195
Total	206,906	24,683,723	200,747	23,980,244	228,135	26,356,232	219,644	25,123,167

[a] Includes a small quantity of orange mineral [b] Some orange mineral included with red lead

IMPORTS.

The following table gives the quantity and value of the imports of corroded white lead, red lead, litharge, orange mineral, lithopone, and Venetian red from 1909 to 1913, inclusive.

The total value of the imports of the chemically manufactured pigments in 1913 was $253,031.

Imports for consumption of basic carbonate white lead, red lead, litharge, orange mineral, lithopone, and Venetian red, 1909–1913, in pounds.

Year.	Corroded white lead.		Red lead.		Litharge.		Orange mineral.		Lithopone.		Venetian red.	
	Quantity.	Value.	Quantity.	Value.	Quantity.	Value.	Quantity.	Value.	Quantity.	Value.	Quantity.	Value.
1909	694,599	$39,963	760,179	$30,428	90,655	$3,740	496,231	$27,562	1,303,316	$44,873	3,999,560	$28,864
1910	686,052	38,917	822,289	32,750	48,693	2,252	600,461	32,199	3,726,135	99,954	2,490,138	21,591
1911	741,071	46,213	1,063,533	42,471	24,662	1,196	504,734	28,515	6,355,212	166,199	2,194,823	20,169
1912	687,705	46,494	757,908	33,854	32,443	1,550	334,551	20,914	5,904,475	153,303	2,828,627	22,916
1913	672,109	45,266	99,832	4,903	31,023	1,750	330,525	22,205	5,066,535	152,98[illegible]	3,311,517	25,927

BASIC CARBONATE WHITE LEAD.

Basic carbonate of lead has a specific gravity of 6.8 and contains about 85 per cent lead oxide and 15 per cent of carbon dioxide and water. Variously sized particles are present. Its opaque nature and excellent body render white lead extremely valuable as a pigment. Its life and wearing properties are considered by many paint manufacturers to be increased when mixed with zinc oxide and other pigments. Checking and chalking progress rapidly when the pigment is used alone.

The marketed production of basic carbonate (corroded) white lead in 1913, as reported to the Survey, was 142,626 short tons, valued at $18,112,219. Of this total, 118,430 short tons, valued at $15,603,431, were reported sold in oil, and 24,196 short tons, valued at $2,508,788, were reported sold dry. The sales for 1913 represented a net decrease from those for 1912 of 4,207 short tons in quantity and of $571,242 in value.

The average price per ton of basic carbonate white lead ground in oil was $131.75 in 1913, as compared with $133.02 in 1912, a decrease of $1.27 per ton; and the average price per ton of dry white lead was $103.69 in 1913, as compared with $100.69 in 1912, an increase of $3 per ton.

This pigment is manufactured by 4 firms in Pennsylvania, by 3 firms in Illinois, by 2 firms each in California and New York, and by 1 firm in each of the following States: Michigan, Missouri, Nebraska, New Jersey, and Ohio. The 2 New York plants produce more than all of the remaining manufacturers of basic carbonate white lead.

Basic carbonate white lead is made by one of the following three processes:

Dutch process.—Clay pots containing dilute acetic acid and lead cast in buckles are stacked in tiers and covered with tanbark. By the interaction of fermenting bark and acid, carbon dioxide gas is produced, which reacts with the lead to form the basic carbonate. The buckles not always entirely corroded are cleaned in revolving drums and the white carbonate is ground, floated, dried, and packed for shipment. This process requires several days for completion.

Quick process.—By the action of acetic acid and carbon dioxide on atomized metallic lead contained in revolving drums, the basic carbonate is produced in a few hours.

Mild process.—This process is claimed by some to produce the most pure pigment. Air is passed through water containing finely powdered lead, forming a basic hydroxide of lead. Carbon dioxide gas is then run into this solution and the basic carbonate lead is produced.

RED LEAD.

The marketed production of red lead in 1913 was 17,635 short tons, valued at $2,127,976, a decrease of 3,485 short tons in quantity and of $443,726 in value from the output of 1912. The average price per ton decreased from $121.77 in 1912 to $120.67 in 1913, a decrease of $1.10. Red lead is produced by heating litharge in reverberatory furnaces. The particles of this pigment vary much in size. It has proved a good inhibitive paint and is used alone and in combination with other pigments as a protective coating for iron and steel. Red lead was made in 1913 at 4 plants in Pennsylvania, at 2 plants each in Missouri and New York, and at 1 plant each in California, Michigan, New Jersey, and Ohio.

LITHARGE.

The marketed production of litharge in 1913 as reported to the Survey was 23,093 short tons, valued at $2,524,707, as compared with 29,111 short tons, valued at $3,194,194 in 1912, a decrease in quantity of 6,018 tons and in value of $669,487. The average price per ton was $110.09 in 1911, but this decreased to $109.72 per ton in 1912 and was further reduced to $109.33 per ton in 1913.

Litharge, or lead monoxide, a buff-colored powder, is made directly by rapid oxidation of lead or indirectly in the metallurgy of silver, and also from acetate of lead. It is used in paints, in glazes, in storage batteries, and in fire-assaying for gold and silver. It is produced at 2 plants in New York and Missouri, at 5 plants in Pennsylvania, and by 1 manufacturer in California, Massachusetts, Michigan, New Jersey, and Ohio.

ORANGE MINERAL.

The marketed production of orange mineral as reported to the Survey was 434 short tons, valued at $71,625 in 1913, as compared with 545 short tons, valued at $88,245 in 1912. The apparent average price per ton was $165.03 in 1913, as compared with $161.92 in 1912. The output given above does not include all orange mineral manufactured, as some producers combined their returns for orange mineral and red lead.

Orange mineral, one of the higher oxides of lead, is prepared by calcining a more or less basic carbonate of lead. It is valued according to the depth and color of its bright orange shade. It is made at 4 plants in Pennsylvania, at 2 plants in New York, and at 1 plant each in California, Michigan, Missouri, and Ohio.

LITHOPONE.

The marketed production of lithopone in 1913 was reported as 29,685 short tons, valued at $2,170,445, as compared with 24,220 short tons valued at $1,702,119, in 1912, an increase in quantity of 5,465 tons and in value of $468,326. The average price of lithopone in 1912 was erroneously printed as $72.28 a ton, whereas the correct figure is $70.28. The average price per ton in 1913 was $73.12, an increase of $2.84.

Lithopone, a very white pigment, is precipitated by mixing solutions of zinc sulphate and barium sulphide, thereby forming an intimate mixture of zinc sulphide and barium sulphate. It contains approximately 70 per cent barium sulphate, from 25 to 29 per cent zinc sulphide, and from 1 to 5 per cent of zinc oxide. It has a characteristic flocculent, noncrystalline appearance when examined under the microscope. The peculiar property which it possesses, of darkening under the actinic rays of the sun, makes it essential that it be combined with other more stable pigments to prolong its life when exposed to weather. It is excellently suited for interior decoration and is used in the manufacture of enamels and flat wall finishes. One company in the United States is marketing a lithopone which it guarantees to be absolutely sun-proof. In 1913, lithopone was made at 3 plants in New Jersey, at 2 plants in Pennsylvania, and at 1 in Delaware.

VENETIAN RED.

The marketed production of Venetian red in 1913, as reported to the Survey, was 6,171 short tons, valued at $116,195, compared with 6,306 short tons, valued at $116,511 in 1912, a decrease in quantity of 135 tons and in value of $316. The apparent average price per ton was $18.83 in 1913, as compared with $18.48 in 1912.

Venetian red is made in different ways, such as by grinding red iron oxide with gypsum, or by roasting ferrous sulphate with lime and grinding the residue—in either case the red is a mixture of iron oxide and calcium sulphate, or by grinding red iron oxide with calcium carbonate, or by calcining pyrite and ferrous sulphate with terra alba, and in sundry other ways. It is sometimes marketed as metallic paint.

PAINT TESTS.

In this report in previous years brief notices and descriptions have been given of the paint tests of the scientific section of the Paint Manufacturers' Association of the United States, of the work of the Institute of Industrial Research, and of the publications regarding the tests in the Proceedings of the American Society for Testing Materials. The most recent publication known to the writer on the result of these tests is contained in volume 13 of the proceedings of the society just referred to and in bulletins 34, 35, and 36 of the scientific section of the Paint Manufacturers' Association of the United States, which are cited in the bibliography at the end of this chapter Since the publication of this report for 1912, neither of these societies have issued any additional data relative to the tests.

LEGISLATION AFFECTING THE MINERAL PAINT INDUSTRY.

On October 3, 1913, the Underwood tariff bill (H. R. 3321) was passed. Certain sections of Schedule A of interest to the producers of metallic paints are given below:

51. Baryta, sulphate of, or barytes, including barytes earth, unmanufactured, 15 per centum ad valorem; manufactured, 20 per centum ad valorem; blanc-fixe, or artificial sulphate of barytes, and satin white, or artificial sulphate of lime, 20 per centum ad valorem.

52. Blues, such as Berlin, Prussian, Chinese, and all others, containing ferrocyanide of iron, in pulp, dry, or ground in or mixed with oil or water, 20 per centum ad valorem; ultramarine blue, whether dry, in pulp, or ground in or mixed with oil or water, and wash blue containing ultramarine, 15 per centum ad valorem.

53. Black pigments, made from bone, ivory, or vegetable substance, by whatever name known; gas black and lampblack, dry or ground in or mixed with oil or water 15 per centum ad valorem.

54. Chrome yellow, chrome green, and all other chromium colors in the manufacture of which lead and bichromate of potash or soda are used, in pulp, dry, or ground in or mixed with oil or water, 20 per centum ad valorem.

55. Ocher and ochery earths, sienna and sienna earths, and umber and umber earths, 5 per centum ad valorem; Spanish brown, venetian red, Indian red, and

colcothar or oxide of iron, not specially provided for in this section, 10 per centum ad valorem.

56. Lead pigments: Litharge, orange mineral, red lead, white lead, and all pigments containing lead, dry or in pulp, and ground or mixed with oil or water, not specially provided for in this section, 25 per centum ad valorem.

58. Varnishes, including so-called gold size or japan, 10 per centum ad valorem: *Provided*, That spirit varnishes containing less than 10 per centum of methyl alcohol of the total alcohol contained therein, shall be dutiable at $1.32 per gallon and 15 per centum ad valorem.

59. Vermilion reds, containing quicksilver, dry or ground in oil or water, 15 per centum ad valorem; when not containing quicksilver but made of lead or containing lead, 25 per centum ad valorem.

60. Whiting and Paris white, dry, and chalk, ground or bolted, $\frac{1}{10}$ cent per pound; whiting and Paris white, ground in oil, or putty, 15 per centum ad valorem.

61. Zinc, oxide of, and pigments containing zinc but not containing more than 5 per centum of lead, ground dry, 10 per centum ad valorem; when ground in or mixed with oil or water, lithopone and white sulphide of zinc, 15 per centum ad valorem.

62. Zinc, chloride of and sulphate of, $\frac{1}{2}$ cent per pound.

63. Enamel paints, and all paints, colors, pigments, stains, crayons, including charcoal crayons or fusains, smalts, and frostings, and all ceramic and glass fluxes, glazes, enamels, and colors, whether crude, dry, mixed, or ground with water or oil or with solutions other than oil, not specially provided for in this section, 15 per centum ad valorem; all paints, colors, and pigments commonly known as artists' paints or colors, whether in tubes, pans, cakes, or other forms, 20 per centum ad valorem; all color lakes, whether dry or in pulp, not specially provided for in this section, 20 per centum ad valorem.

152. Lead-bearing ores of all kinds containing more than 3 per cent of lead, $\frac{3}{4}$ cent per pound on the lead contained therein: *Provided*, That on all importations of lead-bearing ores the duties shall be estimated at the port of entry and a bond given in double the amount of such estimated duties for the transportation of the ores by common carriers bonded for the transportation of appraised or unappraised merchandise to properly equipped sampling or smelting establishments, whether designated as bonded warehouses or otherwise. On the arrival of the ores at such establishments they shall be sampled according to commercial methods under the supervision of Government officers, who shall be stationed at such establishments, and who shall submit the samples thus obtained to a Government assayer, designated by the Secretary of the Treasury, who shall make a proper assay of the sample and report the result to the proper customs officers, and the import entries shall be liquidated thereon, except in case of ores that shall be removed to a bonded warehouse to be refined for exportation as provided by law. And the Secretary of the Treasury is authorized to make all necessary regulations to enforce the provisions of this paragraph.

153. Lead dross, lead bullion or base bullion, lead in pigs and bars, lead in any form not specially provided for in this section, old refuse lead run into blocks and bars, and old scrap lead fit only to be remanufactured; lead in sheets, pipe, shot, glaziers' lead, and lead wire; all the foregoing, 25 per cent ad valorem on the lead contained therein.

162. Zinc-bearing ores of all kinds, including calamine, 10 per cent ad valorem upon the zinc contained therein: *Provided*, That on all importations of zinc-bearing ores the duties shall be estimated at the port of entry and a bond given in double the amount of such estimated duties for the transportation of the ores by common carriers bonded for the transportation of appraised or unappraised merchandise to properly equipped sampling or smelting establishments, whether designated as bonded warehouses or otherwise. On the arrival of the ores at such establishments they shall be sampled according to commercial methods under the supervision of Government officers, who shall be stationed at such establishments, and who shall submit the samples thus obtained to a Government assayer, designated by the Secretary of the Treasury, who shall make a proper assay of the sample and report the result to the proper custom officers, and the import entries shall be liquidated thereon, except in case of ores that shall be removed to a bonded warehouse to be refined for exportation, as provided by law. And the Secretary of the Treasury is authorized to make all necessary regulations to enforce the provisions of this paragraph.

163. Zinc in blocks, pigs, or sheets, and zinc dust; and old and worn-out zinc fit only to be remanufactured, 15 per cent ad valorem.

It is rather early to estimate what effect, if any, the new tariff will have upon the industry. It is certain, however, that during the last year, while a number of economic questions troubled the country, there has been a hesitation in the activities of many industries. As is shown by this report, the output of practically every paint fell off in 1913, and as a rule the prices were lower than in 1912. A marked exception to this statement may be seen in the output of lithopone. Its greater production is possibly to be explained by the growing use of the pigment as a base for flat wall finishes, which are daily becoming more popular.

Possibly the hesitancy of the railroads of the country to invest in new equipment or do much toward rehabilitating old equipment during the last year, while they have been somewhat uncertain as to their relations to the public, had some influence on the output of all classes of mineral paints, as they are among the largest consumers of these products.

A number of States have passed, or are considering, laws to regulate the sale of adulterated paints. The opinion seems to be generally held that laws to regulate branding of paints are more desirable than those to enforce the printing of the formula of the material on a container. Laws embodying the former doctrine are in force in Ohio and Massachusetts. The question of employers' liability has been raised against the paint manufacturers, particularly the makers of white lead. Many companies which produce this pigment have voluntarily provided hospitals, free medical attention, and pensions for their employees, and thus have shown that the policy of supervision has a correct foundation.

In France a law prohibiting the use of white lead in the preparation of paints is to go into effect on January 1, 1915. Just what effect this law will have upon the industry in the United States is not clear, yet it may prove to be of benefit for a time in that the foreign-made zinc oxides and lithopones will find a market nearer home, as a result of which the foreign competition may not be so strong for a time as it has been in the past in the various pigments which might be used instead of white lead.

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SLATE.

By A. T. Coons.

PRODUCTION.

GENERAL CONDITIONS OF THE INDUSTRY.

CHANGES IN OUTPUT AND VALUE.

An increase of $132,158, or 2.19 per cent, marked the slate production of the United States in 1913 as compared with 1912. The output in 1913 was valued at $6,175,476 and in 1912 at $6,043,318. In 1912 there was an increase of $315,299, or 5.50 per cent, over the output of 1911, which was valued at $5,728,019.

The increase in value of the slate output in 1913 as compared with 1912 did not represent any unusual activity in the slate trade; it was caused by an advance in the average price both of roofing slate (with decrease in quantity sold) and of mill stock, although this latter class of slate increased also both in quantity and in value of output. Since 1879, when the statistics of slate production were first collected, the industry has shown only very gradual progress, fluctuating but slightly with changes in trade and financial conditions. In fact, as compared with 1904, 10 years ago, when the slate output was valued at $5,617,195, the output in 1913 shows an increase in value of only $558,281, or less than 10 per cent. The average price per square of roofing slate has fluctuated but little in these 10 years; it was $3.78 in 1904 and $4 in 1913, the latter being the highest average price per square ever reported.

As stated in previous reports, the statistics of the production of slate represent the output as reported by the quarrymen, and include the quantity and value of roofing slate and of mill stock sold by them and the value of a quantity of slate sold for other purposes. The values given for both mill stock and roofing slate represent prices f. o. b. at the point of shipment, and the mill stock being classed as rough or manufactured, according to the condition in which it is sold by the quarrymen, whether as rough blocks to slate mills or in a finished or partly finished condition from mills at the quarries.

In 1912 the slate operators in general reported a better demand and better conditions of trade in the latter part of the year; for 1913 the reports show that the slate trade was much more active from January to September than in the latter part of the year. All the States except New York and Virginia showed an increase in average price per square with decrease in output, but the increase in average price per square in such a large slate-producing district as Northampton County, Pa., was a large factor in the increase for the entire country. The roofing-slate production decreased in quantity but increased in average price per square from $3.87 in 1912 to $4 in 1913. The quantity of mill stock, exclusive of the blackboard and school-slate output, increased both in quantity and in value, with proportionate increase in price per square foot. The output of slate used for blackboards, school slates, and minor purposes increased both in quantity and in value in 1913 as compared with 1912.

All the States except Maryland, Vermont, and Virginia increased in total value of output of slate, the largest increase, 14.62 per cent, being in Maine. New York was the only State that showed increase in quantity of roofing slate produced, and the only increase in value of roofing slate was in New York and Pennsylvania. The production of mill stock in Pennsylvania, including blackboards and school slates, increased, as did that of mill stock alone in Maine and Vermont.

In 1913 eight States contributed to the commercial output of slate in the United States. These States, in order of output, were Pennsylvania, Vermont, Maine, Virginia, New York, Maryland, New Jersey, and Georgia. In 1912 the rank was the same—except that in 1913 Georgia took the place of Arkansas. Of more than 280 firms owning slate deposits, 171 companies were active in 1913. In 1912 175 firms reported as active. The other firms reported their quarries as idle, as in course of development, or as abandoned.

CLASSIFICATION OF SLATE.

Mill stock.—For general purposes slate is classified as mill stock and roofing slate, and the use for these different purposes depends largely although not entirely on the character of the slate. Mill stock requires a finer, more even-grained, and more compact slate than roofing slate, with a smooth cleavage surface. It must be of a fairly uniform color and not too hard to be easily worked by the slate-dressing machinery. The slates of Maine and Vermont and the "soft vein" slates of Lehigh and Northampton counties, Pa., are well adapted for this purpose, and these slates are also among the best of the roofing slates. The Arkansas slate has been used for both electrical and roofing purposes, and the Maryland and New York quarries also furnish a small quantity of mill stock. Much of the slate that goes on the dump from a roofing-slate quarry might be utilized as mill stock.

The value of mill stock, including slate sold for all purposes other than roofing, increased from $1,407,133 in 1912 to $1,714,414 in 1913, a gain of $307,281. Exclusive of blackboard and school slates, the mill stock increased from 5,765,273 square feet, valued at $1,013,220, in 1912, to 6,312,011 square feet, valued at $1,233,838, in 1913, an increase of 546,738 square feet in quantity and of $220,618 in value. The average price per square foot was $0.195 in 1913 and $0.176 in 1912. The greater part of the slate was either entirely milled by the producer or sold partly finished to other mills.

Mill stock includes slate used for blackboards, school slates, flooring, wainscoting, vats, tiles, sinks, laundry tubs, grave vaults, sanitary ware, refrigerator shelves, flour bins and dough troughs for bakeries, electrical switchboards, mantels, hearths, well caps, and billiard, laboratory, kitchen, and other table tops. This material is made in the form of slabs from 1 inch to 3 inches or more thick, and is sold at prices ranging from 4 cents to 50 cents per square foot, according to the size, thickness, and quality of the slate and to the work done on it. It is sold in rough slabs by the quarrymen to the slate mills, or is milled by quarrymen operating their own mills.

Lehigh and Northampton counties, Pa., report the only stock produced for school slates and blackboards. The quarries in these counties can best produce this material on account of the unusually fine cleavage of the slate and the thickness and size of the beds. The quantity and value of the slate produced for these uses increased in 1913.

Roofing slate.—Slate used for roofing is not necessarily of so fine a texture nor with so smooth a cleavage as the mill stock, but it must be hard, strong, and tough, and should not contain carbonates or iron pyrites, which decompose or oxidize under atmospheric conditions. The color should be uniform and free from streaks, and although the slate amy fade somewhat upon exposure, it is not therefore undesirable unless it weathers mottled, owing to irregular distribution of the coloring matter, and thus produces an unsightly roof. A description of the process of dressing roofing slates was given in the report for 1911.

Roofing slate is sold in the United States by the "square," a "square" being a sufficient number of pieces of slate of any size to cover 100 square feet of roof, with allowance generally for a 3-inch lap. The size of the pieces of slate making up a square ranges from 7 by 9 inches to 16 by 24 inches, and the number of pieces in a square ranges from 85 to 686, according to the size of the pieces. The ordinary thickness of a piece is from one-eighth to three-sixteenths of an inch, and the approximate weight per square is about 650 pounds. The slate is generally shipped in carload lots, each lot consisting of 50 to 100 squares, according to the size of the pieces.

The price per square for ordinary slate of No. 1 quality ranges from $3.50 to $10 per square f. o. b. at the quarries and depends on the color, size, thickness, smoothness, straightness, and uniformity of the pieces. Specially prepared slate, with pieces carefully selected with regard to color, quality, extra thickness and size, and extra cutting commands from $30 to $200 per square. For ordinary slate the red slates of New York command the highest prices. The red slates of New York and the green slates of Vermont are the kinds generally prepared for special work.

About 72 per cent of the value of the slate production in the United States in 1913 was represented by slate for roofing, and the roofing-slate output from Pennsylvania and Vermont represented, respectively, about 58 and 30 per cent of the total value of the roofing slate produced. Besides roofing slate, Pennsylvania and Vermont produce also millstock; practically the only use of slate from the other producing States, except Maine, is for roofing.

In 1913 the output of roofing slate was reported as 1,113,944 squares, valued at $4,461,062, the average price per square being $4; in 1912 there were reported 1,197,288 squares, valued at $4,636,185, with an average price per square of $3.87, a decrease in 1913 of 83,344 squares in quantity and of $175,123 in value, while the average price per square increased. All the States except New York showed a decrease in the quantity of roofing slates sold, and New York, Vermont, and Virginia were the only States that did not show an increase in average price per square. The large increase in the total average price per square was, however, caused by the increase in average price in Northampton County, Pa.

QUANTITIES AND VALUES.

The following table shows the number of squares, the value, and the average price per square of roofing slate, and the quantity and the value of millstock, by years, from 1879 to 1913, inclusive:

Quantity and value of roofing slate and millstock produced in the United States, 1879–1913.

Year	Roofing slate.			Millstock.			Other uses (value).	Total value.
	Number of squares.	Value.	Average price per square.	Quantity (square feet).	Value.	Average price per square foot.		
1879	367,857	a $1,231,221	$3.35					a $1,231,221
1880	457,267	a 1,529,985	3.35					a 1,529,985
1881	454,070	a 1,543,838	3.40					a 1,543,838
1882	501,000	a 1,753,500	3.50					a 1,753,500
1883	506,200	a 1,898,250	3.75					a 1,898,250
1884	481,004	1,843,865	3.83		$8,000			1,851,865
1885	536,960	1,638,467	3.05		10,000			1,648,467
1886	536,790	1,610,370	3.00					1,610,370
1887	573,439	1,720,317	3.00					1,720,317
1888	662,400	2,053,440	3.10					2,053,440
1889	835,625	2,797,904	3.35		684,609			3,482,513
1891	893,312	3,125,410	3.50		700,336			3,825,746
1892	953,000	3,396,625	3.56		720,500			4,117,125
1893	621,939	2,209,049	3.55		314,124			2,523,173
1894	738,222	2,301,138	3.12		489,186			2,790,324
1895	729,927	2,351,509	3.22		347,191			2,698,700
1896	673,304	2,263,748	3.36		482,457			2,746,205
1897	1,001,448	3,097,452	3.09		427,162			3,524,614
1898	916,239	3,129,390	3.42		594,150			3,723,540
1899	1,100,513	3,454,817	3.14		507,916			3,962,733
1900	1,194,048	3,596,182	3.01		644,284			4,240,466
1901	1,304,379	4,114,410	3.15		673,115			4,787,525
1902	1,435,168	4,950,428	3.45		745,623			5,696,051
1903	1,378,194	5,345,078	3.88		911,807			6,256,885
1904	1,233,757	4,669,289	3.78		947,906			5,617,195
1905	1,241,227	4,574,550	3.69		921,657			5,496,207
1906	1,214,742	4,448,786	3.66		1,219,560			5,668,346
1907	1,277,554	4,817,769	3.77	5,979,624	943,409	$0.157	$258,042	6,019,220
1908	1,333,171	5,186,167	3.89	4,793,812	793,304	.165	337,346	6,316,817
1909	1,133,713	4,394,597	3.87	5,112,894	876,089	.171	170,732	5,441,418
1910	1,260,621	4,844,664	3.84	5,181,498	999,098	.192	392,997	6,236,759
1911	1,124,677	4,348,571	3.87	5,744,577	1,027,605	.178	351,843	5,728,019
1912	1,197,288	4,636,185	3.87	5,765,273	1,013,220	.176	b 393,913	6,043,318
1913	1,113,944	4,461,062	4.00	6,312,011	1,233,838	.195	b 480,576	6,175,476

a Estimated.

b Includes in 1912, 4,482,571 school slates, valued at $38,852, and 2,898,742 square feet of blackboard material, valued at $352,109; in 1913, 6,174,526 school slates, valued at $51,313, and 3,504,162 square feet of blackboard material, valued at $426,703.

The following table shows the total value of the slate produced in the United States from 1909 to 1913, inclusive, and the percentage of increase or decrease in 1913 compared with 1912.

Value of slate produced in the United States, 1909–1913, by States, with percentage of increase or decrease.

State.	1909	1910	1911	1912	1913	Percentage of increase (+) or decrease (−).
Arkansas	....	....	(a)	(a)	....	....
California	(a)	(a)	....	....	....	....
Georgia	(a)	(a)	(a)	....	(a)	(a)
Maine	$227,882	$249,005	$263,516	$282,678	$323,998	+14.62
Maryland	129,538	78,573	76,035	92,184	83,993	− 8.89
New Jersey	(a)	(a)	(a)	(a)	(a)	(a)
New York	107,436	84,822	120,359	135,207	144,882	+ 7.16
Pennsylvania	2,892,358	3,740,806	3,431,351	3,474,247	3,733,581	+ 7.46
Tennessee	....	(a)	....	....	....	....
Vermont	1,841,589	1,894,659	1,624,941	1,849,975	1,697,820	− 8.22
Virginia	180,775	148,721	188,808	195,392	175,830	−10.01
Other States	b 61,840	c 40,173	d 23,009	e 13,635	f 15,372	+12.74
Total	5,441,418	6,236,759	5,728,019	6,043,318	6,175,476	+ 2.19

a Included in Other States.
b Includes California, Georgia, and New Jersey.
c Includes California, Georgia, New Jersey, and Tennessee.
d Includes Arkansas, Georgia, and New Jersey.
e Includes Arkansas and New Jersey.
f Includes Georgia and New Jersey.

The following table shows the production of slate in the United States in 1912 and 1913, by States, and uses:

Quantity and value of roofing, mill, and other slate produced in the United States in 1912 and 1913, by States, and uses.

1912.

State.	Number of operators.	Roofing slate.			Mill stock.						Other.	Total value.
		Number of squares.	Value.	Average price per square.	Manufactured. Quantity.	Manufactured. Value.	Rough. Quantity.	Rough. Value.	Total. Quantity.	Total. Value.		
Arkansas	1			$7.50								(a)
Maine	3	16,640	$96,079	5.77	428,689	$186,599			428,689	$186,599		$282,678
Maryland	4	18,236	90,993	4.99							$1,191	92,184
New Jersey	2			4.45								(a)
New York	10	27,024	135,136	5.00							71	135,207
Pennsylvania	93	716,770	2,528,791	3.53	3,663,518	520,734	437,682	$32,195	4,101,200	552,929	b 392,527	3,474,247
Vermont	54	373,638	1,576,294	4.22	1,087,513	245,753	146,871	27,829	1,234,384	273,582	99	1,849,975
Virginia	8	42,220	195,392	4.63								195,392
Other States c		2,760	13,500				1,000	110	1,000	110	25	13,635
Total	175	1,197,288	4,636,185	3.87	5,179,720	953,086	585,553	60,134	5,765,273	1,013,220	393,913	6,043,318

1913

State.	Number of operators.	Number of squares.	Value.	Average price per square.	Manufactured. Quantity.	Manufactured. Value.	Rough. Quantity.	Rough. Value.	Total. Quantity.	Total. Value.	Other.	Total value.
Georgia	2	(a)	(a)	$5.71								(a)
Maine	4	15,593	$89,933	5.77	513,745	$234,065			513,745	$234,065		$323,998
Maryland	3	15,913	82,981	5.21							$1,012	83,993
New Jersey	2	(a)	(a)	4.68							(a)	(a)
New York	10	29,868	139,970	4.69	21,300	4,899	42	13	21,342	4,912		144,882
Pennsylvania	90	678,396	2,605,882	3.84	3,470,286	598,916	740,229	49,300	4,210,515	648,216	d 479,483	3,733,581
Vermont	53	332,642	1,351,175	4.06	1,111,174	254,347	455,235	92,298	1,566,409	346,645		1,697,820
Virginia	7	38,330	175,774	4.59							56	175,830
Other States c		3,202	15,347								25	15,372
Total	171	1,113,944	4,461,062	4.00	5,116,505	1,092,227	1,195,506	141,611	6,312,011	1,233,838	480,576	6,175,476

a Included in other States.

b Composed of 4,482,571 school slates, valued at $38,852; 2,898,742 square feet of blackboard material, valued at $352,109; and slate used for structural and other purposes, valued at $1,566.

c Includes, in 1912, Arkansas and New Jersey; in 1913, Georgia and New Jersey.

d Composed of 6,174,526 school slates, valued at $51,313; 3,504,162 square feet of blackboard material, valued at $426,703; and slate used for structural and other purposes, valued at $1,467.

IMPORTS.

Practically no slate is imported into the United States. In 1913, slate valued at $5,479 was imported in the form of mantels, chimney pieces, roofing slate, slabs, etc. In 1912, the imports were valued at $14,768 and included the same articles.

The tariff act of October, 1913, reduced the duty on imported slate by half. Formerly the duty on slates, slate chimney pieces, mantels, slabs for tables, roofing slates, and all other manufactures of slate was 20 per cent ad valorem; at present, the rate is 10 per cent ad valorem.

EXPORTS.

For a period of nine years, from 1897 to 1905, inclusive, the United States had a large export trade in slate, the years 1898 and 1899 showing exports valued at more than $1,000,000. About two-thirds of these exports were to Great Britain, where a strike in the large Welsh quarries enabled slates from other countries to gain a foothold. Since 1905 there has been a marked decrease in slate exports from the United States, until in 1909 the exports amounted to only $209,383. From 1910 to the latter half of 1912 exports of slate were not kept separate from exports of other varieties of stone. In 1912 the exports of slate from July 1 to December 31 amounted to $171,775, and the exports for the entire year 1913 amounted to $226,413.

According to the Slate Trade Gazette, of London, the exports of slate from the United States to Great Britain in 1912 were 4,441 tons, valued at £18,133. In 1913 these exports decreased to 2,498 tons, valued at £9,362, or about one-fifth of the total slate exported.

SLATE INDUSTRY BY STATES AND LOCALITIES.

The slate production of the United States is practically confined to the northeastern part of the country. Although scattered deposits, more or less developed, occur elsewhere, this eastern slate is shipped to supply markets on the western coast as well as in the central and southern parts of the country. The locations of the principal deposits, whether producing in commercial quantities or in process of development, are given below by States.

The slate of most of the deposits in the various States has been described either in Bulletin 275 of the United States Geological Survey, or in previous reports on the slate industry. Bulletin 275 is out of print, but a new revised edition will soon be printed as Bulletin 586 of the Survey.

Arizona.—No operations, other than assessment work, were carried on during 1913 at the slate deposits in Maricopa County, Ariz., belonging to the Arizona Slate Co., and the Phoenix Slate Co.

Arkansas.—There was little activity in the development work at the slate properties in Arkansas in 1913. Lack of transportation is the principal drawback to the development of the industry. The deposits are in Garland, Montgomery, Polk, Pulaski, and Saline counties. The slate is of good quality, both for roofing and for mill stock, and is found in red, green, gray, and black colors.

Full descriptions of these deposits may be found in Bulletins 275 and 430 of the United States Geological Survey, and in a report by the Arkansas Geological Survey.[1]

California.—There was no commercial production of slate in California in 1913. The Eureka Slate Co., owning quarries near Placerville and Slatington, Eldorado County, reported that it expected to resume operations in the spring of 1914. No commercial operations at the recently opened quarry of the California Slate Co., near Planada, Merced County, were carried on in 1913. Slate from this quarry was described in the report for 1911. No work was done at the deposit at Hornitos, Mariposa County. High prices charged for eastern slates are stated to have lessened the demand for slate on the Pacific coast.

Colorado.—No work other than for assessment was done at Marble, Gunnison County, Colo., in 1913.

Georgia.—Slate has been quarried in Georgia at irregular intervals for many years near Rockmart, Polk County, and a small quantity was produced there in 1913. The Rockmart slate is a very dark bluish gray "black" slate. Most of the quarries that have been opened at this place are now abandoned. Near Bolivar, Bartow County, the Southern Green Slate Co., lessee of the slate property of the Georgia Green Slate Co., operated the quarries for about six months, doing development work principally. Good demand was reported for this slate which is a rather light greenish gray in color, and which was described in the report on the slate industry for 1910.

Maine.—Four companies, the Brownsville & Boston Slate Co., the Maine Slate Co., of Monson, the Monson Maine Slate Co., and the Portland-Monson Slate Co., operated slate quarries in Maine during 1913, with an increase of over 14 per cent in the value of the output. The entire output of the State is from Piscataquis County and increased in value from $282,678 in 1912 to $323,998 in 1913, a gain of $41,320. About two-thirds of the product is mill stock, of which the output in 1913 was 513,745 square feet, valued at $234,065, an increase of 85,056 square feet in quantity and of $47,466 in value as compared with the product of 1912, which was 428,689 square feet, valued at $186,599. Much of this mill stock is used for electrical purposes, for which it is especially adapted. The roofing-slate output, which, with some of the companies, is simply a by-product, amounted in 1913 to 15,593 squares, valued at $89,933; in 1912 the roofing slate output was 16,640 squares, valued at $96,079, a decrease in 1913 of 1,047 squares in quantity and of $6,146 in value. The average price per square was $5.77 in 1913, the same as in 1912.

Maryland.—There were but three companies operating in Maryland in 1913—the Peach Bottom Slate Co., of Harford County, the Peerless Slate Co., and the Proctor Slate Manufacturing Co. These companies all work in the "Peach Bottom" district near Cardiff, Harford County, and produce the same slate as that quarried in York County, Pa. This is a black slate well known in the markets all over the world and is used almost entirely for roofing. Notwithstanding the fact that the quarrymen reported a very good demand, the output

[1] Dale, T. N., and others, Slate deposits and slate industry of the United States: U. S. Geol. Survey Bull. 275, pp. 51–55, 1906.
Purdue, A. H., Slates of Arkansas: U. S. Geol. Survey Bull. 430, pp. 317–334, 1910.
The slates of Arkansas: Arkansas, Geol. Survey, 1909.

decreased nearly 9 per cent in 1913 as compared with 1912. Improvements were made in quarry conditions and better prices prevailed partly on account of the selling of the slate by the producers themselves rather than through agents. A new firm, the Maryland Slate, Brick & Tile Co., reports that it expects soon to begin operations on a quarry near Woodsboro, Frederick County, producing green and purple slate.

The roofing-slate output decreased from 18,236 squares, valued at $90,993, in 1912 to 15,913 squares, valued at $82,981, in 1913, a falling off of 2,323 squares in quantity and of $8,012 in value. The average price per square increased from $4.99 in 1912 to $5.21 in 1913.

New Jersey.—The quarries of the Newton Slate Co., of Newton, and the Lafayette Slate Co., of La Fayette, both in Sussex County, were not operated to any large extent in 1913, but considerable sales of slate from stocks on hand were made and this is included in the total for 1913. This practically unfading black slate is used almost entirely for roofing. The sales were somewhat more in 1913 than in 1912, and the average price per square increased from $4.45 in 1912 to $4.68 in 1913.

New York.—The New York slate is used almost entirely for roofing and was all produced in Washington County in 1913, in the northeastern part of the State and adjacent to the slate-producing region of Rutland County, Vt. The output was about 7 per cent greater in 1913 than in 1912, but the average price per square decreased from $5 in 1912 to $4.69 in 1913. The production increased from 27,024 squares, valued at $135,136, in 1912 to 29,868 squares, valued at $139,970, in 1913, a gain of 2,844 squares in quantity and of $4,834 in value. Less demand was reported for red slate, which commands the highest prices. The increase or decrease of sales of this slate causes considerable variation in the yearly average prices of New York slate. Some of the red slate is used in the manufacture of paint.

Pennsylvania.—Pennsylvania showed an increase in value of output in 1913 of over 7 per cent, as compared with an increase of a little over 1 per cent in 1912. The value of the production for 1913 was $3,733,581; in 1912, $3,474,247, an increase in 1913 of $259,334, or 7.46 per cent. Pennsylvania slate is used both for roofing and for mill stock. In 1913 Pennsylvania produced 60.90 per cent of the total quantity and 58.41 per cent of the total value of the output of roofing slate in the United States. The average price per square in Pennsylvania in 1913 was $3.84, compared with $3.53 in 1912, an advance of $0.31. Besides leading in the production of roofing slate, Pennsylvania has a larger output of mill stock than any other State, producing in 1913, exclusive of blackboard stock and school slate, 52.54 per cent of the total value and 66.70 per cent of the total quantity of this material for the United States.

The fluctuations were as follows: In 1913 the output of roofing slate was 678,396 squares, valued at $2,605,882; in 1912, 716,770 squares, valued at $2,528,791, a decrease of 38,374 squares in quantity and an increase of $77,091 in value. The average price per square advanced from $3.53 in 1912 to $3.84 in 1913. The mill stock sold, exclusive of blackboard and school-slate material, was 4,210,515 square feet, valued at $648,216, in 1913 and 4,101,200 square feet, valued at $552,929, in 1912, an increase of 109,315 square feet in quantity and of $95,287 in value. The average price per square foot advanced from 13.4 cents in 1912 to 15.4 cents in 1913. Slate for blackboards, school slates, and a few minor purposes increased in value $86,956, from $392,527 in 1912 to $479,483 in 1913. Pennsylvania produced 60.46 per cent of the value of the total slate product in the United States in 1913, as compared with 57.48 per cent in 1912; 59.90 per cent in 1911; 59.98 per cent in 1910; 53.15 per cent in 1909; and 61.79 per cent in 1908.

Blackboard slate increased from 2,898,742 square feet, valued at $352,109, in 1912 to 3,504,162 square feet, valued at $426,703, in 1913, an increase of 605,420 feet in quantity and of $74,594 in value. The average price per square foot was 12 cents in 1912 and 12.2 cents in 1913. The average thickness of this slate is three-eighths of an inch.

School slates increased from 4,482,571 slates, valued at $38,852, in 1912 to 6,174,526 slates, valued at $51,313, in 1913, a gain of 1,691,955 slates in quantity and of $12,461 in value. The average price per thousand was $8.67 in 1912 and $8.31 in 1913. The average size of the slates as reported is 7 by 11 inches—sometimes sold by the square of about 500 pieces.

In 1913 slate was quarried in Lancaster, Lehigh, Northampton, and York counties. The quarry in Carbon County, the slate from which was described in the report for 1909, has not been operated since 1911. No further development was made on the deposit in Dauphin County, slate from which was described in the report for 1910.

The slate from Lehigh County is used for roofing and for ordinary mill stock, and also, on account of the fineness of its cleavage, for school slates and blackboard material. In 1913 Lehigh County produced 22.10 per cent of the quantity and 19.69 per cent of the value of the Pennsylvania roofing-slate output and 12.85 per cent of the quantity and 11.50 per cent of the value for the entire United States. In 1912 the Lehigh County production was 22.12 per cent of the quantity and 22.59 per cent of the value of the Pennsylvania roofing slate and 13.24 per cent of the quantity and 12.32 per cent of the value of the United States. There was a decrease both in quantity and in value of the roofing slate produced in this country in 1913 as compared with 1912, and the number of producers was two less. Although most of the producers reported a good demand for slate in the early part of 1913, many reported dull trade, poor demand, and prices about the same as 1912. The average price per square of roofing slate, however, decreased but slightly, or from $3.60 in 1912 to $3.58 in 1913. There was a considerable decrease in quantity of mill stock, but an increase in value of output. This same condition also prevailed in 1912 as compared with 1911. Blackboard and school-slate stock increased, both in quantity and in value, in 1913.

The slate of Northampton County has the same uses as the Lehigh County slate, but the total value of the output is over three and one-half times as large. In 1913 Northampton County produced 77.43 per cent of the quantity and 78.12 per cent of the value of the Pennsylvania roofing slate, and 47.16 per cent of the total quantity and 45.63 per cent of the total value for the United States. In 1912 the Northampton County output was 75.34 per cent of the quantity and 73.46 per cent of the value of the Pennsylvania roofing slate, and 45.10 per cent of the quantity and 40.06 per cent of the total value for the United States. There was an increase of $296,756 in the output of this county as compared with 1912. The value in 1913 was $2,897,205; in 1912 it was $2,600,449. Although the majority of the producers in Northampton County reported the demand in 1913 for roofing slate as less than or about the same as in 1912, many reported especially good trade the first part of the year and poor trade in the latter part; but almost without exception the prices were reported as better than in 1912, which is shown by the increase in average price of 44 cents per square in 1913, from $3.44 in 1912 to $3.88 in 1913, while the number of squares sold decreased. The decrease in quantity with increase in value in a county representing so large a proportion of the production of the United States, was largely accountable for the increased average price for the entire country. The figures for the two years are as follows: In 1912 there was sold in Northampton County 525,286 squares, valued at $2,035,796; in 1912, 540,032 squares, valued at $1,857,712, a decrease of 14,746 squares in quantity, and an increase of $178,084 in value.

Demand for structural slate and slate for blackboards and school slates was reported by the producers as greater in 1913 than in 1912, and this is shown in the increase in both quantity and value of the slate sold for these purposes.

York County produces nothing but roofing slate of the same Peach Bottom variety as that of Harford County, Md. There was a decrease in production for this county in 1913, but an increase in average price—from $5.50 in 1912 to $5.71 in 1913.

The Pennsylvania slate is mostly of a dark-gray or other dark color. Many of these dark slates, however, become somewhat lighter in color on exposure to the atmosphere.

The table following shows in detail the production of slate in Pennsylvania, by counties and uses, in 1912 and 1913:

Production of slate in Pennsylvania in 1912 and 1913, by counties and uses.

County.	Number of operators.	Roofing slate.			Millstock.								Other (value).	Total value.
		Number of squares.	Value.	Price per square.	Manufactured.		Rough.		Blackboards.		School slates.			
					Quantity.	Value.	Quantity.	Value.	Quantity.	Value.	Quantity.	Value.		
1912.														
					Sq. ft.		*Sq. ft.*		*Sq. ft.*		*Number.*			
Lancaster	2	18,135	$99,810	$5.71	....	....	....	....	....	....	....	....	....	$99,810
York ("Peachbottom slate")	3			5.50										
Lehigh	33	158,603	571,269	3.60	394,419	$53,764	197,930	$19,619	902,697	$101,686	3,109,417	$27,650	....	773,988
Northampton	55	540,032	1,857,712	3.44	3,269,099	466,970	239,752	12,576	1,996,045	250,423	1,373,154	11,202	$1,566	2,600,449
Total	93	716,770	2,528,791	3.53	3,663,518	520,734	437,682	32,195	2,898,742	352,109	4,482,571	38,852	1,566	3,474,247
1913.														
Lancaster	2	9,965	$57,059	$6.00	....	....	....	....	....	....	....	....	....	$57,059
York ("Peachbottom slate")	3			5.71										
Lehigh	31	143,145	513,027	3.58	353,948	$63,632	191,902	$21,193	1,395,847	$147,119	4,126,144	$34,329	$17	779,317
Northampton	54	525,286	2,035,796	3.88	3,116,338	535,284	548,327	28,107	2,108,315	279,584	2,048,382	16,984	1,450	2,897,205
Total	90	678,396	2,605,882	3.84	3,470,286	598,916	740,229	49,300	3,504,162	426,703	6,174,526	51,313	1,467	3,733,581

Tennessee.—The deposits of slate in Tennessee where more or less development work has been done in recent years are in Blount, Monroe, and Washington counties. The Southern Slate Co., of Columbus, Ohio, with a quarry located at Chilhowee, Blount County, reports that operations at this deposit will probably be begun early in 1914. Analyses made of this slate by Prof. A. F. Gilman at the laboratory of the University of Tennessee are as follows:

Analysis of slate from Chilhowee, Blount County, Tenn.

	Black slate.	Gray slate.
Silica (SiO_2)	57.61	58.51
Lime (CaO)	.412	.68
Carbon dioxide (CO_2) with the lime	.324	.54
Magnesia (MgO)	2.54	2.139
Carbon dioxide (CO_2) with the magnesia	2.79	2.352
Alumina (Al_2O_3)	28.72	29.49
Ferric oxide (Fe_2O_3)	2.02	1.53
Ferrous sulphide (FeS_2)	3.01	.57
Water (H_2O)	2.56	4.18
Total	99.986	99.991

At Tellico Plains the Tellico Co. and the Tennessee Slate Co., represented by W. F. Payne, are owners of slate deposits. Mr. Payne is also interested in a slate deposit at Washington College, Washington County, where arrangements are reported as being made to install machinery for operations in the near future.

Utah.—The Utah Slate & Granite Co., owning slate deposits near Provo, Utah County, did no work in 1913.

Vermont.—Vermont is second among the slate-producing States, being ranked by Pennsylvania. In 1913 Vermont produced 27.49 per cent of the total slate quarried in the United States, and Pennsylvania 60.46 per cent. In 1912 these figures for Vermont and Pennsylvania were 30.61 and 57.48 per cent, respectively—a decrease for Vermont and an increase for Pennsylvania in 1913. The total value of the slate production in Vermont decreased 8.22 per cent in 1913, that of Pennsylvania increased 7.46 per cent. About four-fifths of the slate marketed in Vermont is roofing slate. This amounted to 332,642 squares, valued at $1,351,175, in 1913, as compared with 373,638 squares, valued at $1,576,294, in 1912, a decrease of 40,996 squares in quantity and of $225,119 in value. The average price per square declined from $4.22 in 1912 to $4.06 in 1913. The total mill stock manufactured increased from 1,234,384 square feet, valued at $273,582, in 1912, to 1,566,409 square feet, valued at $346,645 in 1913, an increase of 332,025 square feet in quantity and of $73,063 in value. The average price per square foot was 22.1 cents in 1913, as compared with 22.2 cents in 1912.

Of the mill stock (exclusive of blackboards and school slates) produced in the United States, Vermont supplied 28.09 per cent of the total value in 1913 compared with 52.54 per cent from Pennsylvania. Notwithstanding the decrease in output of roofing slate, most of the producers report the demand much better than in 1912, but with lack of activity both in demand and in prices during the latter part of the year. The Vermont slate is practically all from Rutland County, and the quarries are in the same belt as the New York slate quarries. The Rutland County slate varies in color and is known in the trade as "sea-green," "grayish green," "unfading green," "greenish gray," "purple," "purplish brown," "variegated," and other variations of green, gray, and purple.

Virginia.—Virginia ranks fourth among the slate-producing States, with productive quarries at Esmont, Albemarle County, and Arvonia and Penlan, Buckingham County. This slate is used entirely for roofing, and the production in 1913 was 38,330 squares, valued at $175,774, or $4.59 per square. This was a decrease of 3,890 squares in quantity and of $19,618 in value as compared with 1912, when the output was 42,220 squares, valued at $195,392, or $4.63 per square. The average price per square decreased $0.04 in 1913. Development and prospecting work was also done at Snowden, Amherst County, but no slate was sold.

PUBLICATIONS ON SLATE.

Requests are continually coming to the United States Geological Survey for reports on the distribution, production, and composition of slate and on the methods of working slate quarries.

Bulletin 275 of the Survey,[1] which is a very comprehensive report on the slate deposits and slate industry of the United States, is now out of print, but it can be consulted in libraries or purchased from dealers in secondhand books. This report, however, has been revised, and a new edition will be issued in 1914 as Bulletin 586 of the Survey.

Maps showing the commercial deposits of slate are published in the reports on the stone industry of the United States for 1912 and 1913.

The United States Geological Survey has published a report on the slates of Arkansas, by A. H. Purdue.[2]

The State geological surveys of Arkansas, California, Maryland, and New Jersey have also published descriptions of the slate and slate deposits of these States, and information as to these publications may be had by applying to the respective State geologists.

A publication by E. C. Eckel[3] contains a chapter on slate, which gives information on the slates of the United States and of foreign countries, and also many analyses and tests of slate.

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[1] Dale, T. N., and others, Slate deposits and slate industry of the United States: U. S. Geol. Survey Bull. 275, 1906.

[2] Purdue, A. H., The slates of Arkansas: U. S. Geol. Survey Bull. 430, pp. 317-334, 1910.

[3] Eckel, E. C., Building stones and clays, their origin, character, and examination, John Wiley & Sons, New York, 1912.

POTASH SALTS: SUMMARY FOR 1913.

Compiled by W. C. Phalen.

PROGRESS OF INVESTIGATION DURING 1913.

INVESTIGATIONS BY THE UNITED STATES GEOLOGICAL SURVEY.

The activities of the United States Geological Survey in the investigation of potash salts during 1913 were more restricted than in previous years. In the field drilling was carried on in two areas, Columbus Marsh and Black Rock Desert, Nevada; but it was of short duration, owing to the inaccessibility of the area for an unusually long period of the year on account of the heavy rains, which made it impossible to transport apparatus to the drill sites. A general plan involving the stratigraphic study of the so-called "red bed" salines of certain of the Southwestern States, including New Mexico, Arizona, and Utah, was begun by N. H. Darton, and several months of field work was done. A brief review of certain basins in the Great Basin region of California and Nevada was made by H. S. Gale in the further general study of the hypothesis that potash deposits may be found in desiccated lake basins.

In the laboratory attention has been directed to a few definite problems indicated by the preceding general experimental work.

POTASH SALTS IN THE GREAT BASIN REGION.

DEEP DRILLING EXPLORATIONS.

In addition to the drilling explorations carried out by the Survey and mentioned in the introductory paragraph, the Railroad Valley Co., of Tonopah, Nev., did some deep drilling during the year. Since this company began operations, more than two years ago, it has drilled more than 10,000 feet in seven wells located in Railroad Valley, Nye County, Nev.

During July, 1913, the company in its well No. 2 encountered buried soda-bearing beds made up chiefly of the mineral gaylussite ($Na_2CO_3.CaCO_3.5H_2O$). These were penetrated a distance of 127 feet without reaching bottom. Since potash salts are more soluble than the mineral gaylussite, they would in a normally deposited saline series overlie that mineral. On this basis it was assumed that they did overlie the gaylussite in some other part of the basin, namely, in the deepest part, in which, consequently, they would cover a smaller area than the gaylussite deposits. In the work the gaylussite bed was counted on as furnishing a datum plane to aid in tracing the contours of the basin, and hence in locating the deepest part in which the potash salts were expected to be found. Proceeding on this hypothesis, four additional wells were drilled, but without conclusive results. Two of these wells did not encounter the gaylussite deposit at all. It was also found that the upper portion of the gaylussite beds was flatter and more variable than was expected—conditions which rendered precise correlation and determination of contours impossible. Operations on the seventh well drilled had to be suspended before it reached the depth at which the hoped-for data were expected to be obtained.

The gaylussite beds were encountered only in wells Nos. 2, 4, and 6. In No. 2 they were penetrated a distance of 127 feet, in well No. 6 a distance of 194 feet, and in well No. 4 a distance of only a few feet, In no well was the gaylussite drilled through, but it was found to be purer and more solid toward the bottom. The precise correlation of the two gaylussite deposits found—the one in well No. 2 and the other in well No. 6—was not considered possible, and it was also found impossible to establish synchronism between any two particular beds of wells No. 2 and No. 6. Still, there seems little doubt that the gaylussite series of wells No. 2 and No. 6 are synchronous and represent the same stage of concentration of the same saline solutions.

The most important question confronting the company at present is whether well No. 6 is in or near the deepest depression or whether such depression lies an unknown distance to the south. This doubt can be settled only by further drilling. If such drilling indicated no southward extension of the basin, the chances of finding important segregations of potash salts are very slight. If it be proved that the basin does extend farther to the south, then probably several wells will have to be drilled to obtain some idea of its size and character and of the existence of other saline deposits in it.

In the event that no potash salts are found, it is possible that the gaylussite bed itself may be of value. The extent of this bed will have to be ascertained by drilling, and methods will have to be devised both for mining it and for producing soda from it.

The report of E. E. Free, consulting geologist to the Railroad Valley Co., from which these data were obtained, was transmitted January 2, 1914. This report contains, in addition to the information given, a map showing the location and records of the wells, together with an appendix describing gaylussite and its possible utilization.

It is reported that the Nevada Potash Co., with headquarters at Goldfield, Nev., plans to explore Clayton Lake, 20 miles west of Goldfield.

EXPLANATION OF THE TERM "POTASH."

To meet the numerous inquiries that have been addressed to the United States Geological Survey regarding the exact meaning of the terms "potash," "actual potash," and "potassium," the following explanation is given:

The element potassium, represented by the symbol K, is the basis of all potash salts or compounds. This substance is a metal; that is, it possesses metallic properties. To prevent rapid change it must be kept from air and water, with both of which it combines with great avidity. Combined with oxygen it forms potassium oxide, represented by the symbol K_2O, known as potassa, but popularly as "potash." In estimating the quantity of potassium in the different products of the Stassfurt deposits, this compound, K_2O, is employed as a standard, the object being to establish a basis of comparison for all potassium salts. Among chemists as well as laymen there has grown up the practice of using for this standard the term "potash." When only the term "potash" is used in speaking of potash products, it is understood to refer to the potassium oxide (K_2O) present. As a matter of fact, however, potash salts are not sold in the form K_2O, but as the sulphate or the chloride.[1] By the term "potassium sulphate" is meant potassium (K) combined with the acid radicle of sulphuric acid (SO_4), or potassium oxide (K_2O) combined with sulphur trioxide (SO_3), making the compound K_2SO_4. By "potassium chloride" is meant potassium (K) combined with another element, chlorine (Cl).

In the following table are given the percentages of the element potassium and also the combination known as potash in or obtainable from the common potassium compounds and minerals:

Potassium and "potash" in potassium compounds.

Name.	Symbol.	Percentage of potassium (K).	Chemical equivalent in terms of "potash" (K_2O).
Element:			
Potassium	K	100	120
Potassium salts or "potash salts":			
Potassium chloride (mineral sylvite)	KCl	52	63
Potassium muriate (same as chloride).			
Potassium sulphate	K_2SO_4	45	54
Potassium nitrate (saltpeter)	KNO_3	39	47
Potassium carbonate [a]	K_2CO_3	57	68
Potassium hydrate or caustic potash	KOH	70	84
Potassium cyanide	KCN	60	72
Stassfurt minerals:			
Carnallite	$KMgCl_3.6H_2O$	14	17
Kainite	$MgSO_4.KCl.3H_2O$	16	19
Sylvite (potassium chloride)	KCl	52	63

[a] The term "potash" is often applied to this compound.

DEVELOPMENT OF SALINE POTASH DEPOSITS.

CALIFORNIA.

SEARLES LAKE.

A description of the saline deposits of Searles Lake, Cal., was published in this report for 1912.[2]

Searles Lake, known also as Borax Flat, is a dry lake basin much like many other desert basins in the western arid region. It is a broad, somewhat circular valley or depression lying between the Slate and Argus ranges in the extreme northwestern part of San Bernardino County, and near Kern and Inyo counties. The camp known as The Borax is about 25 miles by road from Searles post office, formerly Garden station, near the Mohave-Owenyo branch of the Southern Pacific Railroad. Searles Lake at present may be reached by the regular stage that runs from Johannesburg by the way of Garden station, or Searles, to Searles Lake, and thence on to Ballarat and Skidoo.

[1] The chloride is also known in the trade by the chemically obsolete term "muriate of potash."
[2] Gale, H. S., Potash salts: U. S. Geol. Survey Mineral Resources, 1912, pt. 2, pp. 884-889, 1913.

Searles Lake for many years was an important source of borax. Later the California Trona Co. was organized to produce soda ash from the deposits; and the lake has now become of interest in connection with the contemplated exploitation of its potash-salts deposits.

The announcement of Searles Lake as a possible source of potash salts was made as the result of the collection and analysis of a set of brine samples from it in March, 1912, by E. E. Free, then of the United States Bureau of Soils, and Hoyt S. Gale, of the United States Geological Survey. A notice was at that time given to the press stating that reports which had been received concerning the unusually high potash content of the brine in this deposit were apparently confirmed by the results of these tests. Analyses of six brine samples taken at considerable depth in old wells at points distributed over the main salt flat showed that an average of 6.78 per cent of the total dissolved salts was potash (K_2O), corresponding to 10.73 per cent potassium chloride (KCl). The individual results obtained were 7.63, 6.23, 6.89, 6.06, 7.27, and 6.57 per cent. The uniformity of these results seemed to indicate, although it did not prove, homogeneity in composition of the brine throughout the salt deposit. Based in part on the logs of the wells that had already been drilled, a statement was also made at that time that "existing data give reasonable assurance that the brine-saturated salt body is at least 60 feet thick and covers an area of at least 11 square miles. On the assumption that the salt constitutes 25 per cent by volume of the brine, the total amount of potassium oxide available is estimated as over 4,000,000 short tons [equivalent to approximately 6,000,000 tons of potassium chloride]. This estimate is based on incomplete data, but it is believed to be conservative."

During the year 1913 the American Trona Co. was incorporated to operate works for refining and marketing the different saline constituents of the Searles Lake deposits. It is proposed to spend $3,000,000 in completing a railway from Searles to the lake and in building a plant to have a capacity of 2,000,000 gallons of brine a day.

Many deep drillings have been made at Searles Lake by the company, and the study of many hundred samples secured has enabled those in charge of the enterprise to devise a process for the treatment of the salines.

The new works will draw from the lake approximately one-tenth of an inch of brine a day; the natural evaporation is much larger and varies from one-fourth to one-half inch a day. The plan of treatment consists in first precipitating the soda as the bicarbonate. The next step involves crystallization in furnaces of simple type but large capacity. The process has been worked out with considerable care, but to insure against possible loss an initial unit with a capacity equal to 1 per cent that of the final plant will be erected and placed in operation before the main plant is built. It is expected that the daily output of the plant will be: Borax, 225 tons; soda ash, 508 tons; salt, 1,507 tons; sodium sulphate, 593 tons; and potassium chloride, 489 tons. The company will depend for its revenue mainly on the potash salts, the soda ash, and the borax. The salt may ultimately be marketed, and it is possible that at some future time a use will be found for the sodium sulphate; but for the present these constituents are not taken into account.[1]

[1] Min. and Sci. Press, June 14, 1913, p. 888.

According to the latest information the experimental unit referred to above is nearing completion and it is expected to be ready for operation in the latter part of 1914. The 31-mile railroad from Searles on the Nevada & California Railroad (Southern Pacific) is completed to the new town of Trona, where the new works are being built. It is expected that 20,000 gallons of brine will be handled daily at the new plant, and that the works will be enlarged at a later date. It is unlikely that the salts from the Searles Lake deposit will enter the market regularly until the latter part of 1914.[1]

OKLAHOMA.[2]

Common salt is found in what are generally termed "salt plains" in Oklahoma; that is, over broad areas in which incrustations of salt occur. This common salt has come from springs, which flow at particular places, or from saline ground waters, which permeate the soil below the saline crusts. Such saline ground waters may also have originated in springs with subterranean outlets. Most of the salt is supposed to have come from salt beds in the so-called "red beds."

One group of these salt plains is found in Jackson County. This group numbers three in all, lying close together on the west side of Sandy Creek, about 3 miles from its mouth, and approximately the same distance south of Eldorado. The northern plain lies in the E. ½ sec. 31, T. 2 S., R. 23 W., the middle one in the NE. ¼ sec. 5, T. 3 S., R. 23 W., and the southern plain in the NW. ¼ sec. 5 of the same township and range. All three plains are on small tributaries which flow northeast into Sandy Creek. The northern and southern plains are each about 100 yards wide and 400 yards long; the middle plain is only 40 yards wide, but is one-fourth of a mile long. The sandy floor of the plains is covered by a thin saline incrustation, and the water does not seem to be saturated.

The analyses of the soluble salts which have been made by the Oklahoma Geological Survey are not given in detail in the reference cited. According to Snider, the analyses that have been made indicate the presence of much more sodium sulphate than sodium chloride; the potassium sulphate is also high. In the incrustation from the middle plain the proportion of sodium chloride is greater than in the two others, and there seem to be sufficient sodium and potassium sulphates to make the commercial recovery of common salt a question. It is possible that the potassium sulphate from the middle plain may be utilized as a by-product.

TEXAS.[3]

In the search for a deep source of potable water at Spur, Dickens County, Tex., a deep well has been drilled by S. M. Swenson & Sons, of New York. The total depth of the well is reported as nearly 4,500 feet. The upper 900 feet of strata penetrated consist chiefly of red sand, beds of shale, gypsum, and anhydrite, and two beds of rock salt, each about 10 feet thick and both more than 500 feet from the surface. Below the 900-foot level occurs a 250-foot bed, consisting chiefly of fine sand, silt, and salt, the proportion of salt varying from 20 to 60 per cent. From the 1,250-foot level to the 2,050-foot level the character

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[1] Eng. and Min. Jour., vol. 97, No. 9, p. 484, Feb. 28, 1914.
[2] Snider, L. C., Oklahoma Geol. Survey Bull. 11, pp. 213-214, 1913.
[3] Udden, J. S., Potash in the Permian rocks of Texas: Am. Fertilizer, Dec. 14, 1912, pp. 40-41.

of the rock passed through is not known from samples, but is thought to consist chiefly of dolomitic limestone. Below this is found red silt or clay, dolomitic and shaly limestone, and anhydrite; then dolomitic limestone; then very pure anhydrite. At 3,060 feet a dark-gray soft shale was met.

The presence of so much anhydrite and salt in the section led to the suggestion by J. A. Udden, of the Bureau of Economic Geology and Technology of the University of Texas, of the possibility of the presence of potash salts in the deposits. The well had in the meantime been cased below 1,300 feet. A sample, however, was taken after the water had been bailed to a depth of 2,200 feet. This sample was examined by S. H. Worrell, also of the bureau, with the following results:

Analysis of water from well at Spur, Tex.

	Grains per gallon.
$CaSO_4$	1, 688. 4
$CaCl_2$	814. 1
$MgCl_2$	263. 2
NaCl	4, 095. 0
KCl	389. 2
	7, 249. 9

The potassium chloride amounts to 6.65 grams per liter and constitutes more than 5.4 per cent of the total salts. As this amount of potash salts is somewhat high for a natural water, arrangements were later made for obtaining samples from different depths below the foot of the casing (1,350 feet). Fourteen samples were next obtained and tested for potash salts, but in only one of them, namely, the sample from the same depth at which the earlier tests showed marked results in the content of potassium chloride, was any considerable quantity of potash salts again found, but the quantity found was approximately only one-third of that shown in the earlier sample. The results seem, therefore, to indicate the presence of a potash-bearing layer, bed, or stratum approximately 2,200 feet below the surface in the well.

ALUNITE AS A SOURCE OF POTASH SALTS.

COMPOSITION AS MINERAL.

The mineral alunite is a hydrous sulphate of potassium and aluminum with the symbol $K_2O.3Al_2O_3.4SO_3.6H_2O$. Theoretically it contains 11.4 per cent K_2O, 37 per cent Al_2O_3, 38.6 per cent SO_3, and 13 per cent water. The composition of alunite found at Marysvale, Utah, a locality at which the mineral occurs on a considerable scale, as will be seen from the table of analyses that follows, is very close to the composition of the pure mineral as given above:

Analyses of alunite from deposit near Marysvale, Utah.

	18	19	Dana.
Al_2O_3	37.18	34.40	37.0
Fe_2O_3	Trace.	Trace.	....
SO_3	38.34	36.54	38.6
P_2O_5	.58	.50	....
K_2O	10.46	9.71	11.4
Na_2O	.33	.56	....
H_2O+	12.90	13.08	13.0
H_2O-	.09	.11	....
SiO_2	.22	5.28	....
	100.10	100.18	100.0

No. 18 is a selected specimen of the supposedly best material. It consists of clear pink, subtransparent, coarsely granular, crystalline rock. No. 19 is a selected specimen of a light pink, very finely granular rock, of almost porcelain-like conchoidal fracture and no distinct structure.

METHOD OF RECOVERING POTASH.

Experiments conducted in the laboratory of the United States Geological Survey have shown that on igniting powdered alunite all the water and three-fourths of the sulphuric acid are driven off. When the residue is leached with water, potassium sulphate dissolves and insoluble alumina is left. The average quantity of potassium sulphate leached from the ignited mineral is 17.9 per cent of the original material used. As the coarsely crystallized alunite was found to contain 19.4 per cent potassium sulphate, 92 per cent of the total potash present was obtained by simple ignition and subsequent leaching. According to the laboratory experiments 32.7 per cent of the ignited alunite consists of available potassium sulphate, which may be obtained by leaching and evaporation. The remaining 67.3 per cent is nearly pure alumina. Several foreign deposits of alunite have been successfully worked for the manufacture of alum.[1]

UNITED STATES GEOLOGICAL SURVEY WORK ON ALUNITE.

There have been incorporated in this chapter in past years notices of all the occurrences of alunite that have been reported and described by members of the United States Geological Survey. The bibliography at the end of this chapter contains the references to this work. Occurrences that have been noted are those near (1) Marysvale, Piute County, Utah; (2) at five localities in the San Cristobal quadrangle, southwestern Colorado; (3) near Bovard, Esmeralda County, southwestern Nevada; and (4) in the Palmetto mining district, 5 miles south of Patagonia, Santa Cruz County, Ariz. E. S. Larsen, who described the occurrence in the San Cristobal quadrangle, Colorado, reports the mineral also at five or six different places in the Uncompahgre quadrangle, also in southwestern Colorado.

NEW OCCURRENCE OF ALUNITE IN UTAH.

Specimens containing alunite were sent to the Survey early in 1914 from the Newton mining district, about 9 miles northeast of Beaver, Beaver County, Utah, by William A. Wilson, of Salt Lake City. The material was said to have been collected from the locality known as Sheep Rocks, situated on the western flank of the same mountain range under geologic conditions similar to those of the occurrence near Marysvale.

The material sent to the Survey has been examined by B. S. Butler and found to be a mixture of the minerals alunite and quartz, there being approximately 30 to 40 per cent of the latter. It should be borne in mind that the presence of alunite in the proportion given above is based on results obtained from the examination of a single specimen. Whether further search will develop a considerable body of the mineral is entirely problematical. It is interesting, however,

[1] Butler, B. S., and Gale, H. S., Alunite, a newly discovered deposit near Marysvale, Utah: U. S. Geol. Survey Bull. 511, pp. 10–11, 1912.

to note, as stated elsewhere in this report, the rather general distribution of alunitization, as this form of rock alteration may be called.

Attention on the part of the owners and others interested in these and other similar deposits should be given to the interesting results obtained in experiments with alunite as a fertilizer both in the raw and in the roasted form. These results are outlined in another part of this report.

UTILIZATION OF ALUNITE.

Though the mineral alunite, since attention has been directed to it as a possible source of potash salts and alumina, has been found to be quite widespread in occurrence in certain of the Western States and has come to be recognized as a rather common form of rock alteration, the Marysvale, Utah, deposit is the only one that has been regarded as of any commercial importance up to the present time. The composition of the Marysvale mineral has already been indicated.

One of the companies interested in the occurrence near Marysvale is the Florence Mining & Milling Co. This company issued a prospectus in 1913 outlining the benefits of potash as a fertilizer and giving some concrete data on the company's holdings of alunite near Marysvale.

Certain newspaper reports regarding the future exploitation of the Marysvale deposits which have come to the Survey's attention but which must be distinctly understood as not authenticated by it, are as follows:

Among the plans for the exploitation of the Marysvale alunite is one for the erection of a roasting and grinding plant, which is to be installed in the spring of 1914. Because of the possible injury to the forests from the fumes of the oxides of sulphur given off during the roasting of the mineral, it is thought that the plant will not be permitted in the mountains near the occurrence itself. It is probable, therefore, that it will be built near the Denver & Rio Grande station at Marysvale, at which locality the prevailing winds will carry the acid fumes into the barren foothills of the ranges east of the valley. An aerial tram is projected to convey the ore from Cottonwood Canyon to the plant.

Method of utilizing alunite.—A process for obtaining sulphate of potash and alumina has been devised by H. F. Chappell and is described in patent No. 1070324 dated August 12, 1913. According to the specifications in this patent, sulphate of potash and aluminum oxide are obtained from natural deposits of alum stone, alum rock, and alunite by heating them at a temperature of about 800° to 1,000° C. until the aluminum compounds present are converted into insoluble aluminum oxide and the potassium compounds present are converted into potassium sulphate. The latter salt is then extracted by lixiviation.

KELP AS A SOURCE OF POTASH SALTS.

PRIVATE INVESTIGATIONS.

The utilization of kelp as a source of potash salts has been discussed in detail in this chapter in the last two years. In the report for 1911, especially, the results of private investigation and those of the Bureau of Soils were outlined. These results will not be repeated here, but the outline of the progress of the work to date and the more important results which apparently have been derived therefrom will be given.

The occurrence of potash salts in large amounts in kelp has been known for many years. The experiments of David M. Balch [1] on the Pacific coast kelps began early in 1905. Balch gives in the article cited a concise description of the range, relative abundance, life habits, and chemical composition of the three most important giant kelps of the Pacific coast. He also considers their econonic value and the practical methods of utilizing their products.

INVESTIGATIONS BY THE BUREAU OF SOILS.

During the spring and summer of 1911 work on the Pacific coast kelps was begun by the Bureau of Soils of the Department of Agriculture. During that year field observations were made on Puget Sound, on the California coast from Golden Gate to Point Sur, and from Cape Conception to Point Loma. Laboratory investigations were carried out on the material collected. The work was continued during 1912, and as a result there have been prepared maps of the kelp groves covering an area of 230 square miles on the Pacific coast from Puget Sound in the United States to the Cedros Islands in Mexico. The details of the work accomplished are contained in different publications of the Bureau of Soils, which have appeared in both official and unofficial journals.

During the season 1913 work both in the field and in the laboratory was done by the bureau. Two parties were engaged in locating and determining the extent and important characteristics of the kelp along the shore line of Alaska. Another party investigated on the ground the possibilities of developing a combined fish scrap and kelp industry on Puget Sound and in Alaska. Observations were made at La Jolla and Point Firmin, Cal., and at Friday Harbor, Wash., on the life history of these algæ, especially in relation to cutting and harvesting them.

Three papers—one on the leaching of potash from freshly cut kelp,[2] the second on the analyses of certain of the Pacific coast kelps,[3] and the third on the composition of the giant kelps [4]—appeared during 1913 or early in 1914. From the experiments of Merz and Lindemuth it is shown "that it is a matter of considerable difficulty to obtain a fair average sample of wet kelp," and also "that freshly cut kelp when immersed in seawater does not, at least at first, lose its potash content very rapidly." In a later paper by Merz [5] the conclusions arrived at by Merz and Lindemuth referred to above were corroborated.

With reference to the composition of giant kelps Merz has found—

> that Nereocystis of Alaskan waters is, as respects potash content, of as great importance as an economic source of potash salts as that of the more southern waters. Macrocystis contains a lower percentage of potassium than does Nereocystis, while Alaria contains a decidedly lower percentage. The seaweeds Fucus and Porphyra are evidently valueless as sources of potash on an economic scale.

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[1] Jour. Ind. and Eng. Chem., vol. 1, No. 12, pp. 777-787, 1909.

[2] Merz, A. R., and Lindemuth, J. R., Jour. Ind. and Eng. Chem., vol. 5, No. 9, pp. 729-730, September, 1913.

[3] Parker, E. G., and Lindemuth, J. R., Jour. Ind. and Eng. Chem., vol. 5, No. 4, pp. 287-289, April, 1913.

[4] Merz, A. R., Jour. Ind. and Eng. Chem., vol. 6, No. 1, pp. 19-20, January, 1914.

[5] Op. cit., p. 19.

Another observation made in connection with Merz's work is that in every instance where stems and leaves were separately analyzed the total salt content and similarly the potash content in the stem exceeded that in the leaves, a conclusion at variance with that previously but tentatively drawn by Cameron. It was also found that (1) the ash content is generally higher in the leaves than in the stem of the same plant, and (2) that the nitrogen content is generally larger in the laminæ than in the stipe of the same plant.

The work of Parker and Lindemuth [1] on the giant kelps has enabled them to draw the following conclusions. These kelps are the most important from an economic point of view, both from their size and from the large amount of potash salts which they contain. They occur from 30 to 200 feet in length and in specific cases much longer, while the smaller varieties occur only from 2 to 12 feet in length. In the northern areas the commercial species are *Nereocystis luetkeana* and *Macrocystis pyrifera;* in the southern areas the commercial species are *Macrocystis pyrifera* and *Pelagophycus porra.* Other conclusions which these workers have been able to draw from their experiments are (1) that the average content in potassium chloride in the giant kelps is high; (2) that apparently no definite relation exists between the different constituents of kelp; (3) that apparently the northern kelps are richer in potassium chloride than the southern; (4) that the potash content of Nereocystis is greater than that of Macrocystis; and (5) that the iodine content of the northern and southern kelps shows no conclusive differences.

In a paper by F. K. Cameron [2] on kelp and other sources of potash, the recent information regarding kelp as a source of potash is summarized up to the time of publication. From the averages of the many existing analytical data Cameron states the following conclusions, derived in part at least from the work of his colleagues of the Bureau of Soils: (1) No definite quantitative relations exist between the different constituents of kelp; (2) the potassium content of Nereocystis is greater than that of Macrocystis; (3) the potassium content of northern kelp is higher than that of southern kelp; and (4) there is no positive difference in iodine content between northern and southern kelps. So far as results obtained are available, Cameron considers that the following conclusions also seem justified—(5) the proximity of the mouth of a fresh-water stream has no appreciable effect on the potash and nitrogen content of kelp; (6) there are no essential differences between the potash and nitrogen content of fronds and stipes [which conclusion was changed by the subsequent work of Merz already referred to]; and (7) there are no essential differences in the potash and nitrogen content of old and young plants, but further data on this point are desirable as well as on the possible variations in the potash content with the season.

COMMERCIAL UTILIZATION OF KELP.

Since interest has been aroused in kelp as a source of potash salts, several companies have been formed having in view its commercial exploitation either in the dried form as a fertilizer or for the potash salts and the other valuable ingredients, such as iodine, which it con-

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[1] Jour. Ind. and Eng. Chem., vol. 5, No. 4, pp. 287-289, April, 1913.
[2] Franklin Inst. Jour., vol. 176, No. 4, pp. 347-383, October, 1913.

tains. The names of 11 companies formed ostensibly to engage in the kelp industry have been brought to the attention of the Survey during the last year. In geographical distribution these companies are located in the vicinity of Puget Sound, with headquarters chiefly at Seattle, and on the southern California coast near Long Beach, Los Angeles, and San Diego. Two of these companies were mentioned in this report for 1912.

The American Potash Co. with offices at Los Angeles, Cal., plans to utilize the kelp in the vicinity of Long Beach. This company was formed by the merging of two other companies, one of which was the Coronado Chemical Co., of San Diego and Cardiff. It is stated that work will begin early in 1914 on the manufacture of potash and other by-products from kelp at a plant to be built at Long Beach. The plant is to be erected on the unit system, and construction work on it began early in 1913. The work of manufacturing potash will begin on the completion of the new buildings that are expected to be finished about April 1, 1914.

The Pacific Products Co., of San Pedro, Cal., with a capital of $100,000, is reported to have a factory site on the California coast opposite the kelp grove outside of Point Firmin.

The Pacific Products Co., of Seattle, Wash., capitalized at $125,000, will build a factory for the manufacture of fertilizer materials and by-products from fish and kelp at Port Townsend, Wash. Several beds of kelp have been optioned at the head of Puget Sound, where a large quantity of seaweed will be harvested each year and transferred to the factory at Port Townsend. This company will also make a business of obtaining dogfish and of utilizing the offal from the fish canneries in the vicinity. The first unit of the plant for converting kelp and dogfish into fertilizer material was reported completed in July, 1913.

The Pacific Kelp Mulch Co. is located at Terminal Island, 1 mile east of East San Pedro, on the San Pedro, Los Angeles & Salt Lake Railroad. The company has been gathering kelp from the ocean during the last two years and disposing of it to the farmers and fruit growers as a fertilizer. The company has developed a machine which harvests the kelp rapidly and on a large scale. The kelp is cut from 4 to 6 feet under water, and care is taken not to disturb the roots of the growing plants. It is loaded on a barge and brought to the boat landing of the plant. Here it is pitchforked from the barge on a belt conveyer which conveys it to the cutter, being subjected during the passage to a steaming process which is practically instantaneous and which, it is asserted, removes all the adhering common salt ($NaCl$) but none of the potash salts. The cutter chops it into pieces 6 to 8 inches long—that is, of a length to be conveniently handled with a manure fork or to be harrowed under the soil after being spread. From the cutter the kelp falls into wagons or to the floor. It is then carted to the railroad and dumped into freight cars and shipped to the centers of consumption. This company has the distinction of being the first to harvest and market kelp on a commercial scale.

The material is said to have many advantages as a fertilizer, and these are explained in a small pamphlet which has been issued by the company.

The other companies whose names have come to the Survey as proposing to engage in the production of kelp on a commercial scale are the following:

Ocean Products Co., Seattle, Wash.
North Pacific Kelp Potash Co., Seattle, Wash.
Pacific Coast Kelp Potash Co., Seattle, Wash.
Puget Sound Kelp Potash Co., Seattle, Wash.
Aquatic Products Co., Seattle, Wash.
Kelp Products Co., San Francisco, Cal.
Mexican Kelp Fertilizer Co., Los Angeles, Cal.

The Survey has no first-hand knowledge of the activities of these companies.

ALUNITE AND KELP AS FERTILIZERS.

In experiments with alunite as a source of potash Waggaman[1] found that a large quantity of water is required to free the ignited residue entirely from soluble salts and that the subsequent evaporation is tedious and expensive. He suggested, therefore, that it might be more economical to use ignited alunite directly as a fertilizer than first to leach the residue for the potassium sulphate contained in it.

Experiments have been made by Skinner and Jackson[2] with alunite as a fertilizer in which both the raw and the ignited mineral have been used. The sample of raw alunite containing 10 per cent potash (K_2O) was finely ground, as was also the sample of the ignited mineral, which contained 14.7 per cent potash. These minerals were applied to the soil in such quantities as would furnish 25, 50, 100, 200, and 500 pounds of potash to the acre. Experiments with kelp were also tried, the material used being in the dried state and containing 19.8 per cent potash. This likewise was applied to the soil in such quantities as to furnish 25, 50, 100, 200, and 500 pounds of potash per acre. Check experiments were also made containing equivalent quantities of potash in the forms of the sulphate and the chloride, while in still another experiment no fertilizer was used. This last was in the nature of a control experiment.

The cultural methods employed and the results obtained from these experiments are as follows:

The soil was weighed into pans, 3 pounds to each pan. The soil in one pan received no fertilizer and was used as a control. To each of the other pans the fertilizer to be tested was added. To the different pans of soil were added raw alunite, ignited alunite, kelp, potassium sulphate, and potassium chloride, each in quantities of 25, 50, 100, 200, and 500 pounds of potash (K_2O) per acre, based on an acre half-foot of soil weighing 2,000,000 pounds.

The soil used in the first experiment was the Carrington loam—a soil which is known to respond well to potash fertilizers in field practice. The soil was treated with the various fertilizers in pans on October 22, was well mixed by sifting, and was potted October 28. Three pots, each holding about a pound of soil, were used for each treatment. Six wheat plants were planted in each pot. The plants grew until November 29. At the end of the experiment the plants were cut and the green weights recorded. The results of the test are given in the accompanying table. The last column gives the relative growth of the different treatments. The growth of the check or control is taken as 100. The second column gives the green weights of the three cultures in each treatment.

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[1] Waggaman, W. H., U. S. Dept. Agr. Bur. Soils Circ. 70, 4 pp., July 31, 1912.

[2] Skinner, J. J., and Jackson, A. M., Alunite and kelp as potash fertilizers: U. S. Dept. Agr. Bur. Soils Circ. 76, 5 pp., Apr. 10, 1913.

Effect of alunite and kelp as compared with that of potassium sulphate and potassium chloride on growth.

	Quantity of K_2O added per acre.	Green weight.	Relative growth.	
	Pounds.	*Grams.*	*Per cent.*	
Soil untreated	....	3.35	100	
Soil+raw alunite	25	3.70	110	114
	50	4.00	119	
	100	4.02	120	
	200	3.77	112	
	500	3.72	111	
Soil+ignited alunite	25	4.58	136	140
	50	4.77	142	
	100	4.80	143	
	200	4.80	143	
	500	4.53	135	
Soil+kelp	25	3.93	117	131
	50	4.67	139	
	100	4.80	143	
	200	4.40	131	
	500	4.30	128	
Soil+K_2SO_4	25	4.27	127	138
	50	4.33	129	
	100	5.12	152	
	200	4.52	135	
	500	4.90	146	
Soil+KCl	25	4.40	131	131
	50	4.33	129	
	100	4.50	134	
	200	4.37	130	
	500	4.40	131	

By examination of the table it is seen that each of the potash fertilizers produced an increased growth over the untreated soil. The raw alunite used in amounts of 25 to 500 pounds of K_2O per acre increased growth from 10 to 20 per cent. The best results were secured with 50 to 100 pounds of potash (K_2O) per acre. The average increase over the untreated soil of the five amounts was 14 per cent. When the growth is compared with that produced by the ignited alunite it is seen that this caused larger growth with each amount used than did the raw alunite. The increase in growth with ignited alunite over the untreated soil varied from 35 to 43 per cent, the average increase being 40 per cent. The growth with the raw alunite was not so good as with similar amounts of potash as potassium sulphate and potassium chloride. The average increase with potassium sulphate was 38 per cent and with potassium chloride was 31 per cent. The effect of ignited alunite was about the same as that of potassium sulphate, and greater than that of the potassium chloride.

Kelp produced a considerable increase in growth over the untreated soil. The increase varied with the different amounts, from 17 to 43 per cent. The average increase over the untreated soil was 31 per cent. The increased growth was about the same as that produced by potassium chloride and was slightly less than that resulting from the use of potassium sulphate. It should be here noted that the potash in the kelp is in the form of the chloride.

Another experiment was made to test the effect of these potash compounds, using this time a different soil. Otherwise, the details of the experiment were the same as in the first test. The soil used in this test was the Volusia silt loam. The plants grew from November 19 to December 21. Three pots were used for each treatment. The results are given in the table which follows.

Effect of alunite and kelp, as compared with that of potassium sulphate and potassium chloride on growth.

Treatment.	Quantity of K_2O added per acre.	Green weight.	Relative growth.	
	Pounds.	*Grams.*	*Per cent.*	
Soil untreated		2.84	100	
Soil+raw alunite	25	3.35	118	116
	50	3.40	120	
	100	3.36	118	
	200	3.36	118	
	500	3.02	106	
Soil+ignited alunite	25	3.54	124	131
	50	3.70	130	
	100	3.70	130	
	200	3.90	137	
	500	3.94	136	
Soil+kelp	25	3.24	114	123
	50	3.54	124	
	100	3.59	127	
	200	3.60	127	
	500	3.45	121	
Soil+K_2SO_4	25	3.08	108	125
	50	3.62	127	
	100	3.87	136	
	200	3.68	129	
	500	3.54	124	
Soil+KCl	25	3.04	108	122
	50	3.50	123	
	100	3.50	123	
	200	3.74	131	
	500	3.60	127	

Each of these potash fertilizers had a beneficial effect on Volusia silt loam. The raw alunite again produced less increased growth than the ignited alunite. This was true with each amount of the substances used. The raw alunite was not as effective as potassium sulphate and potassium chloride. However, the ignited alunite was more effective. The average increase for the raw alunite was 16 per cent, for the ignited alunite 31 per cent, for potassium sulphate 25 per cent, and for potassium chloride 22 per cent.

As in the first experiment kelp again produced considerable increase in growth. The effectiveness in producing plant growth was practically the same as that of potassium sulphate and potassium chloride. Kelp gave as an average 23 per cent increase in growth, potassium sulphate 25 per cent, and potassium chloride 22 per cent increase. In addition to the amount of potash added to the soil by the kelp, it contains a small amount of nitrogen and phosphorus, which should be effective in the soil. From these two experiments it seems that the dried kelp and ignited alunite are about as effective potash fertilizers as the salts, potassium sulphate and potassium chloride.

POTASH SALTS FROM THE SILICATE ROCKS.

If the interest in the problem of the derivation of potash salts from the silicate rocks is to be judged from the number of processes which have been devised and patented, then the year 1913 showed no abatement in this interest. Several patents have been secured covering such processes and a few articles on the subject have also appeared in the scientific literature. The more important of these processes are briefly reviewed below.

Process of Morse and Sargent.—H. W. Morse and G. W. Sargent (patent No. 1041327, dated Oct. 15, 1912) have invented a process in which feldspar is subjected at an elevated temperature, first, to the action of sulphate of lime (gypsum), and, second, to that of an alkaline chloride such as commom salt or to a chloride of an alkaline earth metal as calcium chloride. There are produced oxides of sulphur, a soluble compound of potassium and residual material which may be converted into Portland cement. According to the claims of the patentees, it is the production of the oxides of sulphur and the cement material in connection with that of the soluble potassium compound that makes possible the economical manufacture of the latter.

Process of Gelléri.—In the process of S. Gelléri (patent No. 1058686, dated Apr. 8, 1913) silicates are burned with lime or with an oxide or carbonate of an alkaline earth metal or magnesium for the purpose of decomposing the silicate and obtaining potash and cement clinker. After the silicates have been decomposed in this manner, a large portion of the alkalies in them is still not in a condition whereby it may be leached with water. According to Gelléri's process this disadvantage is overcome by subjecting the silicates in a closed chamber to the action of ammonium carbonate vapor under pressure either after they have been burned with the oxides or carbonates of the alkaline earth metals or without this preliminary burning. By so doing the silicates are completely decomposed, and the whole of the alkali metal may be obtained in the form of an alkali carbonate by leaching with water. The decomposition takes place according to the following reaction:

$$\underset{\text{(feldspar)}}{6KAlSi_3O_8} + 3(NH_4)_2CO_3 + 3H_2O = 3K_2CO_3 + 3Al_2O_3.6SiO_2.6H_2O + 6NH_3 + 12SiO_2.$$

This process has the advantage that the whole of the ammonia in the ammonium carbonate is liberated, and, after the reaction is completed, the free ammonia may be used over again to make ammonium carbonate. This is most economically accomplished by saturating the ammonia with carbon dioxide from the furnace in which the silicates are burned with limestone. In order that a separate furnace may not be necessary to heat the silicates with ammonium carbonate, the furnace gases coming from the burning kiln may be used.

If the silicates have been burned with lime before being treated with ammonium carbonate, they contain all the constituents corresponding with the composition of Portland cement, so that it is possible to burn the silicates which have been decomposed and freed from alkalies to Portland cement by heating them again.

Process of Hart.—According to E. Hart (patent No. 1062278, dated May 20, 1913), when feldspar or similar rock is mixed with potassium or sodium sulphate and carbon and heated to fusion in a furnace, there is formed a soluble glass consisting of a potassium or sodium aluminum silicate. This glass may readily be decomposed by the addition of a suitable acid like sulphuric, which forms practically pure silica and a solution from which potassium and aluminum may be obtained in the form of common potash alum, leaving a mother liquor which contains sulphates of potassium, sodium, or aluminum, some free sulphuric acid, and other sulphates formed by the action of the acid.

The mother liquor is evaporated to dryness and fused with a suitable amount of carbon. The residue consists chiefly of aluminate of soda or potash, or both, or of one or more of these substances, together with alumina. If water be added to the residue, the aluminate of soda or potash will be largely dissolved, and there will be left an insoluble residue consisting chiefly of sulphide of iron, with possibly some alumina. From the solution of the aluminate of soda or potash alumina may be obtained by the usual methods.

Process of Bassett.—An invention by H. P. Bassett (patent No. 1072686, dated Sept. 9, 1913) relates to the treatment of feldspar or feldspathic rock to obtain potash and has particular reference to a process of not only obtaining potash salts from feldspar or feldspathic rock, but also of obtaining, in the form of a by-product, material which is adapted for use in manufacturing pottery.

Bassett has found that potash may be economically and satisfactorily obtained from feldspar by treatment with salt alone, and that the potash salts and by-products of the reaction may be obtained in relatively pure form. In practice, he adds to disintegrated and preferably finely ground feldspar or feldspar-bearing rock, about one-half its weight of sodium chloride. The mixture is next heated to a yellow heat, preferably from 800 to 900° C., in the presence of air, for about one to two hours. The mass is then dumped while still hot into a vat of water in the proportion of about 2 to 5 parts by weight of water to 1 part of the fused mass. The mass is then leached with water and the potash and sodium salts are obtained in any desired manner, preferably by evaporation of the solution to dryness. The potassium and sodium salts are later separated, for example, by crystallization. The leached residue, which corresponds in composition closely with that of the feldspathic rock, except that the potassium is replaced by sodium, and that any iron present in the original rock will have been volatilized as iron chloride, and thus removed, is then dried and ground, the resulting product being a white mass that may be used for pottery or other purposes, such as a paper filler or enamel ware. The feldspar or feldspar-bearing rock may be ground to any desired fineness before treatment, but preferably not less than 40 mesh; finer grinding than 100 mesh is unnecessary. The leached residue is dried and ground and is then ready for use.

Process of Cowles.—Early in 1913 A. H. Cowles[1] described the results of certain experiments having to do with the extraction of potash alum and other soluble potash salts from the insoluble potash silicates. Cowles's experiments differ from those which have been described in that he mixes rock phosphate with the feldspar, thus incorporating a second fertilizer element into the resulting mixtures.

In the first experiments potash feldspar was ground with rock phosphate in such proportion as to furnish two molecular weights of lime to each molecular weight of silica in the feldspar. The mixture was heated to a sintering temperature of about 1,000° C. and the resulting product was leached with sulphuric acid. The resulting yield was practically 100 per cent. The products formed were insoluble dicalcium silicate, soluble potash alum, and orthophosphoric acid.

In the subsequent experiments less acid was used and the results of the leaching gave a product containing all the potash and alumina in the feldspar but only part of the phosphoric acid. Duplicate experiments have been carried out in which hydrochloric instead

[1] Paper read at the joint meeting of the American Electrochemical Society, the American Chemical Society, and the Society of Chemical Industry, New York, Feb. 7, 1913: Jour. Ind. and Eng. Chem., Apr., 1913, pp. 331–335.

of sulphuric acid was used. The solutions in the two cases gave either potash alum or the double chloride of potash and aluminum together with the phosphoric acid in the rock phosphate used in the experiment. Any iron present in the raw material used goes into solution with the aluminum and potash. From either the potash alum or the double chloride of aluminum and potash the opportunities for securing alumina are good. If the potash alum is heated to a dull red heat, the aluminum sulphate breaks down into alumina (Al_2O_3) and sulphuric acid (SO_3) and the potash sulphate may be leached away. If the double chloride of aluminum and potash is treated with water at a low temperature, hydrochloric acid is given off with the formation of alumina. The potassium chloride remains and may be leached away. The Cowles process for obtaining alumina has been described in this volume (Pt. I) in the chapter on bauxite and aluminum and will not be again described in detail in this place.

PRIVATE ENTERPRISE IN CONNECTION WITH THE EXTRACTION OF POTASH SALTS FROM THE SILICATES.

The Spar Chemical Co., with headquarters at Baltimore, Md., has done some experimental work on the extraction of potash salts from the silicate rocks at a plant located at Curtis Bay on the outskirts of the city. It is understood that the products are made according to the Thompson method, an outline of which was published in this chapter for 1911; this outline is repeated below.

Thompson's process is described in patent No. 995105, dated June 13, 1911. It consists first of grinding feldspar rock so that it will pass through a 100-mesh sieve. The powdered rock is then mixed wth an acid alkali sulphate and an alkali chloride, preferably acid sodium sulphate and sodium chloride, respectively. The proportions of the materials used are: Feldspar rock, 5 parts by weight; acid sodium sulphate, 5 parts by weight; sodium chloride, 1.8 parts by weight. This mixture is heated from one to two hours at a bright red heat and becomes thereby partly fused. The mass is then allowed to cool, is ground again, and is leached with water, which removes a mixture of sulphates of potassium and sodium. These salts are then separated by crystallization. The reactions are believed to be as follows: (*a*) The sodium acid sulphate reacts with the sodium chloride to produce hydrochloric acid gas and normal sodium sulphate. (*b*) The hydrochloric acid gas at the high temperature employed reacts on the feldspar, producing potassium chloride. (*c*) The potassium chloride is in turn acted upon by more of the acid sodium sulphate, producing hydrochloric acid gas and potassium sulphate.

The yield of potash is ordinarily from 80 to 90 per cent of the potash in the rock. For the best results the temperature must be controlled within rather narrow limits.

SHIPMENTS FROM GERMAN POTASH MINES.[1]

From data obtained from reliable sources the following table, showing the shipments of potash salts and potash fertilizers in metric tons from the German potash mines for native and foreign consumption during the last two years, has been compiled:

Shipments of potash salts from German mines in 1911 and 1912.

Potash salts.	1911.	1912.
	Metric tons.	*Metric tons.*
Muriate of potash	443,357	471,435
Sulphate of potassium	110,123	115,728
Magnesium, 48 per cent K_2O	49,014	55,987
Magnesium, 40 per cent K_2O	144	173
Manure salts:		
Minimum, 38 per cent K_2O	38,620	48,059
Minimum, 20 per cent K_2O	169,812	174,867
Minimum, 30 per cent K_2O	57,502	64,514
Minimum, 40 per cent K_2O	379,790	483,877
Kainit and sylvinit	3,312,632	3,251,003
Carnallite, etc	80,660	70,462
Total	4,641,654	4,736,105

Changes have been made in the method of preparing the statistics for 1912 so as to preclude comparison in all cases between the shipments of that year with 1911. The following table, however, shows the exports of German potash salts for 1911 and 1912 and the amount shipped to the United States in metric tons, with comparisons where possible:

Exports of German potash salts in 1911 and 1912.

Potash salts.	1911		1912	
	Total.	To United States.	Total.	To United States.
	Metric tons.	*Metric tons.*	*Metric tons.*	*Metric tons.*
Muriate of potash	329,751	229,431	286,528	190,775
Sulphate of potassium	109,529	56,893	85,452	35,366
Sulphate of potassium-magnesium	*a* 282,574	*a* 143,775	48,540	14,172
Carnallite with at least 9 per cent and less than 12 per cent K_2O			6,853	(*b*)
Raw potash salts with from 12 to 15 per cent K_2O			852,984	461,279
Raw potash salts with more than 15 per cent and less then 20 per cent K_2O	*c* 1,167,972	....	35,529	29,533
Manure salts, including potash salts with 38 per cent K_2O.			373,665	149,907
Abraum salts, Stassfurter salts, etc			31,322	9,578
Total	1,889,826	....	1,720,873	890,610

a Includes manure salts.
b Not stated.
c Only the total exports of the last five salts for the year 1911 are given in the new statistics, and the shipments to the United States during that year are not specified.

[1] Daily Cons. and Trade Repts., June 18, 1913.

CONSUMPTION OF POTASH SALTS IN THE UNITED STATES.

In the following table are given the total imports of potash salts in pounds for the years 1910 to 1913, inclusive:

Potash salts imported into the United States for the calendar years 1910–1913, in pounds.[a]

	1910		1911		1912		1913	
	Quantity.	Value.	Quantity.	Value.	Quantity.	Value.	Quantity.	Value.
Potash:								
Carbonate of....	18,963,619	$616,371	20,332,990	$636,356	20,530,846	$658,343	21,436,533	$652,635
Caustic, not including refined..........	8,304,696	346,388	7,069,837	287,116	9,578,437	365,860	8,590,120	335,147
Cyanide of [b].....	....	....	[d] 2,114,684	[d] 316,027	1,138,569	169,627	1,023,167	143,999
Chloride of........	381,873,875	5,252,373	509,119,193	7,651,684	482,265,665	7,229,109	478,826,857	7,120,055
Nitrate of, or saltpeter, crude.........	11,496,904	333,854	7,945,747	265,061	7,315,531	216,492	9,876,910	262,575
Sulphate of......	86,162,874	1,426,975	121,039,192	2,227,820	97,161,010	1,769,676	88,565,073	1,633,114
All other [c]......	3,389,684	387,662	4,583,940	442,042	3,509,444	316,989	6,114,748	554,637
Total..........	510,191,652	8,363,623	672,205,583	11,826,106	621,499,502	10,726,096	614,433,408	10,702,162

[a] This table is based on total imports for the calendar year, not, as nearly all the import tables in this volume, on imports for consumption for the calendar year.
[b] Included in "All other chemicals" prior to July 1, 1911.
[c] Included in "All other chemicals" prior to July 1, 1909.
[d] Figures cover period since July 1.

For comparison the following table is added, which gives the potash salts imported for consumption into the United States during the calendar years 1911, 1912, and 1913, in pounds:

Potash salts imported for consumption into the United States for the calendar years 1911–1913, in pounds.

	1911		1912		1913	
	Quantity.	Value.	Quantity.	Value.	Quantity.	Value.
Potash:						
Carbonate of, crude........	8,604,855	$255,096	7,625,382	$234,868	9,715,878	$272,973
Caustic, not including refined....................	7,072,093	287,097	9,690,494	370,506	8,648,753	[a] 342,056
Cyanide of..................	2,649,040	394,141	726,659	109,434	1,395,987	205,037
Chloride of..................	506,570,661	7,651,693	482,529,396	7,229,121	475,261,595	7,075,745
Nitrate of, saltpeter, crude.	7,944,757	265,061	6,511,208	202,899	9,652,366	261,078
Sulphate of..................	121,710,568	2,240,631	98,237,150	1,783,846	88,698,193	1,677,429
All other....................	15,570,411	689,662	16,858,875	761,611	19,067,144	959,595
Total....................	670,122,385	11,783,381	622,179,164	10,692,285	612,439,916	10,793,913

[a] Including refined.

It will be observed that there was a slight decrease in both quantity and value of potash salts imported in 1913 as compared with 1912. The quantities of carbonate, cyanide, nitrate, and "all other salts" of potassium increased, while the quantity of caustic potash, chloride, and sulphate diminished. The results, especially in the case of the two latter salts, are of interest, for among the potassium salts imported it is presumably these two that enter most largely into the commercial fertilizer industry.

The importation of potash salts given in these tables is only a part of that entering the United States from Germany. To it should be added the importation of kainite and manure salts. The importation of fertilizers, including kainite and manure salts, is given in the following table:

Fertilizers imported and entered for consumption in the United States, 1909–1913, in long tons.

Fertilizer.	1909		1910		1911	
	Quantity.	Value.	Quantity.	Value.	Quantity.	Value.
Apatite	2,925	$19,013			20	$300
Bone dust or animal carbon, and bone ash, fit only for fertilizing purposes	29,035	685,291	48,979	$1,140,476	36,856	943,472
Calcium cyanamid or lime nitrogen	(a)	(a)	3,540	177,552	5,292	292,496
Guano	44,197	772,674	33,565	667,870	36,869	774,315
Kainite	163,943	854,998	582,197	2,798,198	563,957	2,748,140
Manure salts, including double manure salts	b 52,958	601,804	147,242	1,013,009	159,796	1,660,040
Phosphates, crude	9,983	99,060	21,706	235,040	16,153	157,394
Slag, basic, ground or unground	690	5,880	10,774	93,650	12,622	87,994
All other substances used only for manure	184,850	2,879,845	195,991	3,394,279	197,810	4,098,321
Total	488,581	5,918,565	1,043,994	9,520,074	1,029,375	10,762,472

Fertilizer.	1912		1913	
	Quantity.	Value.	Quantity.	Value.
Apatite	100	$1,400	2,962	$22,471
Bone dust or animal carbon, and bone ash, fit only for fertilizing purposes	117,717	878,686	35,012	851,136
Calcium cyanamid or lime nitrogen	9,311	493,519	26,729	1,410,248
Guano	19,128	329,624	16,674	518,429
Kainite	511,976	2,386,362	465,336	2,201,730
Manure salts, including double manure salts	171,757	1,797,057	223,687	2,245,509
Phosphates, crude	28,821	231,255	17,121	124,815
Slag, basic, ground or unground	12,596	114,300	13,186	130,455
All other substances used only for manure	127,932	2,660,887	154,729	3,314,460
Total	999,338	8,893,090	955,436	10,819,253

a Not separately classified. b From Aug. 5 to Dec. 31.

MATERIALS ENTERING LARGELY INTO THE FERTILIZER INDUSTRY IN THE UNITED STATES.

In the following table are given the statistics of materials entering largely into the fertilizer industry in the United States:

Materials entering largely into the fertilizer industry in the United States for the years ending Dec. 31, 1909–1913, in long tons.

	1909		1910		1911	
	Quantity.	Value.	Quantity.	Value.	Quantity.	Value.
Imported:[a]						
Fertilizers	....	$6,505,090	....	$9,438,417	....	$10,816,504
Potassium chloride	133,427	4,780,106	170,479	5,252,373	227,285	7,651,684
Potassium sulphate	31,322	1,301,205	38,466	1,426,975	54,035	2,227,820
Sodium nitrate (Chile saltpeter)	428,429	13,608,195	529,172	16,601,328	544,878	16,814,256
Domestic phosphate rock	2,330,152	10,772,120	2,654,988	10,917,000	3,053,279	11,900,693
Total	....	36,966,716	....	43,636,093	....	49,410,957

	1912		1913	
	Quantity.	Value.	Quantity.	Value.
Imported:[a]				
Fertilizers	....	$8,892,802	....	$10,727,763
Potassium chloride	215,297	7,229,109	213,762	7,120,055
Potassium sulphate	43,375	1,769,676	39,538	1,633,114
Sodium nitrate (Chile saltpeter)	486,352	16,554,404	625,862	21,630,811
Domestic phosphate rock	2,973,332	11,675,774	3,111,221	11,796,231
Total	....	46,121,765	....	52,907,974

[a] Imports are "total imports."

This table requires some explanation. In the first place, the imports given in it are "general imports," or total imports. General imports are those entered at the customhouse for immediate consumption and also imported articles entered for the warehouse but not necessarily removed therefrom for consumption, and hence, strictly speaking, not necessarily consumed in the year under which they are given. This, however, does not destroy the value of comparisons between different years. In the second place, all the sodium nitrate reported is not used in the fertilizer industry. A large part of it is converted into nitric acid and potassium nitrate, the latter being used for making gunpowder and other explosives, matches, pyrotechnics, in assaying, in metallurgical and analytical operations, for curing meat, etc. The magnitude of the importation of this material is, however, very significant. This sodium nitrate is another commodity for which the United States is entirely dependent on a foreign country. Lastly, it is probable that not quite all the potassium chloride and potassium sulphate are used in the fertilizer industry.

The following table shows imports for consumption of materials entering largely into the domestic fertilizer industry:

Materials entering largely into the fertilizer industry in the United States for the years 1911–1913, in long tons.

	1911		1912		1913	
	Quantity.	Value.	Quantity.	Value.	Quantity.	Value.
Imports: [a]						
Fertilizers	1,029,375	$10,762,472	999,338	$8,893,090	955,436	$10,819,253
Potassium chloride	226,148	7,651,693	215,415	7,229,121	212,170	7,075,745
Potassium sulphate	54,335	2,240,631	43,856	1,783,846	39,597	1,677,429
Sodium nitrate	544,532	16,814,268	486,779	16,544,511	612,861	21,630,811
Domestic phosphate rock	3,053,279	11,900,693	2,973,332	11,675,774	3,111,221	11,796,231
Total		49,369,757		46,126,342		52,999,469

[a] Imports for consumption.

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FULLER'S EARTH.

By Jefferson Middleton.

INTRODUCTION.

The fuller's earth industry showed considerable progress in 1913, the marketed production increasing in both quantity and value, the former from 32,715 short tons in 1912 to 38,594 short tons in 1913, and the latter from $305,522 in 1912 to $369,750 in 1913.

According to Parsons:[1]

Fuller's earth is a variety of clay that has high capacity for adsorbing basic colors and can remove these colors from solution in animal, vegetable, or mineral oils, as well as from some other liquids, especially water. It is valuable when its adsorptive powers are strong enough to permit it to compete actively with fuller's earth already accepted as of standard quality for refining oils.

Analyses of various samples of fuller's earth vary so greatly that chemical analyses are now well understood to be no criterion whatever in determining whether or not a particular clay shall be classified as a fuller's earth. Like all other clays, fuller's earth is a hydrous, aluminum silicate containing small proportions of other substances. Most fuller's earths contain a higher percentage of water of composition than most clays, but this water is not an essential factor in the bleaching properties of all fuller's earths; some bleach fully as well after it has been driven off as before, and others lose much of their bleaching power when this water is removed.

OCCURRENCE.

Fuller's earth occurs in Alabama, Arkansas, California, Colorado, Florida, Georgia, Massachusetts, Minnesota, Mississippi, Nebraska, New York, South Carolina, South Dakota, Texas, Utah, and Virginia; but it was produced for the market in 1913 in only seven States, namely, Arkansas, California, Colorado, Florida, Georgia, Massachusetts, and South Carolina, the same number as for 1912, but Texas dropped out in 1913 and South Carolina reentered the list of producers.

MINING AND PREPARATION.[2]

In this country fuller's earth, except in Arkansas, is generally mined with pick and shovel or by mechanical means. When mined it contains more or less water, and is dried either in the sun or by artificial means. After being dried it is ground to suitable mesh, 15 to 80, according to the use to which it is to be put, and is then ready for shipment. In England the earth is washed in long, narrow troughs very much like hydraulic sluice boxes, a large percentage of the mate-

[1] Parsons, C. L., Fuller's earth: Bur. Mines Bull. 71, p. 6, 1913.
[2] For a full discussion of mining and milling methods see Parsons, C. L., idem, pp. 13–17.

rial being allowed to settle out as sand, while the lighter material goes off into settling tanks, where it is dried; it is then sold in the resulting lump form.

USES.

The original use of fuller's earth, from which it obtains its name, was the fulling of cloth. But little is now used in this country for this purpose, its principal use being in the bleaching, clarifying, or filtering of fats, greases, and oils. It is also used in the manufacture of pigments for printing wall papers, for the detection of certain coloring matters in some food products, and as a substitute for talcum powder.[1] The common practice with mineral oils is to dry the earth carefully, after which it is ground to suitable sizes and run into long cylinders, through which the crude, black mineral oils are allowed to percolate slowly. As a result, the oil that first comes out is perfectly water white, and much thinner than that which follows. The oil is allowed to continue percolating through the earth until the color reaches a certain maximum shade.

With the vegetable oils the process is radically different. The oil is heated in large tanks beyond the boiling point of water; from 5 to 10 per cent of its weight of fuller's earth is then added; and the mixture is vigorously stirred and then filtered off through bag filters. The coloring matter remains with the earth, the filtered oil being of a pale straw color, provided the operation has been conducted with sufficient care.

HISTORY.

Fuller's earth was first discovered in the United States in 1891 near Alexander, Ark., by John Olsen, who is still a producer. This earth was used for a time by the Southern Cotton Oil Co., at Little Rock, but its use was finally abandoned.[2] In 1893 fuller's earth was discovered near Quincy, Fla., by accident. An effort was made to burn brick on the property of the Owl Cigar Co.; the effort failed, but an employee of the company called attention to the close resemblance of the clay used to the German fuller's earth. In consequence of this discovery there was considerable excitement and supposed deposits of fuller's earth were reported from a number of States. The material in the most of these deposits was found to be of no value as fuller's earth.

From the inception of the industry Florida has been the leading producing State. At first the production was from only two or three States. In 1897–1899 it was reported from Florida, Colorado, and New York, with a very small production from Utah; in 1901 Arkansas was added to the list. From 1904 to 1907 Arkansas was the second largest producer. Fuller's earth was found in Georgia soon after its discovery in Florida, but Georgia did not appear as a producer until 1907, when it was the third largest producing State; it has ranked second since 1909. In 1904 Alabama and Massachusetts, and in 1907 South Carolina and Texas first reported production; in 1909 California entered the list.

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[1] Bur. Mines Bull. 71, p. 19, 1913.

[2] Branner, J. C., An early discovery of fuller's earth in Arkansas: Am. Inst. Min. Eng. Trans., vol. 43, pp. 520–522, 1913.

PRODUCTION.

The following table shows the production of fuller's earth in the United States from the beginning of the industry:

Marketed production of fuller's earth in the United States, 1895-1913, in short tons.

Year.	Quantity.	Value.	Average price per ton.	Year.	Quantity.	Value.	Average price per ton.
1895	6,900	$41,400	$6.00	1905	25,178	$214,497	$8.52
1896	9,872	59,360	6.01	1906	32,040	265,400	8.28
1897	17,113	112,272	6.56	1907	32,851	291,773	8.88
1898	14,860	106,500	7.17	1908	29,714	278,367	9.37
1899	12,381	79,644	6.43	1909	33,486	301,604	9.01
1900	9,698	67,535	6.96	1910	32,822	293,709	8.95
1901	14,112	96,835	6.86	1911	40,697	383,124	9.41
1902	11,492	98,144	8.54	1912	32,715	305,522	9.34
1903	20,693	190,277	9.20	1913	38,594	369,750	9.58
1904	29,480	168,500	5.72				

In 1913 the production increased 5,879 short tons, or 17.97 per cent, over that of 1912, and the value increased $64,228, or 21.02 per cent. The production in 1913 was but 2,103 tons, or 5.17 per cent, less in quantity, and $13,374, or 3.49 per cent, less in value than the output of 1911, the year of maximum production. The average price, $9.58 per ton, was the highest yet reached for domestic fuller's earth, and was 17 cents higher than the highest price prior to 1913.

The following table shows the marketed production of fuller's earth in 1912 and 1913, by sections of the country:

Marketed production of fuller's earth in the United States, 1912-1913, in short tons.

	1912				1913			
	Number of operators.	Quantity.	Value.	Average price per ton.	Number of operators.	Quantity.	Value.	Average price per ton.
Eastern States [a]	8	31,496	$291,099	$9.24	7	37,869	$361,175	$9.54
Western States [b]	5	1,219	14,423	11.83	3	725	8,575	11.83
Total	13	32,715	305,522	9.34	10	38,594	369,750	9.58

[a] Includes, 1912: Florida, Georgia, Massachusetts, Texas; 1913: Florida, Georgia, Massachusetts, and South Carolina.
[b] Includes, 1912 and 1913: Arkansas, California, Colorado.

Owing to the small number of producers in each State, it is impossible to give State totals, and the table has been made to show simply the production of the Eastern and the Western States. The eastern section of the country continues to produce by far the larger portion of the fuller's earth marketed, its 7 operators reporting 98.12 per cent of the quantity and 97.68 per cent of the value of the entire output. In quantity and value of production Florida was the leading State in 1913, Georgia was second, Arkansas was third, and Massachusetts fourth. Florida and Georgia together contributed over 97 per cent of the quantity and value of the fuller's earth marketed in 1913.

The increase in output and value was in the Eastern States, the Western States decreasing over 40 per cent. The average price per ton increased in the East from $9.24 in 1912 to $9.54 in 1913, and in the West it was the same in both years, namely, $11.83. The number of active firms reporting decreased 3 in 1913, 1 in the Eastern and 2 in the Western States.

NOTES ON THE FULLER'S EARTH INDUSTRY BY STATES.

Arizona.—The Arizona Earth Products Co. reports having located a fuller's earth claim near Benson, Cochise County, Ariz. No shipments were reported for 1913, but operations were expected to begin early in 1914.

Arkansas.—Only 1 of the 6 mine owners in Arkansas reported production in 1913, namely, John Olsen, the original discoverer of fuller's earth in the United States. The earth from this State is reported as having been used in refining edible oils.

California.—Of the 8 fuller's earth miners in California only 1, the Eight Oil Co., reported a marketed product. The California fuller's earth is reported as being suitable for the refining of animal, vegetable, and mineral oils.

Colorado.—The American Clay Co., Akron, Colo., is the only producer in the State. Its earth is used in bleaching cottonseed oil.

Florida.—Of the 6 owners of fuller's earth properties in Florida, 3 firms were active in 1913, namely, the Atlantic Refining Co., at Ellenton; the Floridin Co., at Quincy and Jamieson; and the Fuller's Earth Co., at Midway. This fuller's earth is reported as having been used in filtering mineral and vegetable oils. Florida is the leading fuller's earth producing State, having reported for 1913 over two-thirds of the marketed output of the entire country.

Georgia.—There are but 2 operators in Georgia, both of whom were active in 1913, the Lester Clay Co., with mine at Attapulgus, and the General Reduction Co., with mine at Dry Branch. The demand was reported good, and the fuller's earth was used in refining mineral, vegetable, and animal oils.

Massachusetts.—Only one firm has produced fuller's earth in Massachusetts for several years—J. E. & R. M. Farnworth, of Lancaster. The earth is reported as used for fulling woolen goods.

Minnesota.—The only known deposit of fuller's earth in Minnesota is near Austin, and was not worked in 1913. It is owned by the P. D. McMillan Land Co., of Minneapolis.

Mississippi.—A large deposit of fuller's earth, said to be suitable for clarifying vegetable oils, is reported to occur at Bay Springs, Miss. It has not been developed. The deposit is owned by A. H. Longino, of Jackson.

New York.—The only developed deposit of fuller's earth in New York is that of the New York Fuller's Earth Co., in Oneida County. It was not worked in 1913.

South Carolina.—Of the three known deposits of fuller's earth in South Carolina only one, that of the Palmetto Kaolin Co., was operated in 1913, and this was worked only in an experimental way.

South Dakota.—Three operators reported from South Dakota for 1913—the Argyle Fuller's Earth Co., Argyle; Willaim Bodenner, Fairburn; and the South Dakota Fuller's Earth Co., Rapid City. All were idle.

Texas.—None of the operators in Texas reported sales of fuller's earth in 1913. Three of the 10 operators have retired from the business.

Utah.—The only deposit of fuller's earth in Utah known to the Survey was not worked in 1913. It is located in San Pete County, and is owned by George F. Young, whose address is North Powder, Oreg.

IMPORTS.

The following table shows the imports of fuller's earth for consumption from 1897 to 1913, inclusive:

Fuller's earth imported for consumption into the United States, 1897 to 1913, in short tons.

Year.	Unwrought or unmanufactured.			Wrought or manufactured.			Total.		
	Quantity.	Value.	Average price per ton.	Quantity.	Value.	Average price per ton.	Quantity.	Value.	Average price per ton.
1897 *a*	2,585	$14,283	$5.53	2,395	$20,037	$8.37	4,980	$34,320	$6.89
1898	2,283	15,921	6.97	7,073	55,123	7.79	9,356	71,044	7.59
1899	4,192	23,194	5.53	7,366	46,446	6.31	11,558	69,640	6.03
1900	2,723	14,750	5.42	6,431	50,047	7.78	9,154	64,797	7.08
1901	3,266	17,230	5.28	8,792	63,467	7.22	12,058	80,697	6.69
1902	4,239	26,635	6.28	10,895	75,945	6.97	15,134	102,580	6.78
1903	4,260	28,339	6.65	12,840	92,332	7.19	17,100	120,671	7.06
1904	1,975	9,546	4.83	8,247	64,460	7.82	10,222	74,006	7.24
1905	1,705	12,798	7.51	12,858	93,199	7.25	14,563	105,997	7.28
1906	2,905	20,129	6.93	11,920	88,566	7.43	14,825	108,695	7.33
1907	2,490	16,833	6.76	13,916	105,388	7.57	16,406	122,221	7.45
1908	2,363	16,242	6.87	9,803	77,171	7.87	12,166	93,413	7.68
1909	1,802	12,492	6.93	10,950	88,659	8.10	12,752	101,151	7.93
1910	2,160	14,399	6.67	14,427	118,146	8.19	16,857	132,545	7.86
1911	1,881	10,877	5.78	16,343	132,717	8.12	18,224	143,594	7.88
1912	1,970	11,619	5.90	17,139	133,718	7.80	19,109	145,337	7.61
1913	1,916	12,344	6.44	16,712	133,657	8.00	18,628	146,001	7.84

a July to December.

The imports decreased in 1913 in quantity and increased in value, the quantity decreasing 481 tons, or 2.52 per cent, and the value increasing $664, or 0.46 per cent. The average value per ton of imported fuller's earth increased in 1913—unwrought, 54 cents; wrought, 20 cents—the average increase being 23 cents. The imports are nearly all of wrought or manufactured earth, 89.71 per cent of the quantity and 91.55 per cent of the value being of that classification.

In the following table is shown the quantity and value of the fuller's earth imported from 1867 to 1883 by fiscal years. The wrought and the unwrought earths were not classified separately during this period. From July 1, 1883, to June 30, 1897, fuller's earth was not reported separately in the customhouse returns to the Treasury Department, but was included in minerals "not elsewhere specified."

Imports of fuller's earth into the United States, 1867–1883, in short tons.

Year ended June 30—	Quantity.	Value.	Year ended June 30—	Quantity.	Value.
1867	314	$3,113	1876	277	$3,097
1868	236	2,522	1877	448	4,460
1869	363	3,587	1878	375	4,095
1870	268	2,619	1879	404	4,269
1871	325	3,383	1880	647	6,925
1872	307	3,358	1881	300	3,207
1873	281	2,978	1882	1,017	11,444
1874	310	3,440	1883	1,390	14,309
1875	336	3,694			

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CEMENT.

By Ernest F. Burchard.

INTRODUCTION.

The present practice of the United States Geological Survey with regard to the collection and publication of statistics of the cement industry is to issue some time during the month of January a statement of production and shipments of Portland cement in the United States by commercial districts for the year just closed, and then to publish as early as is practicable the advance chapter from Mineral Resources on the cement industry, which contains complete figures for all classes of cement. The estimate referred to is based on telegraphic data from the larger companies, which report actual figures for the first 11 months of the year, plus estimates for December. The figures in the advance chapter are based on complete reports from every manufacturer. Occasion is taken here to express thanks to those firms whose prompt replies have rendered it possible to prepare early estimates and to those manufacturers whose complete returns have made it possible to prepare this report at an earlier date than formerly. To those manufacturers who heretofore have been indifferent as to the date of making their reports an earnest request is made for prompt cooperation in the future, for the value of this report to the cement industry depends equally on two factors, viz, early publication and completeness. It has been the custom of the writer to use only the reports of producers as a basis for the statistics presented in the chapters on the cement industry and to decline to estimate the output or value of the product of any mill. To an industry of the magnitude of the cement-manufacturing business the importance of having statistics based on actual figures is obvious, and since delay in receipt of reports from only one or two mills correspondingly delays the compilation of all the statistics, the writer feels justified, in the interest of the cement industry, to urge that every firm, in the future, send complete returns to the Survey before the close of January.

The estimate of Portland cement production, which was released to the press on January 22, 1914, prophesied that the increase in production in 1913 would approximate 9,967,900 barrels over that of 1912. The final returns show an actual increase in production of 9,659,035 barrels.

The noteworthy features of the cement industry in 1913 were the substantial increase in average price for which Portland cement was sold and the large increase in production. The increase in average price amounted to 19.2 cents per barrel—the largest recorded since 1902—and the increase in production was the largest since 1910.

The production and price of puzzolan cement both showed an increase in 1913. The decline in the production of natural cement continued, although the price of this commodity rose slightly.

Since the publication in 1913 of Bulletin 522 on the Portland cement materials and industry in the United States the Survey has carried on no field investigations of cement materials. This bulletin and the advance chapter from Mineral Resources on the cement industry in 1910, both illustrated by maps which show the general distribution of limestones suitable for cement manufacture, are available for free distribution by the Survey. The Survey activities in connection with the cement industry are now limited to field studies of cement materials and to the preparation of statistical reports, but requests continue to be received for laboratory examinations of raw materials and for tests of cement and concrete. This is probably because of the fact that the Survey a few years ago conducted laboratories for testing structural materials at St. Louis, Mo., and at Pittsburgh, Pa. The laboratory at St. Louis has long since been discontinued, and the laboratory at Pittsburgh has passed under control of the Bureau of Standards, which carries on at Pittsburgh and at Washington, D. C., certain chemical and physical investigations of structural materials. Inquiries pertaining to tests of cement and concrete should, therefore, be addressed to the Director, Bureau of Standards, Washington, D. C.

The Bureau of Standards is publishing the results of the Survey's tests as well as the results of its own later work in a series of circulars and technologic papers, the following of which are now (March 28, 1914) available:

Circular No. 33: United States Government specification for Portland cement. 28 pp. 1912.

Circular No. 39: Specifications for and measurement of standard sieves. 14 pp. 1912.

Technologic Paper No. 2: The strength of reinforced concrete beams; results of tests of 333 beams. 200 pp. 1912.

Technologic Paper No. 3: Tests of the absorptive and permeable properties of Portland cement mortars and concretes, together with tests of damp proofing and waterproofing compounds and materials. 127 pp. 1912.

Technologic Paper No. 5: The effect of high-pressure steam on the crushing strength of Portland cement mortar and concrete. 25 pp. 1912.

Technologic Paper No. 12: Action of the salts in alkali water and sea water on cements. 157 pp. 1913.

Technologic Paper No. 18: Electrolysis in concrete. 157 pp. 1913.

Technologic Paper No. 29: Variation in results of sieving with standard cement sieves. 16 pp. 1913.

PRODUCTION OF ALL CEMENTS.

The total quantity of Portland, natural, and puzzolan cement produced in the United States in 1913 was 92,949,102 barrels, valued at $93,001,169, as compared with 83,351,191 barrels, valued at $67,461,513 in 1912. This represents an increase in quantity of 9,597,911 barrels, or 11.51 per cent, and in value of $25,539,656, or 37.86 per cent. It should be noted here that any table in which the production of these three kinds of cement is combined to form a total of barrels is necessarily inconsistent, for the weights per barrel of each kind of cement are different. Portland cement is sold in barrels weighing 380 pounds, natural cement in 265-pound barrels, and puzzolan cement in 330-pound barrels. The percentage of increase in quantity is considerably greater than that of 1912 over 1911, which was 4.78 per cent, but the value increased in far greater proportion, the increase for 1912 having been only 1.13 per cent.

The distribution of the total production among the three main classes of cement is shown in the following table for the years 1911, 1912, and 1913:

Total production of cement in the United States in 1911, 1912, and 1913, by classes.

Class.	1911		1912		1913	
	Quantity (barrels).	Value.	Quantity (barrels).	Value.	Quantity (barrels).	Value.
Portland	78,528,637	$66,248,817	82,438,096	$67,016,928	92,097,131	$92,557,617
Natural	926,091	378,533	a 821,231	367,222	a 744,658	345,889
Puzzolan	93,230	77,786	a 91,864	77,363	a 107,313	97,663
Total	79,547,958	66,705,136	83,351,191	67,461,513	92,949,102	93,001,169

a Shipments.

PORTLAND CEMENT.

PRODUCTION AND SHIPMENTS.

The total production of Portland cement in the United States in 1913, as reported to the United States Geological Survey, was 92,097,131 barrels, valued at $92,557,617; the production for 1912 was 82,438,096 barrels, valued at $67,016,928. The output for 1913 represents an increase in quantity of 9,659,035 barrels, or nearly 11.72 per cent, and an increase in value of $25,540,689, or 38.11 per cent. The value assigned to the production is proportionate to the value of the Portland cement shipped in 1913.

The shipments of Portland cement from the mills in the United States in 1913 were, according to reports received by the Survey, 88,689,377 barrels, valued at $89,106,975, compared with 85,012,556 barrels, valued at $69,109,800, shipped in 1912. The shipments therefore represent an increase in quantity of 3,676,821 barrels, or 4.31 per cent, and in value of $19,997,175, or 28.94 per cent. The average price per barrel in 1913, according to these figures, was a trifle less than $1.005, compared with 81.3 cents in 1912. This represents the value of cement in bulk at the mills, including the labor cost of packing, but not the value of the sacks or barrels. The average price per barrel for the country is about 16.7 cents higher than the average price received for Portland cement in the Lehigh district, where it was sold at the lowest price, and is near the average price received in Illinois, Indiana, and Missouri, but falls 45.6 cents below the average price received on the Pacific coast, where Portland cement brought the highest figure during the year.

The quantity of Portland cement produced, 92,097,131 barrels of 380 pounds, is equivalent to 15,623,620 long tons, and the value per long ton is $5.92. Compared with the production of pig iron for 1913, 30,966,152 long tons,[1] the Portland cement production is nearly 50.5 per cent of the quantity of pig iron, but the total value of the cement does not greatly exceed 20 per cent of the value of the pig iron. The value of the cement per ton is about 40 per cent of that of pig iron.

[1] Am. Iron and Steel Inst. Special Stat. Bull., May 15, 1914.

The average price of Portland cement in the United States has been increased slightly over the average for ordinary gray cement by the inclusion in the total of 160,582 barrels of white Portland cement, valued at $2.34 a barrel. The greater part of this white cement was produced in the Lehigh district, so that the value for that district has been increased in greater proportion than that of the other districts. Three mills produced white Portland cement in 1913, 1 being in California and 2 in Pennsylvania, 1 of which produced white cement exclusively.

PRODUCTION AND SHIPMENTS BY STATES.

In the following two tables the production and shipments of Portland cement for 1912 and 1913, by States, are arranged in the order of rank for 1913 where there are three or more producers or shippers in a single State. By the term "producer" is meant a Portland cement manufacturing company, whether the company operates one or more plants. In the table the term "producing plant" is applied to a mill or group of mills located at one place and operated by one company, but each establishment at a different place is counted as a plant. There were producing plants in 24 States in 1912, and in 25 States in 1913, but only 14 of these States contained three or more plants; therefore it has been necessary to group together in these tables a large number of States not closely related geographically. This disadvantage is, however, compensated for in the table "Production and shipments of Portland cement by commercial districts," in which statistics are given for groups, not generally exceeding three in number, of States geographically related.

In the table of shipments will be found the total value of the shipments by States and the average price per barrel of the cement in bulk at the mills.

Production of Portland cement in the United States in 1912 and 1913, by States.

State.	1912		1913		Percentage of change, 1913.
	Producing plants.	Quantity (barrels).	Producing plants.	Quantity (barrels).	
Pennsylvania	23	26,441,338	23	28,701,845	+ 8.55
Indiana	5	9,924,124	5	10,872,574	+ 9.56
California	8	5,974,299	7	6,159,182	+ 3.09
New York	7	4,492,806	8	5,208,020	+15.92
Illinois	5	4,299,357	5	5,083,799	+18.25
Missouri	5	4,355,741	5	4,803,338	+10.28
New Jersey	3	4,246,803	3	4,460,027	+ 5.02
Michigan	11	3,494,621	11	4,186,236	+19.79
Iowa	3	3,228,192	3	3,623,674	+12.25
Kansas	10	3,225,040	10	3,374,836	+ 4.64
Washington	3	1,362,416	5	2,339,202	+71.70
Texas	4	1,807,769	4	2,117,142	+17.11
Ohio	5	1,433,344	5	1,667,739	+16.35
Utah	3	868,312	3	867,433	− .10
Other States [a]	15	7,283,934	16	8,632,084	+18.51
Total	110	82,438,096	113	92,097,131	+11.72

[a] Alabama, Colorado, Georgia, Kentucky, Maryland, Montana, Oklahoma, Tennessee, Virginia, and West Virginia in 1912, with Arizona additional in 1913.

Shipments of Portland cement in the United States in 1912 and 1913, by States.

State.	1912				1913			
	Shipping plants.	Quantity (barrels).	Value.	Average price per barrel.	Shipping plants.	Quantity (barrels).	Value.	Average price per barrel.
Pennsylvania	26	27,539,076	$18,918,165	$0.687	23	28,060,495	$24,268,800	$0.865
Indiana	5	9,634,582	7,237,591	.751	5	10,219,492	10,218,867	1.000
California	8	6,093,790	8,215,894	1.348	7	6,018,262	8,896,734	1.478
New York	7	4,543,060	3,448,735	.759	8	5,136,334	4,801,607	.935
Illinois	5	4,602,617	3,444,085	.748	5	4,734,540	4,784,696	1.011
Missouri	5	4,614,547	3,700,776	.802	5	4,485,820	4,556,822	1.016
New Jersey	3	4,490,645	3,052,098	.680	3	4,255,015	3,638,755	.855
Michigan	11	3,651,094	3,145,001	.861	11	4,081,281	4,228,879	1.036
Iowa	3	3,190,354	2,790,396	.875	3	3,455,800	3,972,876	1.150
Kansas	12	3,592,148	2,815,113	.784	10	3,291,818	3,286,861	.998
Texas	4	1,759,780	2,058,224	1.170	4	2,108,737	2,663,063	1.263
Washington	3	1,438,137	2,012,785	1.399	5	2,023,172	2,853,260	1.410
Ohio	5	1,382,923	1,166,589	.844	5	1,631,055	1,721,423	1.055
Utah	3	760,668	937,119	1.232	3	950,469	1,233,421	1.298
Other States [a]	17	7,719,135	6,167,229	.799	16	8,237,087	7,980,911	.969
Total	117	85,012,556	69,109,800	.813	113	88,689,377	89,106,975	1.005

[a] Alabama, Colorado, Georgia, Kentucky, Maryland, Montana, Oklahoma, Tennessee, Virginia, and West Virginia in 1912, with Arizona additional in 1913.

PRODUCTION AND SHIPMENTS BY COMMERCIAL DISTRICTS.

In addition to considering the Portland cement industry by States, it is also of interest, and perhaps of more practical importance, to regard the commercial district as the geographic unit. Accordingly, beginning in 1911, the plants producing Portland cement were grouped together into 11 districts, the grouping being based to some extent on the relations of the plants to their trade territory. These relations are of course governed largely by transportation facilities and rates, and it has been found advisable to divide Pennsylvania, Indiana, and Texas in order to accomplish a logical grouping. The same grouping was followed in both the 1911 and the 1912 reports, but it has appeared advisable that the Southeastern States should be subdivided, and this has been done in the report for 1913.

The following table summarizes, by commercial districts for 1912 and 1913, the number of active plants producing and shipping Portland cement, the production and shipments, with percentage of change in 1913, and the average factory price per barrel in bulk, with the percentage of change in price in 1913:

Production and shipments of Portland cement in 1912 and 1913, by commercial districts.

[Figures opposite P relate to production; those opposite S to shipments.]

District.		Active plants.		Production and shipments (barrels).			Average factory price per barrel.		
		1912	1913	1912	1913	Percentage of change, 1913.	1912	1913	Percentage of change, 1913.
Lehigh district (New Jersey and eastern Pennsylvania)	P	22	22	24,762,083	27,139,601	+ 9.60	....	....	....
	S	25	22	26,013,891	26,659,537	+ 2.48	$0.674	$0.838	+24.33
New York	P	7	8	4,492,806	5,208,020	+15.92	....	....	....
	S	7	8	4,543,060	5,136,334	+13.05	.759	.934	+23.05
Ohio and western Pennsylvania	P	9	9	7,359,402	7,690,010	+ 4.49	....	....	....
	S	9	9	7,398,753	7,287,028	− 1.51	.757	1.000	+32.10
Michigan and northeastern Indiana	P	13	13	4,308,645	5,057,199	+ 1.73	....	....	....
	S	13	13	4,417,808	4,960,891	+ 1.22	.851	1.030	+21.03

Production and shipments of Portland cement in 1912 and 1913, by commercial districts—Continued.

District.		Active plants.		Production and shipments (barrels).			Average factory price per barrel.		
		1912.	1913.	1912.	1913.	Percentage of change, 1913.	1912.	1913.	Percentage of change, 1913.
Kentucky and southern Indiana	P..	3	3	3,091,603	3,005,417	− 2.78			
	S..	3	3	3,134,841	2,861,624	− 8.71	.764	1.008	+31.93
Illinois and northwestern Indiana	P..	6	6	10,659,357	12,423,799	+16.55			
	S..	6	6	10,677,479	11,576,938	+ 8.42	.744	1.002	+34.67
Maryland, Virginia, and West Virginia	P..	4	4	2,325,885	2,668,338	+14.72			
	S..	5	4	2,536,546	2,529,629	− .27	.726	.865	+19.14
Tennessee, Alabama, and Georgia	P..	5	5	2,411,372	3,082,623	+27.83			
	S..	6	5	2,544,663	2,958,829	+16.27	.746	.899	+20.50
Iowa and Missouri	P..	8	8	7,583,933	8,427,012	+11.11			
	S..	8	8	7,804,901	7,941,620	+ 1.75	.832	1.074	+29.08
Great Plains States (Kansas, Oklahoma, and central Texas)	P..	15	15	5,807,043	6,350,646	+ 9.36			
	S..	17	15	6,174,085	6,190,040	+ .26	.866	1.063	+22.75
Rocky Mountain States [a] (Colorado, Utah, Montana, and western Texas)	P..	7	[a] 8	2,299,252	[a] 2,546,082	+10.73			
	S..	7	[a] 8	2,234,602	[a] 2,545,473	+13.91	1.165	[a] 1.319	+13.21
Pacific coast States (California and Washington)	P..	11	12	7,336,715	8,498,384	+15.83			
	S..	11	12	7,531,927	8,041,434	+ 6.76	1.358	1.461	+ 7.58
Total	P..	110	113	82,438,096	92,097,131	+11.72			
	S..	117	113	85,012,556	88,689,377	+ 4.31	.813	1.005	+23.62

[a] Includes Arizona in 1913.

According to this table there was in 1913, compared with 1912, a decrease in production in only 1 district—Kentucky and southern Indiana, and a decrease in shipments in only 3 districts—Ohio and western Pennsylvania, Kentucky and southern Indiana, and the district comprising Maryland, Virginia, and West Virginia. All these decreases were insignificant, except that of shipments in Kentucky and southern Indiana, which amounted to 8.71 per cent. The largest percentages of increase both of production and of shipments were reported from the Tennessee-Alabama-Georgia district, being, respectively, 27.83 and 16.27 per cent. The mills in New York made nearly parallel increases in production and in shipments, the increases being, respectively, 15.92 and 13.05 per cent. In all the districts but the Rocky Mountain States the increases in shipments fell below the increases in production, but in this group of States the increase in production was 13.91 per cent compared with an increase of 15.83 per cent in shipments. In the Maryland-Virginia-West Virginia district, one of those which showed a decrease in shipments, the increase in production amounted to 14.72 per cent, and in the Illinois-northwestern Indiana, Tennessee-Alabama-Georgia, Great Plains, Iowa-Missouri, and Pacific coast districts the percentage of increase in production exceeded the percentage of increase in shipments by 9 to 11 per cent; in the others there was less difference.

The net change for the country at large was an increase in both production and shipments, amounting to 9,659,035 barrels, or 11.72 per cent, for the former, and to 3,676,821 barrels, or 4.31 per cent, for the latter. In 1912 the shipments exceeded the production of Portland cement by 2,574,460 barrels, or 3.1 per cent of the production; but in 1913 the relation between production and shipments was reversed, and the production exceeded the shipments by 3,407,754 barrels, or 3.7 per cent of the production. This relation was practically a repetition of conditions in 1911.

LEHIGH DISTRICT.

The production of Portland cement in the Lehigh district of eastern Pennsylvania and western New Jersey in 1913 was 27,139,601 barrels, as compared with 24,762,083 barrels in 1912, an increase of 9.6 per cent. The shipments from mills in this district amounted in 1913 to 26,659,537 barrels, as compared with 26,013,891 barrels in 1912, an increase of 645,646 barrels, or 2.48 per cent. Both the production and shipments in the Lehigh district reached a new high record in 1913. The total value of the Portland cement shipped from this district in 1913 was reported as $22,342,102, an average price of 83.8 cents a barrel in bulk at the mills as compared with $17,538,989, or 67.4 cents a barrel, in 1912. The production of white Portland cement from 2 plants in this district is included in the figures for 1913. As the average value reported for the white cement was considerably higher than that reported for ordinary gray cement, the average price for the district is slightly higher than if it represented gray Portland cement alone.

Twenty-two plants produced and shipped Portland cement from the Lehigh district in 1913 as compared with 22 producers and 25 shippers in 1912.

The Lehigh district of eastern Pennsylvania-New Jersey has, except in four years, shown a steady increase in production of Portland cement from 1890 to the present time. The years in which slight decreases were recorded are 1893, 1908, 1911, and 1912. The first two decreases were coincident with years of general business depression, but the decrease in 1911 and 1912 may perhaps be attributed in large part to an overproduction in 1910 and to the building of many mills in other parts of the United States which have restricted the trade territory of the Lehigh district. The percentage which the Lehigh total bears to the total for the United States is slowly but steadily decreasing.

The following table shows the annual production of Portland cement in the Lehigh district since 1890, the total production for the country, and the percentage of the Lehigh district output each year compared with the total production, and the curve, figure 1, illustrates graphically the trend of production during the same period:

Portland cement production in the Lehigh district and in the United States, 1890–1913, in barrels.

Year.	Lehigh district output.	Total output, United States.	Percentage of total manufactured in Lehigh district.	Year.	Lehigh district output.	Total output, United States.	Percentage of total manufactured in Lehigh district.
1890	201,000	335,500	60.0	1902	10,829,922	17,230,644	62.8
1891	248,500	454,813	54.7	1903	12,324,922	22,342,973	55.2
1892	280,840	547,440	51.3	1904	14,211,039	26,505,881	53.7
1893	265,317	590,652	44.9	1905	17,368,687	35,246,812	49.3
1894	485,329	798,757	60.8	1906	22,784,613	46,463,424	49.0
1895	634,276	990,324	64.0	1907	24,417,686	48,785,390	50.0
1896	1,048,154	1,543,023	68.1	1908	20,200,387	51,072,612	39.6
1897	2,002,059	2,677,775	74.8	1909	24,246,706	64,991,431	37.3
1898	2,674,304	3,692,284	72.4	1910	26,315,359	76,549,951	34.4
1899	4,110,132	5,652,266	72.7	1911	25,972,108	78,528,637	33.1
1900	6,153,629	8,482,020	72.6	1912	24,762,083	82,438,096	30.0
1901	8,595,340	12,711,225	67.7	1913	27,139,601	92,097,131	29.5

PRODUCTION ACCORDING TO RAW MATERIALS.

In the following table the production of Portland cement in the United States is classified according to the kinds of raw materials

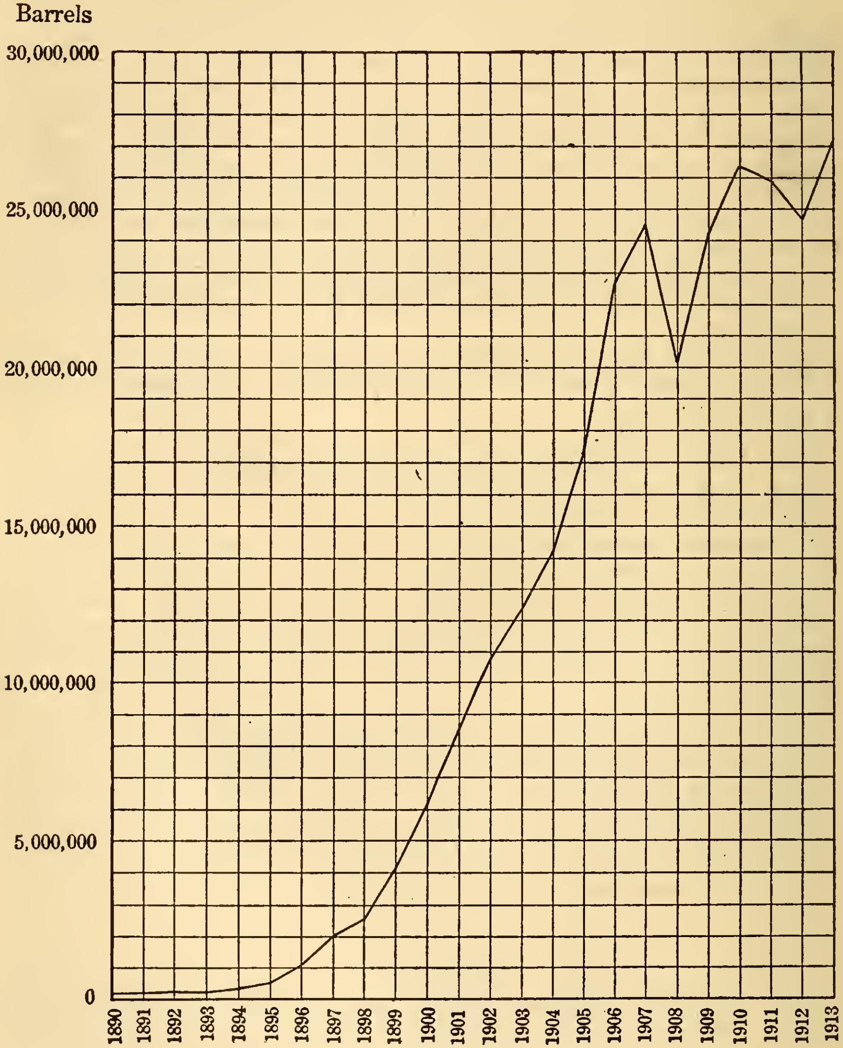

FIGURE 1.—Production of Portland cement in the Lehigh district, 1890–1913.

from which the cement is manufactured. The production is grouped as follows:

Type 1 includes cement produced from a mixture of argillaceous limestone ("cement rock") and pure limestone. This is the combination of materials used in all the cement plants of the Lehigh district of Pennsylvania and New Jersey, and also at a few middle and western plants.

Type 2 includes cement made from a mixture of comparatively pure limestone with clay or shale. This mixture is employed at the majority of plants in the United States.

Type 3 includes cement manufactured from a mixture of marl and clay. This type of mixture is used in certain plants in the States of Michigan, Ohio, Indiana, New York, and Utah.

Type 4 includes Portland cement manufactured from a mixture of limestone and blast-furnace slag.

This table shows, generally, a decrease in the relative production from cement rock (type 1) and from marl (type 3), and a corresponding increase in the production from limestone (type 2) and from blast-furnace slag (type 4).

Production, in barrels, and percentage of total output of Portland cement in the United States according to type of material used, 1898–1913.

Year.	Type 1. Cement rock and pure limestone.		Type 2. Limestone and clay or shale.		Type 3. Marl and clay.		Type 4. Blast-furnace slag and limestone.	
	Quantity.	Percentage.	Quantity.	Percentage.	Quantity.	Percentage.	Quantity.	Percentage.
1898	2,764,694	74.9	365,408	9.9	562,092	15.2	....	....
1899	4,010,132	70.9	546,200	9.7	1,095,934	19.4	....	....
1900	5,960,739	70.3	1,034,041	12.2	1,454,797	17.1	32,443	0.4
1901	8,503,500	66.9	2,042,209	16.1	2,001,200	15.7	164.316	1.3
1902	10,953,178	63.6	3,738,303	21.7	2,220,453	12.9	318,710	1.8
1903	12,493,694	55.9	6,333,403	28.3	3,052,946	13.7	462,930	2.1
1904	15,173,391	57.2	7,526,323	28.4	3,332,873	12.6	473,294	1.8
1905	18,454,902	52.4	11,172,389	31.7	3,884,178	11.0	1,735,343	4.9
1906	23,896,951	51.4	16,532,212	35.6	3,958,201	8.5	2,076,000	4.5
1907	25,859,095	53.0	17,190,697	35.2	3,606.598	7.4	2,129,000	4.4
1908	20,678,693	40.6	23,047,707	45.0	2,811,212	5.5	4,535,300	8.9
1909	24,274,047	37.3	32,219,365	49.6	2,711,219	4.2	5,786,800	8.9
1910	26,520,911	34.6	39,720,320	51.9	3,307,220	4.3	7,001,500	9.2
1911	26,812,129	34.1	40,665,332	51.8	3,314,176	4.2	7,737,000	9.9
1912	24,712,780	30.0	44,607,776	54.1	2,467,368	3.0	10,650,172	12.9
1913	29,333,490	31.8	47,831,863	51.9	3,734,778	4.1	11,197.000	12.2

STOCKS ON HAND.

Reports were received by the Survey from all the mills in the United States which shipped any Portland cement in 1913, giving stocks of finished cement on hand December 31, 1913. The stock on hand at the end of 1913, according to these reports, amounted to 11,220,328 barrels, compared with 7,811,329 barrels on hand at the close of 1912, thus indicating an increase in stock of 3,408,999 barrels, or 43.64 per cent, during 1913.

The two tables following give the stocks on hand by States and by districts at the close of 1912 and 1913, together with the percentage of change in 1913.

Stocks of Portland cement Dec. 31, 1912, and Dec. 31, 1913, by States, in barrels.

State.	Quantity.		
	1912	1913	Percentage of change, 1913.
California	485,182	651,101	+34.20
Illinois	321,116	641,334	+99.72
Indiana	1,193,612	1,888,543	+58.22
Iowa	436,877	542,575	+24.19
Kansas	442,426	520,917	+17.74
Michigan	370,956	473,563	+27.66
Missouri	456,843	855,272	+87.21
New Jersey	231,398	415,799	+79.69
New York	555,989	556,557	+ .10
Ohio	200,800	228,548	+13.82
Pennsylvania	2,135,969	2,835,945	+32.77
Texas	255,494	257,837	+ .92
Utah	113,439	94,914	−16.33
Washington	121,807	406,081	+233.38
Other States [a]	489,421	851,342	+73.95
Total	7,811,329	11,220,328	+43.64

[a] Alabama, Colorado, Georgia, Kentucky, Maryland, Montana, Oklahoma, Tennessee, Virginia, and West Virginia in 1912, with Arizona additional in 1913.

Stocks of Portland cement Dec. 31, 1912, and Dec. 31, 1913, by districts, in barrels.

District.	Quantity.		
	1912	1913	Percentage of increase, 1913.
Lehigh district (New Jersey and eastern Pennsylvania)	1,927,495	2,448,400	27.02
New York	555,989	556,557	.10
Ohio and western Pennsylvania	640,672	1,031,892	61.06
Michigan and northeastern Indiana	515,619	643,770	24.85
Kentucky and southern Indiana	285,422	436,703	53.00
Illinois and northwestern Indiana	1,106,547	1,924,367	73.91
Maryland, Virginia, and West Virginia	184,533	341,120	84.86
Tennessee, Alabama, and Georgia	163,649	287,300	75.56
Iowa and Missouri	893,720	1,397,847	56.41
Great Plains States (Kansas, Oklahoma, and central Texas)	708,657	848,949	19.80
Rocky Mountain States [a] (Colorado, Utah, Montana, and western Texas)	222,037	[a] 246,241	10.90
Pacific Coast States (California and Washington)	606,989	1,057,182	74.17
Total	7,811,329	11,220,328	43.64

[a] Includes also Arizona in 1913.

The next table gives the total stocks of Portland cement on hand at the mills in the United States at the close of each of the last three years, covering the period that data have been gathered on this subject by the Survey:

Stocks of Portland cement at the close of 1911, 1912, and 1913.

	Barrels.
1911	10,385,789
1912	7,811,329
1913	11,220,328

QUANTITY CONSUMED.

An approximate estimate of the total consumption of Portland cement in the United States might be made as follows: To the shipments add the imports and from the sum, which represents the total available supply, subtract the exports, which leaves the total apparent consumption. Of course, there is at all times a variable, but considerable, stock of cement in transit, in warehouses at distributing points, and awaiting use on the ground at large jobs, so that at best the data in this form furnish only a rough approximation. Still another uncertain element in this estimate is the fact that records of imports and exports are classed as hydraulic cement and do not discriminate between Portland and other cements. Portland cement, however, constitutes by far the greater portion of the exports, and, as is shown by the tables, the imports are small. As compared with the apparent consumption in 1912, which amounted to 80,865,527 barrels, the domestic consumption in 1913 increased 4,944,122 barrels, or 6.1 per cent, as compared with an increase of 11.4 per cent in 1912.

The following tabulation gives the figures necessary for estimates of consumption so far as available, since prior to 1911 no records are at hand for stocks:

Apparent consumption of Portland cement, 1911–1913, in barrels.

Year.	Shipments.	Imports.	Exports.	Apparent consumption.
1911	75,547,829	164,670	3,135,409	72,577,090
1912	85,012,556	68,503	4,215,532	80,865,527
1913	88,689,377	84,630	2,964,358	85,809,649

GROWTH OF PORTLAND CEMENT PRODUCTION, 1890–1913.

The growth of the production of Portland cement and its annual value for the years 1890 to 1913, inclusive, also the shipments of Portland cement from 1911 to 1913, are illustrated graphically in figure 2. For comparison the decline in the production of natural cement is plotted on the same diagram.

In the following table statistics are given covering the annual production of Portland cement in the United States from the beginning of the industry in the early seventies to the present day:

Production of Portland cement in the United States, 1870–1913, in barrels.

Year.	Quantity.	Value.	Year.	Quantity.	Value.
1070–1879	82,000	$246,000	1898	3,692,284	$5,970,773
1880	42,000	126,000	1899	5,652,266	8,074,371
1881	60,000	150,000	1900	8,482,020	9,280,525
1882	85,000	191,250	1901	12,711,225	12,532,360
1883	90,000	193,500	1902	17,230,644	20,864,078
1884	100,000	210,000	1903	22,342,973	27,713,319
1885	150,000	292,500	1904	26,505,881	23,355,119
1886	150,000	292,500	1905	35,246,812	33,245,867
1887	250,000	487,500	1906	46,463,424	52,466,186
1888	250,000	487,500	1907	48,785,390	53,992,551
1889	300,000	500,000	1908	51,072,612	43,547,679
1890	335,500	704,050	1909	64,991,431	52,858,354
1891[1]	454,813	967,429	1910	76,549,951	68,205,800
1892	547,440	1,153,600	1911	78,528,637	66,248,817
1893	590,652	1,158,138	1912	82,438,096	67,016,928
1894	798,757	1,383,473	1913	92,097,131	92,557,617
1895	990,324	1,586,830			
1896	1,543,023	2,424,011	Total	682,288,061	654,800,516
1897	2,677,775	4,315,891			

[1] The figures for 1890 and previous years are estimates made at the close of each year and are believed to be substantially correct. Since 1890 the official figures are based on complete returns from all producers.

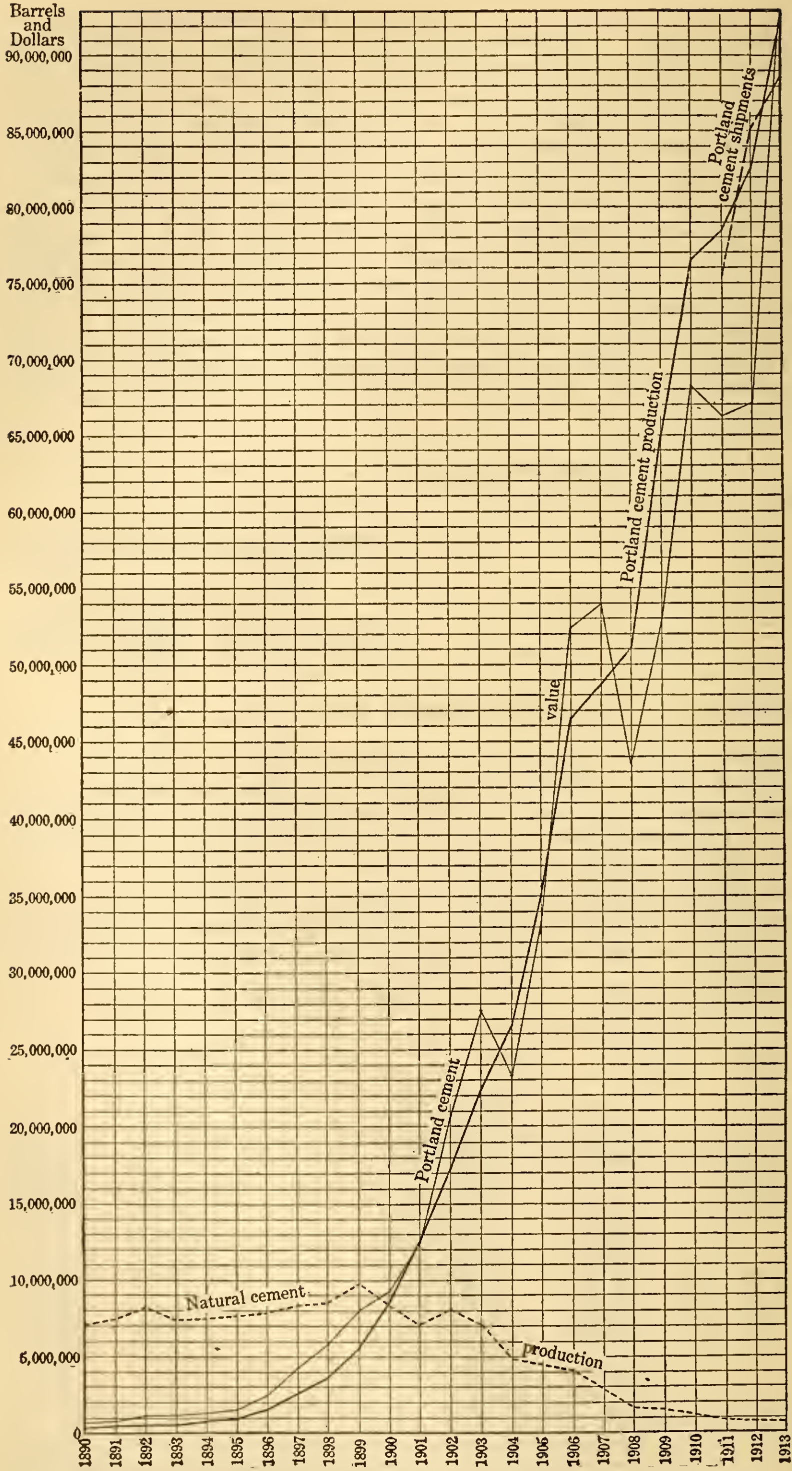

FIGURE 2.—Production of Portland and natural cements and value of Portland cement in the United States, 1890–1913, and shipments of Portland cement, 1911–1913.

The following table summarizes the shipments of Portland cement and their value during the three years that data on this subject have been gathered by the United States Geological Survey:

Shipments of Portland cement in the United States, 1911–1913, in barrels.

Year.	Quantity.	Value.
1911	75,547,829	$63,762,368
1912	85,012,556	69,109,800
1913	88,689,377	89,106,975

The table and the curve of production indicate that the Portland cement industry showed a fair rate of growth from the beginning in the seventies until 1895. At the latter date, however, a rapid development commenced, coincident with the burning of powdered coal in the rotary kiln. This rapid rate of growth continued until 1907, when it was checked temporarily by the financial troubles of that year. Still later there was another short era of growth more rapid than ever before, only to be checked in 1911 by a combination of factors, the most important of which were overproduction in 1910 and generally quiet business conditions in 1911.

In 1912 the rate of growth increased slightly compared with 1911, owing in part to a resumption of construction work that had been deferred. This resumption was no doubt encouraged by the low price at which cement might be obtained. In 1913, encouraged by better prices and an increased demand, the output of Portland cement was pushed up to a total far above that anticipated by the most optimistic manufacturers. The demand, however, did not keep pace with the production, and the year closed with large stocks on hand and diminishing kiln activity.

The output of Portland cement has so far shown an increase each year, rising from 42,000 barrels in 1880 to 335,500 barrels in 1890, to 8,482,020 barrels in 1900, and to 92,097,131 barrels in 1913. The output of natural cement, on the other hand, reached its maximum in 1899, with an output of 9,868,179 barrels. Since that year it has shown an almost continuous decrease annually, until now it is less than three-quarters of a million barrels, and has become a relatively unimportant factor in the cement market.

PRICES.

Average prices of Portland cement per barrel in bulk at the mills are shown in the tables of shipments by States and districts during 1912 and 1913. According to these figures the price in 1913 ranged between 83.8 cents in the Lehigh district and $1.478 in California, as compared with 67.4 cents and $1.348, respectively, in 1912. The average price for the whole country was $1.005 in 1913 as compared with 81.3 cents in 1912, an increase of 19.2 cents a barrel, or 23.6 per cent. This represents the largest increase since 1902, when the price rose 22 cents a barrel. In 1906 there was an apparent rise of 19 cents a barrel, which comes close to the present record. Inspection of these tables shows that in no instance was there a decrease of average price in individual States or districts. The smallest percentage of increase, 7.58 per cent, was reported from the Pacific coast States, where the highest prices have prevailed during recent years, and the largest percentage of increase, 34.67 per cent, was reported from the Illinois-northwestern Indiana district. Substantial increases

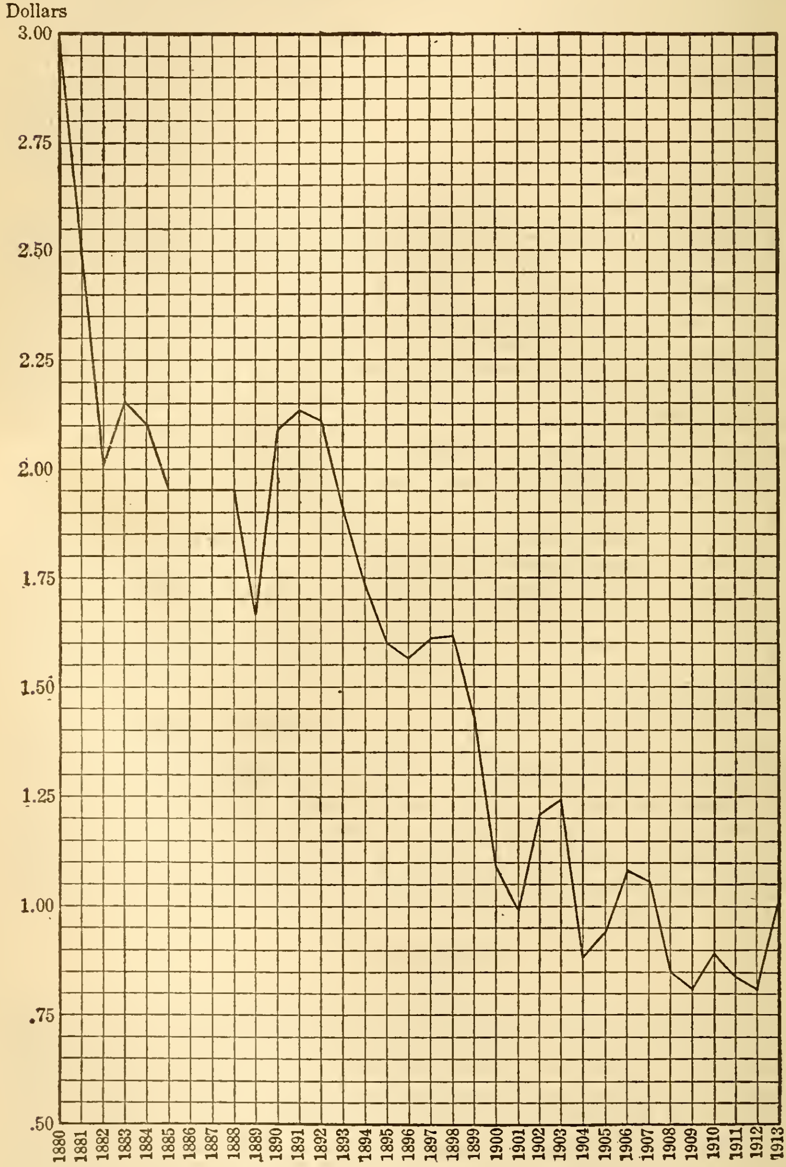

FIGURE 3.—Range in average price per barrel of Portland cement, 1880–1913.

were reported from all the districts, the only ones besides the Pacific coast to fall below a 20 per cent increase being Maryland-Virginia-West Virginia and the Rocky Mountain group of States.

Figure 3 illustrates graphically the rapid early decline and the recent fluctuations in Portland cement prices.

The following table gives the average factory price of Portland cement per barrel in bulk from 1870 to 1913:

Average price per barrel of Portland cement, 1870–1913.

1870–1880	$3.00	1894	$1.73	1905	$0.94
1881	2.50	1895	1.60	1906	1.13
1882	2.01	1896	1.57	1907	1.11
1883	2.15	1897	1.61	1908	.85
1884	2.10	1898	1.62	1909	.813
1885–1888	1.95	1899	1.43	1910	.891
1889	1.67	1900	1.09	1911	.844
1890	2.09	1901	.99	1912	.813
1891	2.13	1902	1.21	1913	1.005
1892	2.11	1903	1.24		
1893	1.91	1904	.88		

PORTLAND CEMENT INDUSTRY.

BUSINESS CONDITIONS.

At the close of 1913 one of the journals devoted to the interests of the cement and concrete industry obtained from officials of many cement companies summaries of the business of the year and views as to the business situation at that time and for the immediate future.[1] From the published statements a quotation is taken. Charles Catlett, president of the Security Cement & Lime Co., gives one of the most comprehensive statements and covers most of the points brought out by other officials:

The increase in the consumption of cement is due primarily to its wonderful properties and the more general distribution of information as to how and where it can be used. This increase in the consumption has continued without intermission since 1890, and even in years when people could get along with less iron, which is so generally considered the barometer of business, they have called for more cement. This annually increased consumption has taken place in spite of panics and broad depressions, and there is no question that the demand will largely increase in the future. It must supplement iron and take the place of lumber. The demand is increasing in old ways and in new ones, and by far the largest new use which is developing is for road making. This use is destined to exercise a material influence on the industry. Even as a student of cement and more or less familiar with its wonderful properties, it has been hard for me to realize that a road made entirely of concrete would be so satisfactory. But the evidence is overwhelming that a concrete road properly made of good material more perfectly meets the requirements of modern highways traffic than anything that has yet been devised when first cost, upkeep, and adaptability are considered. The consumption will continue to grow, and it is to be hoped that the industry is getting on a firmer financial basis. This has not been true for a number of years, some thirty-odd cement companies having gone into the hands of receivers. These receiverships have been partly due to bad promotion, location, and management, but more largely from a fundamental misconception of the profits in the business—a failure to recognize the true or commercial cost. This has been coupled with a failure to recognize the great difference in raw material and the high cost and the long time necessary before a new plant can expect to operate on a normal basis; and, finally, promoters of new plants overlook the fact that the sudden interjection of their output immediately breaks their own local market. These facts have been borne in upon the banking and investment public, and new development will probably only be made, and should be made, where the market requires it. This will do much to insure the stability of the industry.

Practically all who comment on the uses for cement agree that road building will furnish the largest outlet for the product for some years.

[1] Business situation as viewed by the companies: Cement Era, January, 1914, pp. 70–72.

DEPRECIATION AND OBSOLESCENCE OF PLANTS.

The moderate increase in the average factory price of Portland cement during 1913 perhaps comes in response to the growing conviction in the minds of cement manufacturers that recent prices have been little, if any, greater than the bare factory cost of the product. Some profitable discussion of this latter topic began in the latter part of 1911 and was continued during 1912 and 1913 at the meetings of the Society of Mechanical Engineers and the Institute of Chemical Engineers.

The following extracts and notes indicate that engineers are now making efforts to solve the problem of an adequate selling price for cement.

At the moment[1] the question of the depreciation factor in the cost of producing Portland cement is commercial rather than technical. Its urgent importance as a business proposition overshadows its scientific interest. The manufacturers of cement have so notably failed to define the cost of production that few of them have a surplus or depreciation fund of any kind to deal with. In recent years numerous plants have yielded returns little if any greater than bare factory cost, and the commercial rating of the industry as a whole has suffered. The value which a technical discussion of depreciation may have, therefore, will consist chiefly in defining for the commercial end of the business the elements which should be considered to make up a satisfactory price for a barrel of cement. * * * There are then three principal factors to be considered in estimating a depreciation factor: (*a*) Wear and tear; (*b*) obsolescence (the form of depreciation due to improvements in methods or in machines which makes it necessary to modify plant and scrap machinery which is still in good running order); and (*c*) the carrying charges during repairs. * * *

The ordinary procedure of cement plants is to limit their cost data to a monthly cost sheet. This deals simply with factory cost and usually, and quite properly, with only a part of the factory cost. The real and only useful purpose of these monthly cost sheets is to enable operating officers to institute comparisons, locate leaks, and cut down regular operating cost items. Unfortunately, and quite generally, the cement people have made the serious commercial blunder of regarding these factory cost sheets as really representing the cost to be kept in view when making prices. * * *

A factory cost sheet to be useful for comparison of cost items from month to month and from year to year should exclude all occasional or extraordinary expenditures. If items of this character were introduced at random as they occurred the value of the cost sheet would be destroyed. Such occasional or extraordinary expenditures, which are really depreciation charges, must be provided for annually by appropriating a sum for plant renewals to be accounted for separately from the cost sheet. This appropriation can be an arbitrary one, or may vary from time to time as the superintendent's report may indicate the renewal requirements.

Mr. Lewis proposes a method of figuring depreciation involving the assumption that each of the several items of a cement plant will be renewed once in 25 years, and that at the end of that period the entire plant will have reached the end of its usefulness. A given factory cost per barrel of cement, including all ordinary repairs, is assumed, and to this is added, in terms of cents per barrel, a given amount each for depreciation fund, plant renewal fund, administration and selling expenses, and interest on investment. The total amount to be added to the assumed factory cost and ordinary repairs as proposed by Mr. Lewis amounts to about 50 per cent, or 28.6 to 30 cents per barrel, although it is stated that these figures are subject to modification and

[1] Lewis, Frederick H., Some remarks on the depreciation factor in the cost of producing Portland cement: Am. Soc. Mech. Eng. Jour., February, 1913, pp. 257-261.

that it will require a higher average price if the business is to have a credit balance outside of depreciation. Mr. Lewis concludes:

On some such basis as this any manufacturer can estimate a safe selling price, using the actual facts of his own books for capitalization, factory cost, and administration and selling expense. If this is done, most manufacturers will find that current prices have been too low in recent years, and still are so; many will find that an excessive capitalization must be scaled down if business is to continue; and some will find themselves facing conditions which make it impossible to continue the industry.

Mr. Struckmann[1] emphasizes the fact that the rapid development of the cement industry has made it necessary to make continued changes and improvements in plants and has caused the depreciation due to obsolescence to be greater than depreciation due to wear and tear. He also states that a large percentage of the cement mills of this country are equipped with machinery which is out of date, but as provision has been made by hardly any of the manufacturers to replace their machinery they must continue to operate, at a handicap, old and, in some places, obsolete machinery. Where capital stock is increased for the purchase of new machinery the new machinery frequently has to produce sufficient profits to pay interest on the lost capital as well as on the increased capitalization. Mr. Struckmann adds:

Depreciation must be defined as a loss in value which may be due to use, age, or obsolescence, or a combination of these with several contributory causes, and in a cement factory the amount of depreciation is the measure of loss in invested capital.

In the same discussion Mr. Brown[2] calls attention to another important feature, viz, the supply of raw material:

Entirely apart from the mill proper, in every cement-producing plant there is an item of depreciation which must be considered, and that is the depreciation of quarry. Many plants are so situated that this item can be entirely overlooked. The quantity of raw material at hand is so large that for practical purposes it may be considered unlimited. Other plants are situated, however, where the body of raw material is circumscribed, and in such places it is very necessary that a proper depreciation account should be opened to replace the raw material at the expiration of a fixed time.

As to the amount per barrel that should be set aside for depreciation and obsolescence there is still much uncertainty, owing to the varying conditions under which different plants have been financed and are operating. Several investigators believe that 10 cents a barrel would cover this item. On the other hand, Meade,[3] estimating on the basis of a large new Portland cement plant, believes that the sum of 10 cents a barrel is much too high and estimates that a figure not exceeding 4 cents a barrel should cover the needs of a plant operating for 40 years and making 900,000 to 1,000,000 barrels of cement a year.

MANUFACTURING CONDITIONS.

In 1913 there were 113 plants reported as having produced Portland cement, as compared with 110 plants in 1912. The total number of rotary kilns in the producing plants was 873, as compared

[1] Struckmann, H., Depreciation and obsolescence in Portland cement plants: Am. Soc. Mech. Eng. Jour., February, 1913, pp. 262-264.
[2] Brown, G. S., Am. Soc. Mech. Eng. Jour., February, 1913, p. 267.
[3] Meade, R. K., Depreciation and obsolescence: Jour. Indust. and Eng. Chem., September, 1913, pp. 762-766.

with 867 in 1912. These kilns ranged in length from 40 to 240 feet, and the lengths as reported were distributed as follows:

Lengths of rotary cement kilns in the United States, 1912 and 1913.

Length.	Number of kilns. 1912	Number of kilns. 1913	Length.	Number of kilns. 1912	Number of kilns. 1913
Feet.			*Feet.*		
40 to 60	173	157	125	172	157
60 to 90	135	145	125 to 140	63	63
100	103	93	150 or more	29	38
110	106	117			
120	86	103	Total	867	873

There was a gain in the number of operated kilns 90 feet, 110 feet, 120 feet, and over 150 feet in length, but a decrease in the number of 60-foot, 100-foot, and 125-foot kilns. There was a net increase of 6 kilns, and the total number of kilns 100 feet or more in length was 571, as compared with 559 in 1912.

The apparent total annual kiln capacity in 1913 of plants, either active or only temporarily closed, according to producers' reports, due allowance being made for the customary loss of time from breakdowns and from necessary shutdowns for repairs, was about 115,000,000 barrels of Portland cement. This is an increase of 5,000,000 barrels from the total capacity for 1912, which was estimated on the same basis, but the figures for 1913 appear rather high. The total production for 1913, 92,097,131 barrels, was, according to these figures, between 79 and 80 per cent of the normal cement-producing capacity of the country. The apparent average output per kiln in 1913 was about 105,500 barrels, as compared with 95,000 barrels in 1912.

A summary of kiln fuels in 1913 shows that 88 plants, employing a total of 695 kilns, operated with powdered coal as a kiln fuel; 18 plants, with 119 kilns, burned oil; and 7 plants, with 59 kilns, burned natural gas. As compared with 1912 this shows an increase of 3 coal-burning plants, but of no kilns; a decrease of 2 plants and 7 kilns using oil as fuel; and an increase of 2 plants and 13 kilns burning natural gas.

The following table summarizes these data for 1912 and 1913, together with the quantities and percentages of Portland cement produced with coal, oil, and gas:

Summary of Portland cement kiln fuels in 1912 and 1913.

Fuel.	1912				1913			
	Number of plants.	Number of kilns.	Barrels.	Percentage of total.	Number of plants.	Number of kilns.	Barrels.	Percentage of total.
Coal	85	695	69,546,889	84.4	88	695	78,508,891	85.2
Oil	20	126	9,674,276	11.7	18	119	10,013,206	10.9
Natural gas	5	46	3,216,931	3.9	7	59	3,575,034	3.9
Total	110	867	82,438,096	100.0	113	873	92,097,131	100.0

NEW PORTLAND CEMENT PLANTS.

Four new plants produced Portland cement in 1913, 1 each in Arizona and New York and 2 in Washington. The plant of the Arizona Portland Cement Co., at Portland, near Phoenix, Ariz., consists in part of the plant formerly operated by the United States Reclamation Service at the Roosevelt Dam. As reconstructed the plant is reported to comprise two 70-foot kilns, operated on the dry process, to burn oil in the kilns, and to have a capacity of 400 barrels daily of "Arizona" brand. The Thomas Millen Co. has started a plant a Jamesville, N. Y., using limestone and shale, with coal for fuel. This plant is reported to have one 125-foot kiln with a capacity of 800 barrels per day. The 2 plants in Washington are those of the Olympic and the International Portland cement companies. The former plant is situated near Bellingham, uses limestone and clay, with oil for fuel, and is equipped with two 170-foot kilns, wet process, having a total capacity of about 1,700 barrels per day of "Olympic" brand. The International plant is situated at Irvin, on the outskirts of Spokane. This plant uses limestone, cement rock, and shale, and burns coal. It is equipped with two 160-foot kilns, dry process, having a total capacity of 1,600 barrels daily of "Spokane" brand. In addition to these new plants the mills of the Altoona Portland Cement Co. and of the Monarch Cement Co., both in Kansas, which were reported as inactive in 1912, reported some production in 1913. There were 3 plants which were active in 1912, but which suspended operations during 1913, viz, the plant of the Los Angeles Aqueduct, at Monolith, Cal., and plants of the Chanute and the Great Western companies, both in Kansas. Thus, with 4 new plants and 2 revived plants as against 3 inactive plants there was a net gain of 3 producers in 1913, making 113 active producing plants during the year, all of which shipped cement as well. Progress was reported on the construction of 1 or more new plants in each of the States of California, Iowa, Oklahoma, and Oregon.

INVESTIGATIONS OF CEMENT AND CONCRETE.

As stated in the introduction, the Bureau of Standards is carrying on active laboratory investigations of cement and concrete and has published the results of certain of these investigations in a series of circulars and technologic papers. Progress in certain of these investigations, such as waterproofing concrete and relations of cements to alkalies and sea water, were reviewed in this chapter of Mineral Resources for 1911, Part II, pages 508–510.

ACTION OF ALKALI AND SEA WATERS.

The field of investigation of action of the salts in alkali water and sea water on cements[1] is of such general interest that the summary of the latest publication on these tests is quoted here:

> The conclusions must be limited by the scope of this investigation and since the physical tests reported cover a period of exposure not exceeding three and one-half years the conclusions should be considered as somewhat tentative.

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[1] Bates, P. H., Phillips, A. J., and Wig, R. J., Action of the salts in alkali water and sea water on cements: U. S. Bur. Standards Tech. Paper 12, pp. 100–102, 1913.

1. Portland cement mortar or concrete, if porous, can be disintegrated by the mechanical forces exerted by the crystallization of almost any salt in its pores, if a sufficient amount of it is permitted to accumulate and a rapid formation of crystals is brought about by drying; and as larger crystals are formed by slow crystallization, there would be obtained the same results on a larger scale, but in greater time if slow drying were had. Porous stone, brick, and other structural materials are disintegrated in the same manner. Therefore in alkali regions, where a concentration of salts is possible, a dense nonporous surface is essential.

2. While in the laboratory a hydraulic cement is readily decomposed if intimately exposed to the chemical action of various sulphate and chloride solutions, field inspection indicates that in service these reactions are much retarded if not entirely suspended in most cases, due probably to the carbonization [carbonation?] of the lime of the cement near the surface or the formation of an impervious skin or protective coating by saline deposits.

3. Properly made Portland cement concrete, when totally immersed, is apparently not subject to decomposition by the chemical action of sea water.

4. While these tests indicated that Portland cement concrete exposed between tides resisted chemical decomposition as satisfactorily as the totally immersed concrete, it is felt that actual service conditions were not reproduced, and therefore further investigation is desirable.[1]

5. It is not yet possible to state whether the resistance of cements to chemical disintegration by sea water is due to the superficial formation of an impervious skin or coating, which is subsequently assisted by the deposition of shells and moss forming a protective coating, or by the chemical reaction of the sea salts with the cement forming a more stable compound without disintegration of the concrete, or by a combination of both of these phenomena.

6. Marine construction, in so far as the concrete placed below the surface of the water is concerned, would appear to be a problem of method rather than materials, as the concrete sets and permanently hardens as satisfactorily in sea water as in fresh water or in the atmosphere, if it can be placed in the forms without undue exposure to the sea water while being deposited.

7. Natural, slag, and other special cements tested in concrete mixtures showed normal increase in strength with age both in sea water and in fresh water.

8. In the form of neat briquettes most of the Portland cements of high iron content, several of the cements of high or normal alumina content, and one special slag cement did not show any marked difference in tensile strength whether exposed to fresh or sea water for all periods up to two years. Other cements of various compositions showed signs of disintegration after a few weeks.

9. All cements resisted disintegration in sea water better in mortar mixtures than in the form of neat briquettes. In most cases the mortar briquettes had normal strength up to two years' exposure.

10. The physical qualities of the cement, which depend essentially upon the method of manufacture, would seem to determine its resistance to decomposition when brought into intimate contact with the sulphate and chloride solutions.

11. Contrary to the opinion of many, there is no apparent relation between the chemical composition of a cement and the rapidity with which it reacts with sea water when brought into intimate contact.

12. Tricalcium sulpho-aluminate could not be formed, and therefore disintegration could not result from this cause.

13. In the presence of sea water or similar sulphate-chloride solutions: (*a*) The most soluble element of the cement is the lime. If the lime of the cement is carbonated it is practically insoluble. (*b*) The quantity of alumina, iron, or silica present in the cement does not affect its solubility. (*c*) The magnesia present in the cement is practically inert. (*d*) The quantity of SO_3 present in the cement up to 1.75 per cent does not affect its solubility, but a variation in the quantity present may affect its stability by affecting its rate of hardening.

14. The change which takes place in sea water when brought into intimate contact with the cement is as follows: (*a*) The magnesia is precipitated from the sea water in direct proportion to the solubility of the lime of the cement. (*b*) The sulphates are the most active constituents of the sea water and are taken up by the cement. Their action is accelerated in the presence of chlorides. No definite sulphate compound

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[1] In service the concrete extends from the sea bottom to a point above high tide, where the wall or pile would always be exposed to the atmosphere. With this condition the sea water could be drawn up the wall by capillarity, the moisture evaporating and leaving the salts, which would become concentrated, and thus possibly cause disintegration, especially if mixture is porous. An additional series of tests is now being made in which short piles 7 feet in length are being placed in sea water so that 2 feet of the center portion will be exposed to the atmosphere. After various periods of exposure the piles will be sawed and the various sections tested for elastic properties and compressive strength.

was established. (c) The quantity of chlorine and sodium taken up by the cement is so small that no statement can be made as to the existence of any definite chloride or sodium compound formed with the cement.

15. The SO_3 added to a cement in the plaster to regulate the time of set is chemically fixed so that it will not go into solution when the cement is brought into intimate contact with distilled water.

16. Metal reinforcement is not subject to corrosion if embedded to a depth of 2 inches or more from the surface of well-made concrete.

It is to be hoped that these investigations may be prolonged. As stated in the quotation, the conclusions should be regarded as somewhat tentative. On certain of them few writers are yet in full agreement. The inference expressed in paragraph 11 with regard to the relation between the chemical composition of a cement and the rapidity with which it reacts with sea water, in particular, seems not to accord closely with experimental data acquired by certain other investigators.

MICROSCOPIC ANALYSES.

A field of investigation of interest to geologists, particularly to those trained in the use of the petrographic microscope, is the study of the constitution of Portland cement clinker by means of the microscope. The pioneer work in this line by Day, Shepherd, Wright, and Rankin was briefly outlined in this chapter of Mineral Resources for 1910 (Part II, pp. 485–486). Some additional work has been done by P. H. Bates and A. A. Klein, of the United States Bureau of Standards, Pittsburgh, Pa. At this laboratory a miniature rotary cement kiln, together with the necessary grinding apparatus, has been installed so that various types of cements can be burned at will; for instance, if the alumina and iron oxide content be kept approximately constant a burn may range from a low silica and high lime content to a high silica and low lime content, the limit in each case being the limiting product which can be obtained in the rotary kiln. The burns made on pure materials in the laboratory are reported [1] to have checked the results obtained in the Carnegie geophysical laboratory, and it is therefore assumed that commercial Portland cement may contain tricalcium silicate, dicalcium silicate, calcium aluminates, in which the lime and alumina are combined in the ratios of either 3:1, 5:3, or 1:1, and that there is present also free lime. Details of many tests, illustrated by photomicrographs, are given, together with methods and results of microscopic quantitative analyses of the constitution of cement in a given quadrilateral field of a thin section.

In addition to microscopic work on cement clinker it would seem that there is also an opportunity for much interesting microscopic work on cement mortar and concrete.

BLENDED OR SAND CEMENTS.

Notes have been given in the chapter on cement in Mineral Resources for 1910, 1911, and 1912 concerning the manufacture and use of blended or tuff cement, a cement made by regrinding Portland cement with several varieties of tuff (latite tuff, rhyolite tuff, and andesite tuff), in connection with the construction of the Los

[1] Bates, P. H., The constitution of Portland cement: Concrete-Cement Age, Cement mill section, January, 1913, pp. 3–7.

Angeles aqueduct, a project which required about 1,500,000 barrels of cement. A summary of this subject has been published by Lippincott.[1] The service tests of this material will be watched with interest by engineers and cement manufacturers in succeeding years. Studies by Coglan [2] and other chemists and engineers of the United States Reclamation Service have shown that various rocks, when finely ground, may be suitable for making blended cement. Among such rocks are basalt, tuff, and sandstone from Elephant Butte, N. Mex.; granite from near Boise, Idaho; tuffs from Los Angeles aqueduct, and from Lahontan, Nev.; and quartz. It is stated by Coglan in the article just referred to that chemical analyses reveal the fact that several of the igneous and intrusive rocks, as well as sandstones, contain colloidal silica in varying amounts, but it is not shown that the presence of this material is essential to the successful manufacture of sand cement.

The Reclamation Service is reported [3] to have decided to use sand cement in so far as practicable on two of its important projects, the Arrowrock Dam, 22 miles above Boise, Idaho, and the Elephant Butte Dam, on the Rio Grande, in New Mexico. At the Arrowrock Dam, where about 550,000 cubic feet of concrete will be laid, the blending material will be granite from the spillway excavation. Here a sand-cement plant with a capacity of 1,000 barrels per 24 hours, consisting of a crusher and sand rolls, rotary drier, ball mill, mixing machine, and 3 tube mills, all electrically driven, with the necessary bins, hoppers, and conveying machinery, has been erected at a cost of about $46,000 and was put into operation in the latter part of 1912. At the Elephant Butte Dam about 520,000 barrels of cement will be required in the next three years. A sand-cement plant in which Portland cement will be blended with 50 per cent by volume of sandstone has been erected at a cost of approximately $48,000.

Regarding the use of sand cement Charles H. Paul [4] states:

> The use of sand cement in mass work, where the requirements are enough to justify the installation of the necessary grinding machinery, where suitable blending material is available, and where the transportation charges on Portland cement amount to a considerable portion of its cost laid down, will result in a marked saving in construction costs, and will give a product which is at least the equal of the Portland cement from which it was made, in fact, one which for ordinary requirements is not open to the least suspicion.

Mr. Coglan [5] concludes:

> It is to be hoped that the Portland cement manufacturers will interest themselves in this product, and that if it proves its worth its manufacture may become more widespread. Cheaper cement would mean more cement sold, more cement houses and cement work done in the cities and country.

Experiments by E. H. McAlester [6] with blends of Portland cement with natural and artificial puzzolanic materials in Oregon have led to the suggestion that blended cement be used in concrete roads.

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[1] Lippincott, J. B., Tufa cement as manufactured and used on the Los Angeles aqueduct: Am. Soc. Civil Eng. Proc., October, 1912, pp. 1191-1216. See also subsequent discussion by others in the proceedings for December, 1912, and January, February, March, and April, 1913.

[2] Coglan, R. R., Blended, or sand cements: Results of the study and experience of the U. S. Reclamation Service; Eng. News, June 19, 1913, pp. 1270-1273.

[3] Coglan, R. R., op. cit., p. 1272. See also Eng. News, Mar. 20, 1913, pp. 562-563, and Am. Soc. Civil Eng. Proc., February, 1913, pp. 271-275.

[4] Paul, Charles H., Am. Soc. Civil Eng. Proc., February, 1913, p. 275.

[5] Op. cit., p. 1273.

[6] McAlester, E. H., Puzzolan mixtures tested for Oregon roads: Cement Era, October, 1913, pp. 66-68.

The puzzolanic materials used in the experiments consisted of tuffs that are abundant in the Willamette Valley and near Grants Pass and Clackamas, diatomaceous earth from near Eugene, and blast-furnace slag from Oswego.

CONCRETE ROADS.

The construction of concrete roads already requires large quantities of cement, and the building of this type of road has little more than begun. The interest in this subject is so keen that there is a great deal of literature available concerning the experiences of States, counties, and municipalities in building and maintaining concrete roads and pavements, together with detailed figures of costs. The work of Wayne County, Mich., is perhaps the best known, but other portions of the country, particularly in the Middle West and on the Pacific coast, are no less progressive. The United States Government through its Office of Public Roads has constructed a little more than 1 mile of experimental road in Chevy Chase, Md., just beyond the boundary of the District of Columbia.[1]

It is not practicable to review here the voluminous literature on the subject of concrete roads and pavements for the year 1913, but the reader is referred to the September issue of the Concrete-Cement Age, Detroit, Mich., and to the October issue of the Cement Era, Chicago, Ill., for many special articles on the subject.

IMPORTS OF FOREIGN CEMENT.[2]

The following table shows the quantities of foreign cement imported for consumption into the United States during the years 1878 to 1913, inclusive. Owing to the manner in which import statistics are grouped, the quantities given include not only Portland cement but all other hydraulic cements. The Portland cement, however, probably makes up 95 per cent of the total in each year.

The imports in 1913 were approximately 84,630 barrels, of 380 pounds, valued at $138,187, or about $1.63 a barrel as compared with 68,503 barrels, valued at $93,558, or $1.37 a barrel, in 1912. It should be stated here that the number of barrels given in the following table is slightly in excess of the true quantity. The imports of cement as reported by the Bureau of Foreign and Domestic Commerce are given in pounds, and include the weights of barrels, sacks, and other packages. There are no data at hand at present to show what proportion of the imports are received in barrels or in sacks, although it is understood that the greater part of the material is imported in sacks, which of course weigh very little.

The table shows a continuous decline in the imports of foreign cement for the six years ending with 1912. In 1906 and 1907 the imports were much greater than those of 1905, principally on account of the rebuilding of San Francisco following the fire.

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[1] U. S. Dept. Agr. Office Pub. Roads Circ. 98, 1912, and 99, 1913.

[2] Statistics according to the Bureau of Foreign and Domestic Commerce, Department of Commerce.

Imports of foreign cement, 1878–1913, in barrels of 380 pounds.[1]

1878	92,000	1890	1,940,186	1902	1,963,023
1879	106,000	1891	2,988,313	1903	2,251,969
1880	187,000	1892	2,440,654	1904	968,409
1881	221,000	1893	2,674,149	1905	896,845
1882	370,406	1894	2,638,107	1906	2,273,493
1883	456,418	1895	2,997,395	1907	2,033,438
1884	585,768	1896	2,989,597	1908	842,121
1885	554,396	1897	2,090,924	1909	443,888
1886	915,255	1898	1,152,861	1910	306,863
1887	1,514,095	1899	2,108,388	1911	164,670
1888	1,835,504	1900	2,386,683	1912	68,503
1889	1,740,356	1901	939,330	1913	84,630

EXPORTS.[2]

The United States has a comparatively small export trade in cement. In 1913 the total quantity exported was only 2,964,358 barrels, most of which was Portland cement, valued at $4,270,666, or approximately $1.44 a barrel, as compared with 4,215,232 barrels, valued at $6,160,341, or about $1.46 a barrel, in 1912. The quantity exported in 1913 was only about 3 per cent of the total production of hydraulic cements in 1913. The exports in 1910, 1911, and 1912 showed increases, respectively, of 135 per cent, 27 per cent, and 26 per cent over those of each preceding year, but those of 1913 decreased 29.6 per cent as compared with the exports in 1912.

The following table gives the quantity and value of all classes of hydraulic cement exported during the years 1900–1913, inclusive, and the proportion of exports to the total quantity of hydraulic cement manufactured in the United States. The exports are almost wholly of Portland cement at present.

Exports of hydraulic cement, 1900–1913, in barrels.

Year.	Quantity.	Value.	Percentage of total.	Year.	Quantity.	Value.	Percentage of total.
1900	100,400	$225,306	0.6	1907	900,550	$1,450,841	1.7
1901	373,934	679,296	1.9	1908	846,528	1,249,229	1.6
1902	340,821	526,471	1.3	1909	1,056,922	1,417,534	1.6
1903	285,463	433,984	.95	1910	2,475,957	3,477,981	3.2
1904	774,940	1,104,086	2.4	1911	3,135,409	4,632,215	3.9
1905	897,686	1,387,906	2.2	1912	4,215,532	6,160,341	5.1
1906	583,299	944,886	1.1	1913	2,964,358	4,270,666	3.2

PORTLAND CEMENT IN CANADA.

The following extract is quoted from the preliminary report on the mineral production in Canada during the calendar year 1913, issued by the Canada department of mines, mines branch, February 24, 1914, pages 18–19:

The financial stringency during 1913 had an immediate effect in the restriction of building operations of all kinds, and its results are shown in the statistics of production and consumption of structural materials. In the case of cement, while a very substantial increase in production is shown, this has seemed chiefly to displace imported

[1] The statistics from 1899 to the present represent "Imports for consumption." The figures for all preceding years are for "Total imports."
[2] Statistics according to Bureau of Foreign and Domestic Commerce, Department of Commerce.

material, the increase in consumption being only 4 per cent as against an increased production of 24 per cent. Canadian mills supplied over 97 per cent of the consumption in 1913 as against 83 per cent in 1912. The industry has been marked by the extension of old and the completion of new plants, the latter west of the Great Lakes. The total capacity of completed plants at the end of the year is about 50,000 barrels per day as compared with 36,500 barrels at the end of 1912. New plants were placed in operation at Winnepeg, Marlboro west of Edmonton, Princeton, British Columbia, and at Tod Inlet, Vancouver Island, British Columbia. The plants of the Imperial Portland Cement Co. at Owen Sound and of the Crown Portland Cement Co. were not operated during the year.

The total quantity of Portland cement, including slag cement and natural Portland, made in 1913 was 8,880,983 barrels, an increase of 1,739,979 barrels, or 24 per cent over 1912. The quantity of Canadian cement sold or used was 8,658,922 barrels, valued at $11,227,284, or $1.29⅝ per barrel, an increase of 1,526,190 barrels, or 22 per cent, and of $2,120,728, or 23 per cent, in total value. The total imports of cement were 889,324 hundredweight equivalent to 254,092 barrels of 350 pounds each and valued at $409,303, or an average of $1.61 per barrel, as compared with imports of 1,434,413 barrels, valued at $1,969,529, or an average of $1.37, in 1912. The total consumption of Portland cement, therefore, neglecting a small export, was 8,913,014 barrels as compared with a consumption of 8,567,145 barrels in 1912, an increase of 345,869 barrels, or only 4 per cent.

The average price per barrel at the works in 1913 was $1.29⅝, as compared with $1.28 in 1912 and $1.34 in 1911 and 1910.

The imports of cement in 1913 included 77,356 barrels from Great Britain, 172,298 barrels from the United States, 3,443 barrels from Hongkong, and 995 barrels from other countries. The average price per barrel was $1.61, as against an average of $1.37 on imports in 1912.

NATURAL CEMENT.

PRODUCTION.

The natural cement produced in the United States during 1913 amounted to 744,658 barrels of 265 pounds, valued at $345,889, as compared with an output of 821,231 barrels, valued at $367,222, in 1912, a decrease in 1913 of 76,573 barrels, or 9.3 per cent, in quantity, and of $21,333, or 5.8 per cent, in value. The averago price of the natural cement per barrel at the mills in 1913 was 46.4 cents, as compared with 44.7 cents in 1912.

Natural cement was produced in 1913 in 13 plants distributed in 8 States, as compared with 15 plants in 9 States in 1912. The net decrease in 1913 of 2 plants resulted from a decreaso of 1 plant each in Georgia, Pennsylvania, and Texas, and an increase of 1 plant in Ohio. In the following table the natural cement production of 1913 is outlined by States:

Production of natural cement in 1912–13, by States.

State.	1912			1913		
	Producing plants.	Quantity (barrels).	Value.	Producing plants.	Quantity (barrels).	Value.
New York	4	366,236	$162,376	4	255,709	$114,067
Pennsylvania	2			1		
Illinois	1			1		
Indiana	1	229,901	91,787	1	a 266,949	a 121,422
Ohio	1			2		
Minnesota	2	213,500	104,625	2	222,000	110,400
Kansas	1			1		
Georgia	2	11,594	8,434	1	(a)	(a)
Texas	1			0		
Total	15	821,231	367,222	13	744,658	345,889

a In 1913 no production was reported from Texas; therefore the production of Georgia is included with that of Illinois, Indiana, and Ohio.

THE NATURAL CEMENT INDUSTRY, 1818-1913.

The following table contains statistics of production of natural cement since the beginning of its manufacture in this country in 1818. It will be seen that the natural-cement trade reached its greatest prosperity in the period 1887–1903, inclusive, its year of maximum output being 1899, when 9,868,179 barrels of natural cement were manufactured in the United States. Beginning with 1904, the industry has shown a continuous decline in production each year, and its production for 1913 is the lowest on record since before 1880. See also the curve of production, figure 1.

Production of natural cement in the United States, 1818–1913, in barrels of 265 pounds.

1818–1829	300,000	1895	7,741,077
1830–1839	1,000,000	1896	7,970,450
1840–1849	4,250,000	1897	8,311,688
1850–1859	11,000,000	1898	8,418,924
1860–1869	16,420,000	1899	9,868,179
1870–1879	22,000,000	1900	8,383,519
1880	2,030,000	1901	7,084,823
1881	2,440,000	1902	8,044,305
1882	3,165,000	1903	7,030,271
1883	4,190,000	1904	4,866,331
1884	4,000,000	1905	4,473,049
1885	4,100,000	1906	4,055,797
1886	4,186,152	1907	2,887,700
1887	6,692,744	1908	1,686,862
1888	6,253,295	1909	1,537,638
1889	6,531,876	1910	1,139,239
1890	7,082,204	1911	926,091
1891	7,451,535	1912	821,231
1892	8,211,181	1913	744,658
1893	7,411,815		
1894	7,563,488	Total	232,271,122

PUZZOLAN AND OTHER SLAG CEMENTS.

Puzzolan cement was manufactured during 1913 at 3 plants in the United States—at North Birmingham, Ala., Struthers, Ohio, and Sharon, Pa.—and Collos cement was made at Buffalo, N. Y. The output of puzzolan and Collos cements in 1913 was 107,313 barrels, valued at $97,663, compared with 91,864 barrels, valued at $77,363, in 1912. This represents an increase in quantity of 15,449 barrels and in value of $20,300. The average price per barrel of these slag cements in 1913 was 91 cents, and in 1912 it was 84.2 cents, an increase in 1913 of 6.8 cents a barrel, or 8.1 per cent. In 1912 the average price of slag cement was 2.9 cents higher than that of Portland cement, but this lead was not maintained in 1913. One reason why a good average price should be commanded by puzzolan cement is that a considerable quantity of this product is of a light color and is considered to be nonstaining.

The following table summarizes the number of active plants and the production of puzzolan cement during the last five years:

Statistics of the puzzolan cement industry, 1909–1913.

	1909	1910	1911	1912	1913
Number of plants reporting production:					
Alabama	1	1	1	1	1
New York[a]			1	1	1
Ohio	2	2	1	1	1
Pennsylvania	1	1	1	1	1
Total	4	4	4	4	4
Production in barrels of 330 pounds	160,646	95,951	93,230	91,864	107,313
Value of production	$99,453	$63,286	$77,786	$77,363	$97,663

[a] Includes production of Collos cement in 1911, 1912, and 1913.

The following table gives the annual production of puzzolan cement in the United States since 1896, when the first output of this cement was reported. The figures for 1912 and 1913 represent marketed production.

Output of puzzolan cement in the United States, 1896–1913, in barrels of 330 pounds.[1]

1896	12,265	1906	481,224
1897	48,329	1907	557,252
1898	150,895	1908	151,451
1899	335,000	1909	160,646
1900	446,609	1910	95,951
1901	272,689	1911	93,230
1902	478,555	1912	91,864
1903	525,896	1913	107,313
1904	303,045		
1905	382,447	Total	4,694,661

[1] Includes output of Collos cement in 1911, 1912, and 1913.

FELDSPAR.

By Frank J. Katz.

REVIEW OF THE FELDSPAR TRADE.

The marketed production of feldspar in the United States in 1913 was 120,955 short tons, valued at $776,551. Both in quantity and in value this was the largest recorded annual production. Each important producing State—California, Connecticut, Maine, Maryland, New York, North Carolina, and Pennsylvania—showed an increase in both quantity and value. During the year about 50 quarries marketed feldspar. Ten of them were new producers. Notwithstanding the increase in quantity and the production from new sources the average price per ton of the total production was higher than in any other year. The average price per ton of the combined crude and ground output was about 25 cents more than in the best preceding year (1911). The prevailing prices f. o. b. quarries for crude material were about the same as in previous years, but the average price f. o. b. mills of ground feldspar was considerably higher (10 to 12.5 per cent), than in recent years. The feldspar market appears therefore to have been unusually strong and to have consumed an increased production at a rising price. The year should have been a profitable one for the feldspar grinders.

COMPOSITION, OCCURRENCE, AND USES.

Bulletin 420 of the Survey, "Economic geology of the feldspar deposits of the United States," by Edson S. Bastin, published in 1910, is so complete a treatise on the subject that it is not deemed necessary in this place to go into detail regarding the composition and occurrence of feldspar in the United States. All who are interested in the subject are referred to that bulletin, which may be had on application to the Director, United States Geological Survey, Washington, D. C.

In June, 1913, the Bureau of Mines issued Bulletin 53, "Mining and treatment of feldspar and kaolin in the southern Appalachian region," by A. S. Watts, who investigated the pegmatite deposits of the mountain region from Marietta, Ga., to Lynchburg, Va. He describes the pegmatites and discusses prospecting and sampling them for feldspar, quartz, and kaolin, from the point of view of a ceramic engineer. Methods of analyzing and testing feldspar and kaolin for use in pottery are fully described, and analyses and results of tests on feldspar from many deposits are included in the bulletin. Of particular value to feldspar and kaolin producers and to pottery manufacturers is the suggestion[1] by Watts to substitute for part of the feldspar of porcelain mixtures the "semikaolinized" feldspars which occur so abundantly in the pegmatite dikes of the region described.

This publication may be secured by application to the Director, Bureau of Mines, Washington, D. C.

Feldspar is a compound of silica, alumina, and one or more of the bases potash, soda, and lime. There are two principal commercial varieties—the potash spar and the soda spar. Both of these may be present in the same deposit or in the same crystal. The principal members of the potash group are orthoclase and microcline. These varieties are alike in chemical composition ($KAlSi_3O_8$, or $K_2O.Al_2O_3.6SiO_2$) and so nearly alike in physical properties as to be considered commercially identical. The theoretical composition of pure orthoclase or microcline is silica 64.7 per cent, alumina 18.4 per cent, and potash 16.9 per cent. The potash may be partly or completely replaced by soda. When the soda content is greater than the potash content the feldspar is called anorthoclase.

Potash feldspars range in color from white to reddish; some are gray. The soda feldspars vary from white to pale green in color. When first taken from the quarry feldspar is so hard that it is with difficulty scratched with a knife.

Most of the feldspar mined in the eastern part of the United States is of the potash or the soda variety or a mixture of the two. These varieties are used in the pottery industry because after being melted and cooled they form a glass, whereas lime-soda feldspar under these conditions becomes crystalline.

The principal use of feldspar is in the manufacture of pottery, enamel ware, enamel brick and tile, and electrical ware. Of these applications the most important is its use in the body and glaze of the various grades of pottery and vitrified sanitary ware, in which it constitutes from 10 to 35 per cent. Its value in pottery is that it melts at a lower point than the other ingredients and serves as a flux, binding the clay and quartz particles together. In glazes the percentage of feldspar used is higher than in the body and runs from 30 to 50 per cent. Other uses of feldspar, which do not require the high grade demanded by the pottery trade, are in the manufacture of emery and corundum wheels, where it serves as a binder; in the manufacture of opalescent glass; as a poultry grit; as a constituent of roofing material; and for surfacing concrete work. Small quantities of the purest grades of potash feldspar are used in the manufacture of artificial teeth. For this purpose it brings the highest prices—from \$6 to \$8 a barrel of 350 pounds. It is also used in the manufacture of scouring soaps and window wash. Ground feldspar has been used as a fertilizer, but with results of doubtful value. Attempts are being made to extract from feldspar its content of potash. Experiments along this line have not yet developed a commercial process, but it may well be that some of the efforts will be successful.

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[1] Watts, A. S., Mining and treatment of feldspar and kaolin in the southern Appalachian region: Bur. Mines Bull. 53, pp. 58-63 1913.

PRODUCTION.

The marketed production of feldspar in 1913 was 120,955 short tons, valued at $776,551. This, the largest recorded annual production, was an increase over 1912 of 34,383 tons, or 39.72 per cent, in quantity and of $255,989, or 49.18 per cent, in value. The production of crude spar was 45,391 short tons, valued at $148,549, an increase of 18,929 tons, or 71.53 per cent, in quantity and of $59,548, or 66.91 per cent, in value as compared with 1912. The production of ground spar was 75,564 short tons, valued at $628,002, an increase of 15,454 tons, or 25.71 per cent, in quantity and of $196,441, or 45.52 per cent, in value as compared with 1912.

The average price per ton in 1913 for crude spar was $3.31, compared with $3.36 in 1912 and $3.14 in 1911. The average price per ton in 1913 for ground spar was $8.31, compared with $7.18 in 1912 and $7.60 in 1911. The average price per ton in 1913 for the combined crude and ground output was $6.49, compared with $6.01 in 1912 and $6.25 in 1911. Of the total output, 37.53 per cent was sold by the producer crude and 62.47 per cent was sold ground. Of the total value, that sold crude represents 19.13 per cent and the ground 80.87 per cent.

It has been impossible to determine very accurately the proportions of the feldspar output used for various purposes. The following figures are estimates based on incomplete data, but are believed to be reasonably reliable. Of the production in 1913, approximately 4,000 tons, valued at approximately $20,000, representing about 3.5 per cent of the total quantity and about 3 per cent of the total value, was used for abrasives; approximately 7,000 tons, valued at approximately $30,000, representing about 6 per cent of the total quantity and about 4 per cent of the total value, was used for roofing; concrete surfacing and other structural uses consumed about 3,000 tons, valued at $6,000, representing nearly 3 per cent of the total quantity and under 1 per cent of the total value. Approximately 1,000 tons, valued at $3,500, representing about 1 per cent of the total quantity and about 0.5 per cent of the total value, were sold as chicken grits; approximately 1,200 tons, valued at $10,000, representing 1 per cent of the total quantity and about 1.5 per cent of the total value, was used for making glass. Very small quantities were used in chemical work and in experiments on potash extraction and on the direct use of feldspar as a fertilizer. The remainder of the output, over 100,000 tons, or 85 per cent of the total quantity, valued at $700,000, or 90 per cent of the total value, was used in the ceramic industries.

The following tables show the production of feldspar in 1912 and 1913, by States, with the increase or decrease in quantity and value in the several States for 1913 as compared with 1912, and the totals for the United States classified as crude and ground from 1909 to 1913. These figures include feldspar for all purposes, and show the marketed product rather than the quantity actually quarried.

Marketed production of feldspar in 1912 and 1913, by States, in short tons.

1912.

State.	Crude.		Ground.		Total.	
	Quantity.	Value.	Quantity.	Value.	Quantity.	Value.
Connecticut	9,556	$34,943	9,519	$59,154	19,075	$94,097
Maine	67	180	19,024	172,896	19,091	173,076
Maryland	4,689	15,984	4,542	40,014	9,231	55,998
New York	3,192	14,250	19,000	87,275	22,192	101,525
Pennsylvania	1,947	4,985	7,504	66,302	9,451	71,287
California, Minnesota, North Carolina, Vermont, and Virginia	7,011	18,659	521	5,920	7,532	24,579
Total	26,462	89,001	60,110	431,561	86,572	520,562

1913.

State.	Crude.		Ground.		Total.	
	Quantity.	Value.	Quantity.	Value.	Quantity.	Value.
California	1,113	$3,838			1,113	$3,838
Connecticut	10,166	35,867	10,122	$79,903	20,288	115,770
Maine	(a)	(a)	38,114	346,779	[b] 38,114	[b] 346,779
Maryland	11,402	37,155	5,300	45,678	16,702	82,833
New York	6,859	21,304	15,891	97,756	22,750	119,060
Pennsylvania	3,685	19,454	5,944	56,397	9,629	75,851
Minnesota, North Carolina, and Vermont	[c] 12,166	[c] 30,931	193	1,489	[c] 12,359	[c] 32,420
Total [d]	45,391	148,549	75,564	628,002	120,955	776,551

[a] Included with miscellaneous States.
[b] Exclusive of crude product.
[c] Includes crude product from Maine.
[d] Includes 3,953 short tons of feldspar, valued at $19,681, used as abrasive.

Production and value of feldspar, 1912–13, by States, with increase and decrease and percentage of increase and decrease.

State.	1912		1913		Increase (+) or decrease (−) in quantity, 1913.	Percentage of increase (+) or decrease (−) in quantity, 1913.	Increase (+) or decrease (−) in value, 1913.	Percentage of increase (+) or decrease (−) in value, 1913.
	Short tons.	Value.	Short tons.	Value.				
California	(a)	(a)	1,113	$3,838	+ 329	+ 41.96	+ $1,038	+ 37.07
Connecticut	19,075	$94,097	20,288	115,770	+ 1,213	+ 6.36	+ 21,673	+ 23.03
Maine [b]	19,024	172,896	38,114	346,779	+19,090	+100.35	+173,883	+100.57
Maryland	9,231	55,998	16,702	82,833	+ 7,471	+ 80.93	+ 26,835	+ 47.92
New York	22,192	101,525	22,750	119,060	+ 558	+ 2.51	+ 17,535	+ 17.27
Pennsylvania	9,451	71,287	9,629	75,851	+ 178	+ 1.88	+ 4,564	+ 6.40
Other States [c]	7,599	24,759	12,359	32,420	+ 5,544	+ 81.35	+ 10,461	+ 47.64
Total	86,572	520,562	120,955	776,551	+34,383	+ 39.72	+255,989	+ 49.18

[a] Included with other States.
[b] Exclusive of crude product.
[c] Includes also crude product of Maine.

Production of feldspar, 1909–1913, in short tons.

Years.	Crude.		Ground.		Total.	
	Quantity.	Value.	Quantity.	Value.	Quantity.	Value.
1909	25,506	$70,210	51,033	$354,392	76,539	$424,602
1910	24,655	81,965	56,447	420,487	81,102	502,452
1911	28,131	88,394	64,569	490,614	92,700	579,008
1912	26,462	89,001	60,110	431,561	86,572	520,562
1913	45,391	148,549	75,564	628,002	120,955	776,551

FELDSPAR INDUSTRY, BY STATES.

Sales of feldspar in 1913 were reported from the following States, named in order of magnitude of their output: Maine, New York, Connecticut, Maryland, North Carolina, Pennsylvania, California, Vermont, and Minnesota. A shipment was also made for tests or experimental purposes from a quarry in Virginia, and preparation for shipment was made in Colorado.

California.—Five operators reported production of feldspar in California in 1913. One quarry was reported idle and two as being developed. Of those operating, 4 are new quarries near Exeter, Springville, Sulphur Springs, and Lemon Cove, in Tulare County. Other quarries were opened in Tulare County, but no record of production or other information about them could be secured. The quarry near Lakeside, San Diego County, was reported idle. The quarry at Chualar, Monterey County, was active as usual. The entire California output was used for pottery, manufactured at National City and Richmond, in that State. The production for the State in 1913 was 1,113 short tons, valued at $3,838. This was an increase over the production reported for 1912 of 329 tons, or 41.96 per cent, in quantity and of $1,038, or 37.07 per cent, in value.

Colorado.—A feldspar deposit near St. Peters, El Paso County, Colo., was opened, and preparations for shipment of spar were made. Development of the prospect was interrupted by the death of the operator. The writer has seen samples of excellent spar from this property.

Connecticut.—Connecticut was third in the size of its feldspar production in 1913, being exceeded only by Maine and New York. Connecticut's production in 1913, which came from Middlesex and Hartford counties, was 20,288 short tons, valued at $115,770, an increase over 1912 of 1,213 tons, or 6.36 per cent, in quantity and of $21,673, or 23.03 per cent, in value. The price in Connecticut for crude and ground spar ranged from $3.15 to $4.50 a ton and from $7.05 to $10 a ton, respectively. There were 7 producing quarries, and 3, which have in recent years been active, were idle. Three mills were operated. One of these was closed in August and is reported for sale. Connecticut feldspar was used for pottery, enamel ware, tiles, glass, abrasives, and soaps.

Maine.—Maine ranked first in feldspar production in 1913. Seven quarries, in Androscoggin, Oxford, and Sagadahoc counties, were in operation, two of which were new as feldspar producers. Still another quarry made a test shipment. The production was 38,114 short tons, valued at $346,779, which was an increase of 19,090 tons, or 100.35 per cent, in quantity and of $173,883, or 100.57 per cent, in value over 1912. The price of crude spar in Maine was for the most part $3 a ton; some sold at $6. Ground spar sold at prices ranging from $8 to $9.33 a ton. Maine feldspar was used for pottery. Three mills were in operation. The new mill of the Maine Feldspar Co. at Topsham, noted in the 1912 report, ground a large quantity of spar. That company's new quarry, at Cathance, also made a large output. New development began late in the year on an old mica quarry in Peru, Oxford County, which resulted in a small shipment, and a test shipment was made from another new quarry in the same town.

Maryland.—Maryland stood fourth as a producer of feldspar in 1913. There were 12 active quarries, situated in Baltimore, Carroll, Cecil, and Montgomery counties, 5 of which were new; and 6 quarries, which were recently producers, were idle. There is but one mill in the State, that of the Earth Products Co., near Laurel, which is equipped for coarse grinding and sizing. The company plans to install fine-grinding apparatus. The production of the State in 1913 was 16,702 short tons, valued at $82,833. This was an increase of 7,471 tons, or 80.93 per cent, in quantity and of $26,835, or 47.92 per cent, in value. The prices for Maryland crude spar in 1913 ranged from $3.50 to $5.50 a ton. Maryland spar ground at Trenton, N. J., sold at $8.73 to $9.50 a ton. Maryland spar was used chiefly for pottery. Some was sold for chicken grits.

Massachusetts.—There was no production of feldspar in Massachusetts in 1913.

Minnesota.—The one quarry in Minnesota, the product from which was used exclusively for abrasive paper, was not in operation in 1913. Small shipments were made in 1913 of material mined in 1910.

New York.—New York was second in rank as a feldspar producer in 1913. Nearly half of the output of 1913 here listed was unsorted pegmatite which was only crushed or coarsely ground and used for for coating "ready roofing," for concrete facing, and for poultry grit. The remainder is ground finely for use in pottery, enamel ware, glass, and abrasive soaps. There were 5 large quarries in Saratoga, Westchester, and Essex counties, in operation, and some small ones, not listed, whose production is reported by feldspar mills. One recently operated was idle. There are 2 mills for coarse grinding, at Crown Point and Ticonderoga, and 1 for fine grinding at Bedford. The total production for the State was 22,750 short tons, valued at $119,060, an increase of 558 tons, or 2.51 per cent, in quantity and of $17,535, or 17.27 per cent, in value. The average prices in New York for 1913 for crude spar and crushed pegmatite ranged from $2.50 to $5 a ton; ground spar sold at $6 to $8.32 a ton.

North Carolina.—North Carolina in 1913 took sixth place as a feldspar producer. The output was almost entirely by two companies in the Spruce Pine district, Mitchell County. The product was ground at Trenton, N. J., and at East Liverpool, Ohio. Other companies are developing quarries in the Spruce Pine district, and it is reported that the Carolina, Clinchfield & Ohio Railway is building a feldspar mill. There was no progress in the development of feldspar quarries in other parts of the State.

Pennsylvania.—Pennsylvania was fifth among the feldspar producing States in 1913. Nine large quarries in Chester and Delaware counties and several unlisted small ones, whose output is purchased and reported by larger operators, produced 9,629 short tons, valued at $75,851, an increase over 1912 of 178 tons, or 1.88 per cent, in quantity and of $4,564, or 6.40 per cent, in value. Prices for Pennsylvania spar ranged in 1913 from $2 to $4.50 a ton for crude, and from $8 to $9.50 a ton for ground. The Edgemont quarries have again changed hands, having been purchased by the Harris Chemical Co., which reported a small production for "chemical purposes." Pennsylvania feldspar was used for pottery, tile, enamel ware, glass, poultry grits, roofing, and abrasive soaps.

Tennessee.—The Clinchfield Mineral & Milling Corporation began the development of a feldspar quarry at Erwin, Unicoi County. No shipment was made during 1913.

Vermont.—The A. L. Stone Manufacturing Co. continued to be the single feldspar producer in Vermont operating a quarry and mill at Chester, Windsor County.

Virginia.—No feldspar from Virginia quarries was sold in 1913. All quarries were idle, except for the shipment of less than a ton for experimental purposes.

PRODUCTION IN OTHER COUNTRIES.

The following table gives such figures as are available on the production of feldspar in recent years in the United States and other countries:

Production of feldspar in the principal producing countries, 1909–1913, in short tons.

Country.	1909 [a]		1910 [a]	
	Quantity.	Value.	Quantity.	Value.
United States	76,539	$424,602	81,102	$502,452
Belgium		1,655		1,655
Canada	12,783	40,382	15,809	47,667
Germany (Bavaria)	3,473	11,976	2,888	10,697
Italy [b]	34,976	43,832	29,872	40,057
Madagascar				15
Norway [c]	40,167	127,556	43,549	150,336
Sweden	17,385	44,475	23,800	57,566

Country.	1911 [a]		1912		1913	
	Quantity.	Value.	Quantity.	Value.	Quantity.	Value.
United States	92,700	$579,008	86,572	$520,562	120,955	$776,551
Belgium		1,655	(*d*)	(*d*)	(*d*)	(*d*)
Canada	17,723	51,939	[e] 13,733	[e] 30,916	[e] 15,935	56,841
Germany (Bavaria)	3,489	13,689	7,348	49,581	(*d*)	(*d*)
Italy [b]	39,417	44,585	37,416	44,079	(*d*)	(*d*)
Madagascar			(*d*)	(*d*)	(*d*)	(*d*)
Norway [c]	38,429	124,096	(*d*)	(*d*)	(*d*)	(*d*)
Sweden	39,942	89,743	(*d*)	(*d*)	(*d*)	(*d*)

[a] Statistics taken from Mines and quarries: General report and statistics, pt. 4, London, except Italy, the latter being credited to Rivista del Servizio minerario, Rome.
[b] Includes quartz.
[c] Export figures.
[d] Statistics not available.
[e] Preliminary report on mineral production of Canada, 1913, Canada Dept. Mines, 1914.

TALC AND SOAPSTONE.

By J. S. Diller.

DEVELOPMENT OF THE TALC AND SOAPSTONE INDUSTRY.

The talc and soapstone industry has gradually expanded from a marketed production of 97,843 short tons, valued at $908,488, in 1901, to 175,833 short tons, valued at $1,908,097, in 1913. The comparatively uniform development of the industry indicates its stability and gives promise for continued increasing demand.

The following tables illustrate the development of the talc and soapstone industry in the United States since 1880:

Production of talc and soapstone in the United States, 1880–1913, in short tons.

Year.	Quantity.	Value.	Year.	Quantity.	Value.
1880–1900	969,928	$11,224,652	1907	139,810	$1,531,047
1901	97,843	908,488	1908	117,354	1,401,222
1902	97,954	1,140,507	1909	130,338	1,221,959
1903	86,901	840,060	1910	150,716	1,592,393
1904	91,189	940,731	1911	143,551	1,646,018
1905	96,634	1,082,062	1912	159,270	1,706,963
1906	120,644	1,431,556	1913	175,833	1,908,097

The total marketed production of talc and soapstone in the United States during 1913 was 175,833 short tons, an increase of 10.4 per cent as compared with the production of 1912. In the following table this production, with the percentage of increase or decrease with reference to 1912, and its value are shown by States. The succeeding table shows the production in marketed forms from 1910 to 1913. Rhode Island and Maryland in 1913 produced soapstone alone. The other States, except North Carolina, Vermont, and Virginia, produce talc only.

Marketed production of talc and soapstone in the United States, 1912–13, with increase and decrease in 1913, in short tons.

State.	1912		1913		Increase (+) or decrease (−) in quantity, 1913.	Percentage of increase (+) or decrease (−) in quantity.	Increase (+) or decrease (−) in value, 1913.	Percentage of increase (+) or decrease (−) in value.
	Quantity.	Value.	Quantity.	Value.				
California	1,169	$15,653	952	$6,000	− 217	−18.56	− $9,653	−61.67
New Jersey and Pennsylvania	10,400	50,519	11,308	80,780	+ 908	+ 8.73	+ 30,261	+59.90
New York	66,867	656,270	81,705	788,500	+14,838	+22.19	+132,230	+20.15
North Carolina	3,542	63,304	4,676	48,817	+ 1,134	+32.02	− 14,487	−22.88
Vermont	42,413	275,679	45,547	327,375	+ 3,134	+ 7.39	+ 51,696	+18.75
Virginia	25,313	576,473	26,487	615,558	+ 1,174	+ 4.63	+ 39,085	+ 6.78
Other States [a]	9,566	69,065	5,158	41,067	− 4,408	−46.08	− 27,998	−40.54
Total	159,270	1,706,963	175,833	1,908,097	+16,563	+10.40	+201,134	+11.78

[a] Includes Georgia, Maryland, Massachusetts, and Rhode Island.

Marketed production of talc and soapstone in the United States, 1910–1913, in short tons.

Condition in which marketed.	Quantity.	Value.	Average price per ton.	Quantity.	Value.	Average price per ton.
	1910			1911		
Rough	15,425	$56,872	$3.69	13,304	$56,387	$4.24
Sawed into slabs	9,352	78,042	8.34	3,504	70,641	20.16
Manufactured articles [a]	22,363	503,391	22.51	23,179	660,219	28.48
Ground [b]	103,576	954,088	9.21	103,564	858,771	8.28
Total	150,716	1,592,393	10.57	143,551	1,646,018	11.47
	1912			1913		
Rough	15,510	$66,798	$4.31	3,898	$14,687	$3.77
Sawed into slabs	2,642	50,334	19.05	4,371	61,351	14.04
Manufactured articles [a]	21,557	600,105	27.84	20,465	593,331	28.99
Ground [b]	119,561	989,726	8.28	147,099	1,238,728	8.42
Total	159,270	1,706,963	10.72	175,833	1,908,097	10.85

[a] Includes bath and laundry tubs; fire brick for stoves, heaters, etc.; hearthstones, mantels, sinks, griddles, slate pencils, gas tips, burner blanks, crayons, and numerous other articles for everyday use.
[b] For foundry facings, paper making, lubricators for dressing skins and leather, etc.

The importance of the talc and soapstone industry of the United States as compared with that of other countries is illustrated by the following table of the world's production. The figures for 1912 are not yet complete, but it will be noted that the United States contributes more than all the other countries combined.

Production of talc and soapstone in the principal producing countries, 1905–1912, in short tons.

Country.	1905 [a]	1906 [a]	1907 [a]	1908 [a]	1909 [a]	1910 [a]	1911 [a]	1912 [b]
United States [c]	96,634	120,644	139,810	117,354	130,338	150,716	143,551	159,270
Argentina [d]	....	....	28	7	....	....	....	(g)
Canada [d]	500	1,234	1,534	1,016	4,350	7,112	7,300	8,270
France [e]	25,956	29,061	38,262	37,053	38,433	42,316	51,050	(g)
German Empire (Bavaria [f])	2,064	2,131	2,203	2,424	2,567	3,398	3,781	3,551
India [f]	13	11	9	856	652	274	690	(g)
Ireland [f]	....	....	....	....	....	....	....	9
Italy [d]	7,154	9,624	13,574	12,048	13,228	13,727	17,218	17,901
Madagascar [f]	....	....	....	....	....	....	2	(g)
South Africa [f]	....	....	....	....	....	....	7	(g)
Spain [f]	4,810	3,978	15,294	5,214	6,154	5,142	6,225	(g)

[a] Figures taken from Mines and Quarries: General Rept. with Statistics, pt. 4, London, except Italy, the latter being credited to Revista del Servizio minerario, Rome.
[b] Figures taken from various sources.
[c] Talc and soapstone.
[d] Talc.
[e] Talc, soapstone, and asbestos.
[f] Soapstone.
[g] Statistics not available.

This large production accounts for a considerable export trade, especially in grades suitable for the manufacture of paper.

The production in the United States of the best grades of talc, however, such as are used for toilet powders, electric insulators, gas tips, and the like, is not equal to the demand, which is supplied chiefly by importations from Italy and France.

DISTRIBUTION OF TALC AND SOAPSTONE IN THE UNITED STATES.

The distribution and character of the talc mines and the soapstone quarries of the United States was shown on maps and tables in this report for 1912. As there has been no change of importance during the year the maps and tables need not be repeated here.

The crystalline character of talc and soapstone limits their occurrence to areas of crystalline rocks. By far the larger portion of the known occurrences and producing localities are in the Blue Mountain region of the Atlantic States from New England and New York to Georgia, although in recent years attention has been attracted to deposits in southeastern California.

Talc is a definite mineral of which soapstone, as the term is generally used, is only an impure massive form.

Talc is generally mined in small fragments by underground methods. On the other hand, soapstone is quarried in large blocks in open pits. Commercial talc and soapstone are not generally found together nor produced by the same company. Prior to 1912 talc and soapstone have been considered together in the United States Geological Survey reports, but in that year they were also considered separately, a practice which is followed in this report for 1913.

TALC.

PRODUCTION.

The total marketed production of talc for 1913 was 149,271 short tons, valued at $1,280,020, a decided increase as compared with the production of 1912, which was 133,289 short tons, valued at $1,097,483.

The relative rank of the producing States as to quantity and value of the production in 1913 is given in the following table. The production of Pennsylvania and New Jersey and also that of Georgia and Massachusetts are combined to conceal the output of individual producers.

Quantity and value of the talc marketed in the various States in 1912 and 1913, in short tons.

Rank and State.	1912		1913	
	Quantity.	Value.	Quantity.	Value.
1. New York	66,867	$656,270	81,705	$788,500
2. Vermont	41,270	245,679	44,447	302,375
3. Pennsylvania and New Jersey	10,400	50,519	11,308	80,780
4. North Carolina	3,492	63,004	4,576	48,317
5. Georgia and Massachusetts	[a] 6,836	[a] 49,172	3,309	35,416
6. Virginia	3,255	17,186	2,974	18,632
7. California	1,169	15,653	952	6,000
Total	133,289	1,097,483	149,271	1,280,020

[a] Includes also Maryland.

New York continues to be the leading producer, with an output of more than 54 per cent of the total production of the United States, and far outranking all other States except Vermont, which has in recent years so greatly increased its production that in 1912 and 1913 it was more than half that of New York.

Of the total output in 1913, by far the greater portion, 147,529 short tons, was sold as ground talc; 238 tons was sold as pencils or blanks for making gas tips, etc.; and 1,504 tons was sold rough as it came from the mine.

The variation in the annual production of the different States, although due in part to irregularities in the available deposits, which are in most States large, depends also on the market demand.

IMPORTS.

The total imports of talc for consumption in 1913 were 13,770 short tons, valued at $137,680, an increase of 25.3 per cent in quantity and of nearly 12 per cent in value as compared with the corresponding imports for 1912.

Talc imported for consumption into the United States, 1905 and 1909–1913, in short tons.

Year.	Quantity.	Value.	Average price per ton.	Year.	Quantity.	Value.	Average price per ton.
1905	4,000	$48,225	$12.05	1911	7,113	$88,050	$12.38
1908	7,429	97,096	13.07	1912	10,989	122,956	11.19
1909	4,417	56,287	12.74	1913	13,770	137,680	10.00
1910	8,378	106,460	12.71				

As shown by the accompanying table, 33 per cent of the imported talc came from Italy, nearly 40 per cent from France, and 24 per cent from Canada.

Imports of talc, ground or manufactured, into the United States, 1912 and 1913, by countries, in short tons.

Country.	1912			1913		
	Quantity.	Value.	Average price per ton.	Quantity.	Value.	Average price per ton.
Argentina	1	$25	$25.00			
Austria-Hungary	774	18,224	23.55	391	$9,137	$23.37
Belgium	7	133	19.00	8	209	26.13
Canada	1,974	21,045	10.66	3,348	33,107	9.89
England	101	1,368	13.54	34	d 57	16.38
France	3,941	20,260	5.14	5,466	25,242	5.17
Germany	7	261	37.29	15	1,846	123.07
Italy	4,184	61,640	14.73	4,510	65,163	14.45
Netherlands				2	52	26.00
Total	10,989	122,956	11.19	13,774	138,313	10.04

The production of talc in Canada in 1913 was 12,250 [1] short tons, of which nearly 27 per cent, 3,348 tons, came to the United States, as compared with 1,974 tons imported from Canada in 1912.

The imported talc is chiefly of the higher grades, such as is used for making toilet powder, gas tips, etc., for which purposes the supply in the United States is not equal to the demand.

[1] Preliminary report on the mineral production of Canada during the calendar year of 1913 (subject to revision): Canada Dept. Mines.

PRICES.

The prices depend on the grade of talc, which determines the purpose for which it is used. The average price in the rough as it came from the mine in 1913 was, for the whole United States, $3.77 a ton. Some of it sold in 1913 as low as $3 a ton, while material from the same mine worked up into crayons, pencils, etc., sold at the rate of $339 a ton. Ground pyrophyllite ranged in price from $2 a ton in the rough to $10 a ton ground, which is generally the selling price of New York talc. Lower grades of ground talc sell for $5 a ton; more of it sells for $6 and $7 a ton. The average price for manufactured talc in 1913 was $28.99 a short ton. The prices of imports ranged in 1913 from $123.07 for German talc to $5.17 for French ground talc.

The uses of talc, its modes of occurrence, and its preparation for market were discussed in the report for 1912, and as copies of that report are yet available these matters need not be taken up again at this time.

TALC INDUSTRY BY STATES.

CALIFORNIA.

The sudden expansion of the talc industry in California in 1911 and 1912 encouraged the hope that an important industry was developing on the Pacific coast comparable with that of the Atlantic States. A visit was made to Los Angeles and also to a district just east of the Death Valley region of San Bernardino and Inyo counties, where the activity centered. The Tonopah & Tidewater Railroad, connecting with the San Pedro, Los Angeles & Salt Lake Railroad as well as with the main line of the Santa Fe, affords convenient transportation.

The talc of the region is in general remarkable for its whiteness, its mode of occurrence, and its origin. It has been developed and mined at three localities—Zabriskie and Tecopa in Inyo County, and Riggs in San Bernardino County; but all three are within a region about 40 miles long north and south and 20 miles wide east and west. In the southern portion of the region are a number of other prospects, especially on Sheep Creek, about 20 miles northwest of Silver Lake, and at another point 7 miles east of Riggs. The localities at Sheep Creek, Riggs, and Tecopa were the only ones examined, although that west of Zabriskie was seen at a distance. The occurrence is essentially the same at all points. The similarity of the material is evident from the comparison in the accompanying table of the chemical analysis, No. 1, made of the talc at Sheep Creek and kindly furnished by Mr. H. H. Kerchoff, president of the Avawatz Salt & Gypsum Co., of Los Angeles, with analyses Nos. 2 and 3, made by the United States Geological Survey, of the talc mined near Riggs Station and of a sample kindly furnished by Mr. Frank Riggs, of Silver Lake, from a prospect 7 miles southeast of Riggs. The material of analyses Nos. 1, 2, and 3 is evidently a hydrous silicate of magnesia and compares favorably with the fibrous talc so extensively mined in the Gouverneur region of New York.

Analyses of talc.

	1	2	3	4	5	6	7
SiO_2	60.20	60.88	63.36	62.10	61.51	63.5	57.7
MgO	27.98	28.85	27.60	32.40	30.93	31.7	28.9
CaO	2.60	4.28	3.49	[a] 2.15	3.70	....	13.4
Al_2O_3	1.25	.36	.46	....	.83	....	....
Fe_2O_3	2.50	.10	.09	....	....	....	....
FeO	0	.33	.30	1.30	.12	....	....
H_2O	5.70	4.50	3.92	2.05	2.84	4.8	....
	100.23	99.30	99.22	100.00	99.93	100.0	100.0

[a] MnO.

1. Sheep Creek, 20 miles northwest of Silver Lake, San Bernardino County, Cal. Analyst, R. A. Percy.
2. One mile north of Riggs station, 9 miles north of Silver Lake, San Bernardino County, Cal. Analyst, R. C. Wells, U. S. Geol. Survey.
3. Seven miles southeast of Riggs station, San Bernardino County, Cal. Analyst, R. C. Wells, U. S. Geol. Survey.
4. Fibrous talc near Gouverneur, N. Y. Analyst, E. S. Sperry, Dana's System of mineralogy, 6th ed., p. 679, 1911.
5. Fibrous talc, St. Gothard. Analyst, Scheerer. Dana's System of mineralogy, 6th ed., p. 679, 1911.
6. Theoretical composition of pure talc.
7. Theoretical composition of pure tremolite.

Analysis No. 4 from New York, which contains 2.15 per cent oxide of manganese instead of lime, is probably exceptional. C. H. Smyth has shown the derivation of the New York talc from tremolite schist associated with limestone. As the alteration is rarely complete the commercial talc of New York must generally contain a considerable percentage of lime. The fibrous talc of the Alps (St. Gothard) contains an amount of lime to be expected in talc derived from tremolite. The material of analysis No. 3 is well-marked foliated slippery talc, but thin sections of it show remnants of tremolite partly altered to talc. The material of analysis No. 2 is compact and so fine grained that distinct remnants, if any, of tremolite are not determinable. This material is remarkable for its smooth porcelain aspect on slip and fractured surfaces. It is considerably harder than ordinary talc and has hardened somewhat since its removal from the mine. It contains a small quantity of alumina and is therein similar to the fibrous talc so extensively mined at Gouverneur, N. Y. (analysis No. 4), and to that of the Alps (analysis No. 5).

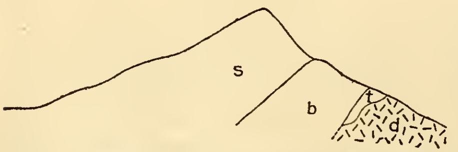

FIGURE 4.—Section of talc deposit 10 miles southeast of Tecopa, Cal. t, Talc, with some limestone, tremolite schist, and serpentine; b, banded, somewhat cherty limestone, 125 feet; s, lighter colored, less ferruginous, and apparently dolomitic limestone; d, diorite.

The mode of occurrence is essentially the same everywhere in the region and may be illustrated by a section of the deposit about 10 miles southeast of Tecopa, at an elevation of 1,000 feet above Tecopa and of 2,500 feet above sea level. (See fig. 4.)

The talc is for the most part very white and lies generally on the contact between diorite and banded limestone on the steep southwest slope of a ridge into which the formations dip. The deposit is irregular and varies somewhat abruptly in thickness from 12 feet or more to a mere film, both vertically and horizontally, but it can be readily traced by the white soil at the surface for a mile to the southeast. Several tunnels have been run into the deposit on the surface, where it has a thickness of about 12 feet. The talc is beautifully white, soft and slippery, and under the microscope finely fibrous; but it needs to be carefully separated from the harder and harsher white accompanying material, which is apparently fibrous tremolite. The deposit has been much squeezed and sheared, developing slickensides like plastic clay, which are generally parallel to the dip. On the side toward the diorite there is much faulting, and masses of tremolite rock are caught in the talc. Nodules of serpentine, and also of calcite and tremolite, from the size of a nut up to sheets a foot in extent, occur in the talc, and they have to be carefully removed. The sheets of calcite are usually bent or crumpled, as in highly crystalline rocks, and many of them have a decided tendency to cross-fiber structure.

This deposit occurs in an arid, treeless country at an altitude of 2,300 feet—about 1,000 feet above the railroad, to which there is a 7-mile wagon haul; and more than 2,000 tons of talc have been removed within the last few years.

The occurrence of talc on Sheep Creek 20 miles northwest of Silver Lake is illustrated in figure 5. The irregularity of the contact

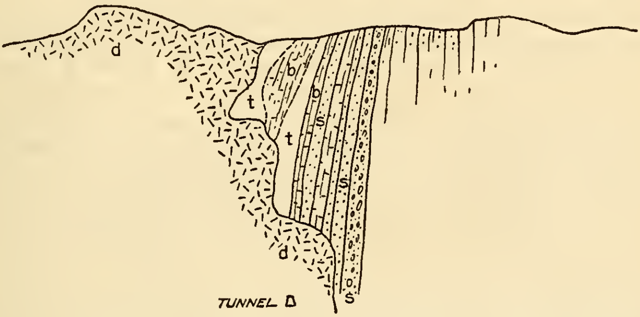

FIGURE 5.—Section of talc deposit and adjacent rocks on Sheep Creek, 20 miles northwest of Silver Lake, Cal. t, Talc; b, banded limestone; s, sedimentary rocks, inlcuding crystalline limestone, quartzite, and hornfels, the result of contact metamorphism; d, diorite.

between the diorite and the sedimentary rocks, as well as the contact metamorphism apparent in the hornfels, indicate that the diorite is later than the sedimentary rocks and may have been a factor in the genesis of the talc, which follows the contact between the diorite and the limestone. Grayish limestone occurs more or less abundantly in the talc—to an irregular thickness of nearly 30 feet. The strike of the deposit is northwest and southeast, and prospects have been opened along the outcrop for half a mile. Other prospects are reported on the same strike 6 miles farther to the northwest. At all the prospects seen the workings run into the talc horizontally. No evidence was seen to prove the continuity of the talc in depth, and the general form of the deposit suggests that it may be limited to near the surface.

The talc deposit near Riggs station on the Tonopah & Tidewater Railroad, 10 miles north of Silver Lake, has been traced northwest and southeast nearly a mile and opened at several points. As elsewhere in the region it lies between limestone and diorite, although there is much red granitic and aplitic intrusive as well as mica schist and other metamorphic rocks near by. This talc body has a thickness of 5 feet and is well banded, as if stratified parallel to the overlying limestone. The best talc is near the bottom, where the material was obtained for analysis No. 2 in the table of analyses. In thin section under the microscope it appears to be made up of fibrous and nonfibrous material, apparently talc and tremolite, a mixture that if chiefly talc would have the composition shown in analyses No. 2. The upper portion of the deposit contains nodules of serpentine, which a thin section shows to be inclosed in the tremolite from which the talc is apparently derived.

The most typical tremolite schist of the region, and very similar indeed to that of the talc region at Gouverneur, N. Y., occurs in a talc prospect 7 miles southeast of Riggs, where it is associated with very slippery foliated talc. A microscopic examination of a thin section of the latter shows clearly remnants of the tremolite from which the talc has been derived. The material from this locality is more decidedly slippery and normally talcose than any other observed in the region. Its derivation from typical tremolite schist suggests that, as in New York, the talc may be expected to persist in depth; but the California deposit has not yet been investigated with reference to depth. Its fibrous character, like that of the New York material, suggests its use in the manufacture of paper.

Talc is used in the manufacture of paper as a filler to produce a softer sheet, to improve the finish of the paper, and to give it a better surface for printing. It is not necessary to have a fibrous talc. "The principal requirements," according to information from the Everett Pulp & Paper Co., of Everett, Wash., are "smoothness, color, and freedom from grit, but of course a fibrous talc combined with the above would be preferable." The chief difficulty in the use of fibrous talc derived from tremolite in the manufacture of paper is the grit it contains. The grit may be lessened if not wholly avoided by a careful selection of material before milling and by including in the milling process properly regulated air-current separation. Complaint has been made also by paper manufacturers that the talc associated with limestone contains too much carbonate of lime, but the carbonate of lime also may be avoided by a careful selection of material at the mine.

The California material is used chiefly in the manufacture of tiles. The production reported for 1913 is less than that for 1912, but whether this was caused by the lack of demand, the high cost of production, or the condition of the deposits is not evident.

The output of talc in California declined 18.56 per cent in quantity in 1913 as compared with 1912. The only other point of production besides those in San Bernardino and Inyo counties is near Lindsay, in Tulare County.

GEORGIA.

Chatsworth, in Murray County, is the center of the talc industry of Georgia. The greater value of its output is in the higher grade of talc used for pencils, crayons, and other forms, although the greater volume of the output is in ground talc. The output decreased in quantity, but increased in value in 1913. As there were only two producers in the State in 1913 the total output can not be given without divulging confidential information.

The talc deposits of Georgia have recently been described by Otto Veatch in Bulletin 23 of the Georgia Geological Survey.

MASSACHUSETTS.

The great talc belt of Vermont extends into Massachusetts and is worked at one point (Franklin County) in the northwest portion of the State. There was only one producer in 1913, but the output of the company increased 14 per cent. The mill burned at Zoar in 1911 has not yet been rebuilt.

NEW JERSEY AND PENNSYLVANIA.

The vicinity of Easton in both Pennsylvania and New Jersey has long been known for its production of mineral pulp verdolite, the various grades of which are made up of several minerals, including talc associated with serpentine. The total production of 3 producers, 2 in Pennsylvania and 1 in New Jersey, in that region in 1913 was 11,308 tons, an increase of 8.73 per cent over the output of 1912. The value of the output increased from $50,519 to $80,780, nearly 60 per cent.

This talc region of Pennsylvania and New Jersey has been fully described by F. B. Peck in recent reports of the geological surveys of the two States, respectively.

Most of the product is ground for paint, plaster, paper, soap, and rubber goods, but some of it is sold in blocks as ornamental stone.

NEW YORK.

New York has been for many years the premier producer of talc in the United States, and that supremacy was maintained in 1913, when it produced nearly 55 per cent of the total output of the United States. It exceeded the production of all the other States combined by 14,139 tons, and it exceeded by practically 10,000 tons its own largest previous annual output, that of 1910. The production in 1913 amounted to 81,705 short tons, valued at $788,500, an increase of 22.19 per cent in quantity and of 20.15 per cent in value as compared with 1912, when the production was 66,867 short tons, valued at $656,270.

There were 5 important producing companies, 4 in the vicinity of Gouverneur and 1 near Natural Bridge. An account of each was given in the report for 1912.

Production and value of the talc of New York, 1880-1913, as compared with that of talc and soapstone in all the other States combined, in short tons.

Year.	New York.			All other States.	
	Quantity.	Value.	Price per ton.	Quantity.	Value.
1880-1900	629,925	$5,933,501	$9.42	340,003	$5,291,151
1901	69,200	483,600	6.99	28,643	424,888
1902	71,100	615,350	8.65	26,854	525,157
1903	60,230	421,600	7.00	26,671	418,460
1904	64,005	507,400	7.93	27,184	433,331
1905	56,500	445,000	7.88	40,134	637,062
1906	61,672	557,200	9.03	58,972	874,356
1907	67,800	626,000	9.23	72,010	905,047
1908	70,739	697,390	9.86	46,615	703,832
1909	48,536	359,957	7.42	81,802	862,002
1910	71,710	728,180	10.15	79,006	864,213
1911	62,030	613,286	9.89	81,521	1,032,732
1912	66,867	656,270	9.81	93,413	1,050,693
1913	81,705	788,500	9.65	94,128	1,119,597
Total	1,482,019	13,433,234	9.06	1,096,956	15,142,521

The most important papers published in the last few years concerning the talc deposits and industry of New York are by D. H. Newland in the New York State Museum Bulletin 161, pages 91–100, July 1, 1912, and by P. B. McDonald, in the Engineering and Mining Journal, April 5, 1913.

NORTH CAROLINA.

The total production of talc and pyrophyllite in North Carolina in 1913 was 4,576 short tons, valued at $48,317, an increase of 31.04 per cent in quantity and a decrease of 23.31 per cent in value, as compared with 1912. There was one producer of talc in Swain County and one in Jackson County, with two producers of pyrophyllite in Moore County; hence the production can not be stated separately without publishing confidential information.

North Carolina contains some high-grade talc for pencils, crayons, and gas tips, competing with that from Georgia. It is, however, the only State producing pyrophyllite. An article on the pyrophyllite of North Carolina by Claud Hafer appeared in the Engineering and Mining Journal for October 4, 1913.

VERMONT.

Vermont produces both talc and soapstone, but the output of the latter was relatively small. In 1913 its production of talc was 44,447 short tons, valued at $302,375, a decided gain over the output of 1912. There were six points of production, three of them operated by one company, the State ranking second in the United States in the production of talc. The new mill at Stockbridge and 4 miles of railroad were completed during 1913 and will contribute largely to increase the output of the State.

VIRGINIA.

Virginia, like Vermont, produces both talc and soapstone, but in this case the production of talc is relatively small. There are four producers of talc, whose output was 2,974 short tons, valued at $18,632. The production was 281 tons less than in 1912, but its value was $1,446 greater, owing to the fact that a new company began the production at Verdierville of a grade of talc that is used in the manufacture of pencils and gas tips. All the talc producers are in the northern portion of the State.

SOAPSTONE.

PRODUCTION.

The production of soapstone in the United States in 1912 and 1913 was not only greater than that of any other country but greater than that of all other countries combined. The total production of soapstone in the United States in 1913 was 26,562 short tons, valued at $628,077, a decided gain both in quantity and in value as compared with the production of 1912. There were five producing States, Maryland, North Carolina, Rhode Island, Vermont, and Virginia, but the output of Virginia exceeded by far the combined output of all the other States. Furthermore, the resources of Virginia are such that its large production may be expected to continue long.

As shown in the following table the total production of soapstone in Maryland, North Carolina, Rhode Island, and Vermont was 3,049 short tons, valued at $31,151, a decrease of 22.3 per cent in quantity and of nearly 38 per cent in value as compared with their output in 1912. On the other hand, the output of Virginia increased nearly 7 per cent in both quantity and value.

There is 1 producer in each of the three States, Maryland, North Carolina, and Rhode Island; 2 in Vermont; and 6 in Virginia—all 6 in essentially the same belt stretching northeast through Nelson, Albermarle, and Orange counties, a distance of nearly 75 miles. The talc producers of Virginia lie farther northeast. One company west of Fredericksburg produces both talc and soapstone, a combination that should enable the company to use nearly all the quarry products advantageously.

Talc and soapstone in Virginia is the subject of an article in The Tradesman for April 10, 1913, by Thomas L. Watson. It gives details of the distribution and points of production of soapstone in Virginia.

Marketed production of soapstone in 1912 and 1913, by States, in short tons.

State.	1912		1913	
	Quantity.	Value.	Quantity.	Value.
Maryland North Carolina Rhode Island Vermont	3,923	$50,193	3,049	$31,151
Virginia	22,058	559,287	23,513	596,926
Total	25,981	609,480	26,562	628,077

PRICES.

The prices of soapstone vary greatly, not only with the form in which it is sold, but also with the size and quality of the stone which determine the purpose to which it can be applied.

In the rough, as quarried, soapstone is reported as valued at $2 a ton; when sawed into slabs its value is increased to more than $15 a ton; and when manufactured into laundry tubs its average value is about $30 a ton.

BARYTES.

By James M. Hill.

PRODUCTION.

The production of crude barytes in the United States in 1913 was 45,298 short tons, valued at $156,275. Compared with the production of the preceding year, which was 37,478 short tons, valued at $153,313, this was an increase of 7,820 tons in quantity and of $2,962 in value.

The average price per ton was $3.19 in 1911, $4.09 in 1912, and $3.45 in 1913. The price given is that paid to the miner for his crude ore, hand cobbed, sorted, and ready for shipment to the mills. This price is not supposed to include the cost of haulage by wagon, boat, or railway, and it is believed that the cost of haulage is not included in the values reported. The price of the crude material f. o. b. mines reported by most of the principal producers in 1913 was lower than in 1912. The average price for the State of Missouri was $3.78 a ton, which was substantially the average price in Washington County, Mo., the principal producing county in the State.

At the close of 1913, 9,181 short tons of crude domestic barytes remained unsold at the mines, according to reports from the producing districts, as compared with 7,606 tons in 1912. From Missouri 60 producers reported an output of crude barytes, but the production of most of them was small. There were 4 producers in Tennessee, 2 producers each in North Carolina and Virginia, and 1 producer each in Georgia and South Carolina.

The total quantity of refined barytes reported as sold by mills in 1913 was 37,033 short tons, valued at $525,300. As compared with the production in 1912, which was 38,225 short tons, valued at $495,895, this was a decrease of 1,192 tons in quantity, but an increase of $29,405 in value. The average price per ton reported as received for refined barytes was $12.72 in 1911, $12.97 in 1912, and $14.18 in 1913.

At the close of 1913 there were 3,380 tons of refined barytes still in the hands of the various refiners. Six firms reported production of refined barytes, their plants being located in Missouri, North Carolina, South Carolina, Tennessee, and Virginia.

The following table shows the production, total value, and average price per ton of crude barytes mined in the United States from 1911 to 1913, inclusive:

Production of crude barytes in the United States, 1911–1913, by States, in short tons.

State.	1911			1912			1913		
	Quantity.	Value.	Average price per ton.	Quantity.	Value.	Average price per ton.	Quantity.	Value.	Average price per ton.
Missouri	21,500	$81,380	$3.79	24,530	$117,035	$4.77	31,131	$117,638	$3.78
Tennessee and Kentucky	8,819	20,053	2.27	[a] 3,718	8,682	2.34	[a] 2,098	3,568	1.70
Other States [b]	8,126	21,359	2.63	9,230	27,596	2.99	12,069	35,069	2.91
Total	38,445	122,792	3.19	37,478	153,313	4.09	45,298	156,275	3.45

[a] Production of Tennessee; no production of barytes reported for Kentucky in 1912 and 1913.
[b] Includes, 1911: Georgia, North Carolina, South Carolina, and Virginia; 1912: Georgia, North Carolina and Virginia; 1913: Georgia, North Carolina, South Carolina, and Virginia.

The following table gives the domestic production of crude barytes in short tons from 1883 to 1913, inclusive:

Production of crude barytes, 1883–1913.

Year	Short tons.	Year	Short tons.	Year	Short tons.
1883	30,240	1894	23,335	1905	48,235
1884	28,000	1895	21,529	1906	50,231
1885	16,800	1896	17,068	1907	89,621
1886	11,200	1897	26,042	1908	38,527
1887	16,800	1898	31,306	1909	61,945
1888	22,400	1899	41,894	1910	42,975
1889	21,460	1900	67,680	1911	38,445
1890	21,911	1901	49,070	1912	37,478
1891	31,069	1902	61,668	1913	45,298
1892	32,108	1903	50,397		
1893	28,970	1904	65,727		

IMPORTS.

The imports of barytes for consumption during the last five years and the value of imported barium compounds, from 1909 to 1913, are given in the following two tables:

Barytes imported and entered for consumption in the United States, 1909–1913, in short tons.

Year.	Manufactured.		Unmanufactured.	
	Quantity.	Value.	Quantity.	Value.
1909	3,016	$25,679	11,647	$29,028
1910	3,565	29,782	21,270	48,457
1911	3,147	22,083	20,214	36,643
1912	3,679	26,848	26,186	52,467
1913	5,463	38,155	35,840	61,409

Under the Payne-Aldrich tariff natural barytes was dutiable at $1.50 a ton, and blanc-fixe was admitted under a duty of one-half cent a pound. Under the present tariff of October 3, 1913, natural barytes is dutiable at 15 per cent ad valorem and manufactured barium sulphate, including blanc-fixe and satin white ($CaSO_4$), is dutiable at 20 per cent ad valorem.

Value of the imports of barium compounds, 1909–1913.

Barium compounds.		1909	1910	1911	1912	1913
Barium carbonate	natural	$31,584	$25,229	$27,351	$15,777	$13,116
	manufactured				9,938	38,949
Barium binoxide		255,013	341,631	270,917	252,320	239,000
Barium chloride		47,352	35,614	28,896	27,655	37,620
Blanc-fixe, or artificial barium sulphate		65,427	67,975	71,049	70,327	62,785
Total		399,376	470,449	398,213	376,017	391,470

The imports of barium chemicals or compounds were greater in 1913 than in 1912. Witherite, the mineral form of barium carbonate, was admitted free of duty under the Payne-Aldrich tariff and has so continued under the Underwood tariff. On manufactured barium carbonate there was a duty of 25 per cent ad valorem, amounting to about $4.37 per ton in 1912, but under the Underwood tariff it is dutiable at 15 per cent ad valorem. Barium binoxide is dutiable at 1½ cents per pound and barium chloride at one-fourth cent a pound under the present law.

In 1912 the Bureau of Foreign and Domestic Commerce, Department of Commerce, first attempted to separate the imports of natural and manufactured barium carbonate. It is thought that much manufactured barium carbonate was imported "duty free" prior to 1912 under the supposition that it was ground natural barium carbonate, witherite. In the table the imports of natural and manufactured barium carbonate have been separated for 1912 and 1913 since it appears that it is now possible to do so safely.

BARYTES IN CANADA.

PRODUCTION.

The following table gives the production of barytes in Canada in 1912 and 1913, the figures for 1913 being subject to revision:

Production of barytes in Canada, 1912–13, in short tons.

Year.	Quantity.	Value.
1912	464	$5,104
1913	641	6,410

OCCURRENCE OF BARYTES IN CANADA.

The entire production of barytes in Canada for 1913 was reported from the deposits at Lake Ainslie, Nova Scotia, which have been worked since 1890. The barite is found in veins, cutting pre-Cambrian felsites, which, though showing many irregularities in size, are fairly persistent, varying from 7 to 14 feet in width.[1]

Other commercial deposits in northeastern Nova Scotia are known at North Cheticamp, Inverness County; at Five Islands and Stewacke, Colchester County; and near River John, Pictou County. Barite deposits are known also in Hull township, Quebec; in Bathurst, North Burgess, McNab, Drummer, Galway, and Summerville townships, Ontario; and on Jarvis, McKellars, and Pie Islands in Lake Superior.

[1] Economic minerals and mining industry of Canada: Canada Dept. Mines, Mines Branch, p. 50, 1914.

CHARACTER OF BARYTES.

Barytes, or heavy spar ($BaSO_4$), is composed of 65.7 per cent barium oxide (BaO) and 34.3 per cent of sulphur trioxide (SO_3). The specific gravity of the mineral ranges from 4.3 to 4.6; its hardness varies from 2.5 to 3.5. It is usually a white opaque to translucent crystalline mineral about as hard as calcite, but it differs from calcite in its greater specific gravity and in the fact that it is perfectly inert when treated with acids. Some barytes is stained reddish pink or yellow by iron oxide. In its common form it is an aggregate of straight or slightly curved cleavable plates, but it occurs also in granular, fibrous, and earthy masses, and in the form of stalactites, as well as in single and clustered crystals. Natural barytes is rarely pure, its most common impurities being silica, lime, magnesia, and the oxides of iron and aluminum. Fine particles of galena are disseminated through many of the deposits in the United States. The commercial grades of the mineral as mined carry 95 to 98 per cent barium sulphate and 1 to 3 per cent of silica.

USES OF BARYTES.

Barytes is used principally as a pigment in mixed paints, in the manufacture of lithopone—a chemically prepared white pigment consisting of zinc sulphide and barium sulphate—and as a base in the manufacture of lake pigments. It is also used in the manufacture of white rubber goods, but it is said that lithopone has lately replaced barytes to some extent for this use. Wall-paper manufacturers are said to use some barytes for giving weight to their products. Barytes is used in the manufacture of asbestos cement, artificial ivory, and in the preparation of fertilizers, boiler compounds, insecticides, peroxide of hydrogen, and artificial driftwood salts. Barium carbonate and some barium chloride are used to prevent efflorescence on bricks. According to Heinrich Ries,[1] the efflorescence is due to soluble salts, especially sulphates, which on evaporation leave a white coating on the surface of the bricks. To prevent the formation of these salts a quantity of barium carbonate or chloride is added to the clay mixture which forms with sulphuric acid the practically insoluble barium sulphate. According to the United States consul at Chemnitz, Germany,[2] barium hydrate, which is considered to be a most satisfactory reagent in the refining of sugar, can probably be more widely used than heretofore owing to a recent German patent, No. 149803, secured by W. Feld for the regeneration of caustic barytes from the barium carbonate which is formed in the refining process.

Barium carbonate, sulphate, or nitrate is used in the manufacture of some glass. The barium oxide is said[3] to increase the specific gravity, refractive index, elasticity, and tenacity, and to impart an attractive surface to glass. It, however, makes the melt harder to work. Barium finds its chief application in rolled glass, hollow ware, crystal and table glass, and in special glasses such as the Jena phosphate crown glass, which contains 28 per cent BaO and 60 per cent P_2O_5.

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[1] Ries, Heinrich, Clay industry of New York: New York State Mus. Bull. 37, vol. 7, pp. 679–686, 1900.
[2] Norton, Thomas H., Barium hydrate in sugar refining: Daily Cons. and Trade Repts., Nov. 4, 1913, p. 639.
[3] Spirgen, L., Some of the uncommon constituents of glass: Eng. and Min. Jour., Jan. 17, 1914.

OCCURRENCE OF BARYTES IN THE UNITED STATES.

Barytes occurs in veins as a gangue of metallic ores and also in veins in sandstone and limestone, or as a replacement of limestone. Differential weathering of the limestone and the barytes has produced deposits of the mineral embedded in residual clay. The mineral has a wide range in geologic age and in geographic distribution, but in the United States the principal sources of supply are the Missouri and the Appalachian districts. In 1913 the Missouri district furnished between 68 and 69 per cent of the total production of the United States. Almost the entire output of Missouri came from Cole, Franklin, Jefferson, Miller, Morgan, St. Francois, and Washington counties, the county last named producing more than 78 per cent of the entire output reported for the State. Among the Appalachian States, Georgia, North Carolina, Tennessee, South Carolina, and Virginia, named in the order of production, reported an output of crude barytes in 1913. The Kentucky fields remained idle during 1913.

As many inquiries are received by the Survey relative to the occurrence of barytes, it is thought best to include in this report brief notes on the more important barytes deposits of the United States and references to a few undeveloped occurrences. The more important districts are shown on the accompanying map, figure 6.

The Survey has not made a detailed study of the various barytes-producing districts, although a number of them have been visited incidentally to other work.

Alabama.—So far as known, no barytes has been produced from Alabama mines since 1906. There are some deposits which probably could be worked in Calhoun, Etowah, and St. Clair counties, in the northeastern part of the State, and in Bibb County, near the center. The residual deposits so far worked are associated with the Chickamauga ("Pelham") limestone, of Ordovician age, and the Knox dolomite, of Cambrian and Ordovician age. They seem to be localized along lines of folding and faulting of the rocks, particularly along the eastern side of the Appalachian fold. The barytes probably occurred originally as veins and replacements along fissured or fractured dolomite. Solution of the dolomite has left the insoluble barium sulphate in nodules and bowlders in the residual clay.

Georgia.—Within a radius of about 15 miles centered about Cartersville, Bartow County, Ga., considerable iron ore, ocher, and barite are mined from residual clays derived from Cambrian and Ordovician rocks. The deposits are on the eastern side of the Appalachian fold, where the sedimentary beds are fractured and fissured, and is a northward continuation of the Alabama field. The barite deposits are most closely associated with the Weisner quartzite and Beaver limestone, though some barite has been found with the Knox dolomite. Barytes, ocher, and iron ore are found in the same pits, and are usually found near the contact of the quartzite and limestone. The iron-bearing materials are most often found near the contact, while the barite is usually some distance from the contact, particularly in deposits on hillsides.

Kentucky.—In Kentucky barite deposits are known in the central (Blue Grass) and western portions of the State. Barite has been mined in Boyle, Fayette, and Garrard counties south of Lexington, though deposits are known in 13 counties centered about the capital. In this region the deposits are associated with Ordovician sediments, particularly in the limestones of Stones River and Trenton age and in the Eden shale. The barite occurs in strong though some-

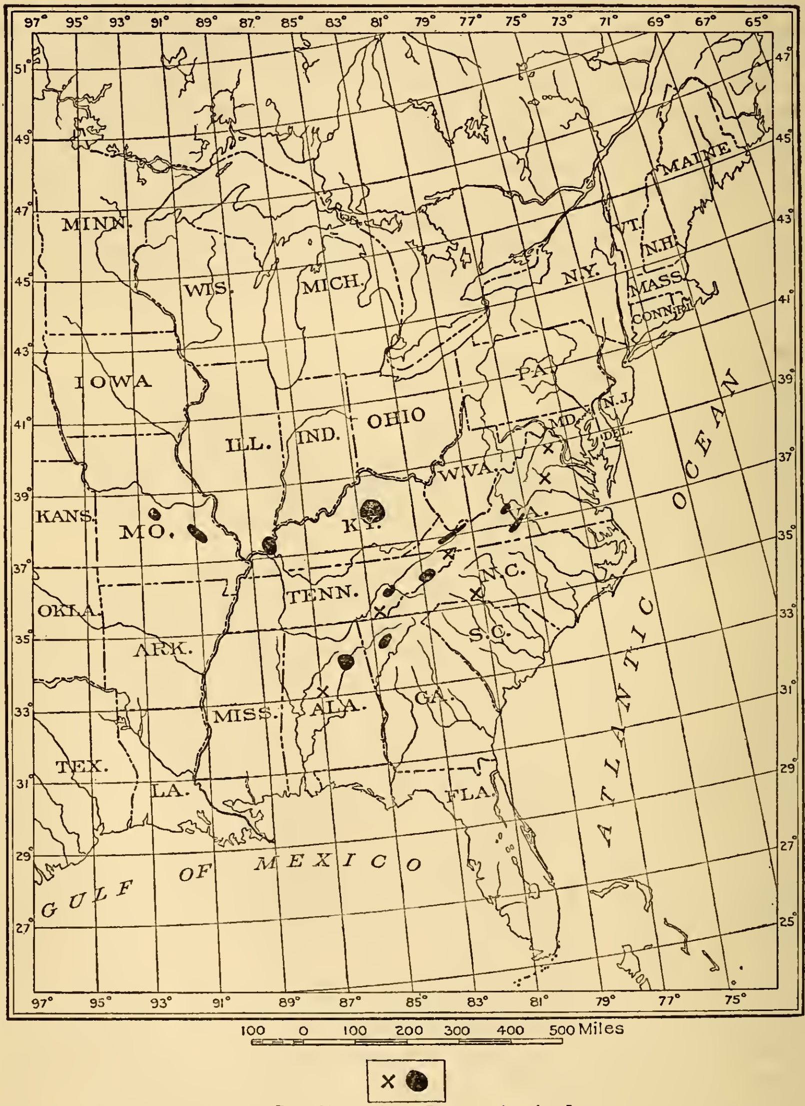

FIGURE 6.—Map of the eastern United States, showing the localities from which barytes has been produced.

what irregular veins inclined to the bedding of the formations, which are apt to become lean and barren of barite in the argillaceous beds, but are of good grade in the limestone layers. Some fluorite, galena, and sphalerite are associated with the barite.

In the western counties of Kentucky lying east of Tennessee River fluorite, barite, and lead and zinc deposits are found in faulted and somewhat folded Carboniferous limestone. The faults strike northeast, northwest, and east, though a few unimportant breaks have a northerly direction. Peridotite dikes cut the rocks and are believed to have been closely associated with the formations of the vein deposits. Barite is not particularly abundant, and most of the deposits have been worked for the metallic minerals or fluorite.

Missouri.—The greater part of the barytes produced in the United States is obtained from deposits in Washington, St. Francois, Franklin, and Jefferson counties of east central Missouri, and from Cole, Morgan, and Miller counties in the center of the State. The deposits are all in an area of Cambrian and Ordovician sediments lying to the northwest of the Ozark uplift. The barytes occur with chert in residual clays derived from the weathering of the dolomitic limestone of the Gasconade formation of Upper Cambrian age, or in the Bonneterre limestone, also of Upper Cambrian age, and as fissure fillings in the formations associated with quartz, pyrite, and galena. Practically all the barytes, locally known as "tiff," is mined from shallow shafts and open cuts in the residual clay by farmers or other people during periods of inactivity of other industries. The barytes is usually sold to local dealers and may pass through the hands of several middlemen before it reaches the refiners.

Tennessee.—Two districts in eastern Tennessee contain important deposits of barite. The French Broad district on the North Carolina line, south and a little east of Knoxville, includes parts of Cocke and Sevier counties. Owing to lack of transportation the veins in this region have not been extensively worked. In the Sweetwater district, including parts of Loudon, McMinn, and Monroe counties centering about Sweetwater, there has been extensive development and a considerable production of barytes in the past. The deposits are of the residual type, that is, pebbles and bowlders are found in the clay and sand derived from the weathering of folded and faulted rocks ranging in age from Cambrian to Ordovician. Most of the workable deposits are associated with the Knox dolomite.

Virginia.—In Virginia barytes occurs in three unlike areas: In the red sandstone-shale series of the Triassic; in the old crystalline metamorphic rocks, particularly in the Piedmont crystalline limestone area; and in the Valley region of faulted and folded Cambrian and Ordovician limestones. The deposits occur as veins and replacements in the limestone, though much of the barytes produced has been taken from residual clays derived from the weathering of the limestones.

The deposits in the Triassic red sandstones of Prince William County in the northeastern part of the State are of little importance at present, though they have been intermittently worked since 1845. The barite occurs as a filling or cement of brecciated impure limestones and red shales. The barite deposits of Bedford, Campbell, and Pittsylvania counties, in the south central part of the State centered about Evington and Toshes, are in highly altered crystalline rocks formed from old sedimentary and igneous rocks. Barite has been found associated with similar rocks in six other counties in the Piedmont region, but has not been mined to any considerable extent. The barite is found as irregular lenslike replacements of the crystalline limestone associated with the schists and gneisses and as lumps in the residual clay, which is often limonitic or manganiferous and has been used in the manufacture of natural mineral pigments.

In southwestern Virginia, in Tazewell, Wythe, Russell, and Smyth counties, barite occurs in the Cambrian and Ordovician limestones or their residual clay. The Knox dolomite and Chickamauga limestone are probably the chief sources of the barite. In the limestone it occurs as replacements and veins associated with sphalerite, galena, and some fluorite.

Other States.—Deposits of barytes are known in Mariposa County in California, in Clark, Elko, Mineral, and Nye counties in Nevada, in Blaine County in Idaho, and in Alaska. Most of the deposits in the Western States are undeveloped, as there has apparently been a limited market for this material in that region. It is, however, possible that the paint grinders on the Pacific coast could use a limited supply of the material.

About 10 miles northwest of Hailey, Idaho, at the head of the north fork of Deer Creek, there is an outcrop of white banded barite, apparently conformably bedded with sandstones and quartzites of Pennsylvanian age. It is said to be 50 feet thick and to have been followed for 1,000 feet.[1]

During 1913 E. F. Burchard, of the United States Geological Survey, discovered a considerable deposit of barite associated with quartzite schists, on Castle Island, in the Duncan Canal, 40 miles northwest of Wrangell in southeastern Alaska. The following notes are taken from his manuscript, which will be published during the year as part of "Mineral Resources of Alaska in 1913."

The barite outcrops as a roughly elliptical mass 75 feet wide by 250 feet long, and is exposed 35 feet above high-tide level on the second island of the group, beginning at the southeast. The barite is finely crystalline, grayish in color, and clouded and streaked with bluish-gray to black material that may be galena or sphalerite. Pyrite and magnetite are disseminated throughout the mass. The powdered material is grayish white in color, but can be cleaned by washing with weak sulphuric acid. Some of the material was submitted to chemical analysis, which showed that it contained about 89.16 per cent of barium sulphate and 5.05 per cent of silica, and that about 2.66 per cent of the remainder was metallic sulphides.

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[1] Personal letter from L. G. Westgate, of the U. S. Geol. Survey.

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STRONTIUM.

By James M. Hill.

During 1913 no strontium was reported as mined in the United States, though strontium-bearing deposits are not unknown in this country. There is, however, a narrowly limited market for strontium compounds, as is shown by the import figures.

No strontium carbonate, oxide, or protoxide was imported in either 1911 or 1912, but in 1913 the total value of imports of these salts was $2,284. Probably some strontium nitrate was imported for use in "red fire," but it is not possible to obtain figures of the imports of any salts of strontia except those named above.

SILICA (QUARTZ).

By Frank J. Katz.

INTRODUCTION.

Silica, the oxide of silicon (SiO_2), heretofore treated in these reports under the heading "Quartz," is the most abundant of mineral substances. Its occurrences of commercial importance are in a great many different forms, such as vein quartz, as a constituent of pegmatites, as sand, sandstone, quartzite, or flint, as tripoli, and as diatomaceous (infusorial) earth. In some forms, such as rose, smoky, and amethystine quartz, it has a gem value. This chapter deals with silica from all sources exclusive of gem quartz, of all forms of silica used for making glass, and also of all silica used in the form of sand, gravel, and crushed material for building, for concrete and mortar, for foundry and furance work, and for cutting and grinding stone. Silica for such purposes is either gem material or sand, and it is commercially so designated. Such materials as are here excluded are separately considered in other chapters of Mineral Resources. Tripoli and diatomaceous (infusorial) earth have heretofore been dealt with as abrasive materials, and as they are to a large extent consumed as abrasives they are also treated in the chapter on abrasive materials.

USES.

Silica (quartz) as treated in this chapter is used for many purposes. The principal uses are in the manufacture of pottery, paints, scouring soaps, as a wood filler, and as a polisher. In pottery the use of silica, generally called flint in the pottery industry, diminishes the shrinkage in the body of the ware; it is also used in many glazes. Silica for use in pottery should contain less than 0.5 per cent of iron-bearing minerals. Considerable quantities of very finely ground silica are used in the manufacture of paint, as much as one-third of the total pigment used in some paints being this material. Finely ground crystalline material is superior to a natural silica sand for this purpose because of the angularity of the grains, which makes them adhere more firmly to the painted surface and after wear affords a good surface for repainting. The same property renders artificially comminuted crystalline quartz superior to natural sands in the manufacture of wood fillers. For soaps and polishing powders ground material is preferred to natural sands on account of its whiteness and angularity. For all these purposes large quantities of pure quartz sands and sandstones are finely ground and yield a product fully equal to that derived by grinding massive crystalline quartz.

The material known commercially in the United States as tripoli, which is the siliceous residue of decomposition of limestones, also yields an excellent grade of pulverized silica, which is used for the same purposes as silica powder obtained from massive crystalline quartz and from sands and sandstones. Diatomaceous (infusorial) earth is also used to make polishing powder for purposes similar to those for which quartz, sand, and tripoli powders are used, but the diatomaceous earth has somewhat different properties and finds for the most part different application.

Quartz crushed and graded to various sizes is used in the manufacture of sandpaper and sand belts, as a scouring agent, and for "frosting" glass with sand-blast apparatus, etc. Blocks of massive quartz and quartzite are used in the chemical industry as a filler for acid towers and as a flux in copper smelting. Ground quartz is also used in filters and in tooth powders and by dentists as a detergent.

Crystalline quartz and also sand have been used in the manufacture of silicon and of alloys of silicon with iron, copper, and other metals in the electric furnace. Quartz may be fused in the electric furnace to make chemical apparatus, such as tubes, crucibles, dishes, etc.

PRODUCTION.

The marketed production of silica in 1913 for the uses considered in this chapter, as reported to the United States Geological Survey, was 232,192 short tons, valued at $953,832. In the preparation of this report on silica in 1913 the attempt was made for the first time to collect statistics of production of silica of all kinds used as outlined above. Sources were considered that were not known when previous reports were compiled. It is not certain that the inquiries upon which this report is based reached all producers, nor that the returns were complete. But it is believed that the measure of incompleteness is well under 10 per cent of the actual total production. The author hopes that by the time the report for 1914 is in preparation he will have discovered all sources of silica and have secured complete returns from all producers. Although the total production is given without any great assurance of accuracy, it is offered as the best approximation that can at present be made. In the following sections silica from various sources is separately considered, and the reliability of the figures in each section is indicated.

Marketed production of silica for pottery, paints, fillers, polishers, abrasives, and other uses in 1913, in short tons.

Material.	Quantity.	Value.
Quartz (vein quartz,[a] pegmatite, and quartzite)	97,902	$201,488
Sand and sandstone [a]	106,857	466,523
Tripoli	20,831	216,517
Diatomaceous earth	6,602	69,304
Flint		
Total	232,192	953,832

[a] Includes only finely ground material. Figures probably incomplete.

QUARTZ.

PRODUCTION.

The marketed production of silica from vein and pegmatite quartz and from pegmatite in 1913 was 97,902 short tons, valued at $201,488 against 97,874 short tons, valued at $191,685 in 1912. This was an almost inappreciable increase in quantity and an increase of $9,803, or about 5 per cent, in value. The decrease in the quantity sold crude was 7,876 short tons, or about 11 per cent, with a decrease in value of $12,814, or about 24 per cent, whereas the quartz sold ground increased 8,057 short tons, or about 34 per cent, in quantity and $22,617, or about 15 per cent, in value. The average price per ton for crude in 1911 was 91 cents; in 1912 it was 82 cents, and in 1913 it was 73 cents. The average price per ton for ground quartz in 1911 was $8.32, in 1912 it was $7.94, and in 1913 it was $6.23. In 1913, of the total marketed output, 75.76 per cent was crude and 24.24 per cent was ground, and of the total value received, 27.02 per cent was for crude and 72.98 per cent was for ground. The figures of the production of quartz for 1913 and previous years are based on complete returns from all known producers.

The following tables show the marketed production of quartz in 1912 and 1913 classified as to crude and ground, by States, and from 1909 to 1913 classified as to crude and ground:

Marketed production of quartz in the United States, 1912–1913, by States, in short tons.

1912.

State.	Crude.		Ground.		Total.	
	Quantity.	Value.	Quantity.	Value.	Quantity.	Value.
Connecticut, Massachusetts, and New York	5,802	$10,701	61	$1,758	5,863	$12,459
Maryland	10,130	15,369	5,995	46,782	16,125	62,151
North Carolina, Pennsylvania, and Tennessee	66,049	40,486	1,200	7,800	67,249	48,286
Other States [a]	224	700	8,413	68,089	8,637	68,789
Total	82,205	67,256	15,669	124,429	97,874	191,685

1913.

State.	Crude.		Ground.		Total.	
	Quantity.	Value.	Quantity.	Value.	Quantity.	Value.
Connecticut, Massachusetts, and New York	8,153	18,711	1,190	20,674	9,343	39,385
Maryland	194	565	7,664	54,877	7,858	55,442
North Carolina, Pennsylvania, and Tenessee	65,829	35,166	1,210	7,260	67,039	42,426
Other States [b]	....	....	13,662	64,235	13,662	64,235
Total	74,176	54,442	23,726	147,046	97,902	201,488

[a] Includes Arizona, California, Michigan, and Wisconsin.
[b] Includes Arizona, Michigan, and Wisconsin.

Marketed production of quartz in the United States, 1909–1913, in short tons.

Years.	Crude.		Ground.		Total.	
	Quantity.	Value.	Quantity.	Value.	Quantity.	Value.
1909	121,459	$131,334	14,010	$118,132	135,469	$249,466
1910	49,886	80,984	13,691	112,773	63,577	193,757
1911	77,759	70,430	10,184	84,692	87,943	155,122
1912	82,205	67,256	15,669	124,429	97,874	191,685
1913	74,176	54,442	23,726	147,046	97,902	201,488

QUARTZ INDUSTRY BY STATES.

Arizona.—In Arizona only one firm reported production in 1913. The material was ground and was used for reverberatory bottoms. The production was many times larger than in 1912.

California.—No production of quartz from California was reported for 1913.

Connecticut.—Only one operator, the Bridgeport Wood Finishing Co., reported production of quartz in Connecticut in 1913. The material was derived from quartz veins and was used for soap, pottery, paint, and wood filler.

Maryland.—Maryland was second in output and first in value of quartz in 1913, reporting 7,858 short tons, valued at $55,442. This was a decrease of about 51 per cent in quantity and about 10 per cent in value as compared with 1912. There was very little quartz sold crude in 1913 against large sales of crude in 1912. On the other hand, over 30 per cent more was sold ground in 1913 than in 1912. There were 5 producers in Maryland in 1913—the Indian Rock Flint Co., at Castleton, the Husband Flint & Milling Co. at, Deercreek, and H. Clay Whiteford & Co., at Conowingo, in Harford County; the Maryland Flint Co., Glen Morris, Baltimore County; and Thomas & Son, at Marriottsville, Carroll County. The product was all derived from quartz veins, and was used for pottery, paint, soap, and scouring powder, and for chemical purposes.

Massachusetts.—The Enos Adams Co., with quarry and mill at Cheshire, Berkshire County, was the only Massachusetts producer of quartz for the purposes mentioned in this chapter. Part of the product of this company was ground and sold for use as abrasives; the remainder was used for building purposes, facing cement blocks, etc. The material quarried is a very pure quartzite.

Michigan.—In Michigan the only producer, as in previous years, was the Michigan Quartz Co., with mine and mill at Ishpeming and another mill at Milwaukee, Wis. Its product is derived from vein quartz and is used for paint and wood filler chiefly, and also for polisher.

New York.—P. H. Kinkel's Sons, at Bedford, Westchester County, N. Y., were the only producers in New York in 1913. The production in 1913 was much larger than in 1912. Quartz is derived from pegmatite and is used for sandpaper, paint, and wood filler.

North Carolina.—The only producer of quartz in North Carolina in 1913 was F. Oliver, of Charlotte, who quarried quartzite at Mount Holly, Gaston County. The output was used for packing acid towers.

Pennsylvania.—Two operators reported production of quartz in Pennsylvania in 1913, the Columbia Flint Co., with quarry near Bendersville, Adams County, and H. T. A. Rhodewalt, with quarry at Comog station, Chester County. The output was less than in 1912.

Tennessee.—In 1913 Tennessee produced more quartz than all the other States combined, but the output was of comparatively low grade and of small value. The Tennessee Copper Co. was the only producer and reported a larger production than in 1912. The product was quarried from quartzite and was used as flux in copper smelting

Wisconsin.—The Wausau Quartz Co. was the only producer in Wisconsin in 1913. This company quarries a very pure quartzite in the town of Fleith, Marathon County, and mills the product in Wausau. It is used for filter beds, for roofing and concrete work, for chicken grits, and for sandpaper.

PRODUCTION IN PRINCIPAL COUNTRIES.

The production of quartz in the United States and other countries for the years 1909 to 1913, inclusive, is given in the following table:

Production of quartz in the principal producing countries, 1909–1913, in short tons.

Country.	1909 [a]		1910 [a]	
	Quantity.	Value.	Quantity.	Value.
United States	135,469	$249,466	63,577	$193,757
Canada	56,924	71,284	88,205	91,947
Germany (Saxony)	....	[b] 10	....	....
Italy	[c] 34,976	[c] 43,832	[c] 29,872	[c] 40,057
Madagascar [f]	....	....	175	11,811
Sweden	11,317	14,449	13,801	15,607

Country.	1911 [a]		1912		1913	
	Quantity.	Value.	Quantity.	Value.	Quantity.	Value.
United States	87,943	$155,122	97,874	$191,685	97,902	$201,488
Canada	61,496	83,864	[d] 100,242	[d] 195,216	[d] 78,261	[d] 169,842
Germany (Saxony)	....	58	([e])	([e])	([e])	([e])
Italy	[c] 39,417	[c] 44,585	[c] 37,416	[c] 44,079	([e])	([e])
Madagascar [f]	43	4,949	([e])	([e])	([e])	([e])
Sweden	27,477	37,711	([e])	([e])	([e])	([e])

[a] Mines and Quarries; General report with statistics, pt. 4, London, except Italy, which is credited to Rivista del Servizio minerario, Rome.
[b] Includes mica and molybdenite.
[c] Includes feldspar.
[d] The mineral production of Canada, Dept. of Mines, Ottawa, 1914.
[e] Statistics not available.
[f] Includes rock crystal.

FLINT OR CHERT.

PRODUCTION.

So far as can be learned no flint (proper) or chert was produced for consumption as silica or for use as pebbles in grinding mills in the United States in 1913.

IMPORTS.

The imports for consumption of flint pebbles into the United States in 1913 were valued at $319,509, as compared with $292,052 in 1912, $236,158 in 1911, $307,286 in 1910, and $301,547 in 1909:

The following table shows the value of imports of flint pebbles in 1913 by country of origin:

Imports of flint pebbles, unground, into the United States, 1913, by countries.

Belgium	$40,947	Germany	$2
Canada	8,599	Newfoundland	10,800
Denmark	134,625	Sweden	56
England	2,626		
France	121,854	Total	319,509

SAND AND SANDSTONE.

Under this heading are presented statistics only of that part of the sand and sandstone production which is finely crushed or ground for the uses previously enumerated in this chapter. Reports of such production in 1913 were made to the Survey by producers in Illinois, Ohio, Pennsylvania, and West Virginia. The data secured indicate a total production of 106,857 short tons, valued at $466,523, but it is not certain that reports were obtained from all producers. Prices per ton ranged from $3.25 to $5.25. The following table summarizes quantity and value of ground sand and sandstone produced in 1913:

Marketed production of ground sand and sandstone in the United States in 1913, by States, in short tons.

State.	Quantity.	Value.
Illinois	38,755	$135,813
Ohio, Pennsylvania, and West Virginia	68,102	330,710
Total	106,857	466,523

TRIPOLI.

The material commercially called tripoli in the United States is a residue from siliceous limestones which have been leached of their carbonate content. This material is nearly pure silica of very fine grain and may be either coherent or pulverulent. Tripoli is also used as an abrasive material and is therefore included in the chapter on abrasive materials. The statistics of tripoli production in 1913 are here repeated because much of the output is used for the same purposes as the other forms of silica treated in this chapter. The following table summarizes the production of tripoli in the United States in 1913:

Production of tripoli in the United States in 1913, by States, in short tons.

State.	Quantity.	Value.
Illinois	12,994	$128,892
Missouri, Pennsylvania, and Tennessee	7,837	86,725
Total	20,831	215,617

DIATOMACEOUS EARTH.

Diatomaceous earth is largely made up of silica. It is a variety of opal—that is, amorphous silica combined with a small quantity of water. It represents the remains of aquatic plants known as diatoms. Diatomaceous earth, which is also commercially called infusorial earth, kieselguhr, and rarely in the United States, although properly, tripoli, is largely used as an abrasive material and is treated in the chapter on abrasive materials. The statistics of production are repeated here because the composition and character of the material are to some extent similar to the other materials here considered and because it is in part put to the same uses.

Production of diatomaceous earth in the United States in 1913, by States, in short tons.

State.	Quantity.	Value.
California, Nevada, and Washington	6,035	$55,056
Connecticut, New York, and Maryland	328	8,065
Virginia, Georgia, and Florida	239	6,183
Total	6,602	69,304

GRAPHITE.

By Edson S. Bastin.

INTRODUCTION.

In the present report there is republished in full or in abstract all of the information on graphite that has appeared in previous Survey reports. This information has been amplified in some particulars and brought up to date whenever possible. It will be unnecessary therefore for readers to refer to any earlier Survey reports dealing with this mineral.

The production of natural graphite in the United States is sporadic, because the milling of disseminated flake graphite is still in the experimental stage and the product is of uneven grade. Because of this unreliability of the domestic supply most of the large consumers prefer to depend on imported material.

In 1913 the quantity of graphite imported into the United States for consumption was 28,879 short tons, valued at $2,109,791. In contrast to this the total domestic production was 4,775 short tons of natural graphite, valued at $293,756, and 6,817 short tons of manufactured graphite, valued at $973,397.

The cause of the unsatisfactory condition of the domestic industry is to be found in (1) the superiority of much of the Ceylon graphite to any graphite that is mined in this country; (2) the low cost of labor in Ceylon, which permits cheap mining, careful sorting, rubbing up, and blending of the product; (3) the facts that the largest domestic deposits are schists which carry small flakes of graphite disseminated through them and that the separation of the graphite from the accompanying minerals, especially mica, in such rocks is a problem of unusual difficulty. The one firm which can be said to have become firmly established in the treatment of such graphite rocks, the Joseph Dixon Crucible Co., possesses important advantage over other firms in that it manufactures much of its product into graphite paints, graphite grease, etc., before placing it on the market. When the margin of profit is small, such control of markets becomes of vital importance.

To-day there are more abandoned graphite mines and mills in the United States than the number in operation. The number of times that some of these properties have changed hands in the course of a few years evinces a record of misrepresentation and disappointment that can hardly be equaled in any other branch of mining, and many properties have been notoriously associated with stock manipulations of doubtful character. It should be clearly understood by anyone who contemplates the development of one of the flake-graphite deposits that the technology of concentrating such materials is yet in its infancy; that there are no well-established systems of treating the materials, such as exist, for example, for the treatment of gold or copper ores; and that the product obtained is variable in quality and in market value and subject to severe competition with foreign graphite. The largest part of the foreign graphite that comes into this country is brought in by American firms who either control or own the foreign mines or have purchasing agents abroad, and are, therefore, in a position to take immediate advantage of any change in the markets at home or abroad. In general, the cost of producing flake graphite is so high and the price at which it is sold so low that even under the most economic conditions the margin of profit is small. Moreover, certain rocks that carry graphite contain other minerals in such intimate association with the graphite as to preclude any possibility of successful concentration—such, for example, are rocks in which graphite flakes are interleaved with mica—and a careful study of the material by an expert should precede any attempt at development.

In a later paragraph the uses of graphite are discussed. These uses are manifold, but it should be remembered that graphite from any one property will be adapted for only certain of these uses, and that not only the purity of the graphite but its physical properties are of importance in determining the purposes for which it is suited. Crucible manufacture, for example, demands a flaky graphite high in carbon, and Ceylon lump, which retains its flaky character after grinding, is excellently adapted to this use. For foundry facings, on the other hand, an earthy, impure graphite is usually adequate. For many purposes—as for the manufacture of pencils—the best result can be obtained only by a careful blending of graphite of several different kinds. The blending in various proportions of slightly different grades of graphite from different mines to obtain products which meet the varied requirements of purchasers is one of the steps in preparing the Ceylon graphite for the market. To a certain extent blending is practiced by some American dealers, especially in marketing the amorphous forms.

PHYSICAL AND CHEMICAL PROPERTIES.

Chemically, the purest graphite is carbon with a fraction of 1 per cent of ash and volatile matter. In the trade graphite is frequently referred to as plumbago, or black lead. The graphites of commerce contain various impurities, sometimes in large quantities. Graphites showing 80 to 95 per cent graphitic carbon are pure enough for the requirements of the general trade, and for many uses, such as paint making, graphites with as low as 30 to 35 per cent of graphitic carbon are employed. The mineral possesses certain physical characteristics which usually enable it to be easily recognized. These are its steel-gray to blue-black color, extreme softness (1 to 2 in the scale of hardness), greasy feel, and the property of making a black metallic mark on paper. It is opaque in even the thinnest flakes, and the flakes, though flexible, are not elastic. Its temperature of fusion or volatilization is unknown, but is probably above 3,000° C. It is combustible at temperatures between 650° and 700° C. The specific gravity generally lies between 2.20 and 2.27. The only mineral with which graphite is likely to be confused is molybdenite, from which it differs slightly in color, the molybdenite having a somewhat bluish or greenish tinge. The two minerals may be distinguished by simple blowpipe tests. Graphite is in general a better conductor of electricity than most of the amorphous forms of carbon. Tests by P. M. Lincoln, of the Niagara Falls Power Co., showed a specific resistance of 0.00032 ohm in an artificial graphite electrode, and an amorphous carbon electrode of the same size showed a resistance of 0.00124 ohm.

In the trade two principal varieties of graphite are generally recognized. The graphite that possesses a lamellar, scaly, flaky, or fibrous structure is classed as crystalline. The other forms of graphite, of whatever occurrence or appearance, are classed as amorphous. The two varieties are not sharply differentiated, and the distinction appears to be largely in the size of the graphite particles. Much of the so-called amorphous graphite mined in the United States is shale or slate containing varying percentages of carbonaceous material, and it is often impossible, even with chemical tests, to tell whether the carbon in such rocks is graphite or ordinary carbon.

The physical character of graphite is usually of the utmost commercial importance, as will be further discussed in the section on uses.

ORIGIN.

Graphite occurs in nature in each of the three great groups of rocks — igneous, sedimentary, and metamorphic. It also occurs as veins, which may traverse rocks belonging to one or all of these groups.

Graphite has been observed in numerous places in igneous rocks, especially granite-pegmatites, so intercrystallized with the other rock minerals as to leave no doubt that it formed a part of the molten magma from which the rock crystallized. In some such occurrences, where the igneous rock is associated with carbonaceous sediments, it is probable that the magma absorbed carbon from these sediments, but in others it is equally probable that the graphite is of inorganic origin, or at least came up from great depths as an integral part of the igneous magma. The frequent occurrence of graphite in meteorites also indicates that it can be of inorganic origin. Except where igneous rocks are associated with carbonaceous sediments, the amount of graphite in them is usually small and of no commercial importance.

Graphite has been found in unaltered sedimentary rocks, but in all such rocks it is present in small amounts and has not been formed in place, but has been washed or weathered out of older igneous or metamorphic rocks.

The deposits of crystalline graphite which are of greatest commercial importance are veinlike in form and have apparently been deposited along fractures in the rocks. Foremost among these in size and importance are the famous Ceylon deposits, which are described further on in this report. The deposits near Dillon, Mont., also described in this report, and certain deposits in the counties of Ottawa and Argenteuil, Quebec, belong to this type. Very little is definitely known in regard to the origin of such vein deposits, although numerous theories have been proposed. It is certain that they were deposited along fracture planes in the rocks, and they were probably formed at considerable depths, but at temperatures which in some cases at least did not exceed 575° C.[1] In some localities they are associated with graphite deposits of contact metamorphic origin and were probably formed during the later stages of such metamorphism.

Many of the commercially important amorphous graphite deposits were coal beds which have been partly or wholly converted into graphite by the metamorphic effect of intrusive igneous rock magmas. Such is probably the origin of the important deposits of Sonora, Mexico, and of the deposit of Turret, Colo.

The large group of so-called disseminated deposits in which the graphite occurs in small flakes disseminated through a foliated rock, usually a crystalline limestone or a schist, is of great importance in the United States, Canada, and Germany. Such deposits have probably been formed by the dynamic metamorphism of sediments which carried carbon in some form scattered through them. Metamorphism by igneous rocks has also played a part in the formation of some of the deposits of this type.

MANUFACTURED GRAPHITE.

The manufacture of graphite on a commercial scale from various forms of amorphous carbon is conducted by the International Acheson Graphite Co., of Niagara Falls, which utilizes electric power generated at the Falls. Dr. Acheson patented the process for the manufacture of graphite by the electric furnace in 1896, and its commercial development has been so rapid that at present the output of artificial graphite is greater than the whole production of natural crystalline graphite in the United States.

The conversion appears to take place on a commercial scale only when certain impurities, usually siliceous, aluminous, or ferruginous, are present. These need not form more than 3 per cent of the total, but to obtain the best results should be evenly disseminated through the mass. The explanation of the conversion which has been advanced by Dr. Acheson supposes that the amorphous carbon first unites with the siliceous, ferruginous, or other impurities present to form carbides, which are later decomposed with the formation of graphite and the volatilization of the other constituents. The small amount of impurity required to effect the change is explained by supposing that the transfer becomes progressive, vapors of iron or silicon traversing the entire charge, combining with molecules of amorphous carbon, and then abandoning them in a graphitic state. This explanation is not, however, accepted by all investigators, and recent investigations appear to show that the product obtained in the electric furnace depends fully as much upon the nature of the original carbon used as upon the impurities present.

Anthracite coal carrying small amounts of evenly distributed impurities is used in the manufacture of the ordinary grades. An anthracite with 5.78 per cent ash is said to have yielded a graphite, with only 0.03 per cent of ash, the siliceous impurities being volatilized in the process. For obtaining the purest grades of graphite, petroleum coke is substituted for anthracite. An important part of the industry at Niagara Falls is the graphitization of rods and bars

[1] Bastin, E. S., Origin of certain Adirondack graphite deposits: Econ. Geology, vol. 5, pp. 152–155, 1910.

of amorphous nongraphitic carbon for use mainly as electrodes in electrochemical industries. These bars are made by pressing hot through a die in a hydraulic press a mixture of tar and ground petroleum coke. They suffer very little change in size or form in the process of graphitization. The Acheson furnaces have permanent heads for conducting the current. The walls are of loose brick construction, designed to retain the materials in place while the furnace is in operation; when the furnace is about to be unloaded the walls are easily torn down. Coke and sand are used for insulating. Although several furnaces connect with each electric unit, only one is fired at a time, the others being in process of loading, unloading, cooling, or repair. Furnaces for the production of ordinary bulk graphite are run for 12 to 24 hours and are allowed to cool for about four days, reloading taking place about every five days. The carbon rods and bars for electrodes must be fired much longer.

Prices for powdered graphite range from 4 cents to as much as 28 cents a pound, according to grade, and for the electrodes from 10 to 12 cents a pound. Much of the powdered graphite is mixed in proportions varying from 1 to 10 per cent with greases of several degrees of stiffness. A specially treated graphite which will remain suspended in oil is marketed in a concentrated form in gallon equivalents. When 1 gallon equivalent is mixed with oil to make 1 gallon of material the mixture contains 0.25 per cent of graphite.

In spite of the development of the manufacture of graphite by the electric furnace, the demand for the natural product has increased very largely in recent years because of the growth of the iron and steel industry, the largely increased use of copper and its alloys, the increased need for lubricants, and the development of electric machinery which calls for graphitized products.

USES.

The characteristics possessed by graphite and already mentioned make it a mineral of great and increasing industrial importance, but also, as already stated, graphite from any one property is never adapted to all of these uses, its purity and physical character determining its industrial application. One of the oldest and most important applications is in the manufacture of crucibles for use in the steel, brass, and bronze industries. Because graphite is nearly pure carbon, is relatively inert chemically, and volatilizes only at high temperatures it has exceptional value for this purpose. Such crucibles must have good tensile strength, and the poorer the binding quality of the graphite used the larger the quantity of less refractory binding material which must be added to hold the mass together, thus increasing the more fusible constituents of the crucible at the expense of the more refractory and materially decreasing its life. It is for this reason that a flaky graphite is used in crucibles, for the interlocking and overlapping of these flakes adds to the tensile strength. Ground Ceylon lump graphite is the material most in favor in the United States for making crucibles, although small amounts of American and Madagascar flake graphite are also used. Amorphous graphite has never been successfully utilized in crucible manufacture with the single exception of very small crucibles machined out from manufactured graphite rods or blocks.

As pointed out by Miller:[1]

In the manufacture of crucibles the graphite owes its value to the fact that it does not fuse at the temperature at which most metals and alloys melt and also is a good conductor of heat. By experiment it has been shown that due to the ease with which the graphite conducts the heat from without the crucible to the metal within less fuel is consumed when graphite crucibles are used than when clay crucibles are employed. Time is also gained because the metal melts more quickly. Further, graphite crucibles can withstand sudden changes in temperature much better than clay crucibles.

Other refractory products, such as muffles, stirring rods, dipping cups, skimmers, and nozzles, are usually made from materials similar to those used in crucibles, although manufactured graphite products are also on the market for many of these uses and for the preparation of molds for metal casting. Manufactured graphite for such uses is made by treating in the electric furnace amorphous carbon articles previously made up into the desired form. The main use of such graphitized carbon rods and plates is as electrodes in electrochemical industries. They can be machined, threaded, and cut with ease.

One of the most important uses of graphite is for lubricating. The addition of graphite to oil results in a lower frictional resistance than would be obtained by the use of oil alone. The quantity of oil required for a given service is also reduced and a lighter grade of oil may be employed without decreasing the quality of the lubrication. Only a small quantity of graphite is required, and the benefits derived from its use persist long after the application has ceased. In light bearings of machinery, where oil can not be used on account of the danger of soiling delicate textiles, graphite can be used alone as a lubricant. Both the amorphous and the crystalline varieties of natural graphite are extensively employed for lubrication, and when used for this purpose should be free from gritty impurities. The purity of the better grades of lubricating graphite usually exceeds 90 per cent. Lubricating graphite is sometimes marketed as dry flake or powder but usually as a mixture with oil or grease.

The use of graphite in the manufacture of pencils is probably both its oldest and its best-known application. This industry in Germany and England is several centuries old, and many of the modern factories manufacture hundreds of varieties of pencils, yet the percentage of graphite used for this purpose is not large, being undoubtedly less than 10 per cent of the world's production, and one authority estimates it as low as 4 per cent. In this industry the physical character of the graphite is of great importance. Crystalline graphite, however pure, would, if used alone, yield a "lead" that would slip over the paper without leaving more than a faint streak. Furthermore, it is almost impossible to grind the easily cleavable flake graphite into a powder of the fineness and evenness of grain requisite for the better grades of pencils. The better grades of amorphous graphite constitute the bulk of the material used in pencil manufacture. For some of the cheaper pencils only one kind of graphite is used, but the graphite for pencils of the better grades is a careful blend of several kinds. One blend, for example, contains about one-third Ceylon crystalline graphite, one-third Bohemian amorphous graphite, and one-third Mexican amorphous graphite. The Ceylon graphite adds to the smoothness of the "lead"; the Bohemian graphite

[1] Miller, B. L., Graphite deposits of Pennsylvania: Pennsylvania Topog. and Geol. Survey Comm. Rept. 6, p. 28, 1912.

adds blackness. Graphite used for pencils is mixed with carefully refined clay, which is usually imported from Germany, no domestic clay having been found entirely suitable for pencil manufacture. The more graphite and the less clay the softer the pencil; the less graphite and the more clay the harder the pencil. The cores of softer pencils are usually made larger than those of the harder ones in order to give them equal tensile strength. For a pencil of medium hardness about one-third clay is commonly used. The wet mixture of clay and graphite is worked and reworked until it is so pliable that it can be looped in coils and even tied in loose knots.

Up to a few years ago every American pencil manufacturer had to import his amorphous graphite from Bohemia or Bavaria. About 14 years ago a large deposit of amorphous graphite was discovered in Sonora, Mexico. This proved to be of excellent quality for pencil making and many other uses, and the American pencil trade now derives its supply mainly from this source. Mexican graphite is also exported to European pencil manufacturers.

A use which has increased rapidly in importance within the last few years is the manufacture of graphite paint, especially for structural iron and steel work. Much of the graphite used for this purpose is rather impure, the specifications frequently requiring not more than 35 or 40 per cent of graphite in the paint pigment, the remainder being generally siliceous, aluminous, or ferruginous material. Most of the graphite used in paints is of the amorphous variety, but some very fine-grained crystalline material is also employed. Six graphite paints used in tests on the Pennsylvania Railroad bridge at Havre de Grace, Md., showed from 19.16 to 97.80 per cent of graphite in the pigment. Recent tests made in cooperation between the Office of Public Roads of the Department of Agriculture and the Paint Manufacturers' Association, for the purpose of determining the relative merits of various paint pigments as preservative coatings for iron and steel, have yielded results of importance, with which makers and users of graphite paint should be familiar.[1]

Large quantities of amorphous graphite and of finely ground crystalline graphite are used for coating molds in foundries. A high degree of purity, though essential for the finest castings, is not necessary in all graphites used for this purpose; in fact, the presence of siliceous material may sometimes be of positive benefit by causing the graphite to cling or spread better on the face of the mold. Considerable amounts both of amorphous graphite and of finely ground crystalline graphite are used in the manufacture of stove-polishing powders and pastes. Another use of crystalline graphite is as a protective polish for gunpowder and as a packing material for the delicate electric-lamp filaments; it is also used in electrotyping and as a filler for dry batteries. Within recent years a considerable market has been built up both for amorphous graphite and for fine flake graphite as a boiler compound. Its presence in the boiler prevents the scale from adhering strongly to the iron.

The proportions of the world's supply of graphite used for various purposes can only be approximately estimated. The following table furnished by Mr. Harry Dailey, of the Joseph Dixon Crucible Co., is in agreement with one published by Miller.[2]

[1] Cushman, A. S., The preservation of iron and steel: U. S. Dept. Agr., Office Pub. Roads, Bull. 35, 1909.
[2] Miller, B. L., op. cit., p. 27.

Estimated percentage (by quantity) of the world's graphite consumption used for various purposes.

	Percentage.
Crucibles	55
Stove polish	15
Foundry facings	10
Lead pencils	5
Paint	5
Lubricants	5
All other uses	5
Total	100

If the value rather than the quantity be considered, about 75 per cent of the world's consumption should be credited to crucibles.

PRODUCTION AND IMPORTS.

NATURAL GRAPHITE.

PRODUCTION.

In 1913, as in 1912 and 1911, the total production of crystalline graphite came from Alabama, New York, and Pennsylvania. All of this crystalline graphite was of the variety known in the trade as "flake" graphite, that occurs as small flakes disseminated through crystalline schists, from which it is separated by more or less complicated milling processes. The production of crystalline graphite, which showed a continuous decrease from 1909 to 1911, increased slightly during 1912 and 1913. This increase was mainly due to increased production in New York and Alabama, the Pennsylvania output being relatively small and much the same.

Amorphous graphite was produced during the year by five different firms, located in Rhode Island, Colorado, Wisconsin, Nevada, and California. Nearly all of this material was of low grade and suited only for paint pigment and foundry facings.

Further details in regard to various properties are given in the summary by States and Territories.

Production of natural graphite, 1909–1913.

Years.	Amorphous.		Crystalline.		Total.	
	Quantity.	Value.	Quantity.	Value.	Quantity.	Value.
	Short tons.		*Pounds.*		*Short tons.*	
1909	[a] 5,096	$32,238	6,294,400	$313,271	8,243	$345,509
1910	1,407	39,710	5,590,592	295,733	4,202	335,443
1911	1,223	32,415	4,790,000	256,050	3,618	288,465
1912	2,063	32,894	3,543,771	187,689	3,835	220,583
1913	2,243	39,428	5,064,727	254,328	4,775	293,756

[a] Includes Georgia graphitic slate.

On account of the small number of producers, figures of production by States, except for Alabama, can not be published without revealing individual productions. The production of Alabama amounted to 2,020,910 pounds of crystalline graphite, valued at $87,336.

IMPORTS.

The imports for consumption of graphite into the United States in 1911, 1912, and 1913, by countries, are shown in the following table:

Imports of graphite for consumption into the United States, 1911, 1912, and 1913, by countries, in short tons.

Country.	1911		1912		1913	
	Quantity.	Value.	Quantity.	Value.	Quantity.	Value.
Ceylon	13,119	$1,132,678	16,791	$1,379,587	16,996	$1,674,764
Mexico	3,368	254,060	3,518	163,107	4,435	198,000
Canada	2,289	78,196	2,688	122,216	1,662	98,665
Japan (Chosen via Japan)	1,256	18,486	1,574	22,875	4,170	58,199
Austria-Hungary	65	1,139	473	8,971	660	9,957
Italy	510	6,242	468	7,450	236	4,061
Germany	48	2,930	102	2,669	90	4,034
Other countries	47	1,998	29	2,462	630	62,111
Total	20,702	1,495,729	25,643	1,709,337	28,879	2,109,791

The following table shows the imports for consumption of graphite from 1909 to 1913, inclusive:

Imports for consumption of graphite into the United States, 1909–1913, in short tons.

Years.	Quantity.	Value.
1909	21,267	$1,854,459
1910	25,235	1,872,592
1911	20,702	1,495,729
1912	25,643	1,709,337
1913	28,879	2,109,791

WORLD'S PRODUCTION.

The world's production of natural graphite for the years 1909–1911 was as follows:

World's production of natural graphite, 1909, 1910, and 1911, in short tons.[a]

Country.	1909		1910		1911	
	Quantity.	Value.	Quantity.	Value.	Quantity.	Value.
United States[b]	8,243	$345,509	4,202	$335,443	3,618	$288,465
Canada	863	45,999	1,392	74,083	1,269	69,576
Mexico	1,878	25,301	2,571	36,207	3,050	36,353
Russia		1,913	(c)	(c)	(c)	(c)
Germany	7,467	64,724	8,174	76,404	12,454	72,754
Austria	44,875	320,289	36,520	281,220	46,855	332,489
Norway			[d] 882	[d] 8,575		
Sweden	29	779	1,526	1,844	72	2,097
France			606	5,353	408	3,601
Italy	12,768	71,148	13,790	74,808	13,912	74,701
Japan	136	5,290	162	5,202	126	8,911
China					22	1,728
Chosen (Korea)		75,012		56,719		[d] 65,727
India	3,508	60,972	4,761	99,661	4,533	45,867
Ceylon	36,056	3,237,751	[d] 35,310	[d] 2,577,600	[d] 30,183	[d] 2,159,529
Madagascar	220		601	21,218	1,373	48,534
South Africa	3		40	6,755	44	6,365

[a] Mines and quarries: General Report with Statistics, pt. 4. London.
[b] Exclusive of artificial graphite, figures for which are shown on a preceding page.
[c] Statistics not available.
[d] Export figures.

MANUFACTURED GRAPHITE.

The following table shows the production of manufactured graphite by the International Acheson Graphite Co., at Niagara Falls, N. Y., for the years 1909–1913, inclusive. The diagram (fig. 7) shows the production from the commercial inception of the industry in 1897.

Production and value of manufactured graphite, 1909–1913.

Years.	Quantity.	Value.	Average price per pound.
	Pounds.		*Cents.*
1909	6,664,017	$480,000	7.20
1910	13,149,100	945,000	7.20
1911	10,144,000	664,000	6.55
1912	12,896,347	830,193	6.44
1913	13,633,342	973,397	7.14

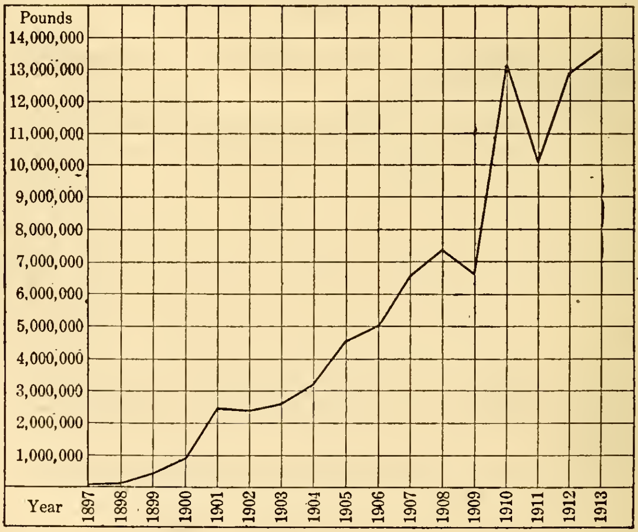

FIGURE 7.—Diagram showing production of manufactured graphite in the United States from inception of the industry in 1897 to 1913, inclusive.

INDUSTRY BY STATES AND TERRITORIES.

ALABAMA.

Graphite is widely distributed among the metamorphic rocks of Alabama,[1] in which it occurs in two forms: (1) In the feebly crystalline schists which have been called the Talladega slates,[2] and which in part at least are Paleozoic sediments of as late age as the "Coal Measures," graphite is often found as a black graphitic clay free from grit. In this condition the graphite is difficult to separate from the other matter with which it is mixed, and the material has not yet been utilized commercially to any great extent. Examples of this mode of occurrence may be seen near Millerville, in Clay County, and

[1] Smith, E. A., Min. Industry, vol. 16, p. 568, 1907.
[2] McCalley, H., Alabama Geol. Survey Rept. valley regions, pt. 2, pp. 36–38, 1897.

about Blue Hill, in Tallapoosa County. (2) In the mica schists and other highly crystalline rocks graphite is found in the form of thin crystalline flakes, which may be separated from the associated minerals. Graphitic schists of this type are now being worked at three localities and have in the past been worked at several others.

Three graphite companies were active in Alabama during 1913. One of these, the Alabama Graphite Co., with mine and mill 6 miles west of Ashland, Clay County, reported a notable increase in production as compared with 1912. The other, the Quenelda Graphite Co. (formerly the Allen Graphite Co.), at Quenelda, Clay County, has completed a new mill to replace the one destroyed by fire in 1911. This mill was put in operation November 1, 1913, and an important quantity of flake graphite was marketed during the year. The mine and mill 4½ miles west of Ashland, formerly operated by the Ashland Graphite Co., have not been in operation since 1911, and it is reported that the company has dissolved. The Flaketown Graphite Co., near Mountain Creek, in Chilton County, reported an important production.

The properties of the Quenelda Graphite Co. and that formerly operated by the Ashland Graphite Co. and a few other Alabama graphite properties were visited by the writer in 1911. The original reports upon them being exhausted, his observations are reprinted below. The property of the Alabama Graphite Co. was not developed at that time and has not since been visited.

CLAY COUNTY.

Ashland, the shipping point of the Clay County graphite properties, is the terminus of a short branch of the Atlanta, Birmingham & Atlantic Railroad. This branch is 7 miles long and joins the main line at Pyriton. The freight rate on refined graphite from Ashland to New York City is about $7 a long ton.

QUENELDA GRAPHITE CO. (FORMERLY THE ALLEN GRAPHITE CO.)

The quarry and mill of this company are located a little over 8 miles west of Ashland, at a settlement shown on the United States Geological Survey's map of the Ashland quadrangle under the name "Graphite." The mine is about half a mile from the mill, with which it is connected by a tramway. The concentrate is hauled over a fairly good road to Ashland for shipment. The mining is entirely from open pits, and because of the decomposed character of the rock can be accomplished largely with the aid of pick, shovel, and crowbar, without much drilling and blasting.

The main pit is about 450 feet in length, 100 feet in average width, and about 60 feet in maximum depth. A small pit just east of the main pit and on the same graphitic band is about 100 feet long, 90 feet wide, and 25 feet deep. A third pit has been opened on the same band of graphitic schist about 1,000 feet east of the main pit on the west face of another hill. This is about 90 feet wide, about 200 feet long, and about 40 feet deep. The strike of the schist at the north end of the main pit is N. 80° E., with a dip of 75° S. This is fairly typical for the deposit as a whole.

The rock mined is highly schistose and is composed largely of quartz and graphite. A white, fibrous mineral, probably sillimanite, is also abundant. Feldspar and mica are rare. Few of the thin graphite flakes so far seen by the writer exceed 2 millimeters across and most of them are under 1½ millimeters. They are arranged subparallel to one another, and to this arrangement and a similar orientation of the sillimanite (?) prisms is largely due the schistosity of the rock. At the west end of the main pit a dike of coarse granite, 1 to 1½ feet wide, parallels the foliation of the schist, and in the easternmost pit the graphitic schist has also been intruded by an irregular body of coarse

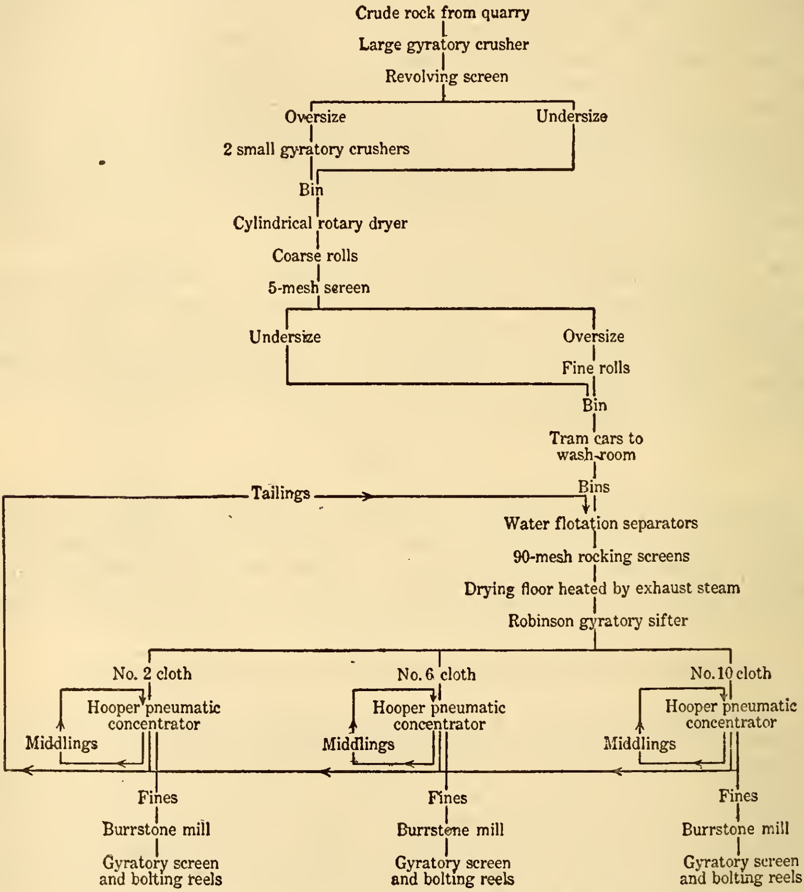

FIGURE 8.—Diagram showing milling processes at Allen graphite mill, Graphite, Ala.

granite pegmatite carrying muscovite crystals up to 3 inches across. The graphitic beds here are also disturbed by faulting. The contact metamorphic effects of these small intrusions on the graphitic schist appear to be slight.

The mill which was in operation at the time of the writer's visit has since been destroyed by fire and replaced by a new one, but as the old mill was studied in some detail a description of the process may still be of value.

The milling process in the old mill was divided into three principal stages—(1) crushing and drying; (2) preliminary wet concentration; and (3) final dry concentration. The details are shown in figure 8.

The most important step in the milling process was the preliminary concentration by water flotation. In these concentrators the dry crushed rock was spread in a thin stream upon the surface of slowly flowing water. The graphite being flaky was supported by the surface tension of the water and floated off, while the granular gangue, mainly quartz, sank and was sent to the dump. The process is cheap where water is plentiful. The tailings seen on the dump carried surprisingly little graphite; that which was present was usually attached to other minerals. Much fine grit, of course, floated off with the graphite but was removed in the final dry concentration.

The crude rock was said by the operators to average about 5 per cent graphite. For two successive years (September, 1908, to September, 1910) the finished product formed, respectively, 2.95 and 2.7 per cent by weight of the crude rock treated. Four principal grades were produced, whose relative proportions were about as follows:

Grades of flake graphite produced by Allen Graphite Co., Clay County, Ala.

	Per cent.
Grade C. Crucible flake	36
Grade 1. Lubricating flake (coarse)	11
Grade 2. Lubricating flake (fine)	18
Grade D. Dust for foundry facings, etc	35
	100

The highest grade averaged over 90 per cent graphite; the dust averaged about 50 per cent graphite. The average prices f. o. b. New York in 1911 were: Grade C, 6½ cents per pound; grade 1, 5½ cents per pound; grade 2, 4½ cents per pound; and grade D, 1 cent per pound.

ASHLAND GRAPHITE CO.

The quarry and mill of the Ashland Graphite Co., which has not been a producer since 1911, are located about 4½ miles west of Ashland. The company was the successor to the Enitachopco Graphite Co. The product of the plant was hauled by team to Ashland. The workings at this property consist of two open pits located in the same belt of graphite schist. The two pits are on neighboring knolls, and the mill is in the small valley between them. The largest or eastern pit is about 400 feet long, 30 to 50 feet wide, and 50 feet deep. It follows along the strike of a band of graphitic schist which averages about 30 feet in width, though broadening locally to about 50 feet. The strike is about N. 55° E. and the average dip is about 45° E. The second pit, located west of the mill, is about 150 feet long, 20 feet wide, and about 20 feet deep. The trend of the schists is similar to that at the larger pit.

The graphitic rock at this quarry is similar in general to that at the Quenelda quarry. The schist is too much decomposed for the complete identification of all the minerals, but quartz is the principal component. As a rule mica is rare, but the brown mica biotite is common in a few places. The graphite forms thin flakes, mostly under 1 millimeter in diameter, although some reach 2 millimeters. No igneous rocks were seen in association with the graphitic schist at this property. The rock being more or less decomposed, can be excavated with pick and crowbar with occasional blasting. It is loaded into tramcars and hauled to the mill.

The mill has a capacity of about 50 to 60 tons a day of 12 hours. The milling process was in general similar to that at the old Allen mill, though differing in details. A dry pan was used in preliminary crushing. The water flotation separators were similar to those at the Allen plant. The final dry concentration was accomplished by screens and burrstone mills.

CHILTON COUNTY.

DIXIE GRAPHITE CO.

The property of the Dixie Graphite Co., is about 6 miles northeast of Mountain Creek, the shipping point, a small station on the Louisville & Nashville Railroad. The company has been out of business for many years and the mill is partly ruined. Two Jeffrey vibratory screens and a rotary drier are all that remain of the milling machinery. The graphitic rock was taken from several small open pits and a short tunnel on the slopes of a small creek valley. The creek is of sufficient size to furnish water for wet concentration but not for power. The tunnel is about 50 feet long and is enlarged at its end to a room about 50 by 50 feet and 15 feet high. The rock is a graphitic quartz schist interbanded with schist rich in muscovite. The general strike is about N. 70° W., and the dip is about 60° N. Quartz lenses are abundant. The graphitic portions are pockety in their distribution, and the flakes are small. For these reasons and because of its distance from the railroad the property is much less promising commercially than others in the State.

FLAKETOWN GRAPHITE CO.

The Flaketown Graphite Co. operates a quarry and mill in the valley of Chestnut Creek, about 3½ miles northeast of Mountain Creek station. The property is about 3 miles west of that of the Dixie Graphite Co. The graphitic rocks lie in the west valley slope and have been developed by a small open pit. South of this pit sufficient prospecting has been done to show that the deposit is of very considerable size. The rock is a graphitic quartz schist very similar to those worked in Clay County. On account of its situation on a steep valley slope, which favors relatively rapid removal of weathered material, the remaining material is not so much decomposed as the deposits west of Ashland, in Clay County.

Small quantities of green micaceous mineral, probably muscovite, are present in some specimens, but in general, mica is rare. The strike of the schist folia at the main pit is N. 35° W., with a dip of 45° SW. A few hundred yards farther south the strike shifts to N. 20° W. and N. 15° W. A dike of granite pegmatite 1 foot wide intrudes the graphitic schist at the main pit. It parallels the foliation, and within 1 to 2 inches of the schist carries graphite in scattered flakes up to one-eighth of an inch in diameter.

An analysis made by the United States Geological Survey of a composite sample of graphitic schist, collected from a number of different exposures on this property, showed 4.63 per cent of graphite.

The mill is located at the quarry, and during part of the year electric power for its operation is generated by water power from a 20-foot dam on Chestnut Creek. Auxiliary steam power is also installed. The details of the concentrating process were not observed. Mountain Creek is the nearest shipping point.

COOSA COUNTY.

A graphite prospect is located about 2 miles northwest of Goodwater, a station on the Central of Georgia Railway. At this locality a large number of small prospect pits are scattered over an area of several acres, and nearly all show graphitic quartz schist. The prospects are on a steep southwest hillside overlooking the iron bridge where the wagon road from Goodwater to Pine Grove crosses Hatchet Creek. The rock is gray when fresh and highly schistose and strikes nearly east and west, with a dip of about 45° S. It is almost identical in character with the graphitic schist worked in Clay County and consists largely of quartz and graphite, the latter in flakes mostly under 1 millimeter in diameter. Very little mica is present. An analysis of a composite sample of graphitic schist collected from a large number of pits on this property showed 2 per cent of graphite, but in certain portions the percentage will undoubtedly be greater. The deposit is unquestionably a large one and its situation on a steep hillside would afford opportunity to work to a considerable depth by open-pit methods. The neighboring Hatchet Creek could furnish abundant water for wet concentration of the graphite.

A second deposit, probably of similar character, has been prospected between Mount Olive and Hollins. It was not visited by the writer, but is said to be of considerable size.

ALASKA.

Graphite mining in Alaska has not yet attained the status of an established industry. During the last six or seven years development work has been in progress at several properties near the Imuruk Basin on Seward Peninsula, and small trial shipments have been made to the United States.

In 1913 a small quantity of hand-picked crystalline graphite was brought into the United States by the Uncle Sam Alaska Mining Syndicate and was treated in an experimental mill at Everett, Wash., to determine its value for the various purposes for which graphite is commonly applied. It is said that about 200 tons of crystalline graphite, averaging 80 per cent carbon, is sacked at the mines ready for shipment in the summer of 1914, and that it is planned to erect a mill at Seattle for its treatment.

The Alaska Graphite Co. did not market any graphite during 1913, but expects to renew operations in 1914.

The following descriptions are in the main abbreviated from the reports of F. H. Moffit and P. S. Smith, of this Survey:

Extensive graphite deposits occur in Alaska on both the northern and the southern slopes of the Kigluaik Mountains in the southern part of Seward Peninsula. On the south side of the range between Grand Central and Windy Creeks [1] a sharp ridge is made up of biotite schists striking east and west intruded by dikes and sills of granite and pegmatite. Some of the schists are highly graphitic, the graphite occurring as abundant small flakes, much of it not distinguishable on casual examination from biotite. Locally graphite is segregated in beds of much flattened lenticular form lying in the cleavage of the schist and

[1] Moffit, Fred. H., The Nome region: U. S. Geol. Survey Bull. 314, pp. 139-140, 1907.

reaching thicknesses of 6, 8, or even 18 inches. Thin beds of schist with numerous large garnets are included, and quartz is nearly everywhere present.

The sills and dikes of pegmatite which cut the graphitic schists also contain graphite. The graphite in these appears to have crystallized at the same time as the other pegmatite minerals. At one place about 8 inches of solid graphite is included between a pegmatite sill and the overlying schist. The steep slopes of the mountains are strewn with loose fragments. One block approximately 7 feet by 6 feet by 30 inches consisted of about equal amounts of schist and apparently almost pure graphite. These deposits are on the south side of the range and have not been developed.

On the north side of the Kigluaik Mountains,[1] near the Imuruk Basin, deposits of graphite occur, upon which some development work has been done. One firm—the Alaska Graphite Co., of San Francisco—has shipped small quantities from this locality to the United States. At the mine of this company graphitic schists are interlaminated with more quartzose biotite schists, and both are intruded by granitic rocks. Much of the graphite is obtained in "blocks" up to 2 feet in length and 1 foot in thickness, practically unmixed with foreign material. Dislocations and fractures make the stoping out of the ore more or less dangerous. After the ore is broken from the ledge it is cobbed and hand sorted. In this sorting less than 25 per cent of the material is retained. This is sacked and hauled down the steep slope of the mountains on sleds to the flats surrounding Imuruk Basin. The sacks are then transported by horses to the shore, where they are put aboard a boat and taken to Teller for shipment. The work thus far has been mainly of a development nature. The small quantity brought to the United States was ground in San Francisco and sold principally for foundry facings. All of the material shipped was crystalline so far as known. It is said to average from 50 to 75 per cent graphite.

During 1912 the Uncle Sam Alaska Mining Syndicate opened a new property on the north side of the Kigluaik Mountains. According to a description obtained through the courtesy of the manager of this company the property comprises nine locations of claims and two mill site locations, nearly 2 miles (10,168 feet) south of Graphite Bay, a branch of the Imuruk Basin. The elevation is about 500 feet above sea level. The graphite occurs associated with schists and gneisses which strike east and west and have steep dips. The richer graphitic portions can, it is claimed, be readily separated by hand sorting.

ARKANSAS.

Graphite has been reported from a locality 2 miles north of Mountainburg, Crawford County. This property was examined by the writer in 1912, and the deposit was found to be a thin bed of sheared carbonaceous shale and not graphite.

CALIFORNIA.

Graphite is known to occur in a number of localities in California and serious attempts have recently been made to develop some of these.

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[1] Smith, Philip S., Investigations of the mineral deposits in Seward Peninsula: U. S. Geol. Survey Bull. 345, p. 250, 1908; also, Recent developments in southern Seward Peninsula: U. S. Geol. Survey Bull. 379, pp. 300-301, 1909.

Calaveras County.—A small amount of material said to carry about 10 per cent of graphite was mined in 1913 near Campo Seco in Calaveras County, and ground with iron oxide at Stockton for use as a paint pigment.

Mendocino County.—In 1909 some graphite was mined near Point Arena by a company known as the Dixon Graphite & Milling Co. The material was said to carry 8 to 10 per cent of graphite. Samples sent to the Survey for examination were graphitic schist, somewhat decomposed, in which the graphite occurs as small flakes. The material is similar in general to some of the graphitic schists of the eastern United States. In 1911 the company was reported to be out of business.

Los Angeles County.—The California Graphite Co., with office in Los Angeles, was incorporated in January, 1913, to develop a graphite deposit near Saugus. It is reported that important development work has been done during the year. Samples forwarded to the Survey for examination show that the material mined is a decomposed fine-grained graphitic schist. The graphite is of the crystalline variety and occurs in small flakes mostly under 0.5 millimeter in diameter. The matrix is quartz and decomposed feldspar. In the samples forwarded little or no mica was observed either in the crude material or in the concentrate. An analysis made in the Survey laboratory of a composite sample obtained by clipping small pieces from 6 larger samples showed 10.4 per cent of graphitic carbon. The writer is not informed in regard to the concentrating process, but the samples of concentrate forwarded were exceptionally clean and after "finishing" should make a high grade of lubricating stock.

COLORADO.

Chaffee County.—Amorphous graphite is mined in Colorado by the Federal Graphite Co., about 2 miles northeast of Turret in Chaffee County. The mine is situated on the west slope of Graphite Hill, within about a mile of the stage road from Salida to Turret (14 miles), and was visited by the writer in the summer of 1909.

The workings at that time consisted of two inclined shafts located about 100 feet apart on the same lode. These shafts had been sunk to a depth of 40 to 50 feet and some drifting and stoping had been done. A tunnel was being driven about 125 feet below the mouths of the inclines, from which a raise could be opened to the graphite bed.

The graphite occurs in one principal and a number of subordinate beds interbedded with white to gray crystalline limestone, buff-colored quartzite, and dark-gray to purplish quartzitic schist. The sediments and associated graphite beds strike about north and dip to the east at 30° to 40°.

The hill slope above the graphite beds is occupied by a gray to purplish quartz schist, but just over the crest of the hill and not more than 500 or 600 feet east of the graphite is a large area of gneissic biotite granite. Fine-grained granite occurs as a dike cutting the sediments within a few feet of the main graphite bed at the mouth of both of the inclines, and a tongue of graphic granite a few inches wide was observed penetrating slightly graphitic material just beneath the productive graphite bed.

The main productive bed as exposed in 1909 varied from 3 to 4 feet in thickness, somewhat more than half of this thickness consisting of the second grade of ore, which is lower in graphite than the first grade, higher in clayey material, and of a grayish or purplish tint. The first grade of graphite is dull black and very pure, the purest portions showing a somewhat foliated structure. Both grades are very fine grained and earthy and are properly classed as amorphous. In the northern incline a second bed 1 foot thick of first-grade ore was exposed about 4 feet above the main bed. What appears to be the same graphite bed had been prospected north and south along the slope of Graphite Hill for about a mile. In the southern incline graphitic beds are separated by a bed of crystalline limestone, tapering from a thickness of 2½ feet to 8 inches in a distance of about 20 feet.

It is evident that this graphite was originally coal and highly carbonaceous shale interbedded with sedimentary rocks. The coal has been converted into graphite and its inclosing sandstone and limestone into quartzite, quartzitic schist, and crystalline limestone through the heating and other contact metamorphic effects of large masses of granite which have been intruded into the sediments. The granite and granite gneiss occupy most of the country between this mine and Turret and form large areas south and east of the mine.

The first-grade graphite is packed in bags; the second grade is shipped in bulk. It is hauled 5 miles, mostly downhill, to a siding on the Denver & Rio Grande Railroad and shipped to the mill of the company at Warren, Ohio. There it is pulverized and air floated and is marketed mainly for paint pigment and foundry facings.

Gunnison County.—Some development work was in progress during 1912 on a new graphite property near the summit of Italian Mountains, in Gunnison County, Colo. The deposits are near the head of Cement Creek and are about 10 miles from the railroad. A company formed for their development is known as the Colorado Graphite Mining & Manufacturing Co., with office in Denver. According to a private report made to this company by S. C. Robinson, mining engineer, there appear to be three parallel "veins" of graphite about 50 feet apart, lying parallel to the inclosing beds of stratified rock, which here stand nearly vertical. The middle "vein" is the largest and has a width of 4 to 6 feet. All development has thus far consisted in open-cut mining. This locality lies either within or just east of the area covered by the Anthracite-Crested Butte folio (No. 9) of the Geologic Atlas of the United States. Within this area coal occurs in the Cretaceous formations. Though normally bituminous, it has locally been altered to anthracite as a result of dynamic metamorphism or of the proximity of igneous rocks. The occurrence of graphite as a result of still more intense alteration is therefore not at all surprising.

GEORGIA.

Georgia produces no material which can properly be described as graphite, but a large quantity of slate containing 2 to 15 per cent of carbon was quarried near Cartersville, in Bartow County, and ground for use as a filler and drier in fertilizers. It is doubtful whether the carbon of this rock is graphite or amorphous carbon. In previous years the production of this material has been included under the heading of amorphous graphite, but as it is not adapted for any of the purposes for which higher grades of amorphous graphite are used, and as these higher grades are never used as fertilizer filler, it is thought best not to include this material under the name of graphite.

The material is simply crushed and ground and then sells for $1.25 to $1.50 a short ton f. o. b. mills. These deposits have been described by Hayes and Phalen.[1]

IDAHO.

In 1908 a graphite mine was opened near Ketchum, in Blaine County, by Messrs. Hampton & Griffith. Some production was reported in 1909, but none has been reported since then. The material is said to be amorphous.

Graphitic schists are known to occur on Salmon River, near Grangeville, Idaho, and analysis of a specimen showed 7.6 per cent of fixed carbon.

MAINE.

Graphite is known to occur at several localities in Maine and in 1905 an unsuccessful attempt was made to mine it near Madrid, in Franklin County. The deposits have been fully described by George Otis Smith,[2] from whose report the following information is taken.

At Madrid the graphite occurs locally in a schist near its contact with granite-pegmatite. In some of the schist the graphite is in particles of microscopic size, but in the best grade of graphite rock it occurs in flakes averaging 0.04 millimeter (range 0.01 to 0.20 millimeter) in diameter. The graphite flakes are fairly evenly distributed and in the sample analyzed constituted 8.5 per cent by weight of the rock. In some specimens the graphite is intimately associated with muscovite flakes, but in others quartz is the chief matrix. In view of the small size of the graphite grains, their separation from the mica and quartz with which they are intergrown would not be economically practicable by any methods now known. Without concentration, the material on account of its small percentage of carbon, would have no present commercial value.

About 1½ miles northwest of Yarmouth village in Cumberland County graphite occurs in flakes disseminated through a dike of granite-pegmatite. In the sample analyzed 9 per cent by weight of graphite was present. As the graphite-bearing dike has an average width of only 1 foot, the deposit can not be considered to have commercial importance.

MASSACHUSETTS.

A graphite deposit occurs near Sturbridge, a small village on the trolley line between Worcester and Springfield, not far from the Connecticut boundary. (See fig. 10, p. 205.) The mine is 3 miles southwest of Sturbridge as the crow flies, but about 6 miles by road, and lies just west of Lead Mine Pond. Although it has not been worked for many years it is of unusual historic interest and forms the subject of a historical paper by G. H. Haynes,[3] from which the following extracts are taken:

The mine was not only the first graphite mine worked in the United States, but one of the first mining adventures of any kind in America. In 1644 there was granted to John Winthrop, jr., son of Gov. Win-

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[1] Graphite deposits near Cartersville, Ga.: U. S. Geol. Survey Bull. 340, pp. 463–465, 1908.
[2] Smith, George Otis, Graphite in Maine: U. S. Geol. Survey Bull. 285, pp. 480–483, 1906.
[3] Haynes, G. H., The tale of Tantiusques, an early mining venture in Massachusetts: Am. Antiq. Soc. Proc., Ann. Mtg., Oct. 31, 1901.

throp, of Massachusetts, "Ye hill at Tantousq, about 60 miles westward (from Boston), in which the black leade is, and liberty to purchase some land there of the Indians." He made the acquisition doubly sure by purchasing the tract from the Indian inhabitants. Development was not begun until 1658, after Winthrop had interested some Boston men in the project. How long this work was continued or how much graphite was obtained is not known, but several letters to Winthrop from his miners are on record in which they complain of the cost and difficulties of mining, and the work seems to have been soon abandoned. Nothing further was done at the property until 1738, when John Winthrop, nephew of the original owner, again started mining and shipped some of the graphite to England, where it brought about 4 pence a pound. A little mining was done in the summer of 1740, when less than a ton was extracted. Discouraged at the small price received for the material, mining was again abandoned, and there is no record of further development while the property belonged to the Winthrop family. It remained idle until 1828–29, when Frederick Tudor, of Boston, secured possession of the mine and operated it as an adjunct to the manufacture of crucibles. After Mr. Tudor's death the property remained idle until sold to the Massachusetts Graphite Co. in 1902. It has remained in the possession of this company up to the present time and has been operated occasionally.

According to B. K. Emerson [1]—

> The deposit is a series of flat pockets reaching 3 to 4 inches in thickness, placed with the bedding, but not very extensive in this plane. The bed is near the base of the Brimfield (carboniferous) and in the zone of strong influence of the granite.

The mine was visited by the writer in the summer of 1912. In the caved and water-filled workings no graphite could be seen in place; it was evident, however, from the form of the workings that the graphite masses lay parallel to the trend of somewhat quartzose mica schists whose strike varies from N. 20° E. to N. 30° E. and whose dip is to the northwest at 70°–80°. Pillars of schist left between some of the pits show no trace of graphite and from this it is inferred that the graphite formed a series of lenses and not a simple continuous vein. None of the schist was observed to be graphitic; it has been intruded by small masses of granitic rock.

The workings begin on the northeast with a drift tunnel whose portal is near the shore of Lead Hill Pond. From this point southwestward for about one-half mile the main graphite-bearing zone has been prospected and locally there has been extensive excavation through shafts or from open pits. Two shafts are each about 100 feet deep. On one of the shaft dumps massive pyroxenite with pyroxene crystals one-half inch in diameter was noted, but the rock was not seen in place. A block of solid graphite from this mine 7 inches across was seen in the Elms Hotel in Sturbridge. It closely resembled the Ceylon graphite and showed bladelike crystals 2 inches in length. It is reported that one lump of solid graphite taken out in 1904 weighed 510 pounds.

It is evident that the deposit belongs to the vein type represented by the occurrences in Ceylon, at Dillon, Mont., and at certain places

[1] Emerson, B. K., The geology of Massachusetts and Rhode Island: U. S. Geol. Survey Bull. (in preparation).

in Canada, but the exposures were too poor to throw much light upon its origin.

Water entering apparently from Lead Hill Pond along the vein is said to have been a considerable handicap to mining in the deeper workings.

MICHIGAN.

Graphitic rock is obtained from Baraga County, in northern Michigan, by the Detroit Graphite Co., and shipped by rail to its mill at Detroit. The mine is located 7 miles south of L'Anse, a station on the Duluth, South Shore & Atlantic Railway. The mine is worked intermittently, most of the rock being hauled to the railroad in the winter over the snow.

The rock mined is a dark reddish-brown graphitic and ferruginous slate which is said to average about 33 to 35 per cent of graphitic carbon. The latter is so finely divided that it should be classed as amorphous. An analysis of this rock, made by the late Prof. A. B. Prescott, of the University of Michigan, and furnished to the writer by the company, is as follows:

Analysis of graphitic rock from Baraga County, Mich.

Carbon, graphitic (C)	28.39
Silica (SiO_2)	46.97
Alumina (Al_2O_3)	16.90
Iron, soluble, as Fe_2O_3	.41
Iron, insoluble, as Fe_2O_3	3.81
Lime (CaO)	.47
Magnesia (MgO)	.52
Water, uncombined (H_2O)	.13
	97.60
Carbon dioxide, combined water, sodium compounds, loss, and undetermined matter	2.40
	100.00

The rock is too fine grained to permit of any concentration of the graphite and is ground just as it comes from the mine and used only as a paint pigment, for which it appears to be well adapted. The lumps of rock are first reduced in a jaw crusher, then dried and pulverized in a continuous feed tube mill. Finally it is air floated, so that an exceedingly fine-grained powder is obtained. The black pigment thus obtained is used not only in the manufacture of black paints, but is mixed with other pigments to yield gray, dark-green, and dark-red paints. A reserve having accumulated, no mining was done during 1913.

Similar material is also mined by the Northern Graphite Works, with mill at L'Anse and mine 9 miles from L'Anse. This company has taken over the mill formerly used by the Hathaway Graphite Co. The material is picked, crushed, ground, air floated, and bolted through silk to a fineness of about 200 mesh. The plant was operated during 1911 and 1912, but was idle in 1913.

The plant of the United States Graphite Co. for the treatment of amorphous graphite imported from the State of Sonora, Mexico, is located at Saginaw.

MONTANA.

The only graphite property operated in Montana is that of the Crystal Graphite Co., near Dillon, whose principal mine was visited by the writer in June, 1911, and is described below in detail. Considerable development work has been in progress there for several years, and it is expected that shipment of the product to eastern markets will soon begin.

The mine of the Crystal Graphite Co., near Dillon, is of more than ordinary interest because in its geologic relations and in the character of its graphite it shows some similarities to the famous deposits of Ceylon. Unfortunately, the quantity of high-grade graphite yet discovered is too small to form the basis of an industry like that of Ceylon, but there seems good prospect of the development of one

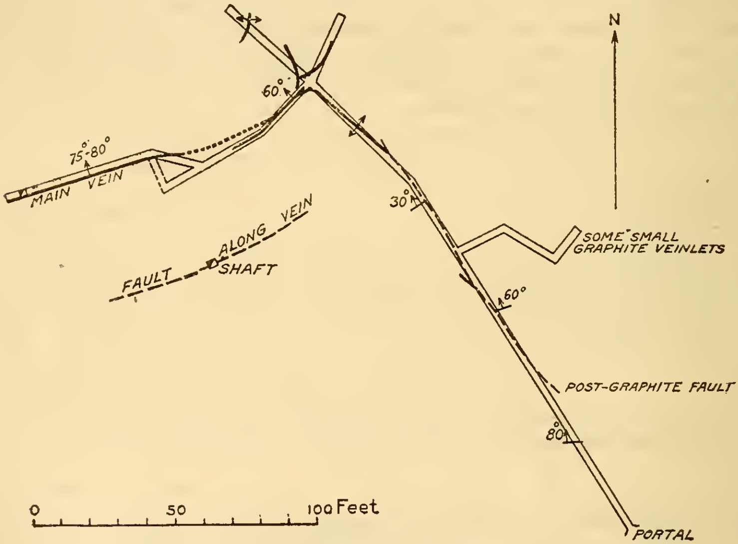

FIGURE 9.—Plan of main workings, Crystal Graphite Co., near Dillon, Mont.

paying mine. The principal workings on the property are located about 9 miles southeast of Dillon (16 miles by road), at the south end of the Ruby Range. The property is within the area of the Dillon topographic sheet of the United States Geological Survey. The mine occupies what is known as Crown Point at an elevation of 9,000 feet, and a good wagon road leads to the mine cabins, within a mile of the mine. From there to the mine the steep mountains must be climbed on foot. Without great expense a wagon road could be constructed to the mine, or the graphite could be transported on pack animals over the steeper part of the trail. The mine is located on the ridge between Timber and Van Camp gulches.

According to Winchell,[1] the rocks exposed in the Ruby Range are chiefly the thick limestone series of the Paleozoic in Montana. The rocks immediately associated with the graphite deposits are limestones and quartzites, apparently of Paleozoic age, which overlie quartz schists and slates that are probably pre-Cambrian. All are

[1] Winchell, A. V., Graphite near Dillon, Mont.: U. S. Geol. Survey Bull. 470, pp. 528–532, 1911.

intruded by granite and pegmatite, and certain rocks of contact-metamorphic origin are developed as a result of this intrusion.

The principal workings are shown in figure 9, the graphite veins being indicated in heavy, solid black lines. The strike of the rocks near the tunnel is variable from N. 5° E. to N. 60° E., with dips of 30° to 60° NW. The first 160 feet of the tunnel may be regarded as crosscut, but the workings beyond follow in part graphite veins. The wall rocks where exposed are pegmatite, quartz schist, and garnetiferous mica schist. As shown in figure 9, in the first 160 feet the tunnel encounters several small graphite veins, but the maximum width of graphite exposed in any of them is only 2 inches, so that they are not workable. The noteworthy feature of this part of the tunnel is the fault plane shown on the map by a broken line. This was formed later than the graphite, for it cuts the graphite veinlets. It carries much gouge but no graphite, except the little that has been dragged out from the veins. At 160 feet from the portal one of the main graphite veins of the mine is encountered and is followed by the tunnel for 30 feet to a point where it turns sharply west. This vein is commonly vertical, but where it turns the dip shifts to 60° N. In places it shows 4 inches of very pure graphite, and in one place the graphite is reported to be 6 inches wide. Beyond the turn this vein merges with the main vein of the mine which is developed by the 120-foot northeast to southwest drift shown on the map.

The main vein shows from 2 to 8 inches of very pure graphite. It dips from 60° to 80° N. Near the main tunnel where it shows 4 inches of pure graphite it is in sharp contact with walls of granite-pegmatite which near the vein contain scattered graphite flakes up to one-fourth of an inch in size. The graphite has been fractured by postmineral movements along the vein and slickensides are developed in both the graphite and the wall rocks.

One of the best exposures in the mine is 10 feet from the face of the main tunnel where a graphite vein is shown in cross section. The wall rock there is altered quartz schist, in places becoming micaceous, and is traversed by a nearly vertical fracture zone along which graphite has been deposited. The vein is about 2 feet wide and consists of an irregular network of graphite veinlets inclosing many sharp-walled schist fragments. The graphite forms about half of the vein material and the veinlets locally unite to form irregular bunches. The south wall is fairly regular, but the north wall is ragged and is penetrated by irregular apophyses from the main graphite mass.

It is evident from this description that the graphite of this mine forms rather irregular veins deposited along fracture planes and more or less broken up by later fracturing.

In comparing the graphite from these veins with that from Ceylon it must be remembered that the workings are shallow and that surface alteration has produced certain changes which will be less noticeable when greater depths have been reached. For example, (1) the luster of this graphite, even when the lumps have been polished or rubbed up, is much less brilliant than that of most of the Ceylon material; (2) thin films of iron oxide occur along parting planes between some of the graphite plates; and (3) the graphite is softer than that from Ceylon and grinds up more readily, though still yielding a flaky product. These differences will probably decrease with depth.

When broken between the fingers the graphite separates into splinters which are roughly spearhead shaped. Truly fibrous varieties, such as the "needle lump" which occasionally occur in Ceylon, were also noted at Dillon.

The absence of the cheap labor available in Ceylon for sorting, rubbing up, etc., is in Montana a handicap which may be offset in a measure by the employment of modern and expeditious methods of mining. If the graphite is steadily produced, a market for use in crucibles might be built up, and it should be excellently adapted for lubricating.

There are numerous other prospect tunnels in this vicinity which show more or less graphite, but none of them are of any commercial promise.

NEVADA.

For a number of years a small amount of graphite has been mined by the Black Lead Mining Co., 3 miles from Carson City, in Ormsby County. The material, which is amorphous, is said to carry from 30 to 50 per cent of graphitic carbon. It is crushed, ground, and bolted, and sold mainly as a paint pigment and for foundry facings.

In 1912 E. Edwin, of Ludwig, Lyon County, reported the discovery of a graphite deposit in that county. He states that the graphite deposit is between 4 and 5 feet thick and is traceable on the surface for several hundred feet. A specimen sent to the Survey was an amorphous graphite of good quality.

NEW JERSEY.

Graphite is known to occur in disseminated flakes in the crystalline rocks of the highlands of northern New Jersey at a number of localities. (See fig. 10.) Several attempts to mine and concentrate the material have been made in the past but have not proved successful, and the State is not now a graphite producer.

The following data regarding the property of the Raritan Graphite Co., of High Bridge, N. J., was furnished by Henry B. Kümmel, State geologist, under date of August 31, 1908:

> The plant consists of a 2-story building with machinery, including two 80-horsepower boilers, two 65-horsepower Atlas engines, one 4-drill air compressor, 1 small hoist, and about 7 dump cars. The graphite-bearing rock forms a bed 30 to 50 feet wide, dipping 70° to the west with a north-northwest strike. It is covered by 6 feet of soil and disintegrated rock. The graphitic bed is considerably decomposed to a depth of 30 feet. The plant was erected in 1906 and up to the middle of November, 1907, they had worked intermittently about seven months. A tunnel was driven into the hill along the strike of the graphite-bearing rock for a distance of about 400 feet, and a pit sunk on top of the hill to a depth of 40 feet to the tunnel. The only ore treated was taken out in driving the tunnel, which was driven in the best part of the bed. The rock is supposed to contain from 4 to 8 per cent of graphite, and the mill test was said to have given about 4 per cent extraction. It is reported that during the seven months of work, 3½ carloads (25 to 30 ton cars) of rock were mined and shipped. The plant is still idle.

The geological occurrence of graphite in this district has been more fully described by Bayley and Stewart.[1] According to these writers the graphite occurs in several ways—(1) as a component of Franklin limestone; (2) in gneisses, which may be in part altered sediments, but in places are certainly mashed pegmatites; (3) in coarse granite

[1] Bayley, W. S., and Stewart, C. A., Note on the occurrence of graphite schist in Tuxedo Park, N. Y. Econ. Geology, vol. 3, pp. 535-538, 1908.

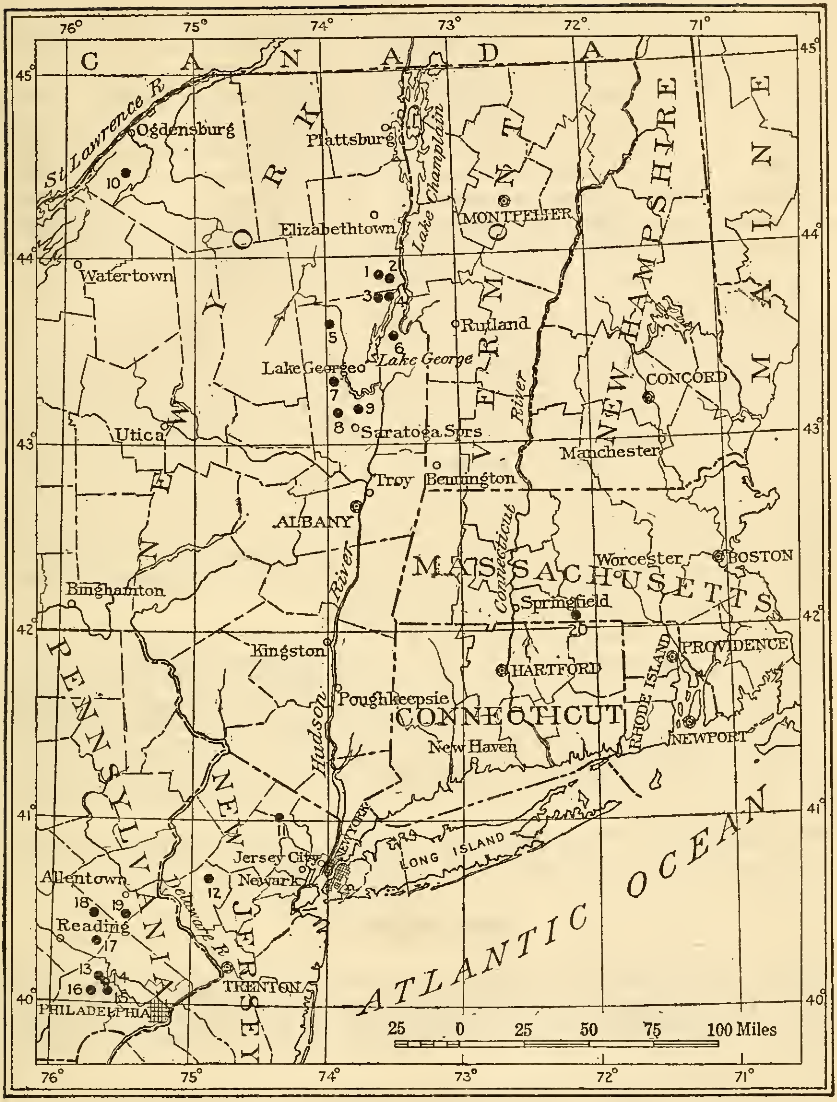

FIGURE 10.—Map showing locations of principal graphite mines in New York, Massachusetts, New Jersey, and Pennsylvania.

New York:
1. Crown Point Graphite Co's. mine and Bly or Jumbo prospect.
2. Ticonderoga (Lead Hill) mine.
3. Dixon's American mine and Faxon's mine.
4. Hague mine.
5. Rowland Graphite Co.'s mine.
6. Champlain Graphite Co.'s mine and Adirondack Graphite Co.'s mine.
7. Sacandaga Graphite Co.'s mine.
8. Empire Graphite Co.'s mine.
9. Saratoga Graphite Co.'s mine.
10. Macomb Graphite Co.'s mine.

New Jersey:
11. Bloomingdale mine.
12. Raritan Graphite Co.'s mine, High Bridge.

Pennsylvania:
13. Eynon Graphite Co.'s mine, Coventryville.
14. Girard Graphite Co.'s mine.

Pennsylvania—Continued.
Rock Graphite Mining and Manufacturing Co.'s mine.
Crucible Flake Graphite Co.'s mine.
15. Anselma Graphite Co.'s mine.
Federal Carbon Co.'s mine.
Chester Graphite Co.'s mine.
16. Acme Graphite Co.'s mine (formerly Continental).
Pennsylvania Graphite Co.'s mine.
Pettinos Brothers' mine.
17. Boyertown (or Columbia) Graphite Co.'s mine.
18. Penn Graphite Co.'s mine, Mertztown.
19. Backenstoe mine.

Massachusetts:
20. Sturbridge mine.

dikes and pegmatites; and (4) in fine-grained quartzitic micaceous schists, especially where they are associated with pegmatites. The last-named mode of occurrence is the most important. Concentrating works at Bloomingdale, at High Bridge, and near Brookside have all failed. In the graphitic schists at Tuxedo Park the graphite plates are usually in parallel intergrowth with biotite plates. The graphitic schist is believed to be the product of the metamorphism of a sediment rich in organic matter. The pegmatites are graphitic only close to the schist or where they carry fragments of this rock.

The following description of the old graphite mine near Bloomingdale is quoted from a report by Cook, published in 1879:[1]

The mine is about a mile south of the village, in Morris County. There are three openings on a northeast and southwest line, on the strike of the gneiss rock. The main one is said to be about 60 feet deep. It is now full of water. The rock, which crops out on the surface on both the northwest and the southeast of the opening, is a micaceous gneiss. From an examination of the material thrown out of this opening and lying about it, the graphite appears as a constituent mineral of the gneiss and of the coarse crystalline rock which is associated with it. The next opening toward the northeast is 80 yards distant. It is a shallow cut across the strata. The gneiss there dips 50° S. 80° E. The northeast opening is about 50 yards from the latter, and is 18 to 20 feet deep. The rock dips 70° SSE. It is here also a micaceous gneiss, which is traversed by a coarse crystalline, feldspathic rock, and the graphite is found in them both. A brown mica, in large plates, and pyrite occur in scattered bunches in the vein mass at all of the openings. The sample selected for examination represents the heaps at the mine. These appear to have been sorted for working. Analysis shows the sample to contain 11.2 per cent of graphite.

The works are about 300 yards southeast of the mine and on the west side of a small stream, which furnishes water power. They contain the necessary stamps for crushing the ore and other machinery for separating the plumbago from the rock, and with very little work they could be put in running order. The stream affords 130 feet head of running water, but the volume is insufficient for steady work and the flume is out of repair. The present location is not as good as could be had on Pequannock River, less than a mile from the mine, and the changes needed in the introduction of new methods of working could be as economically made at another location as in the present mill.

The locations of the principal graphite deposits that have been worked in New Jersey are shown on figure 10.

NEW MEXICO.

Small quantities of graphite have been mined in the past near Raton, Colfax County. The deposits have been examined by Willis T. Lee,[2] of this Survey, and the following extracts are taken from his report:

A large body of amorphous graphite occurs in the canyon of Canadian River, about 7 miles southwest of Raton, in Colfax County, N. Mex. The bed lies practically horizontal and has been prospected for a distance of several miles along the outcrop in the Canadian and its tributary canyons and traced laterally into the principal coal bed of the Raton field, which contains bituminous coking coal. Igneous material was forced into the coal-bearing sedimentary rocks in many places in this field and usually formed coke where it came into contact with the coal, but in the Canadian Canyon the intrusive mass took the form of many sills above, below, and in the coal bed and apparently heated the sedimentary rocks through a considerable thickness. The coal has been most completely graphitized where the bed was fractured and diabase forced into it. The graphite occurs in "pockets" or irregular masses in the diabase and is more or less columnar, the columns usually standing normal to the faces of the

[1] George H. Cook, New Jersey State Geologist, Ann. Rept. 1879, p. 154.
[2] Lee, W. T., Graphite near Raton, N. Mex.: U. S. Geol. Survey Bull. 530, pp. 371-374, 1913.

igneous rock. The columnar parts are relatively pure, but the noncolumnar parts seem to have resulted from what was originally bony coal or carbonaceous shale.

The writer collected a sample of the graphite for analysis 160 feet from the mouth of an old opening, at a point where the bed was about 3 feet thick. In order to obtain a representative sample, the weathered material was cleared from the exposed face of the bed. The sample represents the entire thickness of the graphite at this point, and therefore the analysis shows a greater percentage of impurity than would be found in pieces selected from the best material.

The prospect from which this sample was taken was opened in 1889 by the Standard Graphite Co., of New York, and 250 tons of graphite was shipped from it to Moosic, Pa., where the ore was tested as to its availability in the manufacture of paint. One of the objects of the company was to ascertain whether the graphite could be handled profitably, and careful accounts were kept. According to the statement of one member of the company it was ascertained that the graphite could be placed in the bins at Moosic for $17.50 a ton, the greater part of the cost being shipping charges. At Moosic, at an additional cost of 90 cents a ton, it was ground and separated from some of its impurities by means of air blasts. The refined product contained 80 per cent of carbon, the 20 per cent impurity being mostly silica, which was not regarded as objectionable in the manufacture of paint. The tests were satisfactory to the company and the mill was being taken apart for shipment to Raton when it was destroyed by fire. Nothing has since been done toward developing the graphite.

The sample was analyzed as coal in the laboratory of the United States Geological Survey at Pittsburgh and showed fixed carbon, 76.11 per cent; volatile matter, 6.07 per cent; ash, 16.51 per cent; and moisture, 1.31 per cent. The sulphur was separately determined as 0.177 per cent.

NEW YORK.

The Adirondack region has for some time been the leading and most regularly producing district in the country, largely because of the steady production of one mine at Graphite, operated by Dixon's American Graphite Co. Many other properties which have thus far produced little are of very considerable scientific interest and some are of economic promise. Nearly all of the New York deposits that have been worked are located in the eastern and southeastern Adirondack region, in Essex, Warren, and Saratoga counties, and the northern part of Washington County. (See fig. 10.) West of the Adirondacks some prospecting and development work has been done in St. Lawrence County. All the deposits are located within the area of pre-Cambrian metamorphic rocks. The more important localities are described below. In 1913 the only producers of natural graphite in New York were Dixon's American Graphite Co. and the Graphite Products Corporation, of Saratoga.

ESSEX COUNTY.

CROWN POINT MINE.

A graphite mine formerly operated by the Crown Point Graphite Co. has been idle since the fall of 1910. It is situated about 7½ miles southwest of Crown Point Center, 11 miles from Crown Point Station, and about 10 miles from the railroad at Ticonderoga. A concentrating mill is located at the mine and a finishing mill at Crown Point Center.

The mine is located on the northern slope of the low ridge north of Chilson Lake. The ore is a graphite-bearing crystalline limestone, and the single bed worked strikes about N. 65° to 70° E. and dips

55° to 60° S. The width of the limestone bed varies from 3 to 7 feet and it is traceable along its strike for over 1,000 feet, east-northeast from the shaft. A second bed of graphitic limestone occurs about 375 feet south of the main bed, but is apparently narrower and not traceable far along its trend. Other bands and lenses of graphitic limestone thus far discovered in the vicinity appear to be small and probably are not of much commercial importance.

The best ore from this mine is light gray in color and is made up almost entirely of calcite grains and plates of graphite, with a few scattered grains of pyroxene. Much of the ore, however, is a darker gray in color, owing to a greater abundance of pyroxene. Under the microscope this type of ore is found to consist of interlocking grains of calcite averaging about 2 millimeters in diameter, of pyroxene largely altered to chlorite, and of graphite plates. Most of the latter range from 0.9 to 3 millimeters in length and from 0.15 to 0.3 millimeter in thickness. The rock shows very little tendency toward a schistose structure and the graphite plates are oriented in every direction. A faint banding is due to the greater abundance of pyroxene (green to the naked eye) in certain layers than in others. Little or no mica is present.

A composite sample of the ore selected by the writer so as to represent approximately the run of the mine was analyzed in the laboratory of the United States Geological Survey and showed 2.97 per cent of graphitic carbon.

Granite occurs near the ore body in dikes which are mainly parallel to the limestone in trend, but which here and there cut across the trend of the limestone and the associated schists and are therefore distinctly intrusive in them. At several points typical granite occurs within a few feet of the ore bed. Rocks in which gray bands alternate with bands which are dark green to brownish black are interbanded with the ore; they consist largely of pyroxene, some biotite, quartz, and feldspar, with occasionally some calcite and pyroxene grains. Certain phases of the schist associated with the ore are coarsely crystalline, showing dark-brown pyroxene crystals over 1 inch in length, crystals of calcite one-half inch to 1 inch across, pyrite grains one-half inch or so in diameter, and graphite plates up to one-half inch across.

This locality lies near the border of a large area of granite of pre-Cambrian age. The even distribution of the graphite through the crystalline limestone renders it probable that the carbon formed an original constituent of the limestone. Its conversion to the graphitic state, the recrystallization of the limestone, and the development in it of the mineral pyroxene are the result of metamorphism, possibly in part dynamic, but due to some extent to the contact effect of the neighboring masses of granite rock, as shown by the development of pyroxene schists and coarse crystalline aggregates of pyroxene, calcite, pyrite, and graphite. As already stated, the ore bed persists laterally with fairly uniform width and values for over 1,000 feet. There is no evidence that it may not also persist to a considerable depth, although the proximity of intrusive granite renders it liable to be cut off at any point by that rock.

The development work, aside from shallow surface pits, consisted in the spring of 1909 of an inclined shaft about 72 feet in depth, from which the miners have drifted eastward along the ore bed, removing a considerable amount of ore by stoping, and finally reaching the surface again about 150 feet east-northeast of the shaft. From the shaft the ore was hoisted direct to storage floors at the mill and after preliminary crushing and drying was concentrated by dry processes which were not made public. The mill is said to have a capacity of 30 to 50 tons per 10-hour day. From this mill the concentrates were hauled by teams 7½ miles to a finishing mill at Crown Point Center. The finished product was bagged and hauled 2½ miles to the railroad at Crown Point. The ore, being calcareous is soft and easy milling.

BLY OR JUMBO GRAPHITE PROSPECT.

This prospect is located on Bear Pond Mountain, in the town of Ticonderoga, and is reached by an 11-mile drive from Crown Point. Only prospecting work has been done at this locality, but it has extended over a large area, so that a very good idea can be obtained as to the extent of the ore. At a test pit dug across the trend of the schist on the northeast slope of Bear Pond Mountain the schists strike about N. 65° W., and are nearly vertical. Farther west strikes of N. 80° E. and N. 85° W. were observed; and at the upper pit, high up on the northwestern slope of the mountain, the strike was nearly 70° E. and the dip vertical. This latter hillside pit is 15 feet in maximum depth and 15 feet wide, and exposes 20 feet of graphitic, schist at right angles to the strike. Strippings above the pit raise the known thickness of graphitic rock to about 100 feet. At another small pit about 10 by 12 feet and only 5 feet in depth, at the extreme western part of the summit of the mountain, the schists are vertical and strike about east and west. They are also more quartzose and more contorted than at the other pits. The first pit which was opened is on the south side of the summit and is about 20 by 20 feet and 15 feet in depth. Exposures in the pit and strippings above the pit show about 40 feet of graphitic schist measured at right angles to the trend. The pits on the south side of the mountain are plainly in a separate graphite bed from those on the north side of the mountain.

Exposures in these pits and the natural outcrops show that almost the whole mountain is composed of quartz-mica schists, locally becoming very highly quartzose, which have a fairly regular strike of about east and west and are about vertical in dip. Within these masses occur at least two broad bands of graphitic schist, one on the north side of the mountain which locally attains a width of at least 100 feet, and another on the south side of the mountain locally at least 40 feet wide. Both of these, and especially the northern one, have been traced for considerable distances parallel to the trend of the schist. The supply of graphitic rock is unquestionably large, probably larger than at any other locality thus far prospected in the State. The ore is typically a dark gray, rather coarse and even-grained schist, containing locally small lenses of quartz and feldspar which are much coarser and are pegmatitic in their texture. These may represent small intrusions of granite pegmatite, but the apparent lack of connection between them and any larger masses of granite favors the idea that they are portions of the schists which crystallized more coarsely in the metamorphism that has affected all the rocks in the mountain. At some of the shallow openings on the northeast slope of the mountain the rock is much decomposed, and the graphite, instead of being evenly distributed, is most abundant in small lens-shaped masses which constitute what is called by the owner of this property the "soft ore." Careful examination shows this to be graphitic schist similar to the hard ore but much more decomposed.

Three samples of ore from different prospect pits on this property were examined under the microscope and were found to be composed of interlocking grains of quartz and feldspar in nearly equal abundance, with much biotite (brown mica) and an occasional grain of epidote. Nearly all of the graphite present is either intergrown with the biotite or closely associated with it. Most of the graphite plates are bordered on both sides by biotite and lie between the biotite laminæ as between leaves of a book. Thus biotite crystals 0.15 to 0.45 millimeter thick may inclose graphite flakes of about one-tenth this thickness. The fairly well-developed schistose structure is due to the fact that most of the biotite and graphite plates are oriented in a common direction.

The parallel intergrowth of much of the graphite with brown mica in this ore would unquestionably increase the difficulty of the separation of these two minerals in the milling processes. Fine grinding of some of the ore by the writer shows, however, that a partial separation can be effected in this manner, and portions of the deposit may be found which are sufficiently free from biotite so that this difficulty need not be reckoned with.

Analyses of four samples of ore from various pits at this property made for the owners are reported to run 6.4, 6.6, 6.2, and 8.8 per cent of graphitic carbon. An analysis of a composite sample selected in 1904 to represent as nearly as might be the general run of the mine showed about 5 per cent of graphitic carbon. So far as known, no development work has been done at this prospect since the writer's visit in April, 1909.

TICONDEROGA GRAPHITE MINE.

This mine is located on the eastern slope of Chilson, or Lead Hill, about 3 miles northwest of Ticonderoga, and was worked for many years by Dixon's American Graphite Co. It has now been idle for a number of years, but the supply of graphite ore is not exhausted, and it is possible that the property will be worked again in the future.

The workings consist of a large number of small open pits and several of larger size scattered over an area of several acres in extent. One of the largest of the open pits is about 20 by 40 feet and 20 feet deep, and two short tunnels have been driven from it. The workings first reached in approaching this property along the wagon road are underground and are said to be quite extensive. At the time of the writer's visit they were partly filled with water and could not be entered for any great distance.

Geologically this is one of the most interesting localities with which the writer is familiar. The rocks are of three types: (1) Intrusive igneous rocks, including granite gneiss, pegmatitic granites, and coarse granite pegmatite; (2) crystalline limestone, mica schists, and quartzitic schist that are all probably regionally metamorphosed sediments; and (3) certain unusual rocks characterized by a typical assemblage of contact-metamorphic minerals. These are believed to have been formed through the contact metamorphic effects of the igneous rocks on limestone and in them most of the graphite is found.

Where the granite gneisses are exposed they strike about east and west, nearly parallel to the trend of the associated schists. The gneissic phases of the granite grade into others which are somewhat pegmatitic, although their feldspar crystals seldom exceed 2 inches in diameter. The only coarse pegmatite exposed at this locality is a highly quartzose mass exposed at one of the larger pits. The quartz of this mass is white to dark gray, feldspar is absent from most of the rock, but is present with pyroxene and an occasional black tourmaline in some of the apophyses. This quartz pegmatite is largely barren of graphite, though carrying an occasional isolated plate near its border. In the finer-grained pegmatites and the granite gneiss practically no graphite occurs, except close to the contact with other graphite rocks. The schists intruded by the pegmatite trend at one place east and west, with a dip of about 55° S. Crystalline limestone at one place shows a trend of about N. 70° W., and a dip of 30° S. Much of the schist is highly quartzose and was probably originally an impure sandstone. The beds of crystalline limestone pinch and swell and are sometimes cut off by the granitic rocks. None were observed which were over 3 to 4 feet in thickness. Occasional schist fragments are inclosed in the pegmatitic granite, and, although more or less recrystallized, still preserve their angular outlines and schistose structure.

Most of the graphite occurs irregularly distributed through the contact metamorphic rocks above referred to. In these it forms plates usually less than one-half inch across, but locally over 1½ inches, oriented in every direction, the interspaces being occupied sometimes by scapolite, which superficially resembles light-gray feldspar, sometimes by pinkish to green pyroxene, and sometimes by an association of both these minerals. Some aggregates, several inches across, are composed almost wholly of graphite plates, and constitute one of the principal types of rich ore. Masses several feet across associated with the graphite consist of a granular aggregate of dark-green or pinkish pyroxene grains averaging about 2 millimeters in diameter, with only an occasional crystal of calcite, scapolite, or graphite. Between this and the rich graphite ore there is every possible gradation. Aggregates of coarsely crystalline graphite and scapolite sometimes traverse the fine-grained granular pyroxene aggregates in a more or less veinlike, though irregular manner. Near the contact between the pegmatitic granite and the crystalline limestone, as exposed at the most extensive of the underground workings, the graphite is associated with large crystals of dark-green pyroxene 6 inches across, crystals of calcite of equal size, and large crystals of quartz, scapolite, and biotite. Weathering away of the calcite in some cases shows the pyroxene with very perfect crystal forms. Vesuvianite was observed in crystals about one-half inch in diameter, associated with the pyroxene at this working.

A second mode of occurrence of the graphite at this locality is in narrow veins from 1 to 2 inches wide, most of which are vertical and trend nearly north and south. They cut indiscriminately across the schists and pegmatitic granite, but in a number of cases terminate abruptly when crystalline limestone is reached. In them graphite is usually the only mineral recognizable and forms aggregates of nearly parallel blades arranged about at right angles to the walls of the vein and closely resembling certain of the Ceylon occurrences. In most places the walls of the veins are sharp, and the pegmatitic granite shows no change of texture next to the vein. In a few places, however, the pegmatite becomes pyroxenic, finer grained, and somewhat graphitic next to the vein.

In conclusion, the field evidence seems to indicate a contact metamorphic origin for the graphite of this locality and its associated pyroxene, scapolite, vesuvianite, coarsely crystalline calcite, quartz, etc. In less technical language, these minerals appear to have been formed through the alterations produced in masses of limestone of varying purity by masses of pegmatite and pegmatitic granite which were forced into them in a hot and somewhat fluid condition. Since graphite is not observed in the granitic rocks at a distance of more than a few feet from the sedimentary rocks, it was probably not derived from these igneous rocks, but, on the contrary, was an original carbonaceous constituent of the sedimentary rocks, and has been recrystallized in the contact metamorphism. The vein occurrences of graphite appear to have been formed in the later stages of this metamorphism.

SARATOGA COUNTY.

SACANDAGA GRAPHITE CO.'S MINE (FORMERLY THE GLENS FALLS GRAPHITE CO.

The mine of the Sacandaga Graphite Co. is in the town of Day, Saratoga County. It is about 1¼ miles due west of Conklingville in the Sacandaga Valley, and may be reached by an 8-mile drive from Hadley, on the Adirondack branch of the Delaware & Hudson Railroad. The mine was opened in the spring of 1906. It consists of a single open pit on a southwest hill slope at an altitude of about 1,000 feet. The excavations had in April, 1909, extended to a depth of about 20 feet and covered an area of about 1 acre. The rocks are gneisses, whose strike varies from about N. 70° W. to east and west, with an average dip of about 30° N. The gneiss is coarsely banded and shows notable variation in composition from layer to layer. Some bands are light gray and are composed mainly of interlocking quartz and feldspar grains; other layers are highly garnetiferous. These barren portions of the gneiss alternate with bands which are graphitic.

Much of the graphitic gneiss at this locality is dark silvery gray in color and shows an alternation of thin layers which are highly micaceous and graphitic with other layers from one-eighth to one-fourth of an inch across, which are largely composed of feldspar or quartz. Under the microscope finer-grained bands are seen to consist of a granular aggregate of quartz, orthoclase, and biotite, with some graphite flakes. Other layers are rich in epidote. The graphite plates are not so evenly distributed as in the schist at the American Graphite Co.'s mine, but usually occur in very irregular aggregates, and some of the plates have a length of 3 or 4 millimeters.

Only the more highly graphitic portions of the gneiss were saved in the mining. These usually form more or less lens-shaped masses from a few inches to a foot or more in length, inclosed by the less graphitic rock. Much of the ore mined in 1909 was partly decomposed and rather soft. Although the percentage of graphite is locally much higher than in deposits like those at Greenfield and Graphite, where the flakes are more evenly disseminated, the graphite is much less regular in its distribution, and it is difficult to predict the probable extent of the ore laterally beyond the present exposures, or in depth. The origin of the graphite-bearing gneiss is not entirely clear. It probably represents, in part at least, sediments which have been severely metamorphosed, but there is some indication in their highly feldspathic character that they may, previous to the metamorphism, have been more or less injected by granitic material.

The mill of this company is located about 1,700 feet southwest of the mine and is operated by the water power of a small creek. Its equipment in 1909 included a Sturdevant crusher, Sturdevant rolls, hexagonal revolving screen, wet screens, a drier of special pattern, burrstone mill, and equipment for bolting and grading. In 1912 the following grades were produced:

Grades of graphite produced by Sacandaga Graphite Co. in 1912.

Grade.	Percentage of carbon.	Average price per pound.
		Cents.
Pulverized flake	92	15
No. 1 flake	90	9
Stove-polish grade	80	6
Foundry facings grade	60	3½

The property was not in operation during 1913.

EMPIRE GRAPHITE CO.'S MINE.

A graphite mine worked by the Empire Graphite Co. is located about 2¼ miles west of Porter Corners in the town of Greenfield, Saratoga County. The property was visited by the writer in April, 1909, and its appearance at that time was as follows: The excavations covered about 2 acres along a small ravine on an eastern hill slope, but were only about 25 feet in maximum depth. One tunnel 100 feet long and another about 50 feet long had been driven. The rocks are schists which strike about N. 80° W., and dip about 25° S. They were observed to be graphitic for a thickness of at least 25 feet.

In general appearance the ore is similar to that of the Dixon mine at Graphite, though the graphite flakes seem to be somewhat smaller. The schist is pure silver gray in color when fresh, but weathers to rusty brown and yellow. Certain layers interbedded with the highly graphitic portions are coarser grained and contain only occasional graphite plates, being composed largely of quartz, altered feldspar, and some biotite.

A sample of the best ore when examined under the microscope showed quartz in interlocking grains as its principal mineral; feldspar, in part plagioclase and in part orthoclase, nearly as abundant as quartz; brown biotite present in small quantities; and occasional small apatite prisms. Graphite occurs in plates about 0.8 millimeter in average length and 0.09 millimeter in average thickness, though few attain a length of over a millimeter. A considerable quantity of pyrite is also present, the grains usually being in contact with or closely adjacent to the graphite plates.

Outcrops are scarce in the immediate vicinity of the mine, but the graphitic schists have been traced by test pits for over 1,000 feet along their strike. At a locality about half a mile north of this mine on the Nathan Towne farm graphitic schists similar to those at the Empire mine are interbedded with granite gneiss like that associated with the ore at Graphite, and with thick beds of quartzite bearing occasional mica plates from one-eighth to one-quarter of an inch in diameter. These quartzite beds grade gradually into layers of graphitic schist. They furnish good evidence of the sedimentary origin of the rocks of this vicinity, the original beds being in all probability an alternation of beds of sandstone and shale. These have been brought to their present form of quartzites and graphite schists and garnet schists through regional metamorphism.

A mill has been erected at the mine and the process of concentration there employed has been described by F. C. Nicholas,[1] as follows:

The mill is arranged on the gravity principle and has a capacity of 200 tons every 24 hours.

The material taken from the mine or quarry is delivered to a rock breaker and is reduced to 1½ to 3 inches in size. From the breaker the rock drops to a set of heavy rolls, some 20 feet long by 2½ feet in diameter. In these rolls the material is crushed to a fine sand and drops to a bin, where it is held in check and delivered evenly as required over a second set of rolls the same size as the first, but closely set. In these rolls the material is ground to a fine powder, which is then delivered on an incline and discharged into two great buddles, the tanks of which are 4 feet high and 18 feet in diameter.

The buddles are built of cement and have a steel lining. In the center is an axle and hub, from which long arms and paddles protrude to within about ½ inch from the steel casing. Water and pulverized material fill the tanks and the hubs are set in motion turning the paddles with great rapidity. By this action the material is vigorously agitated, stirred, and turned over for about two hours, every particle having become thoroughly separated and brought under the influence of the water.

In this state the pulp is run to a second set of buddles and is agitated again. The lighter graphite as it rises to the surface of the buddles being completely isolated from the grit is allowed to flow over the top, while the waste is from time to time sluiced into a pit by opening gates in the buddles. The graphite which is run over an outlet at the top of the buddles is then delivered to a set of wet screens and is separated into two sizes. During this separation any remaining grit is disposed of, this operation being simply to allow the water to act on any grit which may remain.

After the separation is completed and all remaining traces of grit have been removed, the graphite is passed to a steam drying cylinder, which weighs about 15 tons. This cylinder revolves till the graphite is thoroughly dried, after which it is passed over silk cloth screens, separated to four sizes, and the process is completed.

The milling process appears to be successful in separating the quartz, feldspar, and other granular constituents, but does not effect a separation of the foliated minerals, biotite (brown mica), and chlorite. Fortunately, in much of the ore these foliated minerals are rare. Some of the ore is said to analyze as high as 12 per cent graphitic carbon, though the average would probably not exceed 7 per cent. The actual percentage saved in milling would probably be considerably lower. The output is hauled 4 miles to the Delaware & Hudson Railroad at Kings station.

The appearance of the property in 1911 has been described as follows by Newland:[2]

The work in 1911 consisted mainly of development incident to a change from surface to underground methods of mining. The deposit along the outcrop has been decomposed with the formation of clayey matter which complicated the separation of the graphite. The matrix is a feldspathic quartzite resembling that at the American

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[1] Min. World, vol. 28, p. 18, 1908.

[2] Newland, D. H., Mining and quarry industry of New York: New York State Mus. Bull. 161, p. 34, 1912.

(Dixon's) mine, but the flake averages a little smaller in size. Two distinct beds are in evidence, separated by 4 feet of limestone and barren quartzite. The upper bed has a thickness of from 10 to 14 feet and the lower of from 4 to 5 feet. The immediate walls consist of mica schist, carrying pyrite, but thick-bedded garnetiferous gneisses occur in the upper part of the series, south of the workings. The outcrop of the beds strikes nearly east and west and is marked by a slight depression in the easterly sloping ridge. It is traceable for 1,500 feet or more from the present mine openings which are at the eastern end of the outcrop. The dip is about 30° S. The principal development aside from the open cuts, consists of an adit driven in the side hill along the course of the upper seam for a distance of about 125 feet. Additional workings will be necessary before the mill can be maintained in steady operation.

In 1912 the company reported that the following grades were produced:

Grades of graphite produced by Empire Graphite Co.

Grade.	Percentage of carbon.	Average price per pound f. o. b. mill.
		Cents.
Large flake	90	8½
Medium flake	87	7¼
Small flake	85	5

The property was not operated in 1913.

GRAPHITE PRODUCTS CORPORATION'S MINE.

This mine, near Kings Station north of Saratoga Springs, was first opened in 1912 under the name of the Saratoga Graphite Co. The property is described as follows by D. H. Newland:[1]

The mines are open cuts along the outcropping edges of a quartz-graphite schist which occurs in broken areas within the pre-Cambric formations that are otherwise represented by crystalline limestone, quartzite, amphibolite, and gneissoid eruptives of granitic and basic character. They lie about one-half mile west of the Saratoga-Mount McGregor highway on the side and top of the ridge that marks the eastern boundary of the pre-Cambrics as they fall off and disappear below the Paleozoic strata which border the Adirondack area. The first outcrop of the graphite rock on the north side of the ravine in which the mill is located shows from 10 to 12 feet in a single bed. The outcrop is much softened and iron stained through the decomposition of pyrite that is present in the fresh rock. This soft clayey material is of little value for milling purposes. The bed dips 30° southeast, nearly parallel with the hill slope. The open cut is 50 feet long and 25 feet in width. Specimens of the less altered schist show an abundance of graphite, but in finely divided condition, most of the scales being less than 1 millimeter diameter. There is some brown mica present. About one-fourth mile farther west and higher up a second area of the schist appears and has been opened by a pit, which is 75 feet long by 30 feet in width. The schist here is not so thinly laminated and contains knots and stringers of feldspar. The beds dip to the southeast at a lower angle than in the easterly pit; they have a pitch to the northwest. The graphite here is somewhat coarser, the diameter of the flakes running up to 2 or 3 millimeters. The two areas are separated by a rather massive, dark hornblende gneiss that appears to be a metamorphosed gabbro. The output of refined graphite thus far has been small. The mill has the usual equipment of the Adirondack graphite mills. Stamps are used for final crushing and the separation is effected mainly by buddles, supplemented by air jigs and revolving screens for the final treatment.

ST. LAWRENCE COUNTY.

The Macomb Graphite Co., in 1911, reported a small production of crystalline graphite from its mine near Pope's Mill. The property was idle in 1912 and 1913.

[1] Newland, D. H., The Mining and quarry industry of New York State: New York State Mus. Bull. 166, p. 32, 1913.

WARREN COUNTY.

AMERICAN GRAPHITE CO.'S MINE (DIXON'S MINE).

The American Graphite Co.'s mine is located in the northeastern part of Warren County, about 3 miles west of Lake George in the town of Hague, at a small settlement known as Graphite. The mine is owned by the Joseph Dixon Crucible Co. and has been operated by that company for over 30 years. It is by far the largest producing graphite mine in the United States. The ore is a medium-grained quartz-graphite schist, dark silver-gray when fresh, but becoming stained yellow and brown upon weathering. This rusty weathering is of assistance in tracing the outcrops of the ore bed. A composite sample of ore taken from the bins at the mill, selected so as to be somewhat representative of the run of the mine, was analyzed in the laboratory of the United States Geological Survey and showed 6.25 per cent of graphitic carbon.

A sample of this ore when examined under the microscope showed quartz in irregular grains as its dominant mineral. Muscovite occurs as aggregates of small shreds forming irregular bands and patches. Some of these probably represent decomposed and altered feldspar grains. Apatite is abundant in small prisms with more or less rounded outlines. There is an occasional small plate of biotite. The graphite forms flakes of an average length of about 0.9 millimeter and an average thickness of about 0.09 millimeter. The longest flake in the section was 2.8 millimeters, and a few were as much as 0.2 millimeter in thickness. Cross sections of the plates show them to possess very ragged and irregular borders.

The texture of the rock is decidedly schistose, due to a tendency for the quartz grains to be more or less elongate in the same direction and for many of the graphite plates to be oriented parallel.

The rock overlying the ore bed is in most cases a gneiss with pink garnets up to half an inch in diameter in a matrix composed of interlocking grains of brown biotite, feldspar, and quartz, with a few scattered plates of graphite. Another dark-gray schistose rock which is locally interbedded with the ore, but which is discarded in the mining, is shown under the microscope to consist wholly of quartz, plagioclase feldspar, and greenish-brown biotite, with no graphite. Evidence of sedimentary origin of the rocks of this locality is found in (1) the highly quartzose, nonfeldspathic character of much of the ore; (2) the highly and evenly garnetiferous character of much of the wall rock; (3) the even dissemination of the graphite in the schist which forms the ore; (4) the persistence of ore beds and garnetiferous gneisses with fairly uniform trend, width, and character for considerable distances, and (5) the presence locally of interbanded masses of crystalline limestone. They probably represent carbonaceous quartzites alternating with beds which were less carbonaceous and with thin masses of crystalline limestone, all of which have been wholly recrystallized with the development of a schistose structure and the conversion of the original carbonaceous material into graphite through the processes of dynamic metamorphism.

The general strike of the schist at this locality is nearly N. 45° E. and the dips are from 20° to 25° SE. Ore has been mined from two beds several hundred yards apart. The southeastern of these beds is not now worked, but was excavated several years ago at what is known as the "summer pit," the workings being shallow and operated only during the summer season. The ore bed here strikes about N. 50° E. and dips 20° SE. The thickness at the mouth of the pit is from 6 to 10 feet. The workings extend at least 600 feet along the strike, but were not carried to great depth along the dip. This pit was opened about 1890 and operated for two or three summers after that. The ore is similar to that of the bed now being worked, and a large supply is apparently still untouched. It is not improbable that this bed represents a repetition by faulting of the bed exposed in the main workings.

The main or northwestern bed (which is the one now being worked) is parallel to that at the "summer pit" in strike and dip. Its outcrop is visible at a number of old workings near the mine. All of the present work is underground, and excavations have extended for about 2,000 feet along the dip of the ore bed, the deepest parts of the mine being about 200 or 250 feet below the surface. The thickness of the productive bed varies from 3 to 20 feet, the average being much nearer the larger limit than the smaller. Occasional lens-shaped enlargements of the productive bed occur, and one of these is being mined at the present time in what is known as the "sink." At one of the outcrops a strike of nearly N. 60° E. and a dip of 25° SE. was observed; at another the dip was similar, but the strike nearly N. 45° E., and the thickness about 10 feet. Because of the gentle inclination of the ore bed no tunnels or shafts need be driven through barren rock, and practically all of the excavation is within the ore bed itself, the wall being supported by timbering and by occasional pillars of ore. The excavating is accomplished by compressed-air drills and blasting, and the ore is broken with sledges into pieces under 8 or 10 inches in diameter, loaded upon cars, and hauled by electric locomotives to the mill. The latter is located at the mine, but was not visited by the writer, the processes of treatment being at that time kept secret.

In a communication from the company received in February, 1912, the milling process is briefly described as "crushing, rolling, and buddling to a 70 per cent concentrate." The concentrates obtained are said to average about 3 per cent by weight of the ore mined. From this mill the concentrates are hauled by teams 11 miles to Ticonderoga where they receive final treatment in the finishing mill, the process consisting in grinding between burrstones and bolting. The finished graphite is then shipped by rail to the factory of the Joseph Dixon Crucible Co., in Jersey City, N. J., where it enters into various graphite products.

What was known as the Lake Shore mine, worked by this company at Hague several years ago, has been abandoned and the mill at Hague demolished.

FAXON'S MINE.

The property adjoining the American Graphite Co.'s land on the southwest is owned by William H. Faxon, of Chester, N. Y. Considerable excavating and drilling have been done, but no ore has been shipped. The principal workings are located about a mile southwest of the mill of the American Graphite Co. Here the ore bed shows in a natural exposure on the side of a small creek valley, and a tunnel about 40 feet long has been driven horizontally along the strike of the ore bed. The ore and associated rocks here strike N. 50° E. and dip about 20° SE. In general appearance the ore is practically identical with that at the Dixon mine. The microscopic appearance of the sample is as follows:

Under the microscope quartz in irregular interlocking grains is seen to be the most abundant mineral. Feldspar, in part plagioclase and in part microcline, also occurs, but has suffered considerable alteration. Brown biotite is present in small quantities, as are also small rounded prisms of apatite. Graphite occurs in plates averaging about 0.45 millimeter in length and about 0.075 millimeter in thickness, though a few plates are 0.75 millimeter long. The schistose structure, which is quite marked in this rock, is due to the parallel elongation of many of the graphite and biotite plates and a slight tendency for the quartz grains to be elongate in the same direction.

The ore bed here has a thickness of about 25 feet, though the percentage of graphite varies somewhat from layer to layer. The rock overlying the ore bed is in part a gneiss studded with pink garnets similar in every way to that overlying the ore at the Dixon workings. This gneiss contains a few graphite flakes. Interbedded with the gneiss occurs crystalline limestone, light gray in color and fine-grained, which under the microscope shows scattered pyroxene grains and a few quartz grains and graphite plates. There is evidence of shearing movement in the beds overlying the ore, lenses of quartz schist surrounded by crystalline limestone having been broken in several instances and the fragments dragged apart, though still preserving their angular outlines. There is also some crumpling in the more quartzose layers.

It is possible that the ore bed at the Faxon mine is the continuation of one or the other of the beds worked by the American Graphite Co., though their continuity has not been certainly traced. The ore is similar in quality, and there seems to be no reason why this property should not in the future be worked as successfully as the adjoining one.

The following more recent information in regard to the Faxon mine is quoted from reports by D. H. Newland:[1]

Adjoining the American mine on the southwest, the property of W. H. Faxon, of Chester, N. Y., has been explored recently with promising results. The same series of quartzites, limestones, and gneisses are in evidence, though the graphite deposits appear to occupy a higher position than those of the American (Dixon's) mine.

This property has been explored recently with considerable thoroughness by test pits and diamond drilling, but still awaits active development. The exploration has demonstrated the continuity of the graphite beds over a distance of fully 4,000 feet along their course to the southwest and, with some interruptions, for several hundred feet on the dip, which follows a low angle to the southeast. The same series of gneisses, limestones, and graphitic quartzites is found here as in the area under exploitation. The graphitic quartzite that constitutes the principal ore body has a thickness ranging from 5 or 6 to 25 feet, showing local pinches and bulges as is usual in the Adirondack deposits. There is considerable variation in the size and abundance of the flake, but as a whole the character of the quartzite is quite like that in the American mine. Near the southwestern end of the property the graphite series outcrops in a little ravine where a short drift has been extended into the north bank; two distinct beds are found here separated by a band of garnetiferous gneiss. In a drill hole (No. 2) 300 feet or so northeast of the drift a similar relation holds, the upper bed measuring about 4 feet and the lower 18 feet thick with 26 feet of gneiss between them. The two beds appear to merge a little farther northeast, for in No. 3 drill hole just east of a camp a single seam over 20 feet thick was encountered and this apparently con-

[1] Newland, D. H., The mining and quarry industry of New York State: New York State Mus. Bull. 142, pp. 37–38, 1910, and Bull. 161, pp. 32–33, 1912.

tinues with local variations as to thickness to the northeastern limits of the property, except in one place where the series is invaded by a gabbro intrusion. The deepest hole, No. 7, was put down in the flat about 600 feet east of No. 3 and twice that distance from the outcrop of the graphite bed on the ridge to the northwest. The data for this boring have been kindly supplied by Mr. Faxon and are illustrative of the general conditions under which the graphite occurs.

	Ft.	in.
Rock with large flake graphite	2	0
Garnetiferous gneiss	20	0
Garnetiferous gneiss and limestone	24	0
Limestone	9	0
Limestone and quartz	8	10
Limestone	36	8
Black rock (hornblende?)	4	0
Limestone	5	3
Lost core	1	6
Graphite	0	6
Good flake graphite	5	4
Fine flake graphite	5	6
Good large flake graphite	12	2
Garnetiferous gneiss	24	0
Black rock	5	8
Total	164	5

In hole No. 1 on the northeast, next to the American property, the graphite bed measured 20 feet thick.

ROWLAND GRAPHITE CO.

This company reported a small production in 1909 from their property near Johnsburg, but has since been idle.

WASHINGTON COUNTY.

In October, 1909, the writer paid a very brief visit to the idle graphite properties situated in the town of Dresden, Washington County. They lie northwest of South Bay, an arm of Lake Champlain. The mine and mill of the Champlain Graphite Co. are within a few rods of the shore of the bay near a prominent bluff known as the "Diameter." The mine and mill of the Adirondack Graphite Co. are also located near the bay about 1 mile farther northeast. The properties may be reached by team and ferry from Whitehall (4–5 miles) or by boat from Whitehall (5–6 miles). The third mine, that of the Silver Leaf Graphite Co., is little more than a prospect pit and is situated in the woods about 1 mile northwest of the Champlain Graphite Co.'s plant. All three mines were opened about 1904.

The mine of the Champlain Graphite Co. is an open pit about 100 feet in length, and 25 feet in maximum depth, on a steep eastern hill slope. The rock is a quartz schist of rather variable character and not very regular foliation. The general strike is about N. 10° E. Some of the more massive layers which are dark gray and fine grained are seen under the microscope to be a granular association of greenish-brown hornblende, feldspar (labradorite), and magnetite, with a little biotite and quartz, but no graphite. They may represent dikes of diabasic rock which have later been metamorphosed to hornblende diorite. The rock in which these dioritic layers occur is schistose and graphitic. Some phases are finely and others coarsely foliated. A specimen typical of most of the material which has been milled when examined under the microscope was found to consist of quartz, muscovite aggregates, which probably represent decomposed feldspars, somewhat altered biotite, and graphite. The latter occurs in flakes which in the thin sections examined varied from 0.015 millimeter to 0.25 millimeter in thickness and up to 1.3 millimeter in length. The average length does not exceed 0.75 millimeter. The graphite is usually closely associated with the biotite, the two being interleaved in some places, as at the Bly mine in Ticonderoga. The schist contains small isolated lenticles up to 2 inches wide of coarsely crystalline calcite, feldspar, quartz, and some garnet.

The mill at this mine had not been running for some time and the milling process could not be studied in detail. The equipment includes a jaw crusher, 12-inch rolls, broken-screw agitators, 3 buddles, drying floor, bolting machines, tube mill, etc.

A prospect opened by the Silver Leaf Graphite Co. is situated in the woods about 1 mile west of the Champlain Co.'s mine. It consists of one pit 15 feet wide, 40 feet long, and 5 or 6 feet deep. The ore is similar to that at the Champlain Co.'s mine. The graphitic schists strike N. 10° W. and dip 25° E. More quartzose layers alternate with others which are more argillaceous and more graphitic. The company has no mill.

The mine and mill of the Adirondack Graphite Co. are about a mile northeast of the Champlain Graphite Co.'s plant, near the wagon road which skirts the South Bay shore. The hillside quarry is about 100 by 100 feet and 30 feet in maximum depth, and all the rock exposed is more or less graphitic. The ore is a dark-gray, readily cleavable schist, which is much more uniform in character than that at the Champlain mine. The strike is quite regular and averages about N. 80° W. The dip is about 30° S. A thickness of 25 feet of graphitic schist is exposed. A thin section of typical ore when examined under the microscope shows quartz as the most abundant mineral with sharply bounded muscovite aggregates, which probably represent altered feldspar grains, and abundant brown biotite. Associated with the last and for the most part interleaved with it occurs the graphite, which according to an analysis made in the laboratory of the United States Geological Survey,[1] constitutes 5.29 per cent of the rock. The sample analyzed was a composite one collected by the writer from various parts of the quarry and probably approaches closely the average run of the mine. Some chlorite and zoisite occur, and certain bands parallel to the schistosity are very rich in pyrite. The rock owes its foliated structure to subparallel arrangement of the graphite and the biotite flakes. The graphite flakes in the thin section studied vary from 0.02 millimeter to 0.15 millimeter wide and range up to 0.9 millimeter in length. The average length is not over 0.05 millimeter.

The mill of this company was situated at the quarry, but at the time of the writer's visit had not been running for many years. The equipment includes a jaw crusher, crushing rolls, a stamp mill with two batteries of 5 stamps each, an inclined screw washer, Wilfley table, 2 buddles, and a flotation separator of special design.

NORTH CAROLINA.

Graphite is known to occur at many localities within the area of crystalline rocks in the central and western parts of the State.

A number of years ago an unsuccessful attempt was made by the Southern Graphite Co. to work a graphite deposit near Graphiteville,

[1] George Steiger, analyst.

McDowell County. According to an article by F. W. Ihne,[1] the graphite is of the flake variety and occurs in a graphitic mica schist. The belt of graphitic schist is in places 300 feet in width, and the percentage of graphite as determined by assays on hundreds of samples is commonly between 3½ and 9 per cent, though in places as high as 18 or even 27 per cent. Some lean bands or lenses occur within the graphitic zone. The milling process, which was complicated and included some processes devised particularly for this mill, is briefly described in the article referred to.

In 1911 Charles Rennie, of Franklin, N. C., reported the occurrence of flake graphite 4 miles west of Franklin. A few tons were shipped for treatment to the Federal Graphite Co., at Warren, Ohio.

In 1912 a few tons of graphitic schist were mined at Barretts Mountain, in Alexander County, but none was refined or shipped.

PENNSYLVANIA.

DEPOSITS.

Graphite occurs at many places in the area of old crystalline rocks in the southeastern part of the State, and has been mined in Chester, Berks, Bucks, and Lehigh counties. The most important deposits are in the Pickering Valley, in Chester County.

The graphite deposits of Pennsylvania have recently been made the subject of a special report prepared by B. L. Miller, for the State of Pennsylvania.[2]

This report may be procured by addressing Richard R. Hice, State geologist, Beaver, Pa., and to it the reader is referred for fuller details. The observations given below were made by the writer in 1909, and supplement to some extent those given by Dr. Miller in the report just cited. The location of the principal mines is shown on the map (fig. 10, p. 205).

CONDITION OF INDUSTRY IN 1913.

The only graphite producers operating in Pennsylvania in 1913 were the Graphite Products Co. and Pettinos Bros., near Byers, and the Rock Graphite Mining & Manufacturing Co., near Chester Springs, all in the Pickering Valley in Chester County. Pettinos Bros. operated only part of the year, their plant having burned to the ground on August 2, 1913. The Graphite Products Co., on June 1, 1913, leased the plant of the Pennsylvania Graphite Co., and during the remainder of the year scored an important production.

CHESTER COUNTY.

Chester County has for many years been the center of the graphite industry of Pennsylvania, and within the last 10 years has been the sole productive district. A single mine is located near Coventryville, in the valley of French Creek, but most of the mines are in the Pickering Valley, which is served by a branch of the Philadelphia &

[1] Ihne, F. W., Graphite in the South: Manufacturers' Record, vol. 54, p. 138, 1909.
[2] Miller, B. L., Graphite deposits of Pennsylvania: Pennsylvania Top and Geol. Survey Comm. Rept. 6, 1912.

Reading Railway, running from Phoenixville to Byers, a distance of 11 miles. Ten different mines with extensive equipment have from time to time been operated in this valley.

UWCHLAND OR BYERS GROUP OF GRAPHITE MINES.

A group of three graphite mines probably situated along the same belt of graphite-bearing rocks near Byers station (Uwchland post office), in Chester County, are similar in the character of the material mined.

The mine and mill of the Acme Graphite Manufacturing Co. are about three-quarters of a mile west-southwest of Byers station. The mine was operated in 1907 by the Continental Graphite Co. The present company began operations in 1909, rebuilding the mill, and continued work until December, 1910. Since then the property has been idle.

The graphite-bearing rocks strike nearly east and west (N. 85° E.) and dip about 45° S. They have been developed by an inclined shaft descending along the dip of the graphitic beds (45° S.). From the bottom of this shaft drifts have been driven eastward for about 150 feet and westward about 20 feet along the graphitic beds. An older level, now in part abandoned, is cut by the shaft at about 70 feet below the surface. A part of this drift was caved, but it was open for about 70 feet east and 30 feet west of the shaft. The mill is close to the mine.

The mine and the mill of the Pennsylvania Graphite Co. are located about a quarter of a mile south of Byers station. They were in active operation at the time of the writer's visit in 1909. The workings are mainly underground, but some ore is "milled" down from open pits into cars in the drifts and thence hauled to the shaft for hoisting. The underground workings accessible aggregated over 900 feet in length to the east of the shaft; to the west of the shaft the drifts were said to extend for about 800 feet, but because of caving only 300 feet were accessible. Considerable stoping has been done above this level. Drifts driven many years ago at higher levels aggregate several hundred feet more, but for the most part were inaccessible. The graphitic beds have a general east and west strike, and dip about 35° S. The shaft descends along the dip to the 70-foot level and from there descends vertically to a depth of 154 feet. There are several open pits. The largest one, temporarily abandoned, is about 30 feet in maximum depth, 100 to 150 feet in width, and about 400 feet in length along the strike of the deposit. The main open pit which was worked in 1909 was 25 feet in maximum depth, 100 feet in width, and 150 feet in length along the strike of the deposit. The width of the underground excavations, though variable, is usually about 15 feet. The mill of the Pennsylvania Graphite Co. had up to 1909 handled only the softer types of graphitic rock available in this mine, the harder material being held in reserve pending the installation of new equipment. The mill was complicated in the arrangement of the machinery, though the types of machinery used are not very numerous. The concentration was accomplished by broken-screw log-washers and wet reels of various mesh. After passing through a rotary drier the concentrate was finished by repeated grinding in burrstone mills and screening, progressively finer screens being used after each grinding. The coarsest flake for crucible stock required grinding on three stones; the finest material passed over six or seven stones. This mill was destroyed by fire.

The graphite mine of Pettinos Bros. is situated about a quarter of a mile east of the Pennsylvania Graphite Co.'s plant on the same general belt of graphitic rock. The underground workings were not accessible at the time of the writer's visit (October, 1909). The shaft is said to be 98 feet deep and to connect with drifts aggregating several hundred feet in length. Graphitic rock has also been taken from several open pits, the largest of which is 25 feet in maximum depth, 100 to 150 feet in width, and 200 feet in length, parallel to the strike of the graphitic beds. Because of weathering and caving there are no good exposures of the graphitic rocks. The mill, which was located at the mine, was destroyed by fire in August, 1913, and has not been rebuilt.

As already stated, all three of these mines are located on the same low east-west ridge and probably on the same belt of graphitic rock. The graphitic rocks at the Acme and the Pennsylvania mines are similar, and those at the Pettinos mine, though not now exposed, probably belong to the same types. The freshest specimen of graphitic rock obtained was from the dump at the Pennsylvania mine. It is a gray, coarse, crystalline limestone containing graphite flakes oriented in every direction and ranging up to one-quarter of an inch in diameter, and plates of brown mica (biotite) up to one-eighth of an inch across. Rock of this freshness is rare, however, and a much commoner graphitic rock at both mines shows graphite flakes embedded in a dull white to greenish matrix which effervesces feebly or not at all with dilute hydrochloric acid. Under the microscope the whitish matrix in which the graphite flakes lie is found to consist of a finely granular aggregate of quartz and calcite (or dolomite) with some zoisite and epidote. Another type shows a more coarsely crystalline matrix consisting mainly of calcite with abundant chlorite (penninite) and an occasional crystal of tremolite and epidote. Most of the so-called "hard ore" at the Pennsylvania mine belongs to one of the types described above, characterized by a white, rather highly calcareous matrix inclosing the graphite flakes.

At both the Pennsylvania and the Acme mines much of the graphitic rock is characterized by a dark, greenish matrix. This type usually can be excavated by pick and shovel without drilling and is thus termed "soft ore." A specimen of this ore contained graphite flakes in a matrix which the microscope showed to be almost exclusively epidote. Much of the decomposed rock exposed in the open pits is a rather fine-grained quartz-feldspar-graphite schist carrying a little muscovite. The schists at all three mines show a fairly regular east and west trend and dip to the south at 35° to 45°. Interbanded nongraphitic talc schists are exposed in the upper level of the Acme mine, where they form the wall rock at several points, and occur as lenses in the graphitic portions.

The other abundant rocks at this group of mines are granitic, mostly fine-grained granite pegmatite. At one of the open pits these rocks make up about one-half of the total exposures. They are distinctly intrusive in the graphitic rocks, and vary in size from very narrow stringers to masses many yards across. The intrusions for the most part parallel the trend of the graphitic rocks, though frequently breaking across. The granitic rocks contain graphite only in the immediate vicinity of the highly graphitic schists and limestones. Even near such contacts there are only occasional flakes.

The excavations at the Pennsylvania mine show beyond question the presence of at least three adjacent belts of workable graphitic rock. These are in general parallel in trend, but mining experience has shown that they are frequently cut off or displaced by irregular intrusions of pegmatite and by numerous fault planes, some of the latter being nearly parallel to the trend of the graphitic beds and others nearly at right angles to them. The soft character of much of the graphitic rock is due to the disintegrating action of surface waters, and it is to be expected that at greater depths the rocks will become firmer. The amount of graphitic rock available, even of the soft types, is unquestionably large.

A graphite mine has been worked by the Eynon Graphite Co. in the town of Coventry, 12 miles from Byers station, but the output has been small and the property was not visited.

ANSELMA GRAPHITE MINE.

A graphite mine and mill which have been abandoned for many years are located about 1 mile southeast of Anselma station. The workings are mainly underground and are now filled with water. Where the graphitic rock outcrops it is a coarse-grained quartz-graphite schist showing graphite flakes up to half an inch across. The strike is N. 85° E. and the dip 40°. This trend, if continued westward, would connect this deposit with those at Byers, which exhibited similar strikes and dips, and it is possible that they lie in the same belt of graphitic rock. The mill located at the mouth of the shaft has been in part dismantled.

ROCK GRAPHITE MINING AND MANUFACTURING CO.

The mine and mill of the Rock Graphite Mining and Manufacturing Co., formerly the Sterling Graphite Co., are located about 1 mile northwest of Chester Springs station. The property was opened in 1904 and has been operated intermittently since then. The mine is an open pit, about 100 by 100 feet and 25 feet in maximum depth, and is located on a northeast hill slope. The rock as here exposed is dark-gray schist, striking north and south and dipping 35° E. Its character is quite uniform throughout its exposed thickness of 18 to 20 feet, if we except the presence of a few stringers of granite pegmatite. Some of the latter carry an occasional graphite flake up to one-fourth of an inch across. Under the microscope the texture is found to be granular. Quartz is the principal mineral, with abundant altered feldspar, biotite, and graphite. The biotite and graphite flakes are frequently attached to one another in parallel growth. The graphite flakes average about 0.6 millimeter in greatest dimension, though some reach 1.5 millimeters. The mine differs from all others in the district in the relatively hard and little weathered condition of most of the rock utilized. Only about 4 feet of weathered material occurs at the surface. In physical character the rock utilized is much like that mined by the Dixons at Graphite, N. Y.

The mill of this company is near the mine and is connected with it by a tramway. The schist is first crushed in a jaw crusher, then passed to a rotary drier, crushing rolls, pneumatic sizing machines, and flotation separators. The concentrates from these separators pass to a rotary drier and are finished in burrstone mills and classifiers. The capacity of the mill is 1,200 to 1,500 pounds of finished product in 10 hours, and the weight of the finished product is stated to be about 3 per cent of that of the rock as mined, about 35 tons of the rock yielding 1 ton of finished graphite. The percentage of graphite in the finished product varies from 42 per cent in the lower grades of dust to over 96 per cent in the high-grade crucible stock.

CRUCIBLE FLAKE GRAPHITE CO.

The mine and mill of the Crucible Flake Graphite Co. are located about 1 mile northwest of Chester Springs station. The mine is located at the summit of a small knoll only a few hundred yards from the mine of the former Sterling Graphite Co. It is a single open pit, about 100 feet by 100 feet and 20 feet in maximum depth. The graphitic rock is part of the same body worked at the Sterling mine and is of essentially the same character. A tramway, traversing a tunnel for part of its length, connects the mine with the mill. The types of machinery used were similar to those at the Sterling mill, though differently arranged. The power of the large Corliss engine is first used to drive a dynamo, and the electric power is then distributed to motors connected with the different parts of the milling machinery. This arrangement has certain advantages in permitting greater freedom in the arrangement of the machinery and in permitting the suspension of certain parts of the milling process while others are still going on.

The last mining done at this property was in 1909. In 1910 the company was reported to be out of business, and the mill has been partly dismantled.

CHESTER GRAPHITE CO.

The mine and the mill formerly worked by this company are located about 1 mile southeast of Chester Springs station and were in active operation at the time of the writer's visit (October, 1909). The graphitic rock was excavated from open pits and dumped down chutes leading to a tunnel about 400 feet in length. From the chutes it was drawn into cars and trammed to the mill. One of the open pits is about 300 feet long from east to west, 100 to 200 feet wide, and 50 feet in maximum depth; another is 100 feet along the strike of the rocks, 60 feet wide, and 50 feet deep.

The rocks exposed in the pits and tunnel are much weathered, and in most of the excavating only picks and shovels need be used. The commonest rocks are quartz-feldspar-graphite schists of medium coarseness, in part quite free from mica, but locally carrying it (muscovite variety) in abundance. Their general strike is about N. 25° E. with a dip of 35° SE. These schists have been extensively intruded by granitic rock (granite pegmatite), the injection locally being on such a small scale that the whole rock becomes a typical injection gneiss. Many of the smaller granitic stringers carry some graphite, The flow sheet for the mill of this company has been published with explanatory descriptions in Mines and Minerals.[1]

This property was last operated in 1910, and in 1913 the company was reported to be out of business.

FEDERAL CARBON CO.

The mine of the Federal Carbon Co. is located about half a mile northeast of that of the Chester Graphite Co. It has been idle for several years. The development includes both an open pit and underground workings. The open pit averages about 100 feet wide, with a maximum depth of about 30 feet; its length in a N. 50° E. direction parallel to the general trend of the graphitic schists is several hundred feet. From the open pit the graphitic rock, which is very soft, is "milled" down into the underground workings. The latter lie beneath the open pits in the same belt of graphitic rock, and the drifts, being for the most part parallel to the trend of the schists, are also parallel to the length of the open pit. The underground workings consist of a vertical shaft 143 feet deep, connecting with three levels at vertical depths, respectively, of 55, 80, and 143 feet. The tunnel of the upper or 55-foot level extends northeast for 500 or 600 feet from the shaft, with a tunnel entrance close to the mill. The graphitic rock of the open pit has been "milled" down into this tunnel, and the rock hoisted from the 80-foot and the 143-foot levels has also been transported to the mill via this level. The drifts on the 80-foot level aggregate about 500 feet in length. The mine below the 80-foot level was filled with water at the time of the writer's visit. The drifts on the 143-foot level are said to aggregate about 700 feet in length. Very little stoping has been done from the 80-foot to the 143-foot level, but the drifts are in graphitic rock for nearly all of their length.

The graphite-bearing rock at this mine is a weathered quartz-graphite schist practically identical with that at the Chester Graphite Co.'s mine. The strike varies from N. 30° E. to N. 55° E. and the dip from 30° to 35° SE. The workings all appear to lie in a single belt of graphitic schist, which varies from 6 to 30 feet in width. The hanging wall in one portion of the 80-foot level was pegmatite, and in a number of places dikes of aplitic granite were found cutting the graphitic schist. The quantity of graphitic rock blocked out by these workings is unquestionably very large.

The mill of this company is located close to the mine and about 1 mile from Pikeland, the nearest station on the railroad. A wet process of concentration was used, the equipment including jaw crusher, crushing rolls, log washers, revolving drier, hexagonal dry screens, burrstone mills, and bolting machines.

GIRARD GRAPHITE CO.

The mine and the mill of this company are located about 2 miles southwest of Kimberton. The first excavations here were for iron ore, but graphite was the mineral sought later. The large open pit about 400 by 300 feet was excavated principally in mining the iron ore. The pit and a 65-foot vertical shaft near by were filled with water at the time of the writer's visit (October, 1909). None

[1] Graphite: Mines and Minerals, vol. 30, pp. 394–395, 1910.

of the graphitic rock utilized could be seen, but the mill concentrates showed that some of it must have been quite coarse grained, some of the flakes of mica (muscovite) and graphite being one-fourth of an inch across. Some of the crushed material seen in the log washers was granite pegmatite. The mill equipment included log washers, drier, pneumatic separators, burrstone mills, and classifiers. The property has not been worked for many years, and in 1911 the machinery was entirely removed.

AMERICAN FLAKE GRAPHITE CO.

The mine and the mill of the American Flake Graphite Co. are located about 3 miles southwest of Phoenixville and 1½ miles southeast of Kimberton station. The shipping point is Harveyville on the Pennsylvania Railroad about midway between the mine and Phoenixville. The mine is a single pit on a southern hill slope. It is about 150 feet long from northwest to southeast, 40 feet wide, and 30 feet in maximum depth.

The rock is a decomposed quartz-graphite schist containing relatively little mica, and so soft that it can be mined with pick and shovel. Its general strike is N. 15° E. and dip 30° to 35° SE. The pit exposes a thickness of at least 20 feet of this graphitic schist. There are a few lenses and stringers of gray quartz up to 4 inches wide and of fine-grained, much decomposed granite-pegmatite up to 1½ feet across. The pegmatite dikes are largely quartz and feldspar; they carry little or no graphite, and were discarded in the mining.

The ore was loaded into a mine car, which was hauled by a mine cable up an inclined trestle to the upper floor of the mill. The concentration was accomplished by a combination of wet and dry processes. The equipment included crushing rolls, log washers, pneumatic separators, and flotation separators of special design. The finishing was accomplished in the usual manner with French burrstone mills and screens.

The company was an important producer for three years, from 1909 to 1912, but has since been idle and the mill has recently been dismantled.

BERKS COUNTY.

The graphite deposits of this county have been described in detail in the report by Miller, already referred to.[1]

In summary Miller says:

> Graphitic gneiss is widely distributed in the crystalline rocks of South Mountain, or Reading Hills, and several graphite mines and prospects have been worked in the county. All of them were unsuccessful, however, for one reason or another, and no graphite mines have been operated in this county for several years. The mines are located in two regions, near Boyertown and in the vicinity of Rittenhouse Gap.

LEHIGH COUNTY.

Some development work has been done on the graphitic gneisses of South Mountain, in the southeastern corner of the county, but so far as known no attempt has been made to concentrate the graphite.

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[1] Miller, B. L., op. cit., pp. 111-115.

BUCKS COUNTY.

Several occurrences of graphitic schist in this county have been described in detail by Miller,[1] his summary being as follows:

Graphite occurs in several places in the narrow band of crystalline rocks that extends across the southern portion of the county from Morrisville through Langhorne to Trevose. The graphite is found in a graphitic gneiss mainly, but in one place it is present in the coarse-grained crystalline Franklin limestone.

Graphite has been mined at two places in Bucks County, in both places in the graphite gneiss.

RHODE ISLAND.

Graphite shales have been worked in Rhode Island for many years, and in 1913 a considerable tonnage from Fenner Ledge at Cranston was marketed crude for use in foundry facings and as paint pigment. The average value of the material was $6.75 a ton f. o. b. mines, and it is said to average about 50 per cent graphitic carbon.

The deposits occur in the vicinity of Providence and near Tiverton, in Newport County, and have been studied by Prof. C. W. Brown, of Brown University, who in 1908 kindly furnished the following descriptions of their mode of occurrence and development for use in these reports:

Graphite has been known in the State for more than twenty years, and during the excavation of the sandstone on the east side of Rocky Hill, in Cranston, about 1,000 tons of graphitic "waste" were dumped on the site of the present Narragansett brewery. No successful attempts at development were made, however, until about 1888. All of the graphite of the Narragansett basin region is similar in character and in mode of occurrence. The largest workings are located at Cranston, near Providence. Smaller deposits occur at Saunderstown, and at Pawtucket and Valley Falls. All the deposits thus far enumerated occur in the Kingstown series of Carboniferous rocks near the western border of the Narragansett basin. Graphite is found also at one locality on the eastern border of the Narragansett basin between Tiverton and Little Compton, and at two localities nearer the center of the basin at Portsmouth, and in the College Hill tunnel in Providence. At these localities it occurs in carbonaceous beds of the Aquidneck series.

PROVIDENCE COUNTY.

Cranston mines.—The largest of the Rhode Island mines is at Fenner Ledge, in Cranston, a suburb of Providence, and is typical of the mode of occurrence in the western portion of the Narragansett basin. This locality has in the past been worked by a number of companies, among others the Rhode Island Graphite Company. A stock company, capitalized at $50,000, was formed in 1898 by J. Mason Gross. The venture, however, was not a success, and for the last two years the property has been worked on a small scale by Mr. Fenner.

The section at Fenner Ledge, as exposed from west to east on a quarried face, is as follows:

Section at Fenner Ledge, Cranston, R. I.

	Feet.
Slightly sheared coarse sandy shale, with occasional pebbly beds	60
Darker, more carbonaceous shale, speckled with glistening plates of ottrelite	75
Graphitic shale, much crumpled and possibly faulted	20
Sandy shale	25
Highly contorted graphitic shales showing lustrous graphite on the sheared surfaces, with more clayey material between; some small quartz and pyrite veins (this is the principal portion which has been worked for graphite)	30
Somewhat carbonaceous shales, with a small bed which is quite graphitic	100+

[1] Miller, B. L., op. cit., pp. 117-118.

Just south of the cliff section described above, at the openings formerly worked by the Rhode Island Graphite Company, the most graphitic portions show close folding with westerly overturning and a gentle northerly pitch. The worked bed is 12 to 14 feet wide, and pinches out upward. The strike is north-northeast, with an easterly dip of 50°. A drift some 30 feet high has been carried along this bed for about 100 feet. As much as 15 tons was taken from this property per diem with a working force of 12 men. In all, about 30,000 tons must have been taken out during the intermittent operations of this property for the last ten years. The plant, which is now abandoned, consisted of a 50-horsepower hoisting engine, sheds for crushing, pulverizing, drying, bolting through silk or brass mesh (from 160 to 220 to the inch), and barreling. The product was shipped to eastern and western firms for foundry facings.

The present operations are confined to the open quarry face, whose detailed section is given above, and about 300 tons of crude material have been shipped in the last two years, at an average selling price of $6 per ton. The material is excavated cheaply by hand drilling and blasting, and shipments are made to the Springfield Facing Company, Springfield, Mass.; to Cincinnati; Detroit; Hamilton, Ontario; New York City; and to New Jersey firms.

NEWPORT COUNTY.

Tiverton quarry.—The graphitic schist worked between Tiverton and Little Compton is exposed in an open cut on the beach. It is exposed for a length of 70 feet and a width of 25 feet. Since it is located at tidewater, any downward development will have to take this factor into consideration. Henry Sisson has worked this occurrence on a lease for the last ten years, and in that period has extracted at a low cost per ton about 200 tons. After grinding by the Springfield Facing Company, it is sold for paint at about $100 per ton. Recently some contracts for painting bridges and gasometers with this paint have been made. The graphite at this locality appears to be more unctuous to the touch than that at other places. There has been more shearing and faulting, but less contortion, than to the westward. Underneath there are also some occurrences of crude hematite and larger quartz veins than at Cranston.

Other localities with shafts were filled with water, and no data could be secured.

All the evidence shows that the graphite represents an original carbonaceous constituent of these rocks, which has been converted into its present form by heat and pressure. The most highly graphitic portions of the graphite-bearing formations are the softest and the most crumpled.

In the following table analysis No. 1 shows the composition of an average specimen of the graphitic shale from the Cranston property, and analysis No. 2 shows the composition of a selected specimen:

Analysis of graphitic shale from Cranston mines, Rhode Island.

	1	2
Volatile	5.92	7.86
Graphitic carbon	40.76	25.27
Ash	53.32	66.87
	100.00	100.00

TEXAS.

The following description of occurrences of graphite in the Llano region of Texas was furnished by Sidney Paige, of the United States Geological Survey:

Graphite-bearing schists are widely distributed throughout the pre-Cambrian series, though the content of graphite is very variable. In most instances the graphite schists are associated with limestone or marble, a natural occurrence since carbonaceous shales are often associated with limestone strata. Often these schists can be traced for long distances.

Graphite-bearing schists were noted at many localities, but since only one of these is as yet considered of importance a description of the occurrence at this locality will serve as a measure of those left undescribed; for it may be said in general, that it would not be advisable to spend money upon prospecting or testing at other localities until the deposit in question is proved a commercial success. If any exception be made to this statement it would be that perhaps certain beds carry sufficient graphite to be of value as a paint pigment, in the industrial manufacture of which a very impure graphite can be used.

The locality which has received and warranted the most attention is 1⅞ miles due south of Lone Grove, is approximately 1,500 feet west of Little Llano River, and about 800 feet north of the Houston & Texas Central Railroad. The property is controlled by R. H. Downman, of New Orleans.

The graphite occurs in graphitic schists associated in this vicinity with considerable limestone. Granite and pegmatite intrusions have locally disrupted the beds, and at a first glance the impression might be formed that pegmatite had introduced the graphite. A careful examination of the graphite bunches in the pegmatite shows, however, that they represent broken fragments of schist. A specimen was polished and etched with hydrochloric acid, which in dissolvng out the calcite contained between the laminæ of the schist fragments showed clearly the schistose nature of the graphite.

The graphite-bearing schists can be traced with interruptions for half a mile northwestward from a point a little west of the railroad bridge, through the present workings, to a point where the series disappears beneath overlying Cambrian sandstones. Graphite is also reported across the river to the south in the same trend.

The deposit has been prospected by a shaft with underground workings and by a number of surface cuts, four or more, over a distance of about 500 feet.

A private report made in 1902 by William Young Westervelt and furnished by the courtesy of Mr. R. H. Downman contains much interesting data on this property, and the following notes re copied or abstracted from it.

An average sample taken over the length of a 72-foot prospect cut showed a carbon content of 11.45 per cent.

A number of tests were made with the following results:

A general sample was made up of all the samples secured underground and crushed to pass a 10-mesh sieve. It was assayed and found to contain 14.50 per cent graphite. * * * Further tests indicate that ore containing 14.50 per cent carbon (the assay of the made-up general sample) will yield from 1 to 4 per cent of its weight of flake graphite [1] containing from 56 to 40 per cent carbon, whose impurities contain less than 2 per cent each of iron (Fe) and lime (CaO), the most common of the objectionable impurities for crucible manufacture. Also * * * that fine graphite could be produced amounting to from 27 to 28 per cent of the original ore and containing from 29.75 to 25.80 per cent pure graphite, the total recovery of graphite in the form of flake and fines being 60 to 61 per cent of the total graphite in the original sample.

Other tests on specially selected samples were made, but need not be presented here.

Much of the territory included in this property has not been adequately tested by surface cuts, and it is believed that possibilities exist for the successful establishment of a graphite industry at this point.

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[1] Too large to pass a 60-mesh sieve.

South of Llano, about 2 miles, graphite schists trending in a northwest-southeast direction toward Sharp Mountain may be observed. In this vicinity, perhaps, with the exception of the property already described, exists the most favorable opportunity to prospect, though graphite schists occur at many localities throughout the region. It must be borne in mind, however, when making an estimate of the graphite content of a given band of schist that appearances are very deceptive, a very little graphite making a very striking showing.

UTAH.

During 1909 a supposed graphite mine was opened near Brigham City, in Boxelder County, Utah, by the Homber Mining Co. of Salt Lake City. According to Hoyt S. Gale,[1] of the United States Geological Survey, the deposits are located on Three Mile Creek between Brigham and Perry. They are carbonaceous schists, which form part of an extensive series of altered sediments. The beds as exposed in the shallow prospects are at least 20 feet in thickness and appear to be persistent for considerable distances. The rock when rubbed takes on a black lustrous polish similar to that shown by certain slates carrying amorphous graphite. It has not a greasy feel, but is free from coarse grit. An analysis made in the laboratory of the United States Geological Survey of a composite sample showed 3.48 per cent of fixed carbon. A selected sample of the most carbonaceous-looking material showed 5.59 per cent of fixed carbon. All of this carbon burns off readily in the ordinary Bunsen flame, and is therefore not graphite. Though probably lacking some of the resistant qualities of slates containing amorphous graphite, the material has proved to be marketable after grinding as a paint pigment.

VIRGINIA.

Although no graphite is now produced in Virginia it is known to occur at a number of localities in the Piedmont region east of the Blue Ridge.[2] Near Somerset station in Orange County on the Somers place a large exposure of graphitic schist occurs, and at the same place much graphite is reported mixed with pyrite in a pyrite vein. In Louisa County, near Green Spring, specimens of graphite of considerable purity are found. Good specimens of the mineral have also been obtained on the road from Drakes Branch to Saxe in Charlotte County. It is reported from near Jefferson post office in Powhatan County.

A graphite mine was opened years ago about 2 miles west of Buck Mountain in the northern part of Albemarle County by the Naylor-Bruce Graphite Co. The mine has been idle for some years, and the openings were so covered at the time of the writer's visit in April, 1911, that very little could be seen of the geology of the deposit. The mine is on a northeast hillside on the farm of W. A. Naylor. A lower pit only 20 feet above the creek level is about 10 by 10 feet and 15 feet deep, and was water filled. The rock exposed near the pit is a mottled green and gray rock of somewhat gneissic texture, which is stated by T. L. Watson to be a pyroxene syenite.

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[1] Gale, Hoyt S., Supposed deposits of graphite near Brigham, Utah: U. S. Geol. Survey Bull. 430, pp. 639–640, 1909.

[2] Watson, Thomas L., Mineral resources of Virginia, pp. 188–190, 1907. Published by Jamestown Exposition Commission.

The principal working is a short distance higher up in the hillside, and consists of an open pit 40 by 30 feet and 12 feet deep, and of a shallow shaft. A small shaft house has been erected. The principal wall rock is the pyroxene syenite, which strikes N. 60° E. and dips about 80° SE. This syenite is intruded by diabase dikes, one dike at this pit being 14 inches wide, and by a 3-inch dike of pegmatite much weathered but showing feldspar crystals up to three-fourths of an inch and quartz crystals up to one-half inch across.

Graphite is exposed only on the south wall of the open pit where the rocks are much weathered. Here there is a single vein cutting the pyroxene syenite and varying from 1 to 2 inches across. This sends off into the syenite numerous short branches up to three-fourths of an inch across. The vein is composed largely of graphite with little or no gangue material. The graphite is in part earthy in texture, but in other places is crystalline with a well-developed fibrous structure. Some hand specimens forwarded to the Survey show some of the graphite fibers oriented at right angles to the sharply defined walls of the vein, but in other specimens they curve through angles of over 90°, possibly as a result of movement along the vein. In some places the fibers even lie parallel to the vein walls. The property is said to have yielded single blocks of graphite weighing several hundred pounds. An analysis by Froehling and Robertson, of Richmond, gave 76.28 per cent of graphitic carbon.

In general the exposures were too poor to reveal much in regard to the origin or probable extent of the deposit.

WISCONSIN.

The only graphite company operating in Wisconsin during the year 1913 was the Wisconsin Graphite Co., having a mill near Stevens Point and a mine about 2 miles northwest of Junction City. The mine is a narrow open pit about 300 feet long from north to south, from the bottom of which a shaft inclined about 30° W. has been sunk. There are three levels in the underground workings. The underground workings were not accessible and little could be learned of the size or shape of the workable body of rock. It appears to strike nearly north and south and to dip gently to the west. The material mined is hauled to Junction City and transported by rail to the company's mill on Big Clover River south of Stevens Point. The product is crushed, dried, pulverized in tube mills, and air-floated. The pulverized product is said to bring from $25 to $35 per ton f. o. b. mills, according to fineness and percentage of carbon. The carbon is said to range from 30 to 40 per cent.

The mine of the Pioneer Graphite Co. is about one-eighth of a mile north of that of the Wisconsin Graphite Co. It has been idle since 1909, when the mill was destroyed by fire. An open pit 100 feet long from north to south and 40 feet wide is now filled with water. A shaft, said to be 86 feet deep, connects with several levels, and about 250 tons of material in all has been mined.

The rock mined at both of these properties is a black slate or shale of hackly fracture, which has in places been sheared with the development of a schistose structure and glossy slickensided surfaces. Occasional small seams of quartz and pyrite traverse this rock. A rock associated with the black rock is bright terra cotta colored and is evidently very rich in iron oxide. The carbon is in a very finely divided state so that concentration is impracticable and the whole rock must be utilized. It is uncertain whether the carbon is true graphite or merely amorphous carbon.

WYOMING.

The following paragraph in regard to the Wyoming graphite deposits is quoted from a recent bulletin by the State geologist:[1]

> This mineral [graphite] is found in Laramie, Albany, Carbon, and Fremont counties, the carbon content, as shown by analyses of samples, varying from 10 to 60 per cent. In Albany County there is a large district known as Plumbago Canyon, where there are a great many deposits of graphite. In Fremont County a deposit of graphite, which is said to be extensive and very pure, occurs near Miners Delight. The graphite found in the State is mostly of the amorphous variety and suitable for paint and foundry facings.

Graphite deposits in the Haystack Hills, Laramie County, have been described by Ball,[2] and the following data are taken from his report:

The graphite occurs as a constituent of a pre-Cambrian mica schist at and near its contact with granitic intrusive rocks. The schists at some distance from such contacts carry carbon but not as recognizable graphite flakes. The largest band of graphitic schist observed has a thickness of only 8 to 10 feet but can be traced along its strike for at least 1,000 feet. The richest material contains upward of 16 per cent of graphite, but estimates based on analyses indicate that the average would be from 6 to 8 per cent. The associated minerals are quartz and tourmaline with a little biotite, muscovite, and feldspar. The graphite flakes are very minute—from 0.04 to 0.15 millimeter in diameter. Profitable separation of such fine material from its matrix could probably not be accomplished by any methods now known, and the quantity of material available is small when compared with many of the flake graphite deposits of the Eastern States. The deposits were prospected as early as 1881, but have never been worked.

MARKETS AND PRICES.

The prices paid by crucible makers and others for Ceylon graphite during 1913 were approximately as follows:

Prices of Ceylon graphite at New York City in 1913.

	Cents per pound.		Cents per pound.
Ordinary lump:		Dust:	
Best	9½–11	Best	4 –5½
Medium	7½– 9	Medium	3 –4
Poor	6½– 8	Poor	2 –3
Chip:		Flying dust:	
Best	7½–10	Best	2½–3½
Medium	6½– 8½	Medium	2 –3
Poor	4 – 7	Poor	1½–2

The rise in prices of Ceylon graphite which began in the last half of 1912 continued in 1913, reaching its highest point in September or October. After this the prices receded somewhat, though still maintaining a very high level. The average prices for Ceylon gra-

[1] Jamison, C. E., Mineral resources of Wyoming: Wyoming State Geologist Bull. 1, ser. B, p. 34, 1911.
[2] Ball, S. H., Graphite in the Haystack Hills, Laramie County, Wyo.: U. S. Geol. Survey Bull. 315, pp. 426–428, 1907.

phite in 1913 were at least 30 per cent higher than for 1912. This notable increase appears to have been mainly a direct result of mining and trade conditions in Ceylon as is indicated by the following statement taken from a report by Chas. K. Moser, United States consul at Colombo:[1]

The surprising increase in the price of plumbago or graphite during the last year appears to have led to some misapprehension in the iron and steel trade throughout the world as to the real causes for it. In Ceylon especially the price has risen beyond all expectation, and European importers have been inclined to place the blame on local shippers. The three reasons assigned locally are the severe floods of 1913, the increased expense of mining as the mines increase in depth, and the shortage of labor.

The followiug comparative figures, taken from the books of one of the largest exporting firms in the island, show the rise in plumbago prices.

Quality.	January, 1912.	January, 1913.	October, 1913.
	Per ton.	*Per ton.*	*Per ton.*
Medium lump	$85.97	$123.27	$162.20
Superior flying dust	45.42	68.13	113.54
Common dust	*a* 25.95	26.76	*b* 66.50
Medium ordinary lump	97.32	134.63	197.88
Superior chip	94.08	131.38	194.64
Superior ordinary lump	154.09	178.42	235.18

a 58 to 60 per cent carbon test. *b* 56 to 57 carbon test.

Uncured plumbago that ordinarily commands about $88 per ton now brings $162 to $195.

* * * In the opinion of Colombo shippers the only solution of the difficulty is for all mine owners to abandon as far as possible the old methods and old machinery and equip their mines with modern machinery. The most necessary machine is a mine pump that will pump out 2,000 to 3,000 gallons per hour with an engine of 25 to 35 horsepower to run it. At present there is one American pump in the island of a type that gives entire satisfaction. * * * The supply of plumbago near the surface has been practically exhausted throughout the plumbago district and the mines in going deeper to get more material have naturally encountered more water. Buckets and hand pumps and coolie labor have been unable to cope with the inflow.

The average price for the best grades of Chosen (Korea) graphite during 1913 was about $25 a ton c. i. f. New York City, or about the same as in 1912. Poorer grades sold as low as $20 a ton.

The few American firms that produced flake graphite during the year reported a fair demand for their product. The prices were extremely variable, but in most cases from 6 to 7½ cents a pound f. o. b. cars was obtained for the better grades of finished crucible and lubricating flake. Some firms sold a part or all of their product as partly finished concentrates, which brought a somewhat lower price.

CEYLON.

The following account of the graphite deposits of Ceylon is condensed from a paper[2] by the writer published in 1911. Those desiring more complete information should consult the original paper and its accompanying bibliography.

The graphite deposits of Ceylon are of especial interest to Americans because most of the graphite used in this country comes from

[1] Daily Cons. and Trade Repts., Dec. 27, 1913.

[2] Bastin, E. S., The graphite deposits of Ceylon; a review of present knowledge with a description of a similar graphite deposit near Dillon, Mont.: Econ. Geology, vol. 7, pp. 419–433, 1912; also U. S. Geol. Survey Mineral Resources for 1911, pt. 2, pp. 1094–1103, 1912.

that island and because the United States has for many years been the largest consumer of the Ceylon material. Much has been printed in regard to these deposits, but it is widely scattered through publications in various languages which are not readily accessible to the American public. The writer has, therefore, summarized the more important facts which are on record, with apologies for any errors which may have crept in on account of his lack of personal knowledge of the island.

Although their existence was known in early times and mentioned in print as early as 1681, the graphite deposits of Ceylon were not

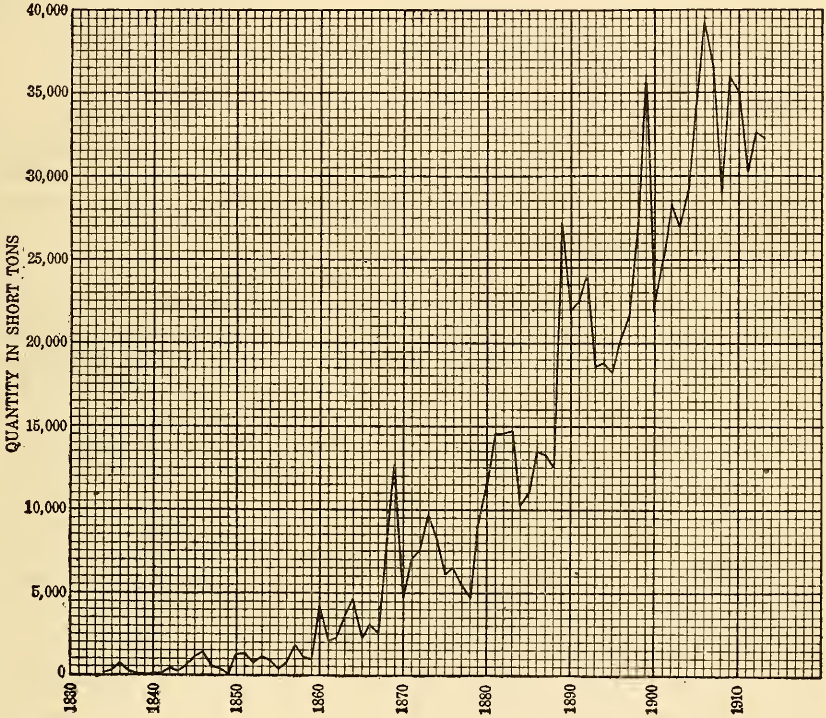

FIGURE 11.—Diagram showing quantity of graphite (plumbago) exported from Ceylon from 1834 to 1913.

exploited until some time between 1820 and 1830. Joseph Dixon is said to have imported a small quantity into the United States in 1829, but it was not until 1834 that the industry assumed any commercial importance. From that time to this, as a result of the growth of metallurgical industries and the resulting demand for refractory materials, the industry has developed rapidly, until at present graphite is subordinate in value only to tea and the products of the cocoanut palm among the exports from the island. Figure 11 shows the exports of graphite from Ceylon from 1834 to 1913.

From the early days of the industry up to 1901, Great Britain consumed more Ceylon graphite than any other country. Since 1901 the United States has assumed the first place, with Great Britain second until 1909, when Germany took second place. The distribution of graphite exports for one year in each of these trade periods is shown in the following table:

Exports of graphite from Ceylon, in short tons.

Destination.	1885 a	1902 a	1913 b
United Kingdom	7,670	7,586	5,995
United States	3,074	15,244	16,381
Germany	67	3,833	7,039
Belgium	....	1,096	2,216
Other countries	187	453	622
Total	10,998	28,212	32,253

a Figures from Ceylon Government Blue Book.
b Advance figures issued by the Ceylon Chamber of Commerce.

With the exception of a limited amount of graphite mining done on tea estates, the industry is in the hands of native Sinhalese. It has been estimated that the various processes of mining, sorting, "curing," packing, and shipping graphite, as well as the making of barrels in which it is exported, provide employment for about 50,000 men, women, and children.

The island of Ceylon is just off the southern point of the peninsula of British India, the channel between being nowhere deep enough for the passage of large ships. The island is more or less pear-shaped in form, and has a length from north to south of about 275 miles and a maximum width of about 135 miles. A railroad extends the entire length of the island, with branches into the central interior. Colombo, the capital and principal seaport, is on the western coast, and is the port from which nearly all of the graphite is shipped. A small quantity is shipped from Galle.

The island of Ceylon may be divided into two natural divisions—a mountainous region of crystalline rocks, which forms the southwestern part of the island, and a lowland area made up of coral limestones and marine sands of much later origin to the north and east. In the mountainous region there are 10 peaks which rise to elevations of over 7,000 feet, the highest being 8,296 feet. This region covers about one-fifth of the area of the island. The principal mines are in the south-central and southwestern parts of the island, and all are within the mountainous region.

The most abundant rocks of the mountainous crystalline area are gneisses of both light and dark varieties. Intimately interbanded with the commoner types of gneiss in bands varying from a few inches to hundreds of yards in width are crystalline limestones, many of which are dolomitic. The origin of the gneisses is not certainly known, but the presence of beds of crystalline limestone will be regarded by most geologists as proof that a part of them at least are metamorphosed sediments. Others are probably altered igneous rocks.

The groundmass of gneissic rocks has been intruded by several types of massive igneous rocks, among which granite pegmatites are conspicuous. The graphite is present locally in small amounts disseminated in the crystalline limestones and some of the gneisses. The commercially important deposits, however, are all veinlike in character and were deposited along fracture planes in the rocks. They were thus formed distinctly later than the rocks which they traverse. In most of the graphite districts the main veins parallel the foliation planes of the gneisses, thus striking northwest and southeast. In the Kurunegale district, on the other hand, the principal veins strike northeast and southwest parallel to a system of joint fractures. In any pit or series of pits there is usually a single main vein or several parallel veins following one of these directions of fracturing and sending off minor veins or stringers along the less prominent set of fractures. In some places the extent of the veins along their trend is so slight that they may be more correctly described as lenses. In other places veins of considerable width may contract to mere seams only to widen again when followed farther. The width of the veins varies from less than an eighth of an inch to several feet, and some as narrow as 2 or 3 inches are worked. The walls are usually sharply defined, and the bordering rock is not impregnated with graphite to a distance of more than half an inch from the veins.

In small veins the graphite usually forms an aggregate of parallel platy needles set at right angles to the vein wall. In the larger veins most of the graphite shows a coarse platy structure, though the needlelike structures may be developed in a band from a few millimeters to 2 or 3 centimeters across next the walls or next masses of wall rocks inclosed in the vein. The needlelike aggregates are in high favor commercially because of their highly fibrous structure and are known as "needle lump." Spherulitic aggregates of graphite plates are of occasional occurrence.

Usually the veins consist almost entirely of graphite, but sometimes other minerals occur in important amounts. Pyrite is almost always present either disseminated between the individual flakes or needles or concentrated in a more or less definite band in the central portion of the vein. Occasionally a pyrite crystal is penetrated by graphite flakes. Quartz, usually milky, often forms a part of the vein, sometimes occurring as a central band. In a few places rosettes of graphite flakes occur in the quartz, and in other places quartz grains lie between flakes of graphite. Quartz and pyrite are the only accessory minerals which are nearly always present, but occasional minerals are biotite, orthoclase feldspar, pyroxene (usually augite), apatite, allanite, and rutile; the last is sometimes developed along cleavage planes in the graphite crystals. In one mine a remarkable cavity or "vug" was encountered which was about 15 feet high, more than a yard wide, and oval in section. Its walls were lined with flaky graphite, and similar material filled its lower portion. In some of the graphite veins slight movements subsequent to their formation have bent the graphite flakes or crushed them to an earthy mass and developed slickensided fracture surfaces.

The graphite is mined either from open pits or through vertical shafts connecting with underground workings. The majority of mines are not deeper than 100 feet, though a few go as deep as 400 or 500 feet. On account of the heavy rainfall water is one of the chief obstacles in deep mining. In a few mines steam pumps and hoists are employed, but as a rule the mining methods are still crude, the acme of mechanical ingenuity being reached in a windlass operated by five or six men for hoisting the graphite in a sort of tub.

The workmen usually ascend and descend by means of rough wooden ladders, tied with jungle ropes and rendered exceedingly slippery by the graphite dust and water.

The mineral as it comes from the pits may contain as much as 50 per cent of impurities, mostly in the form of quartz and wall rock. It is conveyed in bags to a dressing shed, where it is picked over and the impurities reduced to 5 or 10 per cent. It is then packed in barrels for transportation to Colombo or Galle. At these ports it is unpacked and submitted to further treatment known as "curing." The graphite merchants have fenced yards or "compounds" for the final preparation of the graphite for the market. In the methods of "curing" there is some diversity, but the first step is usually to set aside the large lumps and to pass the remainder through stationary screens of several different sizes of mesh. The large lumps and the screened pieces are then broken with small hatchets by Sinhalese women to remove the coarser impurities, such as quartz, and are then rubbed up by hand on a piece of wet burlap and finally on a piece of screening to give them a polish. Finally, various grades coming from several mines or differing in size or texture are blended to meet the requirements of purchasers, a process requiring skill and long experience.

The poorer material is usually beaten to a powder with wooden mauls or with beaters shaped like a rolling pin, and is then sorted into different grades. In some establishments the impure grades are washed in a tub or pit. In this process the mineral is placed in saucer-shaped baskets and by a circular "panning" motion of the immersed baskets the graphite particles are thrown off into the pit, while the heavier impurities, especially pyrite, remain behind. To separate the very fine material, the powdered graphite is placed in a basket with somewhat the shape of a large dustpan. The contents of the basket are thrown into the air, and the heavier particles fall back into the basket, while the finer material is blown forward and falls on the floor.

CHOSEN (KOREA).

The following information in regard to the graphite deposits of Chosen (Korea) is taken from a private report prepared in 1909 and placed at the writer's disposal through the courtesy of Mr. Charles Pettinos:

The existence of large deposits of graphite in Chosen has long been known, but no attempt has been made to develop them until within the last few years, the first mention of graphite in the Chosen customs returns being in 1903, although sample shipments had been made before that time. Graphite is known to occur in all the Provinces, but appears to be most abundant in the Province of Kyeng-Sang, which is nearest to Japan, in Chung-Cheng, one of the western Provinces, and in the northern Province of Pyeng-an. In northern Kyeng-Sang the graphite is interbedded with gneiss. Up to June, 1909, 65 mining rights had been granted under the Chosen laws for the mining of graphite and over 40 more were pending.

In 1909 there were five producing mines in Chosen, all operated by Japanese firms. The first of these mines is situated in the northern part of Chung-Cheng Province, not far from Whang-gan station on the Seoul Fu-San Railway, over which the product is shipped to Fu-San.

The second mine is not far from the first in the northern part of the Province of Kyeng-Sang. The graphite from this mine is transported by river to another station on the Seoul Fu-San Railway. Both of these mines are controlled by the same company, which employs in them about 30 Japanese and 100 Koreans.

The other three productive mines are located in close proximity to one another in the northern customs district of Gen-San and employ about 345 Koreans and 32 Japanese. Transport is costly, being effected partly by oxcarts, partly by river boats, and partly by junks to the port of Gen-San.

An American firm of Seoul is investigating several graphite deposits and has done considerable development work on a property on the east coast about midway between Fu-San and Gen-San. The graphite can be transported by junks to Gen-San at small cost.

All the deposits mentioned above are amorphous graphite. Nothing is published concerning their geologic relations or origin, but a report on them by the Japanese Government is in process of preparation. Some of them are said, however, to be of large size and easily mined. The percentage of carbon in the material which has been shipped is said to vary from 60 to 85.

In December, 1913, six graphite mines were said to be active in Chosen.

Crystalline graphite is also known to occur in Chosen, and one property in Pyeng-an Province, northern Chosen, is being developed. Samples are similar to the graphite of Ceylon, but no information is available in regard to the size or extent of the deposits.

The exports of graphite from the ports of Fu-San and Gen-San, which includes practically the whole Chosen output, are as follows:

Exports of graphite from Chosen (Korea), 1906–1908.

	Long tons.
1906	733
1907	1,154
1908	6,455

Most of the Chosen graphite which has gone to Europe or America has been shipped from Japanese ports. It can be laid down at these ports at a cost of from $10 to $13 a long ton. Considerable quantities of Chosen graphite are now being utilized in the United States, where it comes into competition with the amorphous graphite imported from Mexico. It is used for paint pigment, foundry facings, and for powder glaze. In the latter utilization it is often mixed with Mexican amorphous graphite.

MADAGASCAR.

GENERAL CONDITIONS OF INDUSTRY.

Within the last two years increasing quantities of crystalline graphite have been brought into the United States from the French island of Madagascar, off the east coast of Africa. In general, this graphite is after concentration similar to the flake graphite obtained from New York, Pennsylvania, and Alabama, but in some lots certain of the flakes are bladelike and resemble Ceylon chip in form. The carbon in most of the concentrate thus far imported ranges from 80 to 85 per cent. It has been used in conjunction with Ceylon graphite in the manufacture of crucibles by several American firms, and has been otherwise applied as a substitute for Ceylon chip and American flake. The Morgan Crucible Co., of London, is a large buyer and has a plant at Tananarivo, in which the low-grade material is enriched. The opening for through service in March, 1913, of the new railroad between the port of Tamatave and Tananarivo in one of the graphite mining districts of the plateau should serve to stimulate the industry. A railroad which will traverse a graphite-bearing district is under construction from Tananarivo to Antsirabe, 107 miles farther south, and will probably be completed in 1917. According to one of the Madagascar graphite dealers, the Morgan company buys according to a graded scale of prices based upon size of flake and percentage of carbon, the prices in the latter part of 1913 varying from a little over 2 cents a pound for the smaller sizes (passing a No. 60 French standard screen), carrying 70 per cent carbon, to about 6½ cents a pound for the large sizes (between Nos. 30 and 40 French standard screen), carrying 97 per cent carbon. The prices paid for material carrying 85 per cent carbon vary from about 3½ cents to 5 cents according to size. The graphite for export is commonly packed in bags holding 80 to 100 kilograms. The freight rate from Tamatave to New York City is about $15 per 1,000 kilograms.

Up to December 31, 1911, the total number of claims taken up was 200; by the end of 1912, the number had increased to 942; and by April 1, 1913, to 1,392.

The graphite deposits are found to extend nearly the whole length of the island from near the Amber Mountains on the north to Ambalavao on the south. Those deposits that are now worked are in the central plateau and on the east coast.

The following information in regard to the graphite industry of Madagascar is quoted from a report[1] by James G. Carter, United States consul at Tamatave:

Exports of graphite from Madagascar, 1909–1913.

	Quantity.	Value.
	Metric tons.	
1909	200	$14,320
1910	554	55,713
1911	1,281	86,188
1912	2,638	....
1913 (first half)	2,383	....

The Madagascar graphite may be easily separated from the débris by simply washing it with the hands and, if the work is carefully done, may be concentrated up to 80 or 85 per cent. The graphite thus far produced, however, has averaged from 70 to 80 per cent, due to the fact that it has been washed almost wholly by natives with pans or sluices, the latter method giving the better results. By the use of machinery it is estimated that the concentration may be brought up to 95 or 98 per cent. As the decomposed quartzite and rotten schists retain moisture, only machinery suitable for handling such materials should be employed. Only three of the large producers of graphite have as yet installed machinery at their plants. These are the Maison Suberbie and the Syndicat Lyonnais, at Tananarivo, and Arton et Allemand, at Mamjakandriana, with European headquarters at Antwerp.

[1] Daily Cons. and Trade Repts., Jan. 29, 1913, and Dec. 24, 1913.

The greater portion of the graphite is purchased on the island by local commercial houses for exportation to their European headquarters and by the local representatives of European crucible syndicates or companies. Of the local commercial firms active in the purchase and exportation of graphite are Messrs. Ulysse Gros & Darrieux, Wm. O'Swald & Co., and the Cie. Marseillaise de Madagascar (L. Besson & Co.), with European headquarters at Paris, Hamburg, and Marseille, respectively. The first-named concern is understood to be also purchasing for a European syndicate. The Morgan Crucible Co. (Ltd.), of London, through its established agency at Tananarivo, is also one of the largest purchasers of graphite. Another concern, with purchasing agents at Tananarivo and Antsirabe, is the Syndicat d'Exploitation des Graphites de Madagascar, with headquarters at No. 50 Boulevard Haussmann, Paris. A representative of Arthur Bramwell & Co. (Ltd.), of London, has also been to Madagascar; but this office is without any information as to what purchasing connections the company has established on the island.

Purchasers of graphite for export either buy outright for cash or by contract for a certain number of tons per year at a stated price. The large purchasers also advance money to the holders of claims for working expenses. The contract usually binds the producer to sell to the contracting purchaser only. The large producers, however, except in one or two instances, are yet "unengaged" and export their own graphite.

If American concerns are interested, there seems to be no reason why they should not be able to establish direct relations with the producers of Madagascar graphite and purchase the product upon equal terms with European houses. A list of the largest producers, with whom correspondence might be carried on in regard to the purchase of graphite or the sale of machinery for working it, is herewith forwarded [and may be obtained from the Bureau of Foreign and Domestic Commerce]. The better plan, however, would be to have a representative in the place to establish the desired connections. An American prospector residing at Tananarivo [name obtainable on application at the bureau] is familiar with graphite and mining conditions in Madagascar and would doubtless be pleased to correspond with American firms with a view to purchasing or working graphite for their account.

The present price of Madagascar graphite varies from 200 to 700 francs ($38.60 to $135) per ton f. o. b., according to the percentage of carbon and size of the flakes. Graphite averaging 80 per cent carbon sells for 350 to 400 francs ($67.55 to $77.20) and that averaging 88 to 90 per cent 675 francs ($130.28).

The freight per metric ton on graphite, as quoted by the Messageries Maritimes Steamship Co., is $17 from Tamatave to New York and $20 from Vatomandry and Mananjary, the two southern ports from which graphite is shipped.

Three samples of the crude and one each of the four following grades of refined Madagascar graphite accompany this report: No. 1, 88½ per cent carbon; No. 2, 86 per cent; No. 3, 84 per cent; "averages," 80 per cent. The samples of crude graphite were taken out of a body 3 meters (9.84 feet) wide, at a depth of 10 feet. [These will be loaned by the bureau to American firms interested.]

The samples of Madagascar graphite which accompanied Mr. Carter's report were examined by the writer. The crude material was in lumps as much as 3 inches across that showed a decided foliated structure, and more than half of it appeared to be crystalline graphite, the remainder being more or less decomposed and iron-stained feldspar, quartz, etc. In some of the lumps curved flakes of graphite 0.8 inch in length occur, but in general the graphite flakes are much smaller. Three samples of the concentrate were graded as follows:

No. 1.—Said to average about 88½ per cent carbon. Thin flakes from 0.02 to 0.05 inch in width and from 0.03 to 0.15 inch in length. Luster more brilliant than No. 2 or 3.

No. 2.—Said to average about 86 per cent carbon. Slightly thicker flakes, averaging 0.03 to 0.07 inch in width and from 0.05 to 0.2 inch in length. Luster rather dull.

No. 3.—Said to average about 84 per cent carbon. Thicker flakes, averaging about 0.1 inch in width and from 0.1 to 0.4 inch in length. Luster rather dull.

A notable feature of all the samples is the apparent total absence of mica, but some altered mica (biotite) was observed in another sample of Madagascar graphite obtained from a different source. The impurities consist of fragments of quartz and altered feldspar, more or less iron stained, and possibly other minerals. In general, the refined product differs from the smaller grades of Ceylon material in being flaky and differs from most American flake in that the flakes are commonly somewhat elongate rather than nearly equidimensional.

OCCURRENCE IN MADAGASCAR.

An interesting account by P. Contanciel of the occurrence of graphite in Madagascar was published in a French journal[1] in 1912. The parts likely to be of interest to Americans are summarized below. For exact locations, maps, and diagrams the reader is referred to the original article.

The known occurrences of graphite in Madagascar are confined to the area of ancient crystalline rocks that forms the eastern half of the island. This crystalline tract is in turn divisible into a high plateau region and a lowland tract. Graphite occurs in each but in a somewhat different manner.

GRAPHITE IN THE HIGH PLATEAU TRACT.

The climate of the plateau tract is much less humid than that of the lowlands and vegetation is less prolific. The plateau is in many places separated from the lowlands lying east of it by a steep escarpment whose heavily forested slope extracts much moisture from the prevailing easterly winds.

Because of the climatic features rock exposures are much more abundant than in the lowlands, and there are no deep deposits of "laterite," that is, soil resulting from prolonged rock decay. The graphite deposits are, therefore, strictly bedrock deposits. In the commonest type the graphite is a constituent of a graphitic schist and forms flakes lying between grains of quartz or altered feldspar. Biotite or black mica is sometimes present, but in general is not abundant in the highly graphitic schists. The graphitic schists discovered up to 1912 occur in three principal bands, two of which pass near Tananarivo, the capital of the island. Most of the deposits now known have been covered by claims, but development had at the time this article was written not advanced beyond the "prospect" stage. Their exploitation would involve the crushing of the rock and the separation of the graphite by washing or other means from the feldspar, quartz, and mica with which it is intergrown.

A second mode of occurrence of graphite in the plateau tract is in so-called flat veins (filons couchés). Their exact character is not quite clear from M. Contanciel's descriptions. He states that they lie parallel to the foliation of the schists, and that some of them attain a thickness of as much as 20 meters.

Their graphite content is higher than that of the ordinary graphitic schists, and may reach 30 per cent, though seldom more. They have been the object of serious exploitation at several places, the excavations commonly being open pits, though in a few places

[1] Contanciel, P., Note sur les graphites de Madagascar: Soc. indust. min. Bull., November, 1912, pp. 505-530.

shafts and galleries have been driven. The open pits seldom exceed 25 meters in depth and are all, therefore, in more or less decomposed material which is easily excavated.

The Tsarazafy concession northwest of Tananarivo is an example of a property worked by underground methods. The method of concentration employed at the Tsarazafy concession is described as follows: The crude material, which seldom contains more than 30 per cent of graphite, is first washed in tubs by women laborers along the river bank. By this washing the graphite concentration is raised to about 50 per cent, much being lost in the process. The material is next spread on hearths heated by brush fires, to dry, and then fed to a series of screens with round openings 3, 2, and 1 millimeters in diameter. The oversize from the 3-millimeter screen is sent to crushing rolls and then again passed over the screens. The sized product from the screens goes to winnowing machines, somewhat similar to those used in vanning corn. The products of these machines are tailings that are discarded, middlings that are re-treated, and two sizes of graphite concentrate (1 to 2 millimeters and 2 to 3 millimeters). The vanning is not very efficacious in separating the fine rock dust and much of it is eliminated by further screening. The final product, averaging about 80 per cent graphite, is only 5 to 10 per cent by weight of the rock mined. After sacking it is ready for shipment. Electric power for the mill is supplied from a power plant at a falls 2 kilometers distant. The cost of mining and milling by this process is about 90 francs ($17.37) per metric ton (2,205 pounds) of concentrate produced.

The native process is still simpler, and at the Louys mine, at Isaha, is carried on as follows: A laborer breaks the lumps of crude material with a mallet or a club and throws the material into a cubical tub 0.6 meter in diameter. A current of water enters at one side of the tub and leaves at the other, and the same laborer agitates the material in the tub with a spade. The overflow from the tub goes into a slightly inclined wooden trough 4 meters long, 0.3 meter wide, and 0.3 meter deep, whose lower end is half closed by a board 0.15 meter high. The agitation in the tub tends to float off the slime, while the sand and most of the graphite remain behind. Whatever graphite floats off is caught in the trough. The washed mixture of sand and graphite is dried in the sun on floors and then passed to screens of 4, 8, 12, and 16 meshes per centimeter. After the screening the several sizes are sacked. The product averages about 70 per cent graphite and forms about 2 per cent by weight of the rock as mined. The cost of mining and milling is about 100 francs ($19.30) per metric ton (2,205 pounds) of concentrate produced.

The two plants, whose methods have just been described, were up to the time this article was written the only important producers in the plateau tract, other properties being merely prospects. As regards the future of the industry, M. Contanciel says:

> Aside from these exceptional cases, the exploitation in the high plateau tract is destined to encounter considerable difficulties. There is never a lack of water, and means of communication can easily be developed; but for crushing the rocks and for wet processes of separation it is necessary to install complicated and expensive machinery, hardly warranted by the value of the product obtained.

GRAPHITE IN THE LOWLAND TRACTS.

The lowland tract, east of the plateau tract, is characterized by great humidity and by prolific vegetation, which completely masks the bedrock. The soil resulting from rock decay ("laterite") is deep and in it the graphite occurs. The original rock before decay was probably similar to the graphitic schist of the plateau tract. The process of rock decay has served to increase somewhat the percentage of graphite by removing some of the more soluble constituents of the rock, and has yielded an incoherent and easily excavated material which requires no crushing. The greater ease and cheapness with which the graphite deposits of the lowlands can be worked, as compared with those of the plateau, is counterbalanced to some extent by transportation difficulties. Real roads are practically lacking, and if constructed are almost impossible to maintain. It is hard to conceive how difficult it is for the natives themselves to cover even small distances along the paths that are pompously called "roads," and all transportation in our day, at least, must be on the backs of men. Because obscured by vegetation, the deposits are less easily located and followed by the prospector than in the plateau tract. M. Contanciel does not describe the methods of concentration used in the lowland tract.

MEXICO.

For a number of years the United States Graphite Co. has been an important producer of amorphous graphite from mines in the State of Sonora, Mexico. The crude material is shipped by rail to Saginaw, Mich., where it is ground in continuous feed tube mills and is subsequently air floated. Some of the product is mixed with greases to make a prepared lubricant or with other pigments and oil for black, dark green, and dark brown paints. The remainder is marketed in the dry state for practically all the purposes to which any graphite is applied, except the manufacture of crucibles and related refractory products.

The following description of the graphite mines of Sonora, Mexico, has been furnished by Frank L. Hess, of this Survey, who visited these properties early in 1909:

The Santa Maria graphite mines, which are owned by the United States Graphite Co., of Saginaw, Mich., are situated about 20 miles south and a little east of La Colorada, in central Sonora. They are the largest amorphous-graphite mines in the western hemisphere and probably in the world. The country rock is composed of metamorphosed sandstone, ranging in fineness from shaly material to conglomerate containing pebbles of 1½ inches diameter. Considerable andalusite in small crystals is developed in the sandstone. The rocks are probably of Upper Triassic age. They are intruded by granite, which has been the metamorphosing agent. Intercalated with the sandstone are at least seven beds of graphite, ranging in thickness up to 24 feet and standing at high angles. The rocks are considerably folded, and the graphite beds show the effect of movement more than the inclosing sandstone; in places they are almost cut off through squeezing, while in other places they show thickening. The graphite beds are also intruded by granite dikes, and in places the walls are of granite. The graphite was undoubtedly formed through the metamorphism of coal beds, which in other parts of the State are to be found in the form of coke, anthracite, and bituminous coal. The graphite of the Santa Maria deposits is entirely amorphous, and from the main vein worked averages about 86 per cent graphitic carbon. Specimens may be picked which carry 95 per cent graphitic carbon. The graphite is shipped to Saginaw, Mich., for refining. A large part of the best pencils, both of European and American manufacture, are made from this graphite. It is also used as a lubricant, for powder coating, and for foundry facings. A few miles north of Torres, and 3 miles west of the railroad, Pettinos Brothers, of Bethlehem, Pa., own graphite deposits, for which a good price was paid a few years ago. A small amount of graphite was shipped, but the property is now lying idle. Prospecting is being carried on for graphite on the east side of Yaqui River, a few miles above Onavas. The geology is similar to that of the deposits at Santa Maria, about 75 miles west. At San Marcial, between Santa Maria and Onavas, coal is found partly graphitized; and at points on Yaqui River above Onavas unaltered coal beds are reported, which, it is said, the Southern Pacific controls and will use for fuel on its Mexican lines.

LITERATURE.

GENERAL TREATISES AND NEW PUBLICATIONS.

The best general treatise in English on the occurrence, methods of treatment, and uses of graphite is that by Fritz Cirkel, listed as No. 14 of the bibliography. During 1912 a report by B. L. Miller on the graphite deposits of Pennsylvania was published; it is listed as No. 44 of the accompanying bibliography. It describes in detail, with maps and illustrations, the graphite deposits of that State, describes briefly the occurrences of graphite in other parts of the country, and gives a large amount of general information on the character, treatment, and uses of graphite. The report may be obtained from Richard R. Hice, State geologist, Beaver, Pa.

The best general treatise on the geologic occurrence of graphite is that by Stutzer, listed as No. 75 of the bibliography. This summarizes the geology of the more important deposits of the world, but only touches briefly on uses and methods of treatment. The book is in German.

Two general treatises in German are the following: Der Graphit, by A. Haenig, 1910, and Der Graphit, by E. Donath, 1904.

The literature dealing with graphite is voluminous and contains many abstracts and quotations. The following list is selected, so far as possible, to avoid duplication and yet to convey all the important information relative to the occurrence and production of the mineral in the United States. Under each reference the general scope of the paper is described, and attention is directed to its most important features. Canadian publications are not listed unless they are of general interest or include mention of United States deposits. For references to the voluminous Canadian literature and many foreign publications the reader is referred to the monograph by Fritz Cirkel, already referred to.

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[1] The numerals given in this index are the numbers prefixed to the entries in the bibliography, pp. 246 to 251.

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2. ——— Discussion of artificial graphite: Mineral Industry, vol. 8, pp. 351, 352, 1899.

3. ARSEN, W. C., Transformation of other forms of carbon into graphite: Am. Electro-Chem. Soc. Trans., vol. 20, pp. 105–119, 1911. Discusses experiments by the author and others bearing upon the question whether the transformation of ordinary carbon into graphite can take place by simple heating or only in the presence of certain impurities, which act as catalytic agents. In the author's experiments all samples were fired in a small tube furnace for 15 minutes at temperatures of approximately 3,000° to 3,300° C. Comparative tests were made of various forms of carbon when pure and when mixed with 5 to 10 per cent of impurities. The presence of impurities seemed in most cases to retard rather than to accelerate the conversion to graphite. The character of the carbon used appeared to be important, some forms, such as petroleum coke, being readily converted, while others, such as lampblack, were not graphitized. The author suggests that graphite may be defined as "that allotropic form of carbon having a specific gravity of 2.25 to 2.26."

4. BAYLEY, W. S., and STEWART, C. A., Note on the occurrence of graphite schist in Tuxedo Park, N. Y.; Econ. Geology, vol. 3, pp. 535–538, 1908. Observations in the New York and New Jersey Highlands west of the Hudson River indicate that graphite occurs (1) as a component of Franklin limestone, (2) in gneisses which may be in part altered sediments but are in places certainly mashed pegmatites, (3) in coarse granite dikes and pegmatites, and (4) in fine-grained quartzitic micaceous schists, especially where these are associated with pegmatites. The last-named occurrences are the most important. Concentrating works at Bloomingdale, Highbridge, and near Brookside have all failed. Describes in detail the occurrence of graphite in schists at Tuxedo Park. The graphite plates are usually in parallel intergrowth with biotite plates. The graphitic schist is believed to be the product of metamorphism of a sediment rich in organic matter. The pegmatite is graphitic only near the schist or where it carries fragments of this rock.

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through squeezing to a thin seam, yet in other places bulging to 24 feet. The wall rock is in most places a sandstone, though locally granite. Limestone also occurs near the mine. The graphite probably represents a coal bed of Upper Triassic age, which was graphitized by the intrusion of granite. The graphite is of the amorphous variety, and it is excavated from extensive underground workings and hauled by 10 to 14 mule teams 20 miles to the railroad at La Colorada. From there it is shipped to the factory of the operating company—the United States Graphite Co., at Saginaw, Mich. Map and sketch plan of vicinity of mines. Seven half-tone illustrations.

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49. ——— vol. 7, pp. 382–387, 1898. Description, by T. C. Hopkins, of graphite properties near Chester Springs, Chester County, Pa., with quotation from Weinschenk on mode of occurrence in Bavaria and Bohemia.

50. ——— vol. 8, pp. 348–352, 1899. Description, by T. C. Hopkins, of the occurrence of graphite in Berks County, Pa. Discussion, by E. G. Acheson, of artificial graphite.

51. ——— vol. 9, pp. 378–383, 1900. Discussion, by F. S. Hyde, of assay of graphite by blast and fusion.

52. ——— vol. 10, pp. 367–373, 1901. Two pages devoted to manufactured graphite.

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tures is less readily attacked by the usual reagents than that formed at lower temperatures. The swelling exhibited by certain graphites when heated with aqua regia is believed to be due to the sudden evolution of gases. All the artificial graphites produced by simple elevation of temperature were nonswelling; all obtained from fusion with metals exhibited swelling. The temperature of swelling lies between 165° and 175° C.

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63. ——— Bull. 120, pp. 29–31, 1907. Describes briefly mines near Conklingville, in Saratoga County, and near Rossie, in St. Lawrence County. Discusses effects of presence of mica and influence of size of graphite flake in concentration.

64. ——— Bull. 142, pp. 37–38, 1909. Describes the graphite property of W. H. Faxon, near "Graphite."

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71. ——— Graphite: U. S. Geol. Survey Mineral Resources, 1904, pp. 1157–1167, 1905. Good brief summary of occurrence and uses.

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87. Watson, Thomas L., Mineral resources of Virginia, pp. 188–190, 1907. (Published by Jamestown Exposition Commission.) Mentions the localities at which graphite has been found in Virginia. No detailed descriptions.

88. White, David. Some problems of the formation of coal: Econ. Geology, vol. 3, p. 298, 1908. The discovery of hydrocarbon-bearing strata composed largely of such organisms (algæ) in rocks as old as the Ordovician strongly suggests an algal origin for the graphites interbedded in still older metamorphic sediments of the Laurentian or the Algonkian.

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90. ——— A theory for the origin of graphite as exemplified in the graphite deposit near Dillon, Mont.: Econ. Geology, vol. 6, pp. 218–230, 1911. This article covers in more detail the same ground as 89. It describes the mode of occurrence of graphite on the property of the Crystal Graphite Co., near Dillon, and discusses various theories of graphite formation. To account for the veinlike deposits the writer suggests that a reversible reaction may have taken place whereby the water vapor of a granitic magma first reacted with carbon in bordering carbonaceous rocks with the resulting formation of oxides of carbon (mainly CO) and hydrogen; that these gases became incorporated in the magma; and that they were finally given off as the magma cooled and penetrated fissures in the rock where, through a reversal of the reaction, graphitic carbon and water were formed.

ABRASIVE MATERIALS.

By Frank J. Katz.

REVIEW OF THE ABRASIVE INDUSTRY IN 1913.

The total value of the abrasive materials considered in this chapter, which entered trade during 1913, increased about 8 per cent as compared with the value for 1912. There was an increase both in domestic production of natural abrasives and artificial abrasives and in importation. The value of natural abrasives produced increased about 3 per cent; of artificial abrasives, about 15 per cent; and of imports, about 2 per cent.

In the natural abrasive industry gains were shown in the production of garnet and tripoli and diatomaceous earth. There was a decrease in the quantity of millstones and of quarry products made in connection with them, such as chasers and drag stones; of grindstones and pulpstones; of oilstones, whetstones, and scythestones; of emery; and of pumice. The total estimated value of all the abrasive materials consumed in the United States during the six years 1908 to 1913, inclusive, is given in the following table:

Total value of all abrasive materials[a] consumed in the United States, 1908–1913.

Year.	Natural abrasives.	Artificial abrasives.	Imports.	Total value.
1908	$1,074,039	$626,340	$476,073	$2,176,452
1909	1,329,750	1,365,820	653,779	3,349,349
1910	1,406,805	1,604,030	977,718	3,988,553
1911	1,526,763	1,493,040	815,854	3,835,657
1912	1,601,993	1,747,120	898,892	4,248,005
1913	1,648,578	2,017,458	916,913	4,582,949

[a] Exclusive of feldspar and the various forms of silica. See chapters on feldspar and silica.

The value of abrasive materials imported for consumption into the United States during 1912 and 1913 is as follows:

Value of abrasive materials imported into the United States, 1912 and 1913.

Materials.	1912	1913
Millstones and burrstones	$27,562	$40,198
Grindstones	131,080	139,386
Hones, oilstones, and whetstones	45,398	40,222
Emery and corundum	491,725	474,299
Infusorial earth, tripoli, and rottenstone	24,253	28,696
Pumice	74,478	93,408
Diamond dust and bort	94,396	100,704
Total	888,892	916,913

NATURAL ABRASIVES.

Under the head of natural abrasives in this report are included (1) millstones and related quarry products, such as chasers and drag stones, (2) grindstones and pulpstones, (3) oilstones and scythestones, (4) corundum and emery, (5) abrasive garnet, (6) diatomaceous earth and tripoli, and (7) pumice. The difficulty of separating abrasive quartz and feldspar from the quartz and feldspar produced for other purposes has led to their omission from the chapter on abrasives, and such information as appears about them in "Mineral Resources" will be found in the chapters entitled "Feldspar" and "Silica." The statistics in this report represent only that part of the production of natural abrasives that properly comes under the abrasive industry, except as indicated below; thus only a small percentage of the sandstone that is quarried is used in the manufacture of abrasives—grindstones and pulpstones—the remainder being used chiefly in the building industry. There is difficulty in separating that portion of the production of tripoli and diatomaceous earth which is used as an abrasive from that which is not; hence the production of these substances is given in full. A large part of both of these products is not used as an abrasive, but is applied to other and diverse uses. Diatomaceous earth, for example, which is a nonconductor of heat and is of light weight, is used extensively as a packing material for furnaces, steam pipes, and boilers, and as a fireproof building material. Similarly, tripoli, in addition to being ground and used as an abrasive is used as a filtering medium. Almost the entire output of millstones, pumice, emery, and garnet (except gem garnet) is used in the abrasive industry.

Natural abrasives were produced in 1913 in 26 States, which are listed below:

Alabama: Millstones.
Arkansas: Oilstones.
California: Diatomaceous earth.
Connecticut: Diatomaceous earth.
Georgia: Tripoli.
Florida: Diatomaceous earth.
Illinois: Tripoli.
Indiana: Oilstones.
Kansas: Pumice.
Kentucky: Oilstones.
Maryland: Diatomaceous earth.
Michigan: Grindstones and scythestones.
Missouri: Tripoli.
Nebraska: Pumice.
Nevada: Diatomaceous earth.
New Hampshire: Garnet and scythestones.
New York: Millstones, emery, garnet, and diatomaceous earth.
North Carolina: Millstones and garnet.
Ohio: Grindstones, pulpstones, oilstones, scythestones.
Pennsylvania: Millstones.
Tennessee: Tripoli.
Utah: Pumice.
Vermont: Scythestones.
Virginia: Millstones and diatomaceous earth.
Washington: Diatomaceous earth.
West Virginia: Grindstones.

In the following table is given the value of the natural abrasive materials produced during the last five years:

Value of natural abrasives produced in the United States, 1909–1913, by kinds.

Abrasive.	1909	1910	1911	1912	1913
Millstones	$35,393	$28,217	$40,069	$71,414	$56,163
Grindstones and pulpstones	804,051	796,294	907,316	916,339	855,627
Oilstones and scythestones	214,019	228,694	214,991	232,218	207,352
Corundum and emery	18,185	15,077	6,778	6,652	4,785
Garnet	102,315	113,574	121,748	163,237	183,422
Abrasive quartz and feldspar	(a)	(a)	(a)	(a)	(a)
Infusorial earth and tripoli	122,348	130,006	147,462	125,446	285,821
Pumice	33,439	94,943	88,399	86,687	55,408
Total	1,329,750	1,406,805	1,526,763	1,601,993	1,648,578

a See chapters on feldspar and silica.

MILLSTONES.

PRODUCTION.

The production of millstones and related quarry products, burrstones, chasers, and drag stones in the United States in 1913 amounted to $56,163 in value, a decrease of $15,251, or 21.36 per cent, compared with the value in 1912. The production of millstones in this country in 1913 was nevertheless larger than in all but three years since 1888, when it was valued at $81,000.

For the last 25 years the returns to the Survey from this industry have shown great fluctuations, which have been difficult to account for satisfactorily. It is natural to suppose that the market for millstones, made as they are from quartz conglomerate, would have declined in recent years because of the introduction of other grinding machinery. The replacement of the millstones, it is but natural to assume, would be gradual, and the value of millstones would therefore show a steady falling off. This, however, has not been the case. From a maximum value of $200,000 in 1880 the value of millstones fell to $100,000 in 1887; from $81,000 in 1888 the value declined rapidly to $16,587 in 1891; in the following year there was a rise in value to $23,417, followed by a marked decline in the two following years, until the lowest production ever reported, namely, $13,878, was reached in 1894. Since that year the values have risen and fallen, as will be observed from the table of production, without any apparent rule.

Millstones were produced in 1913 in Alabama, New York, North Carolina, Pennsylvania, and Virginia, the same States that have produced them in recent years. The output in New York fell off about 35 per cent and it decreased slightly in the other States except Pennsylvania, which made practically the same production as in 1912. Virginia was first, New York second, and North Carolina third in value of output.

In the following table is given the value of millstones, chasers, and rider or drag stones produced in the United States from 1909 to 1913, inclusive:

Value of millstones produced in the United States, 1909–1913, by States.

State.	1909	1910	1911	1912	1913
New York	$13,138	$13,753	$13,335	$34,246	$21,987
Virginia		5,273	17,635	25,866	23,530
North Carolina	22,255	9,191	9,099	9,352	8,772
Pennsylvania				1,950	1,874
Alabama					
Total	35,393	28,217	40,069	71,414	56,163

The following table gives the value of millstones produced in the United States since 1880:

Value of millstones produced in the United States, 1880–1913.

1880	$200,000	1897	$25,932
1881	150,000	1898	25,934
1882	200,000	1899	28,115
1883	150,000	1900	32,858
1884	150,000	1901	57,179
1885	100,000	1902	59,808
1886	140,000	1903	52,552
1887	100,000	1904	37,338
1888	81,000	1905	37,974
1889	35,155	1906	48,590
1890	23,720	1907	31,741
1891	16,587	1908	31,420
1892	23,417	1909	35,393
1893	16,639	1910	28,217
1894	13,887	1911	40,069
1895	22,542	1912	71,414
1896	22,567	1913	56,163

IMPORTS.

The imports of burrstones and millstones for consumption in the United States in 1913 were valued at $40,198, as compared with $27,562 in 1912. The increase was in material imported in the rough as well as in imports of finished stones. The latter have never been large, but have increased somewhat over the imports of the four preceding years.

The value of the imports of burrstones and millstones during the last five years is given in the following table:

Value of burrstones and millstones imported and entered for consumption in the United States, 1909–1913.

Year.	Rough.	Made into millstones.	Total.	Year.	Rough.	Made into millstones.	Total.
1909	$22,125	$465	$22,590	1912	$26,236	$1,326	$27,562
1910	33,740	1,023	34,763	1913	36,276	3,922	40,198
1911	35,153	875	36,028				

THE MILLSTONE INDUSTRY.

In this report for 1909 notes were given on the millstone industry in New York and Virginia. The industry is one which undergoes little change from year to year, and statements made in the former report still hold; the descriptions are therefore given again below.

New York.—New York has led for many years in the production of millstones and chasers, the latter term being applied to stones which run on edge or on a horizontal shaft. The raw material is obtained in Ulster County, southeastern New York, and is known as Esopus stone, Esopus being an early name for Kingston, which was formerly the main point of shipment. The material suitable for millstones is quarried from the Shawangunk conglomerate, which is found near the western base of Shawangunk Mountain, in the valley of Rondout River. This material is exceedingly scanty, being confined in linear extent to a strip extending from High Falls on the north to Kerhonkson on the south, a distance of approximately 10 miles. Beyond these limits the texture and other properties of the rock have been found unsuitable for the highest grade of stones.

The methods employed in quarrying the rock are simple. The rock is pried or split out, advantage being taken of the joint planes, especially the concentric-surface joints. The tools used are the ordinary hand drill, together with plugs and feathers. Blasting is often resorted to, but the charges of powder are usually light. The rough stones thus obtained are quarry dressed and finished, these operations being performed entirely by hand, the chief tools employed being the bull point and the hammer. The operation of drilling the "eye" is performed by centering the stone and then drilling from the center of both faces inward. In many stones the eye is square. To fashion a square eye a round eye is first drilled out and then squared up. A few of the men engaged in the industry make a modification of the regular millstone for use in grinding paint. In this modification the ordinary millstone is cut in halves and an iron casting is placed between the halves, which are then joined together by an iron band.

Chasers are larger than the regular millstones. They are used for heavier work, such as grinding quartz, feldspar, barytes, etc., and, as already mentioned, they run on edge. Though they are made with a diameter as short as 24 inches, they are usually turned out with diameters ranging from 50 to 84 inches, and are as much as 22 inches in thickness. These chasers are run on pans paved with roughly cubical blocks of the conglomerate, with edges about a foot in length. In grinding quartz in such pans the chasers are used in the preliminary crushing; then rough blocks, usually three in number, are either attached to or carried along by lateral arms, which in turn are joined to a vertical revolving shaft. By the circular movement of these blocks the material placed in the pan is ground to powder.

Fourteen operators in New York reported production in 1913.

Virginia.—The millstone industry in Virginia is confined to quarries near Prices Fork, Montgomery County, about 5 miles west of Blacksburg, the site of the Virginia Polytechnic Institute. The rock is regarded as of Mississippian (lower Carboniferous) age. The material from which the stones are quarried varies from a normal conglomerate to a fine-grained quartzitic rock. It includes pebbles, some of them as large as walnuts, though most of them are smaller. The rock has a bluish cast. Its bedding planes are very distinct, and layers only an inch thick may be observed. It is extremely hard and tough and resists erosion to a marked degree. It underlies Brush Mountain for miles, and for this reason the millstones are frequently termed Brush Mountain stones. The stone can not be quarried by blasting, and it is therefore extracted by hand power, with drill and hammer, plug and feathers. Millstones and drag or rider stones are the principal products made at the Virginia quarries.

Three operating firms or individuals reported production during 1913.

North Carolina.—Three operators reported production of millstones near Salisbury, Rowan County. The stones are made of granite.

Pennsylvania.—Millstones were made at East Earl and Lincoln, Lancaster County.

Alabama.—A few millstones were quarried and made at Dutton, Jackson County.

GRINDSTONES AND PULPSTONES.

The value of the grindstones and pulpstones produced in the United States in 1913 was $855,627, a decrease of $60,712, or nearly 7 per cent as compared with $916,339, the value for 1912. The decrease is in the value of the grindstones, the pulpstone production having increased slightly over 1912.

The States and the number of quarries in each State producing grindstones in 1913 were: Michigan, 3 quarries; Ohio, 25 quarries; and West Virginia, 2 quarries. Ohio, as usual, maintained the leading position in the industry, the value of the output of the State being between six and seven times that of Michigan. The output of West Virginia was comparatively small. Ohio also produced pulpstones from 2 quarries. Montana and Utah have ceased to be producers of grindstones.

The following table shows the value of grindstones and pulpstones produced in the United States from 1909 to 1913, by States:

Value of grindstones and pulpstones produced in the United States, 1909–1913, by States.

State.	1909	1910	1911	1912	1913
Colorado	(a)	(a)	(a)	....	....
Michigan	(a)	(a)	(a)	(a)	(a)
Montana	....	....	(a)	(a)	....
Ohio	$679,930	$699,033	$742,107	$787,621	$737,572
Utah	....	....	....	(a)	....
West Virginia	(a)	(a)	(a)	(a)	(a)
Other States	b 124,121	b 97,261	c 165,209	d 128,718	e 118,055
Total	804,051	796,294	907,316	916,339	855,627

a Included in "Other States."
b Includes Colorado, Michigan, and West Virginia.
c Includes Colorado, Michigan, Montana, and West Virginia.
d Includes Michigan, Montana, Utah, and West Virginia.
e Includes Michigan and West Virginia.

The value of the production of pulpstones and grindstones in the United States from 1880 to 1913, inclusive, is shown in the following table:

Value of grindstones and pulpstones produced in the United States, 1880–1913.

1880	$500,000	1892	$272,244	1904	$881,527
1881	500,000	1893	338,787	1905	777,606
1882	700,000	1894	223,214	1906	744,894
1883	600,000	1895	205,768	1907	896,022
1884	570,000	1896	326,826	1908	536,095
1885	500,000	1897	368,058	1909	804,051
1886	250,000	1898	489,769	1910	796,294
1887	224,400	1899	675,586	1911	907,316
1888	281,800	1900	710,026	1912	916,339
1889	439,587	1901	580,703	1913	855,627
1890	450,000	1902	667,431		
1891	476,113	1903	721,446		

IMPORTS.

The value of the imports of grindstones increased in 1913 to $139,386, as compared with $131,080 in 1912. This is the greatest importation recorded during the last five years and exceeds that for 1906, which amounted to $134,136.

The imports for the last five years are given in the following table:

Value of pulpstones and grindstones imported and entered for consumption in the United States, 1909–1913.

1909	$99,153	1912	$131,080
1910	106,596	1913	139,386
1911	123,727		

CANADIAN PRODUCTION.[1]

The value of the production of grindstones in Canada in 1913[2] amounted to $43,900 as compared with $44,290 in 1912. In the following table is given the value of the Canadian production of grindstones during the last six years:

Value of production of grindstones in Canada, 1908–1913.

1908	$45,128	1911	$52,942
1909	50,944	1912	44,290
1910	47,196	1913	43,900

OILSTONES AND SCYTHESTONES.

PRODUCTION.

The production of oilstones (including hones and whetstones) and scythestones in the United States during 1913 amounted to $207,352 in value, a decrease of $24,866 as compared with the value for 1912. Oilstones were produced in Arkansas, Indiana, Ohio, and Kentucky, especially in Arkansas, which has led in the production for many years. New Hampshire led in the production of scythestones, but

[1] From reports of Canada Dept. Mines.
[2] Preliminary report on the mineral production of Canada during 1913: Canada Dept. Mines, 1914.

Vermont, Ohio, and Michigan also contributed important quotas. A description of the scythestone industry in New Hampshire was given in this report for 1909, and a description of Arkansas oilstones, oilstone deposits, and industry was included in this report for 1911. In the following table is given the value of oilstones (including whetstones) and scythestones produced in the United States since 1891:

Value of oilstones and scythestones produced in the United States, 1891–1913.

1891	$150,000	1899	$208,283	1907	[1] $264,188
1892	146,730	1900	174,087	1908	[1] 217,284
1893	135,173	1901	158,300	1909	[2] 214,019
1894	136,873	1902	221,762	1910	[1] 228,694
1895	155,881	1903	366,857	1911	[2] 214,991
1896	127,098	1904	188,985	1912	[2] 232,218
1897	149,970	1905	244,546	1913	[2] 207,352
1898	180,486	1906	268,070		

IMPORTS.

The following table shows the value of all kinds of hones, oilstones, and whetstones imported into the United States in the last five years:

Value of imports of hones, oilstones, and whetstones, 1909–1913.

1909	$68,018	1912	$45,398
1910	45,819	1913	40,222
1911	54,379		

CORUNDUM AND EMERY.

PRODUCTION.

The United States produced no corundum in 1913 and has produced none since 1906.

The domestic production of emery in 1913 appears to have come entirely from the region near Peekskill, in Westchester County, N. Y. The Survey received no report of production in 1913 from the mines in Chester, Hampden County, Mass., which have for many years produced an annually diminishing quantity. The returns from New York producers have been incomplete, and the entry in the following table for 1913 is an estimate, which is, however, believed to be a close approximation to the actual quantity produced. The value given in the table is merely an estimate of the cost of mining and preparing the material as shipped from the mines, based on reports made by some of the producers. The estimated domestic production for 1913 is 957 short tons, which is 35 tons, or about 3.5 per cent, less than the estimated output for 1912. The estimated value of the output for 1913 (cost of production) is $4,785, which is $1,867, or about 38 per cent, less than that of 1912.

In the following tables are given the quantity and estimated value of the corundum and emery produced in the United States from 1881 to 1906, and the quantity and estimated value of emery produced in the United States since 1906:

[1] Includes a quantity of "rubbing stone" quarried in Indiana.
[2] Includes a quantity of honestone quarried in Kentucky and "rubbing stone" quarried in Indiana.

Annual production of corundum and emery, 1881–1906, in short tons.

Year.	Quantity.	Value.[a]	Year.	Quantity.	Value.[a]	Year.	Quantity.	Value.[a]
1881	500	$80,000	1890	1,970	$89,395	1899	4,900	$150,600
1882	500	80,000	1891	2,247	90,230	1900	4,305	102,715
1883	550	100,000	1892	1,771	181,300	1901	4,305	146,040
1884	600	108,000	1893	1,713	142,325	1902	4,251	104,605
1885	600	108,000	1894	1,495	95,936	1903	2,542	64,102
1886	645	116,190	1895	2,102	106,256	1904	1,916	56,985
1887	600	108,000	1896	2 120	113,246	1905	2,126	61,464
1888	589	91,620	1897	2,165	106,574	1906	1,160	44,310
1889	2,245	105,567	1898	4,064	275,064			

[a] Estimated.

Annual production of emery, 1907–1913, in short tons.

Year.	Quantity.	Value.[a]
1907	1,069	$12,294
1908	669	8,745
1909	1,580	18,185
1910	1,028	15,077
1911	659	6,778
1912	992	6,652
1913	[a] 957	4,785

[a] Estimated.

IMPORTS.

The following table gives the quantity and value of the emery and corundum imported into the United States from all foreign countries during the last five years. The year 1913 was marked by a decrease in the imports as compared with the preceding year. Both the quantity and the value of the imports have fluctuated irregularly during the last decade.

Emery and corundum imported into the United States, 1909–1913.

Year.	Grains.		Ore and rock.		Other manufactures.	Total value.
	Quantity.	Value.	Quantity.	Value.	Value.	
	Pounds.		*Long tons.*			
1909	2,696,960	$132,264	9,836	$186,930	$19,803	$338,997
1910	2,311,464	106,570	28,948	509,661	13,527	629,758
1911	1,382,813	76,027	10,822	245,459	15,158	336,644
1912	2,135,922	105,325	16,391	369,529	16,871	491,725
1913	2,496,372	114,786	17,123	342,809	16,704	474,299

CANADIAN CORUNDUM.

The following table gives the quantity and value of Canadian corundum shipped during the last five years:

Shipments of Canadian corundum, 1909–1913, in short tons.[a]

Year.	Quantity.	Value.	Year.	Quantity.	Value.
1909	1,491	$162,492	1912	1,960	$239,091
1910	1,870	198,680	1913	1,177	137,036
1911	1,472	161,873			

[a] Figures taken from the annual reports on mineral production of Canada, Canada Dept. Mines.

ABRASIVE GARNET.

PRODUCTION.

The production of abrasive garnet in the United States in 1913 amounted to 5,308 short tons, valued at $183,422. This was an increase of 361 tons, or 6.8 per cent, in quantity, and of $20,185, or 11 per cent, in value, as compared with the production for 1912. The industry was confined, as usual, to three States, New Hampshire, New York, and North Carolina. The following table gives the quantity and value of abrasive garnet produced in the United States since 1895:

Production of abrasive garnet, 1895–1913, in short tons.

Year.	Quantity.	Value.	Year.	Quantity.	Value.	Year.	Quantity.	Value.
1895	3,325	$95,050	1902	3,926	$132,820	1908	1,996	$64,620
1896	2,686	68,877	1903	3,950	132,500	1909	2,972	102,315
1897	2,554	80,853	1904	3,854	117,581	1910	3,814	113,574
1898	2,967	86,850	1905	5,050	148,095	1911	4,076	121,748
1899	2,765	98,325	1906	4,650	157,000	1912	4,947	163,237
1900	3,185	123,475	1907	7,058	211,680	1913	5,308	183,422
1901	4,444	158,100						

NOTES ON THE ABRASIVE GARNET INDUSTRY.

NEW YORK.[1]

The production of garnet for abrasive purposes is a well-established industry in the Adirondack region of New York. The quarries and mills are in the upper Hudson River valley, in Warren and Essex counties. North Creek, the terminus of the Adirondack branch of the Delaware & Hudson Railroad, is the principal point of shipment.

The garnets produced are almandite, the iron-alumina variety, and have a greater hardness, about 8 in the Mohs scale, than is ordinarily ascribed to garnet.[2] The colors of the garnets from the several deposits are different shades of red.

The quarry (Hooper's mine) and mills of the North River Garnet Co., owned by Richards & Hooper, are in Warren County, about 3¼ miles southwest of North River village, with which they are connected by good roads for motor truck. The quarry in 1913 was a large cut 200 by 100 feet and 100 feet deep at the back; it is near the summit of a considerable hill and in a banded feldspar-hornblende-garnet gneiss containing a little biotite. In a second opening, a little east of the large pit, the banding of the gneiss shows in the west wall, but eastward it becomes disturbed in attitude and obscure, and in places it disappears. There are in this opening several masses or bands of finer-grained gneiss containing, besides feldspar, hornblende and garnet, also magnetite and pyrite. Such rock is not quarried. The gneiss is a part of the pre-Cambrian Grenville series, which is extensively developed in this part of the Adirondack region.

[1] Recent articles on the New York garnet deposits by W. J. Miller have been published in Econ. Geology, vol. 7, pp. 493–501, 1912; New York State Mus. Bull. 164, pp. 95–103, 1913; and New York State Mus. Bull. 170, pp. 78–82, 1914.

[2] Prof. Charles Palache has tested garnets from North River, N. Y., and from Wilmot, N. H., and Spanish garnets, which are imported for abrasive purposes, and reports that their sharpest edges scratch topaz. (Private report on the garnet deposits of Wilmot, N. H., quoted by kind permission of Prof. Palache, A. D. Little & Co., and the United Mineral Co.)

Gneiss of the type quarried occupies many acres in the hill back of and above the mill site and affords a practically inexhaustible source of garnet. The rock is of medium to moderately coarse grain and is banded by segregation of the feldspar and the hornblende. Some bands are composed more or less wholly of one or the other mineral and some of various proportions of both. The garnets are for the most part small and range in size from very small to about 1 inch in diameter, with occasional larger individuals. The largest garnet seen was about 5 inches in diameter. All the garnets are rounded, but many have discernible dodecahedral form. They are scattered abundantly in most bands of the rock; sometimes they appear sparsely and again more abundantly in the purer feldspar bands; and they average probably about 7 or 8 per cent of the rock.

The rock is broken down by blasting and reduced with sledges when necessary, and is then trammed to and dumped on a grizzly of railroad iron which has 4-inch openings. It then passes through three jaw crushers and four sets of rolls. The undersize from each set is removed by shaking screens. All is crushed to one-fourth inch or less and sent to bins, from which are fed four sets of Hartz jigs especially modified for this work. From these machines the product goes through a series of 10 double Hooper vanning jigs especially designed for this work. Only the finest garnet from the last set of vanning jigs is saved. It is treated dry on Hooper pneumatic separators, which make very good separation. The concentrates from the pneumatic separator are mixed with those from the various vanning jigs and are dried over steam coils. They are then packed for shipping in sacks containing about 150 pounds. This mill sells only unsized product, wisely saving the cost of sizing, because there are among consumers of garnets no standards as to size of grain used.

The concentrates from this mill are very clean. They constitute from 5 to 6 per cent of the crude tonnage handled. There appears to be little garnet in the tailings.

H. H. Barton & Sons Co., of Philadelphia, operate the property known as the Rogers mine. The quarry is in Warren County, 4.3 miles south of North River village, near the summit of Gore Mountain. The quarry is opened about 1,000 feet in length and 50 to 100 or more feet in width along a ravine bottom. The rock is of problematic origin.[1] It is dark gray, medium grained, massive, granular, and porphyritic, without banding or schistosity, It consists of a ground mass composed essentially of hornblende and feldspars, in which are nodules of garnet and hornblende and some feldspar and biotite. These nodules form roughly spherical or ellipsoidal masses from 2 inches to 3 feet in diameter. They consist of a core of red garnet surrounded by a shell, one-half inch to several inches thick, of crystals of black hornblende. The garnet in each nodule is a single crystal individual with imperfect dodecahedral form. This form, however, is often very obscure. The garnets are divided into thin plates by a very unique parting or system of cracks, all approximately parallel to one plane. There is also a second less well developed parting inclined at nearly 90° to the first. In some places it was observed that the principal partings of many garnets of the same vicinity in the rock are approximately parallel. There is in all cases a horn-

[1] W. J. Miller (loc. cit.) calls the rock a gneiss and describes it as a block of a member of the Grenville series, which has been included in and severely metamorphosed by syenite.

blende rim around the garnets, but although generally these rims are composed entirely of black hornblende, there are some which have feldspar, green pyroxene, and biotite. The pyroxene is associated with the hornblende. The feldspar and biotite were noticed only next the garnet and usually in a distinct layer between it and the hornblende. These garnet hornblende nodules are colloquially called pockets. They are bunched here and there and to a limited degree are grouped according to size, but in some bunches of pockets there is progressive range in size. In most places the pockets are so close as to coalesce; in a few other places they are 5 feet or perhaps more apart, but it is only exceptionally that there is so great a distance between pockets.

The rock is weathered and softened to various depths, in places as much as 25 feet; both where there is little or no drift cover and also under 20 or 30 feet of till. The garnets are mined by open-cut work in rotten or decomposed rock. Very little work is done in hard rock, which is blasted and broken by sledges. From the rotten rock and the broken hard rock the garnets are cobbed out by hand, and the remaining rock is thrown to waste piles. Much garnet, particularly in the hard rock, is wasted. The garnets obtained by the quarrymen are collected by each in a bucket and carried to a wooden platform, where they are sacked for shipment in the crude state.

The Daniel Lynch garnet mines are 7 miles north-northeast of North Creek at Minerva, Essex County. There the country rock is a coarse feldspar-hornblende gneiss in which are included nonfoliated ellipsoidal rock masses containing the garnets and other minerals. These bodies range in size from small bunches to masses 60 feet wide and 100 feet long. Several old openings for garnet indicate that these bodies are along a narrow zone several hundred yards long. In places a coarse calcite aggregate 2 feet in thickness forms an outer layer of these bodies. Within this or in places on the periphery is a coarse feldspar(oligoclase)-pyroxene-titanite aggregate which has the texture and appearance of pegmatite. The pyroxene is a very dark green to black variety (hedenbergite). The titanite is in fine crystals as much as one-fourth inch in size. In some parts in one of the openings graphite flakes up to one-half inch in diameter are present with the feldspar and pyroxene, and in the same pit is a small mass of fine-grained pegmatite composed of oligoclase, quartz, a little microcline, and very little pyroxene.

In these rocks the plagioclase feldspar is all of the same species, and the pyroxenes are all alike. It is probable that they all represent various phases of the same intrusive (pegmatitic) rock. Tongues of the feldspar-hornblende gneiss penetrate the outer portions of garnet-bearing bodies. The interior and largest part of these ellipsoidal bodies is garnet rock composed of feldspar and garnet. This is in places composed largely of feldspar, in part sericitized, in which small garnets about 1 millimeter in diameter are abundantly studded. The feldspar content changes from place to place, so that with decreasing feldspar the garnet becomes more and more abundant, and here and there are patches of clean massive garnet several inches thick. There is complete gradation between the massive garnet and the garnet feldspar aggregate. Both are merchantable material, but the garnet feldspar aggregate requires more mechanical treatment for separation of the garnet.

Garnet has been quarried from a number of pits on the Lynch property, but recently operation has been confined to one or two of them. The material is blasted from shallow cuts and is hand cobbed. Since the Warren County Garnet Mills at Riparius began operations, garnet rock from the Lynch mines has been carted to that mill for treatment.

The Sanders Bros. garnet quarry is on the north side of Mill Creek about 1¾ miles south of Riparius, Warren County. When visited by the writer there was uncovered a band, not over 30 feet in exposed width, of garnet-pyroxene rock inclosed in fine-grained gneiss. In this band are garnet, calcite, and greenish-black pyroxene (hedenbergite) aggregates of from fine to coarsely granular texture. There are some bands or schlieren almost entirely made up of greenish-black pyroxene. There is a narrow band of marble on the strike of and a short distance south of the garnet body. The material quarried is for the most part a granular aggregate of garnet and black pyroxene (hedenbergite). The rock is blasted from a small open pit, hand sorted, and carted a short distance to the Warren County Garnet Mills' plant.

The Warren County Garnet Mills in 1913 contained two sets of crushing rolls, a shaking screen, a grading machine, and a pneumatic separating table. Crude rock was dumped on the floor of the crushing room and broken by sledges if necessary. The broken rock was fed to two sets of crushing rolls in tandem, from which it was elevated to a shaking screen with one-sixteenth inch openings. Oversize was returned to the rolls. Undersize passed to the hopper of a sizer capable of grading the crushed material into 24 sizes. Each size was then treated on the Sutton, Steele & Steele pneumatic separator which was working efficiently and making a very clean garnet concentrate.

Garnet mining has been carried on at other localities in Warren and Essex counties—at Oven Mountain, 4 miles south of North Creek; at the Rexford mine, 1⅓ miles a little east of south of North Creek; at the Parker mine, just southwest of Dagget Pond and 4½ miles northwest of Warrensburg; and about 1 mile west of the village of North River.

NEW HAMPSHIRE.

The United Mineral Co., Boston, Mass., is the only producer of garnet in New Hampshire. The quarry is near North Wilmot, in Merrimac County, 4½ miles from Converse station, on the Boston & Maine Railroad. Prof. Charles Palache and Messrs. A. D. Little & Co., who examined and reported on the quarry and mill, have, with the consent of the company, kindly permitted the Survey to publish the following notes taken from their reports.

The main deposit is exposed over an area about 200 by 240 feet. The garnet rock is a uniform mixture of garnet biotite quartz and albite, with minute amounts of minor constituents. In the richest rock, garnet constitutes two-thirds of the mass. By mill record 50 per cent of the quarry rock is saved in the concentrates; the garnet content is more than one-half. The garnet is an iron-aluminum species, almandite, with considerable manganese. It forms distinct crystals with an average diameter of three-eighths inch. The range in size is from minute dots to a maximum of three-fourths inch. The crystals are dodecahedrons and trapezohedrons with spherical habit. There is no evidence of foliated structure in the rock. The garnet rock is inclosed on all sides by a coarsely foliated porphyritic pre-Cambrian granite gneiss of igneous origin. The contacts are sharp and traverse the foliation of the gneiss variously.

The following notes on the mill are condensed from an article by E. S. Bardwell:[1] The rock is quarried and afterward broken by sledges into pieces convenient for feeding to the breaker. The rock is trammed a distance of about 600 feet to the rock house. Directly beneath the floor upon which the rock is dumped is a 6 by 10 inch Sturtevant jaw breaker, crushing to 1¼ inches. This breaker has a capacity of 6 tons an hour. The broken rock falls from the breaker directly into the tramway loading bin beneath.

The broken rock is delivered by way of the 1,200-foot aerial tram into a bin at the rear of the mill. The top of the bin is on a level with the third floor of the mill. The rock is delivered by gravity to the crushing department, and first enters a pair of Sturtevant balanced rolls, 26 by 15 inches, capable of crushing 6 tons an hour to ⅜-inch size. From these rolls the product is taken by a bucket elevator, to an American Process Co. drier. It is warmed to remove any superficial moisture and to promote screening.

The revolving cylinder of the drier projects into a reinforced-concrete dust chamber which extends through the side of the mill. The dust is discarded for the reason that it contains almost no garnet.

The second elevator delivers the sand to a No. 3 Newaygo separating screen. The screen cloth is 4-mesh, 14-wire, and is set on a slope of about 45°. The oversize (over 2 millimeters) goes by chute to a pair of Sturtevant balanced rolls, 26 by 15 inches, set to crush to 2 millimeters, the product going with the undersize to the separator bin, from which material under 2 millimeters is delivered to the separating department by a belt elevator. The crushing department is usually run about four hours a day, and during this time is capable of crushing enough rock to keep the separating department supplied during the entire 10-hour run.

The crushed material first passes through a No. 3 Newaygo separating screen. This screen is situated on the upper floor of the screening tower and has two sieves; the upper screen is 6-mesh, 16-wire, and the lower is 10-mesh, 20-wire. This screen makes two oversize products—that is, through 2 millimeters on 1.4 millimeters and through 1.4 millimeters on 0.75 millimeter. These products go by way of chutes to table bins on the third floor of the mill. The undersize of 0.75 millimeter goes to another Newaygo screen on the floor below. This separator has one sieve, 24-mesh, 29-wire. Two products are made, 0.36 to 0.75 millimeter and under 0.36. The 0.36 to 0.75 millimeter size goes to a third table bin, and the under 0.36 millimeter size goes to waste.

The material from 1.4 to 2 millimeters in diameter goes to a Sutton, Steele & Steele dry concentrating table. This table makes 390 thrusts per minute, has a capacity of about 3,000 pounds an hour, and requires approximately one-half horsepower. It delivers garnet through a spout to the sacking room in the basement of the mill, middlings to the second Newaygo screen, and tailings by screw conveyor

[1] Garnet milling in New Hampshire: Eng. and Min. Jour., June 17, 1911, pp. 1209-1210.

out of the mill. Air is supplied to the table by a No. 10 Green blower making 500 revolutions a minute and belted to the line shaft. The material from 0.75 to 1.4 millimeters in diameter from the first Newaygo and that from 0.36 to 0.75 millimeter in diameter from the second Newaygo is treated alternately on a second Sutton, Steele & Steele dry-concentrating table. This table makes 425 thrusts a minute, has a capacity of about 1,500 pounds an hour, and requires approximately one-half horsepower. The delivery of products is the same as from the first table. Air is furnished to this table by a No. 6 Green blower making 965 revolutions a minute.

The tailings from these tables are practically free from garnet, but contain about 25 per cent of biotite. A Wetherill magnetic separator has been provided to save this biotite, but so far nothing has been done with the product. The sacking room is in the basement of the mill. The garnet is shipped in canvas sacks, each containing 100 pounds. The company has a freight house at South Danbury, N. H., 3 miles distant, with capacity for storing 400 tons. Here the garnet is loaded directly into the cars.

NORTH CAROLINA.

The Blue Ridge Garnet Co. produced garnet at Shooting Creek, Clay County. The quarried rock is crushed and concentrated on Bartlett tables and then graded. It is reported that all the 1913 product was shipped abroad. Garnet mines near Speedwell and Willets, in Jackson County, were idle in 1913. At Willets the Great Ruby Mining Co. reported preparations for a large production in 1914.

PENNSYLVANIA.

The garnet mines near Chelsea and Chester, in Delaware County, have not been operated in recent years.

TRIPOLI AND DIATOMACEOUS EARTH.

The material called tripoli in the trade in the United States is a light, porous, and generally purely siliceous rock which has resulted from the leaching of calcareous material from very siliceous limestones or highly calcareous cherts. Tripoli was produced in 1913 in Georgia, Missouri, Illinois, Pennsylvania, and Tennessee. Deposits in Arkansas and Oklahoma are not yet commercially productive. Some of the Missouri tripoli is and always has been produced and used as an abrasive and for other purposes, but much of it is used in the manufacture of filters. The Illinois product is used as paint, wood filler, metal polish, in soaps, in cleansers, and for making glass and for facing foundry molds.

No attempt has been made to procure from producers of tripoli a definite statement of the exact proportion used as an abrasive, nor has any attempt been made to get at the production of rough tripoli blocks worked up into filter stones. Even if this output had been ascertained it would be impossible to value the product on a uniform basis and thus to obtain a reliable ratio between quantity and value, for the reason that the price of filter stones varies and is dependent not only on the size of the stones but also on the amount of work done on each stone.

Diatomaceous earth, called also infusorial earth and kieselguhr, is a light earthy material, which from some sources is loose and powdery and from others is more or less firmly coherent. It often resembles chalk or clay in its physical properties, but can be distinguished at once from chalk by the fact that it does not effervesce when treated with acids. It is generally white or gray in color, but may be brown or even black when mixed with much organic matter. Diatomaceous earth is made up of tests of minute aquatic plants composed of a variety of opal, which, chemically, is hydrous silica. Owing to its porosity it has great absorptive powers and high insulating efficiency. The hardness, the minute size, and the shape of its grains make it an excellent metal-polishing agent.

Heretofore diatomaceous or infusorial earth has been largely used as an abrasive in the form of polishing powders and scouring soaps, but of late its uses have been considerably extended. Because of its porous nature it has been used in the manufacture of dynamite as a holder of nitroglycerine, but so far as known not in the United States. Its porosity also renders it a nonconductor of heat, and this quality in connection with its lightness has extended its use as an insulating packing material for safes, steam pipes, and boilers, and as a fireproof building material. In this country a new use of the material is reported in the manufacture of records for talking machines. For this purpose it is boiled with shellac, and the resulting product has the necessary hardness to give good results.

In Europe, especially in Germany, infusorial earth has lately found extended application. It has been used in preparing artificial fertilizers, especially in the absorption of liquid manures; in the manufacture of water glass, of various cements, of glazing for tiles, of artificial stone, of ultramarine and various pigments, of aniline and alizarine colors, of paper, sealing wax, fireworks, gutta-percha objects, Swedish matches, solidified bromine, scouring powders, papier-mâché, and many other articles. There is a large and steadily growing demand for it.

Preliminary preparation of the crude material involves drying and roasting to destroy organic matter, if that is present.

The following tables show the production of tripoli and of diatomaceous earth by States in 1913, and the value of the combined annual tripoli and diatomaceous earth output since 1880:

Production of tripoli in the United States in 1913, by States, in short tons.

State.	Quantity.	Value.
Illinois	12,994	$128,892
Missouri	7,529	83,995
Pennsylvania, Tennessee, and Georgia	274	3,694
Total	20,797	216,581

Production of diatomaceous earth in the United States in 1913, by States, in short tons.

State.	Quantity.	Value.
California and Nevada	5,785	$51,556
Connecticut, New York, and Washington	378	9,565
Maryland, Virginia, and Florida	423	8,119
Total	6,586	69,240

Production of diatomaceous earth and tripoli, 1880–1913, in short tons.

Year.	Quantity.	Value.	Year.	Quantity.	Value.	Year.	Quantity.	Value.
1880	1,833	$45,660	1892	....	$43,655	1904	6,274	$44,164
1881	1,000	10,000	1893	....	22,582	1905	10,977	64,037
1882	1,000	8,000	1894	2,584	11,718	1906	8,099	72,180
1883	1,000	5,000	1895	4,954	20,514	1907	....	104,406
1884	1,000	5,000	1896	3,846	26,792	1908	....	97,442
1885	1,000	5,000	1897	3,833	22,835	1909	....	122,348
1886	1,200	6,000	1898	2,733	16,691	1910	....	130,006
1887	3,000	15,000	1899	4,334	37,032	1911	....	147,462
1888	1,500	7,500	1900	3,615	24,207	1912	....	125,446
1889	3,466	23,372	1901	4,020	52,950	1913	....	285,821
1890	2,532	50,240	1902	5,665	53,244			
1891	....	21,988	1903	9,219	76,273			

IMPORTS.

The value of the imports of rottenstone and of tripoli for the last five years has been as follows:

Value of tripoli, diatomaceous earth, and rottenstone imported for consumption into the United States, 1909–1913.

1909	$24,024	1912	$24,253
1910	56,657	1913	28,696
1911	35,665		

NOTES ON THE TRIPOLI AND DIATOMACEOUS EARTH INDUSTRIES.

Illinois.—In Illinois six producers in Union County and one in Alexander County reported production in 1913. No new deposits were developed, and a number of mines formerly worked were idle during the year.

Missouri.—Five operators reported production from near Seneca and Racine, Newton County, Mo., in 1913. There were no new developments.

Oklahoma.—One company, which began development on a tripoli deposit near Peoria, Okla., suspended operations because of financial difficulty; another company reported preparations for production.

Tennessee.—A tripoli deposit was discovered near Butler, Johnson County, Tenn., which was opened and began producing in 1913. The following notes are taken from a report by L. C. Glenn: [1]

The tripoli is interbedded with the shales and thin limestones that compose the Watauga shale (Cambrian), the beds having a dip of 30 to 50 degrees. Six belts of tripoli have been found within a comparatively small area. One of these, which has been explored sufficiently to determine well its thickness and extent, shows a very large quantity of easily available tripoli.

The tripoli is a bright-yellow color, of almost uniform shade, is porous, and at the surface is mostly pulverulent. The soft material has a characteristic dry and somewhat harsh feel. The lumps that cohere are porous, light in weight, and rub to pieces readily under the pressure of the fingers, though they offer some resistance to such rubbing away. Pieces break with the brittleness of a piece of chalk. Either wet or dry, it is easily cut with a pick or shovel, and would be readily sawed or bored if pieces large enough to work in this way should be obtained. The material will grind to a powder very readily.

The texture or grain is very nearly uniform throughout the entire 38½ feet of the main bed. At no place was any grit found in it. The microscopic examination showed the

[1] Resources of Tennessee, vol. 4, No. 1, pp. 29–35, 1914.

average diameter of the particles to be slightly less in the harder or more coherent parts than in the softer or more pulverulent parts. In all parts of the deposit the material as found in nature consists of angular to subangular particles that, if mere dust specks—of which there are many—be excluded, range in diameter from 0.0015 millimeter to 0.1 millimeter. The bulk of the material ranges from 0.01 to 0.06 millimeter in size, though there is a good portion that is 0.005 millimeter or less in diameter, and occasional particles 0.1 to 0.16 millimeter are also found. The particles large enough for identification are nearly all of vein quartz, and are coated with a brownish-yellow film of limonite that is readily removed by hydrochloric acid, when the quartz is seen to be clear and glassy, with now and then a particle of amethyst. Besides the quartz there are occasional particles of garnet, limonite, and magnesite. Feldspar particles large enough for identification were rare, although the analysis raises the presumption that a part of the very finely divided material, too small for identification by microscopic methods, is probably arkosic feldspar. Besides this, much of the very finely divided material is kaolinite.

From the above description it is apparent that the tripoli of Butler, Tenn., will make excellent abrasive material. "The crude tripoli from Butler may after grinding be readily separated by screening or by air or water flotation into a number of grades ranging from the finest jeweler's material up to the coarsest grades used in the rougher scouring processes, so that a variety of grades could be marketed each suited for some special purpose."[1] Yet, without detracting from its excellence as an abrasive, it must be pointed out that from this description and as well from the analysis and geologic relations described by Professor Glenn it is evident that the Butler tripoli is different in mineral constitution from the tripoli of Missouri and Illinois. Unlike them the Tennessee material is mineralogically and chemically complex and would appear to have been derived from an originally argillaceous rock, or, at any rate, if the rock were calcareous rock, it contained a far larger amount of clastic material than the Illinois and Missouri rock. These differences will perhaps prohibit the use of Butler tripoli for some of the purposes for which the Illinois and Missouri product are consumed, but they may also adapt that material for other uses.

There may be some doubt about the propriety of calling this material tripoli, but it is here so called primarily because it is a "rottenstone," as are the other tripolis, and because it is very siliceous.

Pennsylvania.—A small production of "rottenstone" was reported from Lycoming County, Pa., and is included with the tripoli statistics.

Georgia.—As in past years, one company produced tripoli near Spring Place in Murray County, Ga.

California.—In California the diatomaceous earth industry was given new impetus in 1913 by the extensive operations of a new company, the Kieselguhr Co. of America. This company's method of quarrying the diatomaceous earth at Lompoc,[2] Santa Barbara County, and of preparing finished products, as well as the general properties and uses of diatomaceous earth were described by Percy A. Boeck in Chemical and Metallurgical Engineering, February, 1914. The following notes are taken from that paper:

The mining or quarrying of this material is carried on by means of open-face workings where the kieselguhr is taken up in huge blocks. This operation is made easier where transverse joints occur in the strata, due to local folding. Where these joints do not

[1] Glenn, L. C., op. cit., p. 34.

[2] These deposits are briefly described by Ralph Arnold and Robert Anderson, Diatomaceous deposits of northern Santa Barbara County, Cal.: U. S. Geol. Survey Bull. 315, pp. 438-447, 1907.

occur it becomes necessary to loosen the kieselguhr slightly by means of powder before the blocks can be removed from the quarry face.

Owing to the large amount of absorbed surface water in the kieselguhr it is necessary that the material be split into convenient blocks for piling and drying. The amount of absorbed water is about 25 to 45 per cent by weight, and, owing to the winds and dryness of the atmosphere of southern California, this amount is reduced to about 5 per cent by natural air drying within 40 to 50 days.

After drying, the kieselguhr is hauled by means of motor truck to the reduction works where it is reduced and transferred by means of a pneumatic system to the different warehouses. It is likewise drawn to the finishing mill from the warehouse by this means, and ground and blown into the several grades used commercially. When blocks are required the material is transported in its natural state direct from the quarry, sawed into the sizes required for building purposes, and dried before shipment. Waste material too fine to be dried is utilized in the making of brick, tile, and other refractory materials of light weight.

Besides marketing diatomaceous earth for abrasive purposes, this company puts out two grades, branded Sil-O-Cel, which is for insulation, and Filter-Cel, for filtration. The company plans also to market various kinds of insulating and refractory brick.

PUMICE.

The pumice produced in the United States in 1913 amounted to 24,563 short tons, valued at $55,408. This was a decrease of 2,583 tons in quantity and of $31,279 in value as compared with 1912.

The statistics of pumice given in the table are those of pumice used for abrasive purposes solely. The pumice used for construction—and it is known that some of the domestic article has been so used—is not included. The material has come from six States: California, from Inyo County; Kansas, from Morton and Phillips counties; Nebraska, from Furnas, Lincoln, and Harlan counties; Idaho, from Cassia and Power counties; Dakota, from Custer County; and Utah, from Millard County. In 1913 the production came from Kansas, Nebraska, and Utah.

The domestic product is almost wholly a finely comminuted material, volcanic dust or "ash." The imported material, which comes from the Lipari Islands, a group of volcanic islands north of Sicily in the Mediterranean Sea, is a massive, very finely pumiceous or vesicular rock. Very little pumice of this type has been produced in the United States.

The production of pumice in the United States during the last five years is given in the following table. The figures for domestic production and for importation are given below:

Production of pumice in the United States, 1909–1913, in short tons.

Years.	Quantity.	Value.	Price per ton.
1909	15,103	$33,439	$2.21
1910	23,271	94,943	4.08
1911	21,689	88,399	4.08
1912	27,146	86,687	3.19
1913	24,563	55,408	2.26

Value of pumice imported for consumption into the United States, 1909–1913.

1909	$100,997	1912	$74,478
1910	104,425	1913	93,408
1911	118,977		

ARTIFICIAL ABRASIVES.

The artificial abrasives include carborundum, which is a carbide of silicon, alundum, which is crystalline aluminum oxide and crushed steel. Other abrasives, or rather abrasives with other names, which have appeared on the market during the last few years, are forms of the abrasives named adapted to special uses. Such, for example, are aloxite and samite, forms of carborundum, and carborundum fire sand. Boro-Carbone is similar to alundum. The abrasive known as "corubin," so far as is known, is not made in this country, but is an European product. Alundum, whose manufacture has been detailed in this chapter in previous years, is finding extended use in the refractory as well as in the abrasive industry, and carborundum is used in certain metallurgical practice.

The production of artificial abrasives since 1906 is given in the following table:

Production of artificial abrasives in the United States, 1906–1913, in pounds.

Year.	Quantity.	Value.
1906	11,774,300	$777,081
1907	14,632,000	1,027,246
1908	8,698,000	626,340
1909	20,468,000	1,365,820
1910	23,027,000	1,604,030
1911	21,292,000	1,493,040
1912	29,002,000	1,747,120
1913	33,489,000	2,017,458

PHOSPHATE ROCK.

By W. C. PHALEN.

PRODUCTION.

The marketed production of phosphate rock in the United States in 1913 was 3,111,221 long tons, valued at $11,796,231. Compared with the production of 1912, which was 2,973,332 long tons, valued at $11,675,774, there was an increased output of 137,889 long tons, or 5 per cent, and an increased value of $120,457, or 1 per cent. In this report the term production means phosphate rock actually sold, not the quantity mined.

The marketed production of the various kinds of phosphate rock, by States, in 1912 and 1913 was as follows:

Production of phosphate rock in the United States, 1912–13, based on the quantity marketed, by States, in long tons.

State.	1912			1913		
	Quantity.	Value.	Average price per ton.	Quantity.	Value.	Average price per ton.
Florida:						
Hard rock	493,481	$3,293,168	$6.67	489,794	$2,987,274	$6.10
Land pebble	a 1,913,418	6,168,129	3.22	a 2,055,482	6,575,810	3.20
River pebble	(a)	(a)	....	(a)	(a)	....
Total	2,406,899	9,461,297	3.93	2,545,276	9,563,084	3.76
South Carolina:						
Land rock	131,490	524,760	3.99	109,333	440,588	4.03
River rock	0	0	....	0	0	....
Total	131,490	524,760	3.99	109,333	440,588	4.03
Tennessee:						
Brown rock	359,692	1,420,726	3.95	} 451,559	1,774,392	3.93
Blue rock	b 63,639	219,750	3.45			
White rock	0	0	....	0	0	....
Total	423,331	1,640,476	3.88	451,559	1,774,392	3.93
Western States	c 11,612	49,241	4.24	c 5,053	18,167	3.60
Grand total	2,973,332	11,675,774	3.93	3,111,221	11,796,231	3.79

a Small quantity of river pebble included with land pebble.
b Includes small quantity of rock from Arkansas.
c Includes, 1912: Idaho, Utah, and Wyoming; 1913: Idaho and Wyoming.

The total production of phosphate rock in the United States from the beginning of the industry in 1867 to 1913 is shown in the following table:

Marketed production of phosphate rock in the United States, 1867–1913, in long tons.

Year.	Quantity.	Value.
1867–1887	4,442,945	$23,697,019
1888	448,567	2,018,552
1889	550,245	2,937,776
1890	510,499	3,213,795
1891	587,988	3,651,150
1892	681,571	3,296,227
1893	941,368	4,136,070
1894	996,949	3,479,547
1895	1,038,551	3,606,094
1896	930,779	2,803,372
1897	1,039,345	2,673,202
1898	1,308,885	3,453,460
1899	1,515,702	5,084,076
1900	1,491,216	5,359,248
1901	1,483,723	5,316,403
1902	1,490,314	$4,693,444
1903	1,581,576	5,319,294
1904	1,874,428	6,580,875
1905	1,947,190	6,763,403
1906	2,080,957	8,579,437
1907	2,265,343	10,653,558
1908	2,386,138	11,399,124
1909	2,338,264	10,796,456
1910	2,654,988	10,917,000
1911	3,053,279	11,900,693
1912	2,973,332	11,675,774
1913	3,111,221	11,796,231
Total	45,725,363	185,801,280

The more important facts brought out by the tables given above are as follows: The States producing phosphate rock in the eastern part of the United States were, as usual, Florida, Tennessee, and South Carolina. No production was reported from either Kentucky or Arkansas. Of the western group of phosphate States, Idaho and Wyoming reported a production. No phosphate came from Utah during the year.

The phosphate rock produced in Florida is of two classes, hard rock and land pebble. Taken as a whole the phosphate rock produced in this State during 1913 showed a substantial gain. This gain was due to the notably increased production of land pebble (with which is included a small quantity of river pebble sold but not mined) which more than offset the slightly decreased production of hard rock. The average prices per ton of Florida rock declined slightly.

In Tennessee the quantity of both brown and blue rock marketed increased as compared with that of 1912. The average price in Tennessee showed a slight advance.

Sales of South Carolina phosphate declined in quantity and value, but increased in average price per ton as compared with sales in 1912.

The phosphate rock marketed from the Western States declined greatly as compared with 1912, amounting to only 44 per cent of what it was that year. The production of the Western States amounted to only one-fifth of 1 per cent of that of the entire country.

The total quantity of phosphate rock mined in 1913 was 3,152,208 long tons, as compared with 3,190,587 long tons in 1912, a decrease amounting to 1.2 per cent. In Florida, however, there was an increase in the quantity of phosphate rock mined amounting to 1.6 per cent, due to the much larger quantity of land pebble mined than in 1912. The hard rock mined decreased in 1913 as compared with 1912. In Arkansas no rock was reported mined in 1913. In South Carolina the quantity mined diminished more than 24 per cent. In Tennessee the quantity mined decreased approximately 8 per cent. In the Western States, where the quantity mined is small to begin with, the rock mined decreased 49 per cent.

Stocks on hand at the close of 1913 showed a gain of 6 per cent in the Florida field and of nearly 5 per cent in the Tennessee field. In South Carolina stocks diminished by about 9 per cent.

PRODUCTION BY STATES.

FLORIDA.

In 1913 Florida, the leading State in the phosphate-rock industry, marketed 2,545,276 long tons of phosphate rock, valued at $9,563,084, or 82 per cent of the entire production of the United States. As compared with the marketed production of 1912, Florida in 1913 gained 138,377 tons, or 6 per cent, in quantity and $101,787, or 1 per cent, in value. The quantity sold for the year was the greatest recorded for the State.

In the figures given in the tables the phosphate produced is classified as hard rock, land pebble, and river pebble. There was no river pebble mined in the State in 1913, but some was sold from De Soto County. These sales are included with land pebble, to avoid divulging confidential information. There was a decrease of nearly 1 per cent in the quantity of hard rock sold. There was a substantial increase in the production of land pebble, the relatively small quantity of river pebble included with the land pebble not affecting the general statements made with reference to the latter.

As will be observed from the preceding table, the average price of hard rock decreased 57 cents per ton; that of land pebble, 2 cents per ton. The average price for the State was less by 17 cents per ton than it was in 1912.

The hard rock marketed came from Alachua, Citrus, Columbia, Hernando, and Marion counties; the land pebble from Polk and Hillsboro counties. The river pebble was sold from De Soto County.

The following table shows the quantity and value based on marketed output of each variety of phosphate rock produced in Florida from 1909 to 1913, inclusive:

Phosphate rock marketed in Florida, 1909–1913, classified by grades, in long tons.

Year.	Hard rock.		Land pebble.		River pebble.		Total.	
	Quantity.	Value.	Quantity.	Value.	Quantity.	Value.	Quantity.	Value.
1909	513,585	$4,026,333	1,266,117	$4,514,968			1,779,702	$8,541,301
1910	438,347	3,051,827	1,629,160	5,595,947			2,067,507	8,647,774
1911	443,511	2,761,449	a1,992,737	6,712,189	(b)	(b)	2,436,248	9,473,638
1912	493,481	3,293,168	a1,913,418	6,168,129	(b)	(b)	2,406,899	9,461,297
1913	489,794	2,987,274	a2,055,482	6,575,810	(b)	(b)	2,545,276	9,563,084

a Includes a small quantity of river pebble. b Included in land pebble.

TENNESSEE.

Tennessee furnished approximately 14.5 per cent of the phosphate rock marketed in the United States in 1913. Tennessee rock is classified as brown, blue, and white. The brown rock in 1913 came from Giles, Hickman, and Maury counties, the blue rock chiefly from

Lewis and Maury counties. No white rock was mined during the year.

The total production of the State was 451,559 long tons, valued at $1,774,392, a gain in quantity of 28,228 tons, or 7 per cent, and in value of $133,916, or 8.2 per cent, as compared with 1912. The average price per ton of Tennessee phosphate rock increased 5 cents in 1913, as compared with 1912.

The following table shows the tonnage and value of each grade of Tennessee phosphate rock marketed from 1909 to 1913, inclusive:

Phosphate rock marketed in Tennessee, 1909–1913, classified by grades, in long tons.

Year.	Brown rock.		Blue rock.		White rock.		Total.	
	Quantity.	Value.	Quantity.	Value.	Quantity.	Value.	Quantity.	Value.
1909	274,410	$1,035,364	66,705	$275,165			341,115	$1,310,529
1910	329,382	1,262,279	[a] 68,806	241,071			398,188	1,503,350
1911	[b] 365,068	1,450,063	[a] 72,302	263,954			437,370	1,714,017
1912	359,692	1,420,726	[a] 63,639	219,750			423,331	1,640,476
1913	[c] 451,559	1,774,392	(d)	(d)			451,559	1,774,392

[a] Includes a small quantity of hard rock from Arkansas.
[b] Includes a small quantity from Kentucky.
[c] Includes blue rock.
[d] Included under brown rock.

SOUTH CAROLINA.

The production of phosphate rock in South Carolina in 1913 was 109,333 tong tons, valued at $440,588. This was a decrease of 22,157 long tons in quantity, or 17 per cent, and of $84,172 in value, or 16 per cent, compared with 1912. Only land rock was mined and marketed, as there has been no production of river rock during the last few years. The price of the rock per ton was 4 cents greater than in 1912. The output of the State constituted approximately 3.5 per cent of that of the country in 1913.

The following table shows the quantity and value of phosphate rock marketed in South Carolina from 1909 to 1913, inclusive:

Phosphate rock marketed in South Carolina, 1909–1913, classified by grades, in long tons.

Year.	Land rock.		River rock.		Total.	
	Quantity.	Value.	Quantity.	Value.	Quantity.	Value.
1909	201,254	$888,611	6,700	$21,975	207,954	$910,586
1910	[a] 179,659	733,057	(b)	(b)	179,659	733,057
1911	169,156	673,156			169,156	673,156
1912	131,490	524,760			131,490	524,760
1913	109,333	440,588			109,333	440,588

[a] Includes a small quantity of river rock.
[b] Included in land rock.

WESTERN STATES.

The production of phosphate rock in Idaho and Wyoming in 1913 was only 5,053 long tons, valued at $18,167, as compared with 11,612 tons, valued at $49,241, in 1912, a decrease of 56 per cent. This production constitutes only one-fifth of 1 per cent of that of the entire country.

The average price of western phosphate rock was $3.60 per ton.

IMPORTS OF FERTILIZER MATERIALS.

The fertilizer materials imported into the United States in 1913 included a considerable diversity of substances, as will be seen from the following table, which gives figures for the last five years:

Fertilizers imported and entered for consumption in the United States, 1909–1913, in long tons.

Product.	1909		1910		1911		1912		1913	
	Quantity.	Value.	Quantity.	Value.	Quantity.	Value.	Quantity.	Value.	Quantity.	Value.
Apatite	2,925	$19,013	....	....	20	$300	100	$1,400	2,962	$22,471
Bone dust or animal carbon, and bone ash, fit only for fertilizing purposes	29,035	685,291	48,979	$1,140,476	36,856	943,472	117,717	878,686	35,012	851,136
Calcium cyanamid or lime nitrogen	(a)	(a)	3,540	177,552	5,292	292,496	9,311	493,519	26,729	1,410,248
Guano	44,197	772,674	33,565	667,870	36,869	774,315	19,128	329,624	16,674	518,429
Kainit	163,943	854,998	582,197	2,798,198	563,957	2,748,140	511,976	2,386,362	465,336	2,201,730
Manure salts, including double manure salts	[b]52,958	601,804	147,242	1,013,009	159,796	1,660,040	171,757	1,797,057	223,687	2,245,509
Phosphates, crude	9,983	99,060	21,706	235,040	16,153	157,394	28,821	231,255	17,121	124,815
Slag, basic, ground or unground	690	5,880	10,774	93,650	12,622	87,994	12,596	114,300	13,186	130,455
All other substances used only for manure	184,850	2,879,845	195,991	3,394,279	197,810	4,098,321	127,932	2,660,887	154,729	3,314,460
Total	488,581	5,918,565	1,043,994	9,520,074	1,029,375	10,762,472	999,338	8,893,090	955,436	10,819,253

[a] Not separately classified. [b] From August 5 to December 31.

This table, strictly speaking, does not include all the material imported into the United States which goes into the fertilizer manufactured and sold in this country. To it should be added those potash salts, listed as such in the import tables of the Bureau of Foreign and Domestic Commerce, which enter largely into manufactured fertilizer. These potash salts are the chloride and the sulphate. Again, considerable imported sodium nitrate (Chile saltpeter) goes into the fertilizer industry. A large part of the sodium nitrate imported, however, is converted into nitric acid and potassium nitrate, the latter being used in the manufacture of gunpowder and other explosives, matches, pyrotechnics, in assaying and analytical operations, for curing meats, etc. The magnitude of the importation of this saline is, however, very significant. Sodium nitrate, together with potash salts, are commodities for the supply of which the United States is entirely dependent on foreign countries.

In the following table are shown the imports for consumption of materials which enter largely into the domestic fertilizer industry, limited as indicated in the statements above:

Imports for consumption of materials entering largely into the fertilizer industry in the United States for the years 1911–1913, in long tons.

	1911		1912		1913	
	Quantity.	Value.	Quantity.	Value.	Quantity.	Value.
Fertilizers	1,029,375	$10,762,472	999,338	$8,893,090	955,436	$10,819,253
Potassium chloride	226,148	7,651,693	215,415	7,229,121	212,170	7,075,745
Potassium sulphate	54,335	2,240,631	43,856	1,783,846	39,597	1,677,429
Sodium nitrate	544,532	16,814,268	486,779	16,544,511	612,861	21,630,811
Total	1,854,390	37,469,064	1,745,388	34,450,568	1,820,064	41,203,238

Adding the production of domestic phosphate rock to the imports of fertilizer an approximate idea at least will be gained of the quantity and value of the chief imported raw materials and of the domestic phosphate rock entering as essential constituents into our manufactured fertilizers. It must not be understood that the following table includes all the materials entering into manufactured fertilizer, as this is not the case. There are included in it chiefly the mineral ingredients which in most cases have gone through preliminary processes of purification and concentration. Even this statement has exceptions. For example, calcium cyanamid is a manufactured product and other substances listed in the table of imported fertilizers are of organic origin or are by-products in the manufacture of other substances. The omissions include also such organic material as fish scrap, dried blood, tankage, etc., and also ammonium sulphate. The table follows:

Materials entering largely into the fertilizer industry in the United States for the years 1911–1913, in long tons.

	1911		1912		1913	
	Quantity.	Value.	Quantity.	Value.	Quantity.	Value.
Imports: [a]						
Fertilizers	1,029,375	$10,762,472	999,338	$8,893,090	955,436	$10,819,253
Potassium chloride	226,148	7,651,693	215,415	7,229,121	212,170	7,075,745
Potassium sulphate	54,335	2,240,631	43,856	1,783,846	39,597	1,677,429
Sodium nitrate	544,532	16,814,268	486,779	16,544,511	612,861	21,630,811
Domestic phosphate rock	3,053,279	11,900,693	2,973,332	11,675,774	3,111,221	11,796,231
Total	4,907,669	49,369,757	4,718,720	46,126,342	4,931,285	52,999,469

[a] Imports are for consumption.

EXPORTS.

During 1913 there were exported 1,366,508 long tons of phosphate rock, valued at $9,996,580. As compared with 1912 this was an increase of 159,988 tons in quantity and of $1,000,124 in value.

The great bulk of the phosphate exported from the United States is from the Florida field. By reference to a preceding page of this report it will be observed that the production of Florida in 1913 was

2,545,276 long tons, valued at $9,563,084, whereas the exports which amounted to only 1,366,508 long tons were valued at $9,996,580, or $433,496 more. There are certain reasons for this apparent lack of correspondence in values.

From the figures tabulated for the Florida production it is evident that land pebble or the lower-grade Florida rock largely predominates and that the total value of the production is consequently proportionately lowered. The proportion of hard rock in the exported material is much greater than in the ordinary production, and this proportion, according to information published by the State geologist of Florida, amounted in 1912 to 39.12 per cent (and there is no apparent reason at the present time to believe that the proportion materially changed in 1913). According to Survey figures the hard-rock production constituted 20.50 per cent of the total Florida production in 1912 and 19.24 per cent in 1913.

The Survey does not collect figures of exported phosphate rock, but accepts those compiled by the Bureau of Foreign and Domestic Commerce. In the figures published by that bureau the grades of rock exported are not shown separately, nor are the sources of such rock given. The figures of exportation for 1913 include rock shipped from Tennessee and possibly from other localities of production. As the value of the exports represents "value at the time of exportation in the ports of the United States whence exported," it is assumed that the declared value at the port of shipment includes freight costs from mine to seaboard.

In the light of these facts—that is, the addition of freight charges and the large proportion of high-grade and consequently more valuable rock present in the exports as compared with the ordinary production—the apparent lack of correspondence in valuation is explained.

PRODUCTION IN PRINCIPAL COUNTRIES.

The production of phosphate rock in the principal producing countries of the world for the years 1910 to 1912, inclusive, was as follows:

Production of phosphate rock in principal producing countries, 1910–1912, in metric tons.

Country.	1910		1911		1912	
	Quantity.	Value.	Quantity.	Value.	Quantity.	Value.
Algeria	412,319	$1,193,664	738,935	$2,139,217	(a)	(a)
Australia	5,283	25,306	5,893	28,226	(a)	(a)
Belgium	202,880	366,015	196,780	319,039	203,110	$316,703
Canada	1,341	12,578	563	5,206	148	1,640
Christmas Island (Straits Settlements)	[b] 139,903	(c)	[b] 155,311	(c)	(a)	(a)
Dutch West Indies:						
Aruba	[b] 20,337	106,216	[b] 27,658	88,430	(a)	(a)
Curacao	[b] 2,165	3,621	[b] 1,836	3,071	(a)	(a)
France	333,506	1,253,708	312,204	1,172,404	(a)	(a)
French Guiana	[b] 6,925	53,074	(a)	(a)	(a)	(a)
French Oceania, Society Islands	[b] 40	209	[b] 12,102	46,378	(a)	(a)
South Africa, Natal	280	1,007	....	....	(a)	(a)
Tunis	1,334,264	5,714,011	1,592,000	6,824,974	1,882,100	8,370,000
United States	2,697,468	10,917,000	3,102,131	11,900,693	3,020,905	11,675,774

[a] Statistics not yet available. [b] Exports. [c] Value not reported.

NOTES ON THE DOMESTIC PHOSPHATE INDUSTRY.

THE SOUTHERN FIELDS.

The States of Florida, Tennessee, and South Carolina have for many years been the main source of phosphate rock in the United States. The output of Florida, the leading State in phosphate-rock production, has about reached its maximum, particularly so far as the hard-rock industry is concerned. The land-pebble industry continues to show a vigorous growth.

In Tennessee the brown-rock deposits, which several years ago were given but a brief future existence, promise to yield as much or more phosphate than has already been extracted from them, as they are now worked on a large scale with modern machinery and under modern mining methods. Pioneer methods are, however, still employed in some parts of the brown-rock phosphate regions and are attended by a great waste of good material. With the passing of the brown and blue phosphate fields into the control of the larger fertilizer corporations, which practice modern mining methods and have installed expensive plants to treat the mined rock, a gradual change has taken place and the life of the fields is being thereby prolonged.

The South Carolina field was the first to be exploited on a commercial basis. Though mining has fallen off in this field, it is quite likely that much rock remains for future use. As the most readily accessible material has been removed, the remaining rock will be correspondingly expensive to mine. The product, moreover, being of medium grade, can not compete with higher-grade rock in the manufacture of superphosphate. Hardly any rock is being exported from this field at the present time.

THE WESTERN FIELDS.

The new western phosphate field was discovered in 1906, and although for economic reasons it has not yet produced on a large scale, it is quite probable that the main production of the future will come from the West, where the principal deposits are located on the public domain. Some of the economic reasons that retard the development of the western phosphate fields are comparative newness, lack of transportation facilities, high freight rates, and remoteness from centers of consumption.

Since the discovery of the western fields systematic investigation has been prosecuted by the Survey, and the results have been published in part. This work has resulted in the discovery of new and important deposits, and its systematic conduct has greatly added to the known extent of the deposits.

PHOSPHATE RESERVES.

Lands remaining in Government ownership that are known to contain valuable phosphate deposits and those that are believed to contain such deposits have been withdrawn from entry temporarily. These reserves are located in Florida, Idaho, Utah, Wyoming, and Montana. The work of surveying the western phosphate lands is still going on, and from the following table will be seen the extent of the territory covered in these preliminary surveys.

Approximate area of phosphate lands, in square miles.

Year.	Reconnaissance surveys.	Detail surveys.	Total.	Withdrawn.	Restored.
1908				7,000	75
1909	1,000	800	1,800	600	3,600
1910	1,400	500	1,900	65	90
1911	1,200	800	2,000	55	237
1912	400	400	800	1,890	495
1913	800	1,500	2,300	360	1,020
Total	4,800	4,000	8,800	9,970	5,517

During the progress of the classification of phosphate lands to date, as a result of presidential orders 2,870,671 acres of land were included in the phosphate reserves January 1, 1914. The phosphate land withdrawn, restored, and outstanding at the end of 1913 is shown in the following table:[1]

Phosphate land withdrawn, restored, and outstanding on Jan. 1, 1914.

State.	Total withdrawals.	Restorations.	Outstanding withdrawals.
Florida	122,656	2,279	120,377
Idaho	2,300,341	1,299,065	1,001,276
Montana	293,378	134,541	158,837
Utah	581,039	544,846	36,193
Wyoming	3,111,362	1,557,374	1,553,988
Total	6,408,776	3,538,105	2,870,671

THE PHOSPHATE INDUSTRY IN THE SOUTHERN STATES.

FLORIDA DEPOSITS.

Location.—The Florida phosphate deposits are the most extensively developed in the United States. They comprise three classes—hard rock, land pebble, and river pebble. The land-pebble industry is the most important at present. The hard-rock industry ranks next. It suffers from competition with the land-pebble industry for reasons stated below, and declined in 1913 as compared with 1912. No river pebble was mined in 1913, but a small quantity was sold from stock on hand.

The area of hard-rock phosphate deposits extends as a narrow strip along the western part of the Florida peninsula from Suwanee and Columbia counties on the north to Citrus and Hernando counties on the south—a distance of approximately 100 miles. The land-pebble area is located farther south in Polk and Hillsboro counties.

Hard rock.—The hard-rock phosphate occurs in a soft matrix of phosphate sands, clays, and other material. The bowlder deposits occur in the form of irregularly sized pockets—the bowlders themselves varying in size from a few inches up to several feet.

[1] For a complete discussion of the classification of the public lands underlain not only by phosphate rock but by coal, oil, gas, salines, and other mineral deposits the reader is urged to secure a copy of Bulletin 537 of the Survey. Copies of this bulletin can be obtained, free of charge, by addressing the Director of the U. S. Geological Survey, Washington, D. C.

The phosphate content of this class of deposits ranges from less than 10 to more than 30 per cent of the mass, the marketable product being not more than 15 per cent of the total mined material. The rock itself runs as high as 85 per cent in tricalcium phosphate $Ca_3(PO_4)_2$. Practically all the rock mined is shipped abroad and sold on a guaranty of 77 per cent tricalcium phosphate.

Land pebble.—The land-pebble deposits are much more regular than the hard rock and occur in beds of varying thickness. For this reason active mining can be carried on cheaply. Moreover, improvements in mining and handling have made it possible to procure relatively low-grade rock cheaply. These reasons have contributed to the present great activity in the land-pebble industry. The phosphate content of the marketed land pebble usually ranges from 60 to 75 per cent tricalcium phosphate.

METHODS OF MINING.

The methods of mining the two main classes of phosphate rock in Florida differ considerably. In working the hard-rock deposits, the material is either dug out or dredged; in the pebble-phosphate field, hydraulic mining is employed. The details connected with these and the subsequent operations are outlined in the report for 1912 and consequently will not be repeated here.

TENNESSEE PHOSPHATE DEPOSITS.

The phosphate deposits of Tennessee are located in the central part of the State, the centers of production in 1913 being in Hickman, Maury, Giles, and Lewis counties. The output comprises brown and blue rock entirely—the white deposits of Perry and Decatur counties not having been worked during the year.

BROWN-ROCK PHOSPHATE.

Brown-rock phosphate, so called in contrast with the bluish-black rock, is variable in character, depending on the formation from which it has been derived. It occurs in plates of varying thickness and also in the form of a porous material which disintegrates to a phosphate sand. The two forms are often associated.

The beds occur in two distinct forms, known as collar and blanket deposits—the first named occurring where the horizontal phosphatic limestone bed outcrops on the slope of a steep hill. The blanket deposits, as the name implies, occur in broad areas lying near the surface. In the Mount Pleasant region in Maury County, about 10 miles southwest of Columbia, the county seat; at the Century mines of the Federal Chemical Co., 8 miles west of Columbia, near Wales, Giles County; and on lower Swan Creek the conditions have been favorable for the formation of such deposits. From their secondary mode of origin, they are of irregular thickness, and scattered through them are chimneys, bowlders, or horses of the original phosphatic limestone. The brown rock is sold under guaranty of 70 to 80 per cent tricalcium phosphate.

BLUE-ROCK PHOSPHATE.

Important deposits of blue-rock phosphate occur along Leatherwood Creek in the western part of Maury County; to the south and east of Centerville, and on both sides of Swan Creek, Hickman County; and in the eastern part of Lewis County. Deposits are also known in Perry and Wayne counties.

From its mode of origin as a sedimentary rock, the blue rock was mixed with clay, sand, pebbles, and gravel from various sources. Thus all stages occur between sandstone and shale at one end of the series and the pure blue phosphate rock at the other. In thickness the phosphate stratum varies from a few inches up to 4 feet rarely, and more often to only 2 or 3 feet. The content in calcium phosphate ranges from 30 to 85 per cent, but rock of the latter content does not occur in quantity.

METHODS OF HANDLING.

Brown rock.—In the process of mining brown rock the overburden is first removed by scrapers or steam shovels, but if heavy it may be removed by a drag line excavator. Mining is done in open pits with steam shovel loading into side-dump cars. In these cars the ore is removed to the washers, where, after first being crushed, it is dumped into sets of log washers. From the second set of log washers it goes to a rinsing screen with spray pipe extending through its center. The oversize is then carefully picked to remove limestone, flint, and mud balls. The plate rock is then ready for drying. The sand phosphate undergoes different treatment, the details of which were outlined in this report for 1912. Drying is accomplished by piling on wood in the open and setting the wood on fire. The more modern way is to dry in rotary kilns.

Blue rock.—Blue rock is a tough granular rock resembling limestone. It is not amenable to washing for the removal of impurities; hence the operations connected with its preparation for market are confined to mining, crushing, drying, screening, and stocking.

Blue-rock mining is conducted by first stripping around the face of the hill. This is accomplished by blasting and stripping with steam shovels. The subsequent operations are those generally involved in mining any flat-lying bed where the overburden is too thick to remove. The room and pillar method of mining is employed. Tunnels are run from the surface, and from these tunnels rooms 25 feet wide are turned at right angles and at regular intervals, leaving pillars about the same width. These rooms may be run any distance, and when work is complete the pillars are drawn, allowing the roof to cave. The roof as a rule forms an excellent support and requires no considerable timbering to prevent falls.

The rock is cut by drills and then loosened by blasting. It is then broken up by picks. The crushed material is next loaded on tram cars and hauled to the mouth of the adit and then to the drying and crushing plant, at which it is prepared for shipment. Washing is not necessary, as it is for brown rock, and the ore is fed from the tram cars to the crusher, where it is broken into fragments an inch and a half in diameter. From the crusher it goes to a rotary kiln drier. The rock contains a low percentage of moisture and some producers do not consider drying necessary. The drying tends to increase the quantity of bone phosphate, however, owing to the presence of organic matter and carbonate of lime, which are removed during the process.

SOUTH CAROLINA PHOSPHATE ROCK.[1]

The phosphate-rock deposits of South Carolina are confined to a belt along the coast, extending inland as much as 20 miles and running from a point about 20 miles beyond Charleston on the north to Beaufort on the south. The most important deposits are situated between the mouth of Broad River and a point near the source of Wando River. The rock occurs in two forms, as land rock and as river rock. The average composition of the South Carolina rock, as compiled by C. U. Shepard[2] on the basis of many hundred analyses, shows that the phosphoric acid present is equivalent to 55 to 61 per cent calcium phosphate.

Phosphate-rock mining in South Carolina began in 1867. Until about 1885 its production constituted more than 95 per cent of the phosphate marketed in the United States. With the advent of Florida and Tennessee into the phosphate industry, the South Carolina production diminished, and in 1913 its marketed production was only 3.5 per cent of the total for the United States. The table of production for the State on a preceding page shows a steady decrease during the last four years, the output now being virtually what it was between 1875 and 1880. No river rock has been mined since 1910. Land mining is confined chiefly to the Ashley district, but at the end of 1913 only 1 dredge was operating on the north side of the river and 2 on the south side. The Virginia-Carolina Chemical Co. is the chief producer, and only one other company is operating. The large washing plant at Lambs is at present the only one in operation, although in the fall of 1913 three other plants were working, 2 on Stono River and 1 on Chisholm's Island, near Beaufort. Conditions in the field are such that profitable mining is practicable only with the use of machinery capable of handling large quantities of material.

Though all the indications are that the South Carolina phosphate field has passed the period of its maximum production, the fact must not be lost sight of that there is a large quantity of 60 per cent phosphate rock still in the ground, which improved machinery may at some later time render workable. Moreover, the South Carolina rock has two advantages: In the first place, the former importance of the field led to the building of a group of large fertilizer factories at Charleston, and the expense of shipping is therefore almost negligible; and, secondly, the rock grinds easily and makes an excellent superphosphate, which, on account of its good mechanical condition, is preferred by many planters to the higher-grade rock of the neighboring fields.

On the other hand, the highest-grade rock that the field can be expected to produce does not average more than 61 per cent lime phosphate, and generally exceeds 3 per cent iron oxide and alumina.

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[1] Compiled and quoted in part from a longer report on the phosphate-rock deposits of South Carolina by G. S. Rogers (U. S. Geol. Survey Bull. 580-J, 1914).

[2] Shepard, C. U., South Carolina phosphate, Charleston, S. C., 1880.

The cost of production is considerably higher than in the Florida and Tennessee fields, so that the 70 per cent phosphate rock from those States can be delivered at Charleston at a price only slightly above that of the local product. This offsets the first of the two points in favor of the South Carolina rock, and the influence of the last can hardly be sufficient to compensate permanently for a difference of 10 per cent in phosphate content. The preference for the South Carolina rock is chiefly local, and, although the demand within the State may continue for some time, it probably can not affect the general phosphate industry.

ARKANSAS.

No phosphate rock was mined in Arkansas in 1913. A prospective producer at St. Joe, Searcy County, reports that he expects to begin mining operations in March, 1914. The White River Phosphate Co. reports some prospecting work done on its deposits in Izard County.

KENTUCKY.

For many years the beds of phosphate rock in the Ordovician limestone near Midway, Woodford County, central Kentucky, have attracted attention. During the last few years more interest has been taken in the Kentucky deposits and a small output has been produced, but no production was reported to the Survey for 1913.

VIRGINIA.

APATITE DEPOSITS.

Rock of igneous origin, rich in titanium and phosphorus, occurs in the eastern foothills of the Blue Ridge in Virginia, near Roseland, about 7 miles northwest of Arrington on the Southern Railroad, and 24 miles northeast of Lynchburg. The titanium occurs in the form of ilmenite, the phosphorus in the form of apatite, these being the dominant minerals. The rock occurs in dikelike forms of varying size and irregular shape, and to it the name nelsonite has been applied.[1]

Many varieties of rock have been included under this name, for example, ilmenite nelsonite, magnetite nelsonite, biotite nelsonite, hornblende nelsonite, and rutile nelsonite, from the dominant mineral which may be present, and gabbro nelsonite, from the rock-type gabbro, which some of the facies of nelsonite resemble. Ilmenite nelsonite, to which the name was first applied, is the normal and most abundantly occurring variety. The apatite present is the fluorapatite, chlorine being present only in traces. The content of the nelsonite in apatite ranges from 0.3 to 30 per cent.

Experiments having as their object the commercial utilization of nelsonite have been carried on at the Bureau of Soils. Both the minerals ilmenite and apatite contain elements which seriously affect each other so far as commercial applicability is concerned.

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[1] Watson, Thos. L., Mineral resources of Virginia, p. 300, 1907; Geology of the titanium and apatite deposits of Virginia: Virginia Geol. Survey Bull. 3 A, pp. 100 et seq., 1913. Watson, Thos. L., and Taber, Stephen, The Virginia rutile deposits: U. S. Geol. Survey Bull. 430, p. 206, 1909.

The problem, then, first, is to separate them. Two mechanical methods have been tried, depending (1) on differences in specific gravity, (2) on the magnetic properties of the ilmenite. Neither of these methods was found entirely satisfactory. The chemical method was then resorted to. In the experiments performed by W. H. Fry, of the Bureau of Soils, it has been found that ilmenite may be almost completely freed from apatite by means of sulphuric acid with a minimum of waste and without involving great expense. Moreover, all the products obtained can be utilized commercially.

Preliminary experiments showed that ilmenite is entirely unattacked by dilute sulphuric acid, while apatite is acted on quite energetically by this reagent. Subsequently it was shown that the apatite remaining in ilmenite after mechanical separation can nearly all be extracted by means of dilute sulphuric acid without appreciably affecting the ilmenite. The details connected with the experiments are outlined in the article by Waggaman cited below.[1]

Thus the possibility is shown of obtaining phosphate fertilizer material from this occurrence.

ALGERIAN PHOSPHATE-ROCK INDUSTRY.[2]

DEPOSITS.

The deposits of phosphate rock in Algeria are continuations of the deposits in Tunis. The two important mining districts in Algeria are located near the towns of Setif and Tebessa, in the eastern part of the State. They have been developed during the last 15 years, the production having increased from 1,057 short tons in 1899 to 550,000 in 1912. The percentage of phosphate in the rock exported from the Setif district ranges from 58 to 63 per cent and that in the rock from the Tebessa district, from 58 to 68 per cent.

TEBESSA DISTRICT.

The deposits of Kouif, the most important exploited in Algeria, belong to the Constantine Phosphate Co., of Constantine. They are located near Tebessa, close to the Tunisian frontier. Of the 5 beds, 3 are workable, the thickness ranging from 3 to 9 feet, 3 to 4½ feet, and 1⅗ to 3 feet, in the different beds. The average percentage of phosphate in the rock varies, being, respectively, 58.64 per cent, 68.50 per cent, and 48 per cent in the 3 beds. Where the overburden does not exceed 24 feet in depth, open-cut mining is practiced; where the overburden is deeper, the rock is mined by tunneling. Because of the basin, or saucer shape of the deposits, the tunnels are inclined.

A 16-mile branch line connects the mine with the railroad from Tebessa to the port of Bône. More than half of this railroad—the section from Tebessa to Souk-Ahras—is a narrow-gage, single-track line, capable of transporting only 330,000 tons of rock annually. Owing to insufficient railroad facilities the phosphate company reduced the quantity of rock mined from 712,817 tons in 1911 to 113,225 tons in 1912. For the same reason, it is intended either to double track the line from Tebessa to Souk-Ahras or to construct a broad-

[1] Waggaman, W. H., A possible commercial utilization of nelsonite: Jour. Ind. and Eng. Chemistry, vol. 5, No. 9, pp. 730–732, 1913.
[2] Daily Cons. and Trade Repts., pp. 1240–1242, Aug. 30, 1913.

gage railroad. Thus far no definite action has been taken, and it may be as much as three or four years before increased railway facilities render possible an increased production in the district.

Important deposits of phosphate rock have been found at Dy Nord and Djebel-Onck, about 62 miles south of Tebessa, which are believed to contain 300,000,000 to 400,000,000 tons of rock. These deposits have not been thoroughly explored, and estimates are therefore not entirely dependable. They have not been exploited, owing to lack of railroad facilities. After the reconstruction or improvement of the line from Tebessa to Souk-Ahras, it is likely that its prolongation to the deposits of Djebel-Onck will receive serious consideration.

SETIF DISTRICT.

In 1906 La Compagnie des Phosphates de Paris leased for 20 years the deposits in the commune of Bordj-Rhir. Its shipments are made by the way of a 12-mile cable to El Anasser, on the railway from Setif to Algeria; thence they go to the port of Bougie, from which the exports amounted to 64,986 short tons in 1910, 64,824 tons in 1911, and 62,702 tons in 1912.

La Compagnie Algérienne des Phosphates is exploiting two deposits in the commune of Tocqueville. The beds are from 1 to 6 feet thick. The phosphate is transported by a 9-mile narrow-gage branch line to the railway station of Texter-Tocqueville. In 1900, 17,807 short tons and in 1912, 230,864 short tons of rock were mined. At present 350 workmen are employed.

Another French company, with a capital of $1,000,000, is exploiting the Mzaita mine in the communes of Maadia. A broad-gage railroad has been built from the mine to the station of Ain-Tassers, and an electric plant of 150 horsepower has been installed for the stamp mill. Only 7,560 tons of rock were extracted in 1912, but it was intended to mine 100,000 tons in 1913, and it is expected that eventually 300,000 tons of rock will be mined annually. The estimated supply of rock is 16,500,000 tons.

EXPORTS OF ALGERIAN PHOSPHATE ROCK, 1902–1911.

The following table gives the quantities in short tons of phosphate rock exported from Algeria to France and to other foreign countries during the decade 1902–1911.

Exports of Algerian phosphate rock, 1902–1911, in short tons.

Year.	France.	Foreign countries.	Year.	France.	Foreign countries.
1902	51,497	89,739	1907	86,761	291,337
1903	77,249	262,004	1908	93,238	308,858
1904	75,479	292,810	1909	44,088	322,696
1905	79,254	303,630	1910	41,276	307,791
1906	72,841	282,788	1911	37,050	331,515

The total exports of phosphate rock in 1912 were 411,269 tons, or 42,704 tons more than in 1911.

LOCAL MANUFACTURE OF FERTILIZERS.

The director of the only company in Algeria manufacturing phosphate fertilizers estimates that the consumption in Algeria in 1912 of phosphate rock mined in the country was about 60,000 tons.

The Société des Engrais et Produits Chimiques constructed a plant at Bône about six years ago for producing superphosphate by treating the crushed rock with sulphuric acid. Plants have been subsequently established near Algiers and Oran. The company, which manufactures the sulphuric acid used at its works, is doing a satisfactory business and produces the greater part of the phosphate fertilizer used in the country.

MARKET.

Algerian mining companies sell their phosphate rock c. i. f. at the important European markets at prices which on July 4, 1913, were as follows: For 63 to 68 per cent phosphate, at British ports and Hamburg, $11\frac{1}{3}$ cents per unit; at Italian ports, $11\frac{1}{5}$ cents; at Antwerp, $11\frac{6}{10}$ cents. For 58 to 63 per cent phosphate, the prices at these ports were, respectively, 11 cents, $10\frac{8}{10}$ cents, and $10\frac{8}{10}$ cents. Sales are based on the metric ton (2,204.6 pounds) and the price is obtained by multiplying the percentage of phosphate in the rock by the current rate paid. Thus the price in Great Britain for rock containing 65 per cent of phosphate would be $7.37 per ton.

COST OF MINING.

No information could be obtained from the Algerian authorities as to the actual cost of exploitation at the mines. This varies materially according to local conditions. As was stated by the government inspector of mines, it was found that the mining companies are not inclined to furnish such information.

COST OF TRANSPORTATION.

The cost of transportation from mine to shipping port varies materially according to cost of shipment from mine to railroad, but according to information received from the government inspector of mines it varies from $1.50 to $2 a ton.

SURVEY PUBLICATIONS RELATING TO PHOSPHATES.

The following papers relating to phosphates have been published by the United States Geological Survey or by members of its staff.

The Government publications, except those to which a price is affixed, may be obtained free by applying to the Director, United States Geological Survey, Washington, D. C. The priced publications may be purchased from the Superintendent of Documents, Government Printing Office, Washington, D. C. Those indicated as being "Out of print" or "Exhausted" are not available for distribution but may be seen at the larger libraries of the country.

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Penrose, R. A. F., Nature and origin of deposits of phosphate of lime: U. S. Geol. Survey Bull. 46, 143 pp., 1888. Out of print.
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SALT, BROMINE, AND CALCIUM CHLORIDE.

By W. C. Phalen.

SALT.

PRODUCTION.

The marketed production of salt in the United States, including Hawaii and Porto Rico, in 1913, was 34,399,298 barrels of 280 pounds each, or 4,815,902 short tons, valued at $10,123,139. In 1912 the production was 33,324,808 barrels, or 4,665,473 short tons, valued at $9,402,772. There was a gain in 1913 of more than 3 per cent in quantity of salt produced and of nearly 8 per cent in value, as compared with 1912.

The average price of salt per barrel in 1913 was 29.428 cents, or $2.10 per short ton, as compared with 28.215 cents per barrel, or $2.02 per short ton, during 1912. The price of salt has been slowly rising in recent years.

In the following table are given the quantity and value of salt produced in the United States from 1893 to 1913, inclusive:

Marketed production and value of salt in the United States, 1893–1913.

Year.	Quantity.	Value.	Year.	Quantity.	Value.
	Barrels.			*Barrels.*	
1893	11,897,208	$4,154,668	1904	22,030,002	$6,021,222
1894	12,968,417	4,739,285	1905	25,966,122	6,095,922
1895	13,669,649	4,423,084	1906	28,172,380	6,658,350
1896	13,850,726	4,040,839	1907	29,704,128	7,608,323
1897	15,973,202	4,920,020	1908	28,822,062	7,553,632
1898	17,612,634	6,212,554	1909	[1]30,107,646	8,343,831
1899	19,708,614	6,867,467	1910	[1]30,305,656	7,900,344
1900	20,869,342	6,944,603	1911	[1]31,183,968	8,345,692
1901	20,566,661	6,617,449	1912	[1]33,324,808	9,402,772
1902	23,849,231	5,668,636	1913	[1]34,399,298	10,123,139
1903	18,968,089	5,286,988			

[1] Includes production of Hawaii and Porto Rico.

PRODUCTION BY GRADES AND STATES.

Salt is produced in various ways. At the outset, the methods of production are divided into two distinct classes. This is owing in part to the fact that salt itself occurs naturally in two very distinct ways—(1) as rock salt in beds or associated with bedded or sedimentary deposits, and (2) in the form of natural brines or bitterns. However, the larger part of our salt production is derived by converting the naturally occurring rock salt into artificial brines, which are pumped to the surface and there evaporated.

The two methods of production referred to above are (1) the mining of rock salt and its purification and separation into marketable sizes, and (2) the production of salt by evaporation of the artificial or natural brines, bitterns, or other solutions containing it.

The processes employed at the present time in the manufacture of salt by evaporation may be outlined as follows: (1) Solar evaporation; (2) direct heat evaporation (*a*) in open kettles, (*b*) in open pans; (3) steam evaporation (*a*) in jacketed kettles, (*b*) in grainers; (4) vacuum pan evaporation. Of the classes enumerated, direct heat evaporation in open kettles and steam evaporation in jacketed kettles have become practically obsolete.

Production by grades.—By the processes outlined above are produced the different main grades of salt made from brine, together with many modifications of them put on the market under different trade and proprietary names. The production of brine salt for the last five years is shown in the following table:

Marketed production of brine salt in the United States, 1909–1913, by grades, in barrels.

Year.	Table and dairy.		Packers' salt.					
			Common fine.		Common coarse.		Packers'.	
	Quantity.	Value.	Quantity.	Value.	Quantity.	Value.	Quantity.	Value.
1909......	3,042,824	$2,240,128	7,745,204	$2,736,917	2,843,393	$929,111	385,802	$169,744
1910......	3,514,748	2,249,827	6,153,296	2,158,386	2,602,737	799,405	327,304	147,434
1911......	3,773,798	2,528,671	6,267,850	2,048,527	2,970,492	1,041,619	408,928	162,945
1912......	3,961,450	3,164,638	6,021,052	2,109,076	2,753,375	1,096,643	751,551	296,238
1913......	3,881,387	3,223,836	6,521,058	2,423,012	3,464,978	1,414,760	(*a*)	(*a*)

Year.	Coarse solar.		Other grades.		Brine.		Total.	
	Quantity.	Value.	Quantity.	Value.	Quantity.	Value.	Quantity.	Value.
1909......	1,283,548	$508,098	97,347	$33,326	8,770,807	$438,540	24,168,925	$7,055,864
1910......	1,223,371	418,495	129,036	44,223	9,389,226	469,461	23,339,718	6,287,231
1911......	1,343,046	444,324	160,233	40,365	10,027,411	501,225	24,951,758	6,767,676
1912......	1,105,935	408,939	231,063	59,093	11,408,623	570,316	26,233,049	7,704,943
1913......	1,161,649	446,342	193,991	67,608	11,588,444	579,014	26,811,507	8,154,572

[a] A small output reported directly as packers' is included under common coarse.

Production of rock salt.—In order to differentiate the rock-salt and the brine-salt industries in the United States, which are quite different, the following table is added, giving the quantity and value of the rock salt mined in the United States during the last five years:

Marketed production of rock salt in the United States, 1909–1913, in short tons.

Year.	Rock salt.	
	Quantity.	Value.
1909..............	[a] 831,421	$1,287,967
1910..............	[a] 975,231	1,613,113
1911..............	[a] 872,509	1,578,016
1912..............	[b] 992,846	1,697,829
1913..............	[b] 1,062,291	1,968,567

[a] Includes California, Idaho, Kansas, Louisiana, Michigan, New York, and Utah.
[b] Includes California, Kansas, Louisiana, Michigan, New York, and Utah.

Rock salt is produced by deep shaft mining in the eastern, central, and southern parts of the United States. The active mines are located, respectively, at Retsof and Halite, Livingston County, N. Y.; one near Detroit, Mich.; two at Kanopolis, Ellsworth County, and one at Lyons, Rice County, Kans.; and one each at Weeks and Avery islands, Iberia Parish, southern Louisiana.

Rock salt occurs near the surface in consequence of the dry climate, and is mined in open cuts or pits, in Sevier Valley, Utah, near Salina, Redmond, and Gunnison, in both Sevier and Sanpete counties. A small production of rock salt near the surface is also reported from near Saltus and Ward, San Bernardino County, Cal.

Production by States.—The following table gives the production and value of the salt produced in the United States from 1910 to 1913, inclusive, by States:

Marketed production and value of salt, 1910–1913, by States, in barrels.

State.	1910		1911		1912		1913	
	Quantity.	Value.	Quantity.	Value.	Quantity.	Value.	Quantity.	Value.
New York	[a] 11,642,520	[a] $2,585,739	[a] 11,234,928	[a] $2,538,151	10,527,221	$2,615,334	10,780,514	$2,865,187
Michigan	9,452,022	2,231,262	10,320,074	2,633,155	10,946,739	2,974,429	11,528,800	3,293,032
Ohio	3,673,850	951,963	4,302,507	1,100,453	5,269,179	1,364,136	5,310,135	1,318,156
Kansas	2,811,448	947,369	2,159,859	806,027	2,573,626	844,292	2,698,079	860,404
Louisiana	(b)	(b)	(b)	(b)	(c)	(c)	(c)	(c)
California	937,514	519,667	1,086,163	555,359	1,090,000	620,196	1,082,993	759,485
West Virginia	155,625	62,955	183,379	78,805	139,121	66,023	113,921	63,803
Texas	382,164	272,568	385,200	299,537	373,064	290,328	355,529	278,008
Utah	249,850	185,869	272,420	171,268	283,293	154,734	330,443	191,686
Hawaii	11,450	9,570	8,463	11,850	8,286	9,180	6,071	5,950
Idaho	885	1,127	314	532	(c)	(c)	(c)	(c)
Porto Rico	(c)	(c)	(c)	(c)	(c)	(c)	(c)	(c)
Nevada	17,535	10,600	12,856	16,952	12,536	15,752	8,971	7,947
Oklahoma	2,564	881	500	431	(c)	(c)	(c)	(c)
Other States	[d] 968,229	120,774	[d] 1,217,305	133,172	[e] 2,101,743	448,368	[e] 2,183,842	479,481
Total	30,305,656	7,900,344	31,183,968	8,345,692	33,324,808	9,402,772	34,399,298	10,123,139

[a] Includes Louisiana.
[b] Included in New York.
[c] Included in "Other States."
[d] Includes New Mexico, Pennsylvania, Porto Rico, and Virginia.
[e] Includes Idaho, Louisiana, New Mexico, Oklahoma, Pennsylvania, Porto Rico, and Virginia.

The following table presents in concise form general information of interest to the salt trade. It gives for the two years 1912 and 1913 the number of operating plants in the individual States, together with their relative rank as to both quantity and value of the salt produced; also the percentage of increase or decrease in both quantity and value of salt produced.

Number of operating plants, rank of States, average price per ton in 1912 and 1913, and percentage of increase or decrease in 1913.

State.	1912				1913				Percentage of increase (+) or decrease (−).	
	Number of operating plants.	Rank of State by— Total quantity.	Rank of State by— Total value.	Average price per ton.	Number of operating plants.	Rank of State by— Total quantity.	Rank of State by— Total value.	Average price per ton.	Quantity.	Value.
California	[a] 21	5	5	[b] $3.00 [c] 4.09	[a] 24	6	5	[b] $3.00 [c] 5.07	− 0.64	+$22.46
Hawaii	[c] 6	14	14	[c] 7.91	[c] 5	14	14	[c] 7.00	−26.72	− 35.19
Idaho	[c] 2	17	17	[c] 13.80	[c] 2	17	16	[c] 12.79	+86.67	+ 72.95
Kansas	[a] 10	4	4	[b] 1.32 [c] 3.30	[a] 10	4	4	[b] 1.24 [c] 3.32	+ 4.84	+ 1.91
Louisiana	[b] 2	6	6	[b] 1.99	[b] 2	5	6	[b] 2.10	+12.85	+ 18.83
Michigan	[a] 26	1	1	[b] 2.55 [c] 1.91	[a] 26	1	1	[b] 2.44 [c] 2.01	+ 5.32	+ 10.71
Nevada	[c] 4	13	13	[c] 8.98	[c] 3	13	13	[c] 6.33	−28.43	− 49.55
New Mexico	[c] 2	15	15	[c] 7.14	[c] 1	15	15	4.00	−11.11	− 51.52
New York	[a] 31	2	2	[b] 1.59 [c] 1.88	[a] 28	2	2	[b] 1.86 [c] 1.92	+ 2.41	+ 9.55
Ohio	[c] 10	3	3	[c] 1.85	[c] 10	3	3	[c] 1.77	+ .78	− 3.37
Oklahoma	[c] 2	16	16	[c] 4.17	[c] 2	16	17	[c] 3.50	− 5.13	− 20.31
Pennsylvania	[c] 1	12	10	[c] 4.70	[c] 1	11	11	[c] 5.25	−30.20	− 22.07
Porto Rico	[c] 2	11	12	[c] 2.32	[c] 2	12	12	[c] 2.90	−65.28	− 56.65
Texas	[c] 4	8	7	[c] 5.56	[c] 3	8	7	[c] 5.59	− 4.70	− 4.24
Utah	[a] 9	9	8	[b] 3.69 [c] 3.95	[a] 6	9	8	[b] 2.97 [c] 4.25	+16.64	+ 23.88
Virginia	[c] 1	7	11	[c][d] .36	[c] 1	7	10	[c][d] .36	+ 2.92	+ 2.92
West Virginia	[c] 3	10	9	[c] 3.39	[c] 3	10	9	[c] 4.00	−18.11	− 3.36
Total brine and rock salt	136			[b] 1.71 [c] 2.10	129			[b] 1.85 [c] 2.17	[b]+ 6.99 [c]+ 2.21	[b]+ 15.95 [c]+ 5.84
Total United States				2.02				2.10	+ 3.22	+ 7.66

[a] Includes both rock and brine salt.
[b] Rock salt.
[c] Brine salt.
[d] The low value of salt in Virginia is due to the fact that the salt is in the form of brine, which is not utilized for its salt content, but is worked up into other sodium salts.

DOMESTIC CONSUMPTION.

The following table gives the consumption of salt in the United States during 1913. In addition to the domestic production, 34,399,298 barrels, 1,105,466 barrels were imported. These imports were in part offset by exports amounting to 502,065 barrels, leaving an excess of imports over exports of 603,401 barrels, which, added to the domestic production, makes the total salt consumed in the United States 35,002,699 barrels. As compared with 1912 this is an increase of 1,125,012 barrels. The imported salt constituted 3.2 per cent of the domestic consumption for the year, which is a slightly greater ratio than for 1912, when it was 2.9 per cent. The significance of these figures is that the United States furnished very nearly all the salt consumed by its people during 1913. The country is amply able to supply the entire home demand, as the capacity of its salt mines and plants is considerably in excess of the present output. Many plants that are either now running at fractional capacity or entirely inactive could easily resume operations should trade conditions warrant. Most of the small quantity imported comes to Atlantic ports, the very low charge for ocean carriage enabling it to compete with the domestic product.

Supply of salt for domestic consumption, 1890–1913, in barrels.

Source.	1890	1900	1910	1912	1913
Domestic production	8,876,991	20,869,342	30,305,656	33,324,808	34,399,298
Imports	1,838,024	1,427,921	979,305	998,664	1,105,466
Total	10,715,015	22,297,263	31,284,961	34,323,472	35,504,764
Exports	17,597	53,650	350,094	445,785	502,065
Domestic consumption	10,697,418	22,243,613	30,934,867	33,877,687	35,002,699
Comparison with preceding year	+877,610	+1,274,634	+46,032	+2,027,885	+1,125,012
Percentage of imports to total consumption	17.2	6.4	3.2	2.9	3.2

IMPORTS.

In 1913 there were imported into the United States 309,530,500 pounds, or 1,105,466 barrels, of salt, valued at $421,745; the corresponding imports in 1912 were 279,625,900 pounds, or 998,664 barrels, valued at $370,648.

Prior to the tariff act of 1913 salt imported into the United States for curing fish was admitted free of duty, which was not the case with salt imported for other purposes. Since the duty has been removed from all salt the necessity for differentiating by classes the imported product no longer obtains; hence the statistics of imports of salt imported for curing fish are no longer kept separate, but are included with salt imported in containers or in bulk. For this reason a comparison of the salt imported by grades during 1913 and 1912 can not be made.

According to figures obtained from the Bureau of Foreign and Domestic Commerce of the Department of Commerce, the quantity and value of the salt imported and entered for consumption in the United States in the last five years are as follows:

Salt imported and entered for consumption in the United States, 1909–1913, in pounds.

Year.	In bags, barrels, and other packages.		In bulk.		For the purpose of curing fish.		Total quantity.	Total value.
	Quantity.	Value.	Quantity.	Value.	Quantity.	Value.		
1909	65,581,839	$220,503	135,735,445	$132,884	97,722,473	$84,440	299,039,757	$437,827
1910	53,143,200	178,000	118,796,400	104,822	102,265,982	88,100	274,205,582	370,922
1911	61,648,200	181,405	108,055,700	95,801	114,475,300	97,824	284,179,200	375,030
1912	57,453,400	179,199	133,080,800	112,749	89,091,700	78,700	279,625,900	370,648
1913	70,433,300	209,752	185,743,900	160,400	[a] 53,353,300	[a] 51,593	309,530,500	421,745

[a] This class was not carried separately after Oct. 3, 1913.

EXPORTS.

The exports of salt in 1913 were 140,578,092 pounds, or 502,065 barrels, valued at $515,194. As compared with the exports in 1912, which were 124,819,713 pounds, or 445,785 barrels, valued at $418,525, this was an increase of 56,280 barrels in quantity and of $96,669 in value. Both the quantity and the value of the domestic salt exported in 1913 were the greatest ever recorded in the history of the industry in the United States. The export of salt of domestic production from the United States from 1909 to 1913 is shown below:

Salt of domestic production exported from the United States, 1909–1913.

Year.	Quantity.	Value.
	Pounds.	
1909	80,306,820	$269,273
1910	98,026,369	320,926
1911	97,745,833	335,285
1912	124,819,713	418,525
1913	140,578,092	515,194

SALT INDUSTRY BY STATES.

CALIFORNIA.

In quantity of salt produced in 1913 California ranked sixth among the salt producing States; in the value of the product the State ranked fifth. The output of the State was 1,082,993 barrels of 280 pounds each, or 151,619 short tons, valued at $759,485, a decrease of 7,007 barrels, or 981 tons, in quantity, but an increase of $139,289 in value as compared with 1912. The value for 1913 represents an average of more than 70 cents per barrel, or $5.01 per ton, as compared with 57 cents per barrel, and $4.06 per ton, in 1912. The prices of California salt in 1913 generally averaged much higher than the prices for the United States at large, which, as stated in the introductory paragraph, averaged 29.426 cents per barrel and $2.10 per short ton. Thus the average price of California salt in 1913 was very nearly two and one-half times that of the rest of the country.

The great bulk of the salt produced in California comes from sea water and is produced by solar evaporation along the shores of San Francisco Bay, in Alameda and San Mateo counties; near Long Beach, in Los Angeles County; and on San Diego Bay, in San Diego County. The salt crop, so called, is harvested chiefly during the fall, and the size of the crop depends very much on the condition of the weather. The severe winter of 1913–14 and the late rains reduced the crop very materially and caused in part the increase in price. Another difficulty encountered by some of the manufacturers was the scarcity of labor.

The basic salt in California is solar salt, and its sale either in the harvested form or after it has been crushed (half ground) or washed and ground for table and dairy use, and known as granulated, constitutes about 75 per cent of the trade. Three firms on the coast recrystallize their product. The cost value of crude solar salt in the stack is fairly well established at $2.50 per ton. The price received f. o. b. shipping point will vary with the varying demands of the industries supplied. The highest grades of salt, such as table and dairy, have practically a uniform market at all times and are not subject to the fluctuation of the crude solar article. The other grades marketed for curing hides, hay, fish, and for making ice cream, have varying prices, according to the work necessary to get them into shape for the market.

About 75 per cent of the salt made on San Francisco Bay is made on the east shore, and the salt companies there forward their product to San Francisco on their own barges or lighters and make all their prices and costs f. o. b. San Francisco. The freight charges from the plants on the west shore of the bay to San Francisco are fixed.

The headquarters of the salt industry are at Alvarado, Newark, Mount Eden, Russell, and Arffs, in Alameda County, on the east shore of San Francisco Bay, and at Redwood City and San Mateo, in San Mateo County, on the west shore of the bay. In the southern part of the State solar salt is made at Ostend station near Long Beach, in Los Angeles County, and on San Diego Bay, San Diego County.

In addition to the output by solar evaporation, salt is also produced in small quantity at inland points, as follows: Keeler, Inyo County; Ward, San Bernardino County; Saltus, San Bernardino County; and near Cedarville, Modoc County. At Cenada, Kern County, the property of the Diamond Salt Co. is now held by the Consolidated Salt Co. Though a large tonnage of salt was obtained by the company in 1913, none of it was sold. The company is awaiting the installation of a railroad track and other facilities for handling its product. It expected to begin operations in the spring of 1914, when all the various grades will be produced. A description of the occurrence of salt at this place was given in the report for 1912.

IDAHO.

Salt was made by two operators in Idaho in 1913. The output came from Stump Creek, Bannock County, but the headquarters of the operators are at Auburn, in Wyoming. The industry is purely local, and is carried on in a very small way. A complete account of the salt resources of the region along the Idaho-Wyoming border has been prepared by C. L. Breger, and the reference to it is listed in the bibliography at the end of this chapter.

KANSAS.

Kansas ranked fourth among the States in both the quantity and the value of salt produced in 1913. The State produced both rock salt and evaporated salt, made by the open pan, grainer, and vacuum-pan processes. Rock salt in Kansas came from the mines at Kanopolis, Ellsworth County, and at Lyons, Rice County. Salt made by evaporative processes came from Ellsworth, Ellsworth County; Anthony, Harper County; Hutchinson, Reno County; and Lyons and Sterling, Rice County.

The production for the year amounted to 2,698,079 barrels of 280 pounds each, or 377,731 short tons, valued at $860,404, a substantial increase as compared with 1912, amounting to 124,453 barrels in quantity and to $16,112 in value.

The rock-salt beds of Kansas furnish all the salt now marketed in the State, including that produced by the evaporative processes. The beds occur in rocks of Permian age. The "salt beds," the name applied to the rock salt layers themselves and the shale layers associated with them, lie within the Marion formation. They grow thinner to the east to beyond Wellington and Little River and die out possibly without coming near the surface. It is thought that the salt springs at Geuda Springs, Sumner County, have their origin in these salt beds. How far the salt beds extend westward is unknown. In the north-south direction the beds are fairly well known from drill records from Kanopolis, Ellsworth County, on the north, to Anthony, Harper County, on the south—that is, very nearly to the Kansas-Oklahoma State line. The beds thin northward. At Anthony they are 404 feet thick (depth 946 to 1,350 feet); at Kingman, 415 feet thick (depth 665 to 1,080 feet); at Hutchinson, 380 feet thick (depth 430 to 810 feet); at Lyons, 275 feet thick (depth 793 to 1,068 feet); and at Kanopolis about 250 feet thick (depth 630 to 880 feet). If the rate of decrease in thickness from Hutchinson northward were maintained, the salt beds would disappear before the north boundary of the State was reached. It must be remembered that where more than one record is obtainable at a given place—for example, at Hutchinson—the exact thickness of the beds, as well as the distanct of the topmost of them below the surface, will vary somewhat and sometimes considerably from the figures given above. The records of the wells at Kanopolis, Lyons, Hutchinson, Kingman, and Anthony contain no reference to appreciable quantities of gypsum below the salt.

Another most interesting question in connection with the geology of the salt beds is their relation to the extensive gypsum deposits in different parts of Kansas and of the Great Plains area. The rock gypsum in the northern part of the State, in Marshall County, lies but a few feet above the Cottonwood limestone, which would place it considerably below the Marion formation. Farther south, in the central gypsum field, the rock gypsum occurs in the Wellington shale. If, therefore, the correlations made by Grimsley[1] are correct, the salt beds were deposited at a period of time intermediate between the formation of the Marshall County rock gypsum and that in the vicinity of Solomon.

It is difficult to understand how such extensive deposits of salt could be formed without a larger amount of gypsum being formed underneath them. The records of the wells at Kanapolis, Lyons, Hutchinson, Kingman, and Anthony contain no reference to gypsum immediately underlying the salt beds. The question is as to what became of the calcium sulphate held in solution by the ocean water from which the rock salt was obtained. It is barely possible that during the period of the formation of the Marshall County gypsum, the inland sea did not reach southward to the salt beds area, and that after the gypsum was principally precipitated out of the inclosed ocean water and before concentration was carried far enough to precipitate the salt, surface movements resulted in draining this partially purified water southward over new areas from which fresh ocean water was excluded, thus permitting the continued evaporation to deposit the salt now found in the salt beds from the same water from which the Marshall County gypsum was produced. It is known that the Permian rocks, in general, become quite thin northward, entirely excluding the upper members of the Permian. So far as this has a bearing on the subject it would tend to favor the view just expressed.[2]

LOUISIANA.

Salt occurs in two districts in Louisiana (1) in the north central and northern part of the State, in the valley of Red River and its tributaries and (2) in the southern part, the most important deposits

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[1] Grimsley, G. P., and Bailey, E. H. S., Special report on gypsum and gypsum-cement plasters (pls. II and III); Kansas Univ. Geol. Survey, vol. 5, 1899.

[2] Haworth, Erasmus, Geology of Kansas salt; Kansas Mineral Resources Ann. Bull. 1898, pp. 88–89, 1899.

and those worked at present occurring in close proximity to the Gulf coast.

The most important salt deposits of the State are located on the Five Islands, so called, situated near the southern coast. From two of these islands, namely, Grand Côte (Weeks Island) and Petite Anse (Averys Island) rock salt is being mined at the present time. Owing to the fact that there are only two producers in the State the figures of production can not be given.

The details connected with the mining of the salt and the geology of these deposits which, with those in Texas, are unique among the salt occurrences of the United States have been described in this chapter in previous years and for that reason will not be given here.

MICHIGAN.

Michigan ranked first among the States in 1913 in both quantity and value of salt produced. The production of the State was 11,528,800 barrels, or 1,614,032 short tons, valued at $3,293,032, a gain of 582,061 barrels in quantity and of $318,603 in value as compared with 1912, in which year the production was 10,946,739 barrels, or 1,532,543 short tons, valued at $2,974,429.

The salt produced in Michigan is obtained from two distinct sources: (1) From rock salt and (2) from natural brines.

The rock salt deposits now worked are in the southeastern and western parts of the Lower Peninsula and are exploited in two ways: (1) Rock salt itself is actually mined from the deposits, and (2) water is allowed to come into contact with the salt and the brine thus formed, which may be considered artificial, is forced to the surface and there evaporated.

The salt industry of Michigan, associated with the natural brines, is confined to the Saginaw Valley. The brine is entirely distinct, not only in its geographic but also in its geologic relations from that in the southeastern and western parts of the lower peninsula. With the salt production in the Saginaw Valley are connected the bromine and the calcium chloride industries. The manufacture of salt in Saginaw Valley is not so important as it is in the other parts of the Lower Peninsula.

Rock salt is mined at Oakwood, near Detroit, Wayne County. In the southeastern part of the State evaporated salt is made at Marine City, Port Huron, and St. Clair in St. Clair County, and at Detroit, Oakwood, Ecorse, and Wyandotte in Wayne County. In the western part of the State evaporated salt is made at East Lake, Manistee, and Filer City in Manistee County, and at Ludington in Mason County. In the Saginaw Valley salt is made at Bay City, Bay County, and Mount Pleasant in Isabella County, and at Carrollton, Saginaw, Saginawtown, and St. Charles in Saginaw County. Calcium chloride is also made at Mount Pleasant and Saginawtown, and bromine at Midland and Mount Pleasant.

The rock salt of the Lower Peninsula of Michigan is found in the lower part of the Monroe formation (Silurian). In the extreme southeast corner of the State the rock salt disappears, and wells drilled at Trenton show the edge of the salt-producing area there, as salt occurs in only one of them. The thickness of the salt-bearing beds increases to the north and this increase holds good into Canada.

In the southwestern part of the State no rock salt occurs, but to the north, at Manistee and Ludington, salt is obtained in the form of brine from beds approximately 2,000 feet below the surface. At Frankfort, still farther north in Benzie County, wells deep enough to penetrate the salt-bearing rocks have been sunk, but they did not strike salt and not even very strong brine. It is possible that Frankfort was just without the area of salt deposition. Wells at St. Ignace and Cheboygan likewise show no salt.

Another place in which rock salt has been found in small quantity, but in which it has not yet been developed, is Alpena, located in the northeastern part of the Lower Peninsula on the shores of Thunder Bay, an arm of Lake Huron. Here five beds of salt with streaks of gypsum and anhydrite are known; these beds aggregate about 300 feet in total thickness.

The brines of the Saginaw Valley occur in the sandstones of the Marshall formation (Mississippian). Thus they are distinct both geographically and geologically from the rock salt horizons described above. It is the sandstones of the Marshall formation which yield the brine so extensively used in the manufacture of salt, bromine, and calcium chloride. The towns and cities already mentioned in the Saginaw Valley are those most prominently identified with these chemical industries.

NEVADA.

The salt produced in Nevada in 1913 amounted to 8,971 barrels, or 1,256 tons, valued at $7,947, a decrease as compared with 1912, when the production was 12,536 barrels, or 1,755 tons, valued at $15,752.

The salt produced in Nevada came from Sand Springs and Leete, in Churchill County, and from Sheepshead, in Washoe County. No work was done at Parran, Churchill County, except to clean out ditches and to prepare for future production. No production was reported from the Silver Peak playa in Esmeralda County.

NEW YORK.

New York ranked second among the States in 1913 in both quantity and value of salt produced. The output of the State was 10,780,514 barrels, or 1,509,272 short tons, valued at $2,865,187, an increase of 253,293 barrels, or 35,461 short tons, in quantity and of $249,853 in value, compared with 1912. The output of the State falls into several classes: Rock salt was made at Halite (Cuylerville post office), and at Retsof, Livingston County. Solar salt was produced in the vicinity of Syracuse, Onondaga County, and brine utilized in the manufacture of soda products came from Tully, Onondaga County. Evaporated salt, or salt made by artificial evaporation in open pans, grainers, or vacuum pans, from brines derived by allowing water to come into contact with the rock salt in place, is the most important class made in the State. Salt thus produced is made at Le Roy, in Genesee County; Piffard, in Livingston County; Watkins, in Schuyler County; Ithaca and Myers, in Tompkins County; and at Rock Glen, Silver Springs, and Saltvale in Wyoming County.

The salt beds of New York belong in the Salina formation (Silurian). This group of rocks contains the gypsum deposits of western New York as well. The Salina as a whole has the form of an irregular lense, the maximum thickness of which is found between Oneida Creek and Cayuga Lake. From this region the formation diminishes in thickness both eastward and westward, a fact which has been determined by plotting the sections of deep drillings which, to the number of more than 200, are distributed over the area in which the salt beds are near enough to the surface to be reached practicably.

The district under which rock salt is known to exist in New York comprises the greater part of Genesee County south of Le Roy, the eastern half of Wyoming County, nearly the whole of Livingston County, and the part of Ontario County west of Canandaigua Lake and chiefly south of the New York Central Railroad. There can hardly be any doubt that rock salt exists west of Warsaw, but the borings put down in Erie County seem to have been beyond the western limit of the deposits.

East of Canandaigua Lake the borings put down at Dundee, Watkins, Ithaca, Ludlowville, and Tully all reached the rock-salt beds. The area underlain by rock salt west of Canandaigua Lake has been computed to be over 1,000 square miles in areal extent; east of this lake the area must be as large or even larger. The northern limit can not be assigned, owing to the solution of the rock salt as it approaches the surface. It is approximately defined by a line drawn from a point south of Oneida Lake westward to Buffalo. South of this line the deposits are encountered at progressively increasing depths in accordance with the dip of the strata, which ranges from 40 to 50 feet per mile. The most easterly point where salt has been found is Morrisville, Madison County. Between this point and Lake Erie salt has been found in almost all the central tier of counties in the State.

OHIO.

Ohio ranked third among the States in 1913 in both quantity and value of salt produced. The output of the State was 5,310,135 barrels, or 743,419 tons, valued at $1,318,156, compared with 5,269,179 barrels, or 737,685 short tons, valued at $1,364,136, in 1912. It will be seen that though the output was larger in 1913 than in 1912 the price received from the product was less.

Ohio salt comes from two districts, the one located in the northeastern part of the State and the other in the southeastern. In northeastern Ohio the salt produced comes from Cleveland in Cuyahoga County, Wadsworth in Medina County, Akron in Summit County, and Rittman in Wayne County. Brine is pumped at Fairport Harbor in Lake County and at Barberton in Summit County, and is used directly in the manufacture of soda. The brine utilized in making salt and soda is obtained by allowing water to come into contact with beds of salt. In the southeastern part of the State, Pomeroy, in Meigs County, is the center of the industry, and in addition to the salt, bromine and calcium chloride are also produced from the natural brines there occurring. The industry in the southeastern part of the State, along Ohio River, suffered considerably from floods during the spring of 1913.

The geology of the occurrence of salt in northeastern Ohio and that of the brine in southeastern Ohio is quite distinct. The salt horizon in the northeastern part of the State is in the Monroe formation of the Silurian. The salt occurs at the same geologic horizon as that in southeastern Michigan near Detroit, Wyandotte, and along St. Clair River. Though the production has been restricted to five counties, as indicated above, the salt deposits are not limited to that territory.

The surface rocks near Pomeroy, in Meigs County, southeastern Ohio, and at Mason, W. Va., lie near the top of the Conemaugh formation, formerly known as the Lower Barren Coal Measures. The depths of wells in this region have undergone great variation. At first wells were very shallow, but later they were extended to greater depths as the supply of brine near the surface became exhausted. When the supply from these deeper wells became inadequate they were sunk to still greater depths. At present salt works both in Ohio and in West Virginia are pumping brine from depths of 1,100 to 1,350 feet. The brine-bearing strata dip toward Pomeroy from the northwest, and as the brine has been removed from the wells the supply has been renewed from the rocks lying at higher levels in that direction. The wells along Ohio River procure their brine chiefly from a horizon approximately near the base of the salt sand of the Carboniferous.

OKLAHOMA.

The small production of salt in Oklahoma in 1913 came from Harmon County. The salt plains of Harmon County are located in small canyons in the gypsum hills south of Elm Fork of Red River, about 5 miles east of the Texas border and 1½ miles south of the north county line. The plains are known locally as the Chaney or Salton salt plain and the Kiser salt plain. They are both small, neither covering an area of more than an acre, and they are not more than a mile apart. The salt is contained in spring water that issues from shallow beds occurring below gypsum. Springs also boil up from the level floor of the plains. A local industry has been carried on for many years in this region at the old Kiser Salt Works and also farther west. The latter springs were worked in 1911, 1912, and 1913, and are now known as the Salton salt beds. The old Kiser salt beds were worked in 1913 by W. H. Stockman. Stock salt is produced at both plains.

PENNSYLVANIA.

Salt, bromine, and calcium chloride are obtained on the North Side, Pittsburgh, Pa. They are obtained from a natural brine, which probably comes from a sand in the Pocono formation (of Mississippian age) which may possibly correspond with the Berea sandstone.

TEXAS.

The production of salt in Texas in 1913 was 355,529 barrels, or 49,774 short tons, valued at $278,008, as compared with 373,064 barrels, or 52,229 tons, valued at $290,328, in 1912. The main salt production was reported from Palestine, in Anderson County, and Grand Saline, in Van Zandt County, in the eastern part of the State. The plant at Colorado, in Mitchell County, in the western part of the State, was not operated during the year.

UTAH.

The production of salt in Utah in 1913 was 330,443 barrels, or 46,262 short tons, valued at $191,686, as compared with a production of 283,293 barrels, or 39,661 short tons, valued at $154,734 in 1912. The salt produced in Utah came from the shores of Great Salt Lake at Garfield and Saltair. Rock salt was produced in the Sevier Valley near Salina and Redmond, in Sevier and San Pete counties, and also near Gunnison, in San Pete County. Though the salt is obtained in the form of rock salt and is sold in large quantity as such, some of it is dissolved, recrystallized, and retailed in the refined form as table and dairy packers' salt, etc. A small production of salt was reported from Saldura, in Tooele County.

VIRGINIA.

Deposits of salt and gypsum occur in Washington and Smyth counties, Va., in a belt of country 20 miles long, running northeast from the village of Plasterco. The Saltville branch of the Norfolk & Western Railway, which joins the main line at Glade Spring, renders the region accessible. The rocks in which the deposits occur are of Mississippian age.

Two gypsum and one salt or alkali works are in operation in the region. Since 1895, when the Mathieson Alkali Works came into control of the property, the brine has been converted into soda products. Over 50 wells have been drilled near Saltville and Plasterco, about 25 of which are now in operation. They range in depth from a few hundred to 2,280 feet, the average depth being about 1,000 feet. The shallower wells are dry and have to be flushed with water through the outer casing. The deeper wells are wet and brine flows into them as fast as it is pumped out.

WEST VIRGINIA.

The production of salt in West Virginia in 1913 was 113,921 barrels of 280 pounds each, or 15,949 short tons, valued at $63,803. The corresponding figures for 1912 were 139,121 barrels, or 19,477 short tons, valued at $66,023. The marked decrease in quantity in 1913 was due in part of the floods in Ohio River in the spring of 1913, which caused much destruction and a consequent closing down of plants for repairs.

The salt in West Virginia, both along Ohio and Kanawha rivers, is obtained from natural brines carrying appreciable quantities of bromine, which, together with calcium chloride, is extracted from them. The geology of the brine-bearing beds at Mason is similar to that at Pomeroy, Ohio, on the opposite side of Ohio River, in Meigs County. The geology of these brine-bearing beds has been worked out by J. A. Bownocker and published in Bulletin 8 of the Ohio Geological Survey; it has been repeated in this report in previous years, and has been outlined under Ohio in the present report. Natural brines also occur near Malden, W. Va., which is located on Kanawha River, a few miles above Charleston, the State capital. The record of a gas well on Cool Spring Branch of Burning Springs Hollow, about 3 miles from Malden, throws some light on the geology of the beds from which the brine is obtained. The record of the well, which is known as the Edwards well No. 1, has been published in a report by I. C. White.[1] According to White the sandstone known to the oil men as the salt sand furnishes the brine in the Kanawha Valley. This sandstone belongs to the Pottsville group and lies very near the base of the coal measures.

HAWAII.[2]

The production of salt in Hawaii in 1913 was 6,071 barrels, or 850 short tons, valued at $5,950, a decrease of 2,215 barrels, or 310 tons, in quantity and of $3,230 in value as compared with 1912.

PORTO RICO.

Both the quantity and the value of the salt produced in Porto Rico in 1913 were less than in 1912. The salt is made by solar evaporation, and unfavorable weather was responsible for a large part of the reduction. Exports to this country have been greatly curtailed since salt has been admitted free of duty into the United States. Another factor causing a falling off in the manufacture of salt in Porto Rico is competition from Curacao, where both wages and living expenses are less than in Porto Rico.

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BROMINE.

PRODUCTION.

The following table gives the production of the bromine produced in the United States since 1880:

Marketed production and value of bromine, 1880–1913.

Year.	Quantity.	Value.	Year.	Quantity.	Value.
	Pounds.			*Pounds.*	
1880	404,690	....	1898	486,979	$126,614
1883	301,000	....	1899	433,004	108,251
1884	281,100	$67,464	1900	521,444	140,790
1885	310,000	89,900	1901	552,043	154,572
1886	428,334	141,350	1902	513,893	128,472
1887	199,087	61,717	1903	598,500	167,580
1888	307,386	95,290	1904	897,100	269,130
1889	418,891	125,667	1905	1,192,758	178,914
1890	387,847	104,719	1906	1,283,250	165,204
1891	343,000	54,880	1907	1,379,496	195,281
1892	379,480	64,502	1908	760,023	73,783
1893	348,399	104,520	1909	569,725	57,600
1894	379,444	102,450	1910	245,437	31,684
1895	517,421	134,343	1911	651,541	110,902
1896	546,580	144,501	1912	647,200	145,805
1897	487,149	129,094	1913	572,400	115,436

The bromine industry is centered in Michigan, Ohio, Pennsylvania, and West Virginia. Accounts of the bromine industry in these States have appeared in this report during previous years, and the reader is referred to these earlier chapters for detailed information.

CALCIUM CHLORIDE.

PRODUCTION.

In connection with the salt and bromine industry in Michigan, Ohio, Pennsylvania, and West Virginia, a considerable quantity of the calcium chloride contained in the brines is recovered.

Statistics for this substance have been collected since 1909 and the following table shows the quantity and value of the output from 1909 to 1913, inclusive:

Quantity and value of calcium chloride marketed in the United States, 1909–1913, in short tons.

Year.	Quantity.	Value.	Year.	Quantity.	Value.
1909	12,853	$63,198	1912	18,550	$117,272
1910	10,971	74,713	1913	19,611	130,030
1911	14,606	91,215			

LIME.

By Ralph W. Stone.

PRODUCTION.

The lime manufactured in the United States in 1913 amounted to 3,595,390 short tons, valued at $14,648,362. This was an increase of 65,928 tons, or 1.87 per cent, in quantity and of $678,248, or 4.85 per cent, in value, when compared with the output for 1912, which was 3,529,462 short tons, valued at $13,970,114. The production in 1913 was the largest in the history of the industry, both in the quantity manufactured and in the value of the output. The average price per ton in 1913 was $4.07, as compared with $3.96 in 1912, and with $4.03 in 1911. The increase in average price was general for the entire country, increased cost of labor and supplies and scarcity of labor being given as the reason by the majority of producers. The value given represents the value of bulk lime f. o. b. at point of shipment and does not include any weight or cost of barrel or package.

The total number of plants reporting operations in 1913 was 1,023 as compared with 1,017 in 1912 and with 1,139 in 1911. Although a small increase is thus shown many of the States exhibit a decrease in plants due in part to the tendency of the industry toward combination, which tendency appears to be established by the record for the last few years, notwithstanding the fact that the total number of kilns reporting operations increased from 2,203 in 1912 to 2,338 in 1913. Many of the operators, however, did not report either in 1912 or in 1913 the number of kilns composing their plants. Isolated lime manufacturers, operating on a small scale, reported their plants as idle on account of cost of production and cost and scarcity of labor, which prevented competition with lime shipped in from the outside. In 1913 44 States, including Hawaii and Porto Rico, reported a production of lime, Nevada also contributing a small output. In 1912 there were 43 States. The five leading States in 1913 were, in order of production, Pennsylvania, Ohio, Wisconsin, Virginia, and West Virginia. In 1912 the order was Pennsylvania, Ohio, Wisconsin, West Virginia, and Maine. The increase in Virginia was for a large quantity of lime burned and used by alkali manufacturers. This output was not included in the 1912 figures. Pennsylvania produced 2.37 per cent of the lime output and Ohio 1.38, but Ohio's production was from 38 plants, while Pennsylvania's output was from 494 operations, mostly the stack kilns of farmers burning lime in small quantities for use as a soil enricher for their own or their neighbors' farms. Although the number of operators in Pennsylvania was practically the same in 1913 as in 1912, this practice of burning in small quantities has been gradually falling off, on account of the difficulty in obtaining labor and wood for burning, as well as of the increased cost of coal. Also many of the farmers prefer patent fertilizers as cheaper and easier to obtain. The lime burned for use by the farmers is valued at 6 to 12 cents per bushel of 70 to 80 pounds, according to whether the fuel is purchased or obtained on the farm. Wood-burned lime has usually a higher value than the coal-burned lime, but the low average price per ton for this lime decreases considerably the average for the entire State. Also in Maryland, Virginia, and West Virginia a considerable quantity of lime is burned in small quantities for agricultural use. A quantity of marl burned or dried and used for agricultural purposes is included in the lime figures for New York, North Carolina, South Carolina, and Wisconsin. A quantity of limestone is sold each year to various burners of small lime kilns and the value of this lime is not included in the lime figures, but is included under the value of stone in the limestone report. This also applies to a considerable quantity of stone quarried and sold to sugar refiners, smelters, and alkali works and burned by them into lime after the stone leaves the hands of the quarrymen. A quantity of lime manufactured in Duluth, Minn., from stone quarried in Ohio is not included in the 1913 figures, as the company quarrying the stone no longer owns the lime plant. Stone from Ohio is also shipped to Wisconsin and there used for the manufacture of lime not included in these figures.

The following table gives the value of the total lime production in the United States for the years 1896 to 1903 and the quantity and value of the production from 1904 to 1913, inclusive:

Production of lime in the United States, 1896–1913.

Year.	Quantity.	Value.	Year.	Quantity.	Value.
	Short tons.			*Short tons.*	
1896		$6,327,900	1905	2,984,100	$10,941,680
1897		6,390,487	1906	3,198,087	12,480,653
1898		6,886,549	1907	3,092,524	12,656,705
1899		6,983,067	1908	2,766,873	11,091,186
1900		6,797,496	1909	3,484,974	13,846,072
1901		8,204,054	1910	3,505,954	14,088,039
1902		9,335,618	1911	3,392,915	13,689,054
1903		9,255,882	1912	3,529,462	13,970,114
1904	2,707,809	9,951,456	1913	3,595,390	14,648,362

Detailed statistics of the production of lime in 1912 and 1913 are given in the following table:

Quantity and value of lime burned in the United States in 1912 and 1913, by States, in short tons, showing rank of State, average price per ton, and number of plants in operation.

1912.

State or Territory.	Rank of State by quantity.	Quantity.	Value.	Rank of State by value.	Average price per ton.	Number of plants in operation.
Alabama	14	79,957	$297,178	17	$3.72	13
Arizona	24	18,528	101,680	24	5.49	4
Arkansas	22	22,404	102,833	23	4.59	5
California	17	72,978	555,822	8	7.62	20
Colorado	29	7,281	36,478	30	5.01	7
Connecticut	15	75,981	371,356	12	4.89	10
Florida	27	12,327	69,938	25	5.67	4
Georgia	32	(a)	(a)	33	4.53	2
Hawaii	35	(a)	(a)	31	9.00	1
Idaho	28	7,402	42,380	28	5.73	7
Illinois	12	98,450	394,892	11	4.01	15
Indiana	13	98,086	329,893	14	3.36	12
Iowa	26	12,935	51,800	27	4.00	3
Kansas	42	232	1,131	42	4.88	3
Kentucky	36	3,397	11,577	39	3.41	7
Maine	5	155,559	644,255	7	4.14	5
Maryland	9	112,104	365,037	13	3.26	40
Massachusetts	7	144,384	738,597	4	5.12	12
Michigan	16	74,720	311,448	16	4.17	11
Minnesota	19	44,063	269,841	18	6.12	6
Missouri	6	148,885	721,896	6	4.85	28
Montana	37	(a)	(a)	35	7.23	2
New Jersey	25	16,538	65,241	26	3.94	17
New Mexico	41	1,325	9,434	40	7.12	3
New York	10	109,800	495,265	9	4.51	31
North Carolina	30	6,693	30,559	32	4.57	4
Ohio	2	464,479	1,929,584	2	4.15	35
Oklahoma	39	2,651	13,538	38	5.11	3
Oregon	31	6,164	39,323	29	6.38	5
Pennsylvania	1	849,159	2,679,420	1	3.16	474
Porto Rico	33	4,907	23,971	36	4.89	45
Rhode Island	38	(a)	(a)	37	6.50	1
South Carolina	40	(a)	(a)	41	3.88	1
South Dakota	34	3,914	28,585	34	7.30	5
Tennessee	11	101,339	316,364	15	3.12	15
Texas	18	45,529	236,101	19	5.19	9
Utah	23	20,325	111,291	22	5.48	12
Vermont	20	39,572	205,409	21	5.19	10
Virginia	8	124,711	488,628	10	3.92	45
Washington	21	29,078	206,032	20	7.09	11
West Virginia	4	232,584	734,644	5	3.16	30
Wisconsin	3	263,052	825,551	3	3.14	43
Wyoming	43	(a)	(a)	43	12.76	1
Other States		b 17,969	b 113,142			
Total		3,529,462	13,970,114		3.96	1,017

a Included in "Other States."
b Includes Georgia, Hawaii, Montana, Rhode Island, South Carolina, and Wyoming.

Quantity and value of lime burned in the United States in 1912 and 1913, by States, in short tons, showing rank of State, average price per ton, and number of plants in operation—Continued.

1913.

State or Territory.	Rank of State by quantity.	Quantity.	Value.	Rank of State by value.	Average price per ton.	Number of plants in operation.
Alabama	16	75,468	$290,394	16	$3.85	12
Arizona	23	18,292	99,550	22	5.44	3
Arkansas	22	19,391	95,846	23	4.94	5
California	17	73,715	569,874	9	7.73	19
Colorado	29	7,875	46,390	29	5.89	8
Connecticut	15	76,192	382,347	12	5.02	10
Florida	24	16,845	89,973	24	5.34	5
Georgia	37	3,550	13,483	38	3.80	3
Hawaii	34	(a)	(a)	31	8.15	1
Idaho	36	4,133	22,413	35	5.42	4
Illinois	12	95,977	433,331	11	4.51	16
Indiana	11	96,359	323,905	15	3.36	10
Iowa	26	10,015	47,520	28	4.74	3
Kansas	42	(a)	(a)	40	4.95	1
Kentucky	31	6,001	24,313	34	4.05	9
Maine	7	146,970	906,604	4	6.17	5
Maryland	10	108,883	357,392	13	3.28	40
Massachusetts	8	130,365	683,541	8	5.24	10
Michigan	14	77,088	331,852	14	4.30	10
Minnesota	21	22,800	112,300	21	4.93	5
Missouri	6	161,770	734,009	7	4.54	27
Montana	30	(a)	(a)	30	5.84	2
Nevada	44	(a)	(a)	44	6.60	1
New Jersey	25	14,378	55,775	26	3.88	15
New Mexico	41	1,246	8,612	41	6.91	3
New York	9	114,071	503,157	10	4.41	34
North Carolina	27	9,815	47,838	27	4.87	4
Ohio	2	497,693	1,976,316	2	3.97	38
Oklahoma	39	2,640	12,160	39	4.61	4
Oregon	32	4,747	30,704	32	6.47	5
Pennsylvania	1	852,927	2,743,197	1	3.22	494
Porto Rico	33	4,738	19,707	37	4.16	38
Rhode Island	38	(a)	(a)	36	6.53	1
South Carolina	40	(a)	(a)	42	3.00	1
South Dakota	35	4,217	28,610	33	6.78	5
Tennessee	13	92,427	288,400	17	3.12	15
Texas	18	45,897	255,893	18	5.57	10
Utah	28	8,680	56,704	25	6.53	10
Vermont	19	32,803	171,138	20	5.22	9
Virginia	4	236,665	805,443	5	3.40	48
Washington	20	28,070	178,945	19	6.37	9
West Virginia	5	232,683	789,901	6	3.39	31
Wisconsin	3	243,006	1,005,496	3	4.14	39
Wyoming	43	(a)	(a)	43	12.92	1
Other States [b]		16,998	105,329			
Total		3,595,390	14,648,362		4.07	1,023

[a] Included in "Other States."
[b] Includes Hawaii, Kansas, Montana, Nevada, Rhode Island, and South Carolina.

USES.

Lime is used for a great variety of purposes, which have been given in detail in previous reports on this subject. The principal uses, as far as it is possible to give them, are shown in the following table. Under the head of "dealers—uses unspecified" is included a considerable quantity of lime which would necessarily raise the figures for all the other products, but the manufacturers were not able to classify the figures given under this heading. Lime used for building represents over one-third of the total output—probably over one-half if this product were segregated from the quantity sold to dealers. In 1913 production of building lime showed a decrease both in quantity and in value of output, but a considerable increase in average price. The output of lime sold to chemical works, sugar factories, tanneries, and dealers and for other uses increased both in quantity and value, while that sold as a fertilizer or soil sweetener decreased both in quantity and value. A considerable quantity of very finely powdered unburned limestone has also been used for the purpose of correcting soil acidity in recent years, and it is possible that this product may have had an influence on the decrease of lime used for this purpose.

Production of lime in the United States in 1912 and 1913, by uses, in short tons.

1912.

	Quantity.	Value.	Average price per ton.
Building lime	1,556,446	$6,571,479	$4.22
Chemical works	282,984	989,309	3.50
Paper mills	290,347	1,107,532	3.81
Sugar factories	30,988	186,164	6.01
Tanneries	40,595	178,686	4.40
Fertilizer	604,607	1,852,530	3.06
Dealers—uses not specified	560,286	2,467,694	4.40
Other uses [a]	163,209	616,720	3.78
Total	3,529,462	13,970,114	3.96
Hydrated lime, included in total	416,890	1,829,064	4.39

1913.

	Quantity.	Value.	Average price per ton.
Building lime	1,358,099	$6,011,856	$4.43
Chemical works	388,369	1,339,228	3.45
Paper mills	284,090	1,187,154	4.18
Sugar factories	32,236	216,768	6.72
Tanneries	49,591	217,390	4.38
Fertilizer	590,229	1,798,566	3.05
Dealers—uses not specified	692,265	3,153,457	4.56
Other uses [a]	200,511	723,943	3.61
Total	3,595,390	14,648,362	4.07
Percentage of increase (+) or decrease (−) in 1913	+1.87	+ 4.85	....
Hydrated lime, included in total	493,269	2,205,657	4.47
Percentage of increase (+) or decrease (−) in 1913	+18.32	+20.59	....

[a] Includes lime for sand-lime brick, slag cement, alkali works, steelworks, glassworks, smelters, sheep-dipping, disinfectant, manufacture of soap, cyanide plants, glue factories, purification of water, etc.

HYDRATED LIME.

The hydrated lime business has exhibited a marked advance each year since the first records of production were compiled in 1906, and although the increase of 18.32 per cent in quantity and 20.59 per cent in value for 1913 showed a very healthy growth it was much less than in 1912, when the increase was 36.87 per cent in quantity and 33.31 per cent in value.

The output for 1913 was 493,269 tons, valued at $2,205,657; for 1912 it was 416,890 tons, valued at $1,829,064, an increase in 1913 of 76,379 tons in quantity and of $376,593 in value. The average price per ton increased from $4.39 in 1912 to $4.47 in 1913. The number of hydrating plants was increased by 16, or from 64 in 1912 to 80 in 1913. Many of the new plants in 1913 showed but a small output for this year, but the outlook is very good for 1914. Twenty-four States reported hydrating plants in operation in 1913, as compared with 20 States in 1912.

The following table shows the quantity and value of the hydrated lime produced in the United States from 1906 to 1913, inclusive, together with the average price per ton and the total number of manufacturers reporting to the Survey:

Production of hydrated lime in the United States, 1906–1913, in short tons.

Year.	Quantity.	Value.	Average price per ton.	Number of plants reporting operations.
1906	120,357	$479,079	$3.98	30
1907	140,135	657,636	4.69	33
1908	136,441	548,262	4.02	46
1909	204,611	904,900	4.43	50
1910	320,819	1,288,789	4.02	51
1911	304,593	1,372,057	4.50	60
1912	416,890	1,829,064	4.39	64
1913	493,269	2,205,657	4.47	80

The following table shows the number of lime-hydrating plants reported to the Survey as operating in the United States during the last eight years, and draws attention to the steady development of this phase of the lime industry:

Number of lime-hydrating plants in operation in 1906–1913, by States.

State or Territory.	1906	1907	1908	1909	1910	1911	1912	1913
Alabama	1	1	1	3	2	2	2	2
Arizona	1	1	1	1	1	1		
California		1	2	2	2	3	3	4
Colorado		1		1	1			
Connecticut	1			1			1	
Florida			1		1			1
Georgia	2	1	1			1	1	1
Hawaii					1			
Idaho				1	1	1	1	
Illinois		1	1	2	2	1	1	1
Indiana	2	2	2	2	2	2	2	2
Iowa	1			1				1
Kansas	1	1		1				
Kentucky								1
Maine	1	1	1	1	1	1	1	1
Maryland			1	1	3	3	3	4
Massachusetts					1	2		1
Michigan	1	1	2	1	2	3	1	3
Missouri		2	2	3	3	3	4	4
New Jersey			1	1		2	1	1
New York	1	2	2	3		2	3	4
North Carolina						1		
Ohio	8	9	11	8	11	15	17	19
Pennsylvania	8	6	11	9	8	8	15	15
South Dakota					1	1		1
Tennessee			1	1	1	1	1	2
Texas			1	3	3	3	3	3
Virginia			1	2		1		2
Washington						1	1	2
West Virginia	1	1	1		2	1	2	3
Wisconsin	1	2	2	2	2	1	1	2
Total	30	33	46	50	51	60	64	80

IMPORTS.

The imports of lime for consumption in the United States in 1913 were reported by the Bureau of Foreign and Domestic Commerce as 4,139 short tons, valued at $48,538, as compared with 4,268 short tons, valued at $48,153, in 1912, a decrease in quantity of 129 tons, but an increase in value of $385.

The tariff act of October, 1913, changed the status of imported lime somewhat. The duty on lime was formerly 5 cents per 100 pounds, including the weight of barrel or package. The present duty is 5 per cent ad valorem.

EXPORTS.

In 1913 there were exported from the United States 294,746 barrels of lime, valued at $212,345, as compared with 260,669 barrels, valued at $199,515, in 1912.

FUELS.

The statistical inquiry of the Survey into the efficiency of various fuels in burning lime has yielded some results, though far from what could be wished. Information sufficient to make reliable averages is lacking, for many producers did not reply to the inquiry, and although some gave figures evidently based on measurements, others sent what appear to be mere guesses. The reports, however, are of interest, and something can be gleaned from them.

Reports on the quantity of lime burned by 1 pound of coal ranged according to the kind of coal used from 1.5 to 6 pounds, but the average was about 3.6 pounds of lime burned by 1 pound of coal. Coke used as fuel for burning lime averaged (in the few reports received) 4.2 pounds of lime to 1 pound of coke. Producer gas is used in a few places, and what little information was received on its use shows that producer gas burns from 3 to 4.1 pounds of lime and averages about 3.42 pounds of lime burned to 1 pound of coal converted into producer gas.

Wood reported as a fuel showed a range from 1,000 to 6,400 pounds of lime burned by a cord of wood. In spite of this wide range the data are believed to be sufficient for an approximate average. The figures submitted by producers show that 1 cord of wood burns approximately 4,000 pounds of lime and varies with the kind of wood used.

It is hoped that in the future more satisfactory data can be obtained on this question of the efficiency of different fuels.

The following tables show the kinds of fuels and number of kilns using the various fuels as reported for 1912 and 1913:

Numbe. of kilns using various kinds of fuel, by States, in 1912 and 1913.

1912.

State or Territory.	Coal.	Wood.	Oil.	Natural gas.	Producer gas.	Coke.	Shavings.	Coal and wood.	Coal and coke.	Total number of kilns.
Alabama	16	9						27		52
Arizona		4								4
Arkansas		14								14
California		9	47			1				57
Colorado	6									6
Connecticut	5	26								31
Florida		19								19
Georgia	4									4
Hawaii			2							2
Idaho	4	9				1				14
Illinois	4	4			1		a 30	8		47
Indiana	46	2		b 3	2			1		54
Iowa		5								5
Kansas	2		2	1						5
Kentucky	3	6								9
Maine	47	18								65
Maryland	59	3				13		8	11	94
Massachusetts	16	11			3			16		46
Michigan	2	29								31
Minnesota	21	6								27
Missouri	23	36			2			15		76
Montana		3								3
New Jersey	42	1								43
New Mexico	1	2								3
New York	25	7			1			6		39
North Carolina		1						4		5
Ohio	209	7		29	30			1		276
Oklahoma		4								4
Oregon		7						2		9
Pennsylvania	673	10		5	6	17		50	c 24	785
Rhode Island	2									2
South Dakota		8								8
Tennessee	28	9				1		8	1	47
Texas	1	12	8	2	2	4				29
Utah	12	2				7				21
Vermont		15						16	c 1	32
Virginia	28	12			3	9		19		71
Washington		24								24
West Virginia	16	2		1	3	18		1	1	42
Wisconsin	3	90						4		97
Wyoming	1									1
Total	1,299	426	59	41	53	71	30	186	38	2,203

a Shavings and manure (13) included.
b Natural gas and oil.
c Includes coal, wood, and coke.

Number of kilns using various kinds of fuel, by States, in 1912 and 1913—Continued.

1913.

State or Territory.	Coal.	Wood.	Oil.	Natural gas.	Producer gas.	Coke.	Coal and wood.	Coal and coke.	Total.
Alabama	18						30		48
Arizona		9							9
Arkansas		12							12
California		7	40			5			52
Colorado	9	2				1			12
Connecticut	7	32							39
Florida		18							18
Georgia	2	3							5
Hawaii			2						2
Idaho	1	7				2			10
Illinois	4	24				1			29
Indiana	50	1	2	1	2				56
Iowa		5							5
Kansas	1								1
Kentucky	7	4	1						12
Maine	43	15							58
Maryland	78	6				25	7	5	121
Massachusetts	3	11			3		18		35
Michigan		25							25
Minnesota	9	6							15
Missouri	19	31			2		22		74
Montana		2							2
Nevada			1						1
New Jersey	33	2							35
New Mexico	2	1							3
New York	39	7			1		6		53
North Carolina							4		4
Ohio	190	5		26	53		6		280
Oklahoma		2							2
Oregon		2					2		4
Pennsylvania	701	21			8	19	76	9	834
Rhode Island	2								2
South Dakota	1	7							8
Tennessee	30	4				1	6	1	42
Texas	1	15	8	2	2	4			32
Utah	9	1				5			15
Vermont		13					17		30
Virginia	43	31				18	14		106
Washington		24							24
West Virginia	28	5		1	3	42	7	7	93
Wisconsin	3	119			2		5		129
Wyoming	1								1
Total	1,334	479	54	30	76	123	220	22	2,338

[a] Includes 19 kilns using shavings.

ECONOMIC NOTES ON LIME.

At the annual meeting of the National Lime Manufacturers' Association held in New York City, February 4–5, 1914, Henry S. Spackman, chairman of the committee on standard specifications for lime, presented the authorized report from the proceedings of the American Society for Testing Materials, taken from the report of the meeting of that body held in June, 1913. Mr. Spackman was chairman of the committee of the American Society for Testing Materials to formulate standard specifications for lime. The proposed standard specifications as amended and published in Rock Products, Vol. XIII, No. 8, pp. 48–49, February 22, 1914, are as follows:

SPECIFICATIONS FOR LIME AS AMENDED.

1. Lime is a product resulting from the calcination at a temperature below the sintering point of a material containing carbonates of calcium or calcium and magnesium, which may be or has been converted to a paste or a dry flocculent powder by slacking.

2. Limes may be divided into two commercial forms:

(*a*) *Quicklime.*—A product coming from the kiln, without subsequent treatment other than sorting, crushing, or pulverization, which slakes on the addition of water. Quicklime may be shipped either as lump lime or pulverized lime. Lump lime shall be kiln size. Pulverized lime is lump lime reduced in size by mechanical means.

Quicklimes are divided into two grades: (1) Selected: A well-burned lime, picked free from ashes, coke, clinker, or other foreign material; (2) run-of-kiln: A well-burned lime without selection.

(*b*) *Hydrate.*—A dry flocculent powder resulting from the hydration of quicklime. Hydrates are divided into two classes: (1) Building and chemical: A lime hydrated to definite chemical proportions, and reduced to a fineness suitable for building purposes; (2) agricultural: A lime reduced to a powder by hydration. As calcium and magnesium oxides play an important but distinct part as fertilizers, agricultural hydrates are divided into two classes, namely, high-calcium and magnesium hydrates.

3. Where quicklime or hydrated lime is to be used for chemical or agricultural purposes the desired content of calcium or magnesium oxide shall be specified in advance by the purchaser.

* * * * * * *

I. Chemical Properties and Tests.

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(B) Chemical tests.

8. (*a*) Selected quicklime shall contain not under 90 per cent of calcium and magnesium oxides, and not over 3 per cent of carbon dioxide.

(*b*) Run-of-kiln quicklime shall contain not under 85 per cent of calcium and magnesium oxides, and not over 5 per cent of carbon dioxide.

9. Building and chemical hydrates shall contain not over 5 per cent of carbon dioxide, and not under 1 per cent of water in excess of that required to fully hydrate the calcium oxide present.

10. (*a*) High-calcium agricultural hydrate shall contain not over 5 per cent of magnesium oxide, and not over 10 per cent of carbon dioxide; and shall contain not under 80 per cent of calcium and magnesium oxides after water of hydration has been subtracted.

(*b*) Magnesium agricultural hydrate shall contain not under 5 per cent of magnesium oxide, and not over 10 per cent of carbon dioxide; and shall contain not under 80 per cent of calcium and magnesium oxide figured on any anhydrous basis.

II. Physical Properties and Tests.

(A) Quicklime.

11. An average 5-pound sample of selected or run-of-kiln quicklime shall be put in a box and slaked with sufficient water to produce a lime putty, which shall be allowed to stand for 24 hours, then washed through a standard 10-mesh sieve. Not over 3 per cent of the weight of selected quicklime, nor over 5 per cent of the weight of run-of-kiln quicklime, shall be retained on the sieve. The sample taken for this test shall not be crushed finer than will pass a 1-inch ring, either before being sent to the laboratory or at the laboratory. (Section 11 was referred back to committee for further consideration.)

(B) Hydrated lime.

12. (*a*) Building and chemical hydrates shall leave by weight a residue of not over 5 per cent on a standard 100-mesh sieve.

(*b*) Agricultural hydrate shall leave no residue on a standard 4-mesh sieve, and shall leave by weight a residue of not over 10 per cent on a standard 20-mesh sieve.

* * * * * * *

HYDRATED LIME.

On account of the marked increase in the manufacture and use of hydrated lime certain important features of the subject which have been well presented by E. W. Lazell, in a paper entitled "The twentieth century form of lime,"[1] are given below.

Probably the earliest method of burning lime was a heap of stone on the ground, with logs of wood for fuel. The pile of stones later was replaced by a crude shaft excavated in the side of a hill, the interior of the shaft being lined with larger stones of the same material as those to be burned. At the bottom of the shaft there was a horizontal passage to the outside. At the place where the horizontal passage joined the vertical shaft, an arch of limestone was made, and on top of this more limestone was placed, until the shaft was completely filled. A fire was then built under the arch, and the burning was continued until the stone was calcined. At a somewhat later date kilns were built in the open, having vertical walls of masonry of a circular or square cross section, but in other ways resembling the shaft in the side of the hill. These types of kilns are still to be found scattered throughout the country. From these early and crude types of lime kilns, the modern shaft kiln, with separate ovens for the fuel, has been developed.

Three factors have operated jointly to keep the lime industry in a comparatively simple, primitive, and undeveloped state.

First, the prevalence and wide distribution of lime rock. Limestone occurs in every State and Territory of the United States, although some States are so poorly supplied (such as Delaware, North Dakota, and Louisiana) that they never can become important producers. This general distribution of the raw material has resulted in many small plants, often poorly and uneconomically constructed, scattered throughout the whole country.

Second, the ease of burning the stone to lime. The comparatively easy and simple process of burning, with the resulting small outlay of capital required to erect a plant, has caused many persons to enter the business without familiarity or previous knowledge of it. Such plants are generally operated in an uneconomical manner and produce a poor quality of lime, the operators often being satisfied with day wages as a return on their investment.

Third, the perishable character of the burned lime. The perishable character of lime has also contributed to keep the burning in the hands of small producers located near some convenient market.

* * * * * * *

These conditions have materially changed in the past few years. Improved methods of quarrying, handling the stone, and burning, while requiring more capital, have resulted in a decreasing cost per unit of output, and larger, more economically operated plants have thus caused the closing down or abandoning of many smaller crude plants. A larger factor in bringing about the centralization of the industry into a comparatively few advantageous locations has been the railroads. A plant well located as to transportation costs can reach broader markets more economically than many small plants. Thus the availability of transportation is to-day concentrating the industry in spite of the three factors mentioned, which by themselves would have kept the industry in the hands of many small producers.

In spite of improvements in the methods of producing lime, greater ease of transportation, and of larger, more economical plants, the output of the kilns—that is, the burned lime—is brought into the market in much the same manner as it was centuries ago. Further, the method of using the lime has scarcely changed.

One of the earliest examples of the employment of mortar in masonry is presented by the pyramids of Egypt. An examination of the mortar between the stones in the Pyramid of Cheops has shown it to be identical with that employed in Europe to-day, although its preparation must have taken place more than 2,000 years before the Christian era. Mortar made from lime was employed by most of the ancient races, notably the Phoenicians, Greeks, and Romans. * * *

The only improvement in the form of the merchantable lime known to the writer is that of hydrated lime. The fact that lime could be slaked to the form of a dry powder has long been known, and three methods have been used in the past to produce this powder.

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[1] Rock Products, vol. 13, No. 10, Mar. 22, 1914.

1. Lime, in comparatively small pieces about the size of an egg, is placed in a basket and immersed in water for one or two minutes, until hydration has commenced, when it is withdrawn. The wet lime is generally put in heaps or silos in order to conserve the heat and prevent the escape of the vapor. The material swells, cracks, and become reduced to a dry powder.

2. Lumps of lime are placed in a heap and wetted at intervals so that the mass is equally moistened throughout. The slaking proceeds as in the first instance.

3. Small pieces of lime are exposed to the air for a munber of months. The material absorbs both water and carbon dioxide from the atmosphere, falling to dry powder. The powdered form consists of a hydrated subcarbonate of lime containing about 10 to 11 per cent of water.

These methods of dry-slaking lime are crude, and unless the greatest care is exercised the resulting product will contain particles of unslaked lime. Further, the hydrates produced by these methods are generally short and possess poor sand-carrying capacity; in fact, hydrated lime produced by any of the above methods is only suitable for use on the soil, and such hydrates should not be confounded with hydrated lime manufactured by modern methods.

The modern method of manufacturing hydrated lime depends upon the addition of an exact amount of water to a predetermined exact amount of lime. By no other method is it possible to produce a hydrate which will contain sufficient combined water to satisfy the demands of the calcium oxide present. It is important that all the calcium oxide is satisfied, otherwise the hydrate will be unsound and unsuitable for many uses.

This point will be insisted upon in any specifications that may be drawn for hydrated lime to be used in the building trade. It is vital that each manufacturer recognize the fact that the formation of hydrated lime is a chemical change, involving the presence of exact amounts of lime and water. Since the process is chemical, it requires the same careful supervision as any other chemical process, such as the manufacture of Portland cement. The production of hydrated lime has been retarded more by the manufacture of only partly hydrated lime than from any other cause. It has only been a few years since it was nearly impossible to buy completely hydrated lime, and even at the present time the records of our laboratories show that more unsound hydrate is offered for sale than sound material, for which conditions the manufacturer is directly responsible. From a selfish standpoint, it is to the advantage of the manufacturer to produce a completely hydrated lime since such a lime contains the maximum amount of water. * * *

It is to the interest of progressive manufacturers to build their business to such dimensions as to warrant the employment of skilled experts and engineers, in order that the cost of manufacturing may be reduced to the lowest possible unit, and, further, to present their products to the market in such form that they will keep and at the same time be convenient to use. The day of the barrel is passing. It is not feasible to market a bulky commodity in a package worth practically as much as the contents. * * * Does not the manufacture of hydrate offer a solution to most of the troubles encountered in the marketing of lime? * * *

One of the greatest difficulties in connection with the burning of lime is due to the perishable quality of the product. In general this means that the common form of lime, lump lime, can not be stored for any great length of time without deterioration, and this makes the operation of the plant dependent upon the seasons and the whims of the weather. Kilns are fired up, damped down or put out, according to the season of the year and the condition of the weather. This unevenness of operation results in higher unit cost. Since hydrated lime can be stored in bins, in a manner similar to cement, it is therefore possible to make the operation of the plant more continuous, thereby introducing economies in the unit costs. Further, the manufacture of hydrated lime also means an increased market, since hydrated lime can be used for a number of purposes for which lump lime is not suitable. * * *

The greatest advantage to the dealer is the ease of handling, less deterioration of the product, and the freedom from fire risk. These three facts alone should convince the dealer that it is more economical to handle hydrated lime than lump lime. * * * In general it may be stated that hydrated lime is suitable for any use in the building trade to which lump lime can be put, and it would appear that as soon as the material comes into general use, its advantages will be found to far outweigh its disadvantages. The use of hydrated lime does away with the necessity of slaking lime to a paste, thus saving the large amount of space required, as well as the labor. Since hydrated lime comes into the market in convenient packages, it is possible to proportion the mortar so as to have exact quantities present. This point is always appreciated by the architect and engineer, since it is a well known fact that when lump lime is used as much sand as possible is added to it, with the result that the mortar is lean and possesses little strength. The sand-carrying capacity of lump lime has been much overrated, especially by the manufacturer, with the result that it is the common practice to oversand the mortar. * * *

As to the uses of hydrated lime in general, it may be stated that they are identical with those of lump lime, except in such chemical industries where the heat of slaking becomes an important factor. To the writer's knowledge, hydrated lime has supplanted lump lime in a number of chemical industries for the following reasons: The greater convenience in handling, the ability to more definitely proportion the amount used, and because of the more uniform lime content of this product. This has been the case even where the cost per ton of hydrated lime is higher than that of lump lime. If hydrated lime is correctly manufactured, and the particle of core and unhydrated lime removed, the resulting product possesses a higher grade of purity than the original lime from which it was made. Further, the product is more uniform, and these two facts appeal strongly to the chemical users of lime. * * *

In June, 1910, the writer presented the results obtained from an extended series of tests on both hydrated and lump-lime mortar, to the American Society for Testing Materials. One of the most important conclusions drawn from these investigations was that the mortar produced from hydrated lime was stronger than that produced from the corresponding lump lime slaked to a paste. This conclusion was to be expected, since it is possible to manufacture hydrated lime by mechanical means under good chemical control, which is more thoroughly slaked than it is possible to slack lump lime on the job. The user in dealing with hydrated lime is handling a tested product which can be definitely proportioned and will produce known results. With lump lime the user is dependent always upon the thoroughness of slaking and it is well known to all users of lime that unless the paste is run off and stored for some considerable time there is no assurance of complete and thorough slaking.

Practically all those who investigate the strength of lime mortars have recommended the use of hydrated lime rather than lump lime. In Bulletin No. 30, of the Bureau of Standards, the following statement is made: "The proportion of impurities in hydrated lime is generally less than that in the lime from which it is made. In building operations hydrated lime may be used for any purpose in place of lump lime, with precisely similar results. The consumer must pay the freight on a large amount of water, but the time and labor required for the slaking is eliminated and there is no danger of spoiling it either by burning or incomplete slaking. * * * For all building purposes hydrated lime is to be preferred to lump lime. By its use the time and labor involved in slaking may be saved and the experience of the laborer is eliminated as a factor in the problem." * * *

In conclusion, it may be stated that hydrated lime possesses advantages for the manufacturer, dealer, and user.

To the manufacturer it means more uniform operation of the plant, less waste in the form of fine lime and forkings, no loss through air slaking, the doing away with the barrel plant, and the manufacture of a product possessing good keeping qualities.

To the dealer it means no fire risk, no loss by air slaking, no barrels to add to the cost of lime, and a more convenient package.

To the user it presents a material possessing all the advantages of lime with none of its disadvantages, the certainty of producing a mortar having definite proportions of lime and sand, and, further, this mortar possesses greater strength than ordinary lime mortar.

Warren E. Emley[1] discusses the process of manufacture of hydrated lime elsewhere in this volume of Mineral Resources, and also in a publication by the Bureau of Standards.

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[1] U. S. Bur. Standards Tech. Paper 16, 1913.

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SAND AND GRAVEL.

By Ralph W. Stone.

PRODUCTION.

The total production of sand and gravel in the United States in 1913 reported directly to the United States Geological Survey was 79,555,849 short tons, valued at $24,217,508, a net increase in quantity of 11,201,286 short tons and in value of $1,104,300 over the production of 1912. Sand for building purposes constituted nearly one-third of the total production. In 1913 a production of 25,397,383 tons of building sand was recorded with a value of $8,007,949. This is an increase in quantity of 1,621,370 tons and in value of $39,822 over the production of 1912. The average value per ton, which increased from 31 cents in 1911 to 33½ cents in 1912, fell to 31½ cents in 1913.

Quantity and value of sand and gravel produced in the United States, 1904–1913, in short tons.

Years.	Quantity.	Value.
1904	10,679,728	[a] $5,748,099
1905	23,204,967	11,223,645
1906	32,932,002	12,698,208
1907	41,851,918	14,492,069
1908	37,216,044	13,270,032
1909	59,565,551	18,336,990
1910	69,410,436	21,037,630
1911	66,846,959	21,158,583
1912	68,354,561	23,113,208
1913	79,555,849	24,217,508

[a] Includes a very small quantity of gravel.

The following table gives the total production of glass sand in the United States in each of the last 10 years:

Quantity and value of glass sand produced in the United States, 1904–1913, in short tons.

Years.	Quantity.	Value.	Average value per ton.
1904	858,719	$796,492	$0.92
1905	1,060,334	1,107,730	1.04
1906	1,089,430	1,208,788	1.11
1907	1,187,296	1,250,067	1.05
1908	1,093,553	1,134,599	1.04
1909	1,104,000	1,163,375	1.05
1910	1,461,089	1,516,711	1.04
1911	1,538,666	1,543,733	1.01
1912	1,465,386	1,430,471	.97
1913	1,791,800	1,895,991	1.06

The following table gives the production of molding sand in the United States in each of the last 10 years, or since 1904, when the first statistics of molding sand were collected:

Quantity and value of molding sand produced in the United States, 1904–1913, in short tons.

Years.	Quantity.	Value.	Average value per ton.
1904	3,439,214	$2,125,370	$0.62
1905	3,084,098	2,102,423	.68
1906	3,371,103	2,063,151	.61
1907	3,682,494	2,460,754	.67
1908	1,980,677	1,342,802	.67
1909	3,122,806	2,146,220	.68
1910	3,636,167	2,431,254	.67
1911	3,376,717	2,132,469	.63
1912	4,485,380	2,718,726	.61
1913	3,563,583	2,230,217	.63

The tables following give the production of the various kinds of sand and the production of gravel by States in 1912 and 1913.

Production of sand and gravel in the United States in 1912 and 1913, by States and uses, in short tons.

1912.

State.	Glass sand.		Molding sand.		Building sand.		Grinding and polishing sand.		Fire sand.		Engine sand.	
	Quantity.	Value.	Quantity.	Value.	Quantity.	Value.	Quantity.	Value.	Quantity.	Value.	Quantity.	Value.
Alabama	(a)	(a)	51,107	$25,284	205,498	$66,586	(a)	(a)	(a)	(a)	(a)	(a)
Arizona					(a)	(a)						
Arkansas			291	291	266,994	108,909						
California	9,535	$8,664	41,302	22,458	332,980	134,168	(a)	(a)	(a)	(a)	28,043	$5,442
Colorado			17,283	5,906	27,220	8,822			(a)	(a)	12,606	5,303
Connecticut			(a)	(a)	20,604	7,585						
Delaware			(a)	(a)	(a)	(a)			(a)	(a)	(a)	(a)
Florida					(a)	(a)					(a)	(a)
Georgia	(a)	(a)	(a)	(a)	304,882	116,614					10,245	2,640
Idaho					(a)	(a)						
Illinois	323,467	225,434	540,728	268,521	1,910,911	598,884	67,040	$49,196	(a)	(a)	59,151	12,916
Indiana	26,040	10,641	243,766	66,620	1,461,689	411,480	247,769	3,889	(a)	(a)	142,060	27,016
Iowa			4,016	3,572	1,011,672	328,882			(a)	(a)	16,456	4,556
Kansas					880,717	178,630					(a)	(a)
Kentucky	(a)	(a)	29,169	27,850	423,389	196,302	(a)	(a)	5,120	$3,589	5,250	3,410
Louisiana	(a)	(a)			90,608	13,263					(a)	(a)
Maine					12,372	10,461						
Maryland	(a)	(a)	(a)	(a)	798,720	285,446	(a)	(a)	(a)	(a)	(a)	(a)
Massachusetts	(a)	(a)	18,575	9,313	150,217	57,315						
Michigan	(a)	(a)	152,433	40,145	902,556	94,115	(a)	(a)			18,575	4,774
Minnesota			15,738	8,673	220,889	82,098	(a)	(a)			(a)	(a)
Mississippi					319,193	119,453					140,584	51,551
Missouri	129,030	81,817	106,983	71,366	1,817,110	521,164	(a)	(a)	(a)	(a)	24,335	5,478
Montana					(a)	(a)						
Nebraska			4,097	1,826	751,233	229,452					2,305	405
New Jersey	102,782	79,027	459,397	279,948	1,425,861	316,435	95,690	47,854	105,843	97,841	55,344	22,077
New Mexico					(a)	(a)						
New York	(a)	(a)	584,314	469,116	4,125,271	1,154,062	(a)	(a)	(a)	(a)	33,975	17,964
North Carolina			2,138	1,204	(a)	(a)	(a)	(a)			(a)	(a)
North Dakota					9,903	7,232					(a)	(a)
Ohio	154,527	164,462	1,186,710	649,896	1,647,508	629,174	17,493	32,280	75,789	47,361	51,940	27,967
Oklahoma					265,596	100,685					(a)	(a)
Oregon					335,980	183,629						
Pennsylvania	427,936	517,383	792,150	627,532	1,648,996	789,819	679,155	399,881	150,068	111,023	128,162	78,671
South Carolina	(a)	(a)	12,355	2,015	(a)	(a)	(a)	(a)				
South Dakota					32,288	15,667					(a)	(a)

a Included in "Concealed totals."

Production of sand and gravel in the United States in 1912 and 1913, by States and uses, in short tons—Continued.

State.	Glass sand.		Molding sand.		Building sand.		Grinding and polishing sand.		Fire sand.		Engine sand.	
	Quantity.	Value.	Quantity.	Value.	Quantity.	Value.	Quantity.	Value.	Quantity.	Value.	Quantity.	Value.
Tennessee	(a)	(a)	36,200	$15,014	363,973	$163,036	(a)	(a)	(a)	(a)	72,371	$18,129
Texas			3,135	4,050	290,675	181,617	(a)	(a)			(a)	(a)
Utah					28,668	10,595	(a)	(a)			(a)	(a)
Vermont			(a)	(a)	(a)	(a)						
Virginia	(a)	(a)	21,701	11,746	374,894	164,456	(a)	(a)	8,046	$4,851	20,205	9,091
Washington			(a)	(a)	259,270	74,394					1,943	825
West Virginia	244,881	$287,038	28,303	24,999	171,269	81,019	(a)	(a)	(a)	(a)	60,442	34,182
Wisconsin	(a)	(a)	77,026	49,599	744,182	234,441	(a)	(a)	(a)	(a)	202,720	37,560
Wyoming					(a)	(a)					(a)	(a)
Concealed totals	47,188	56,005	56,463	31,782	142,225	292,237	402,324	$170,264	110,588	54,077	201,804	58,913
Total	1,465,386	1,430,471	4,485,380	2,718,726	23,776,013	7,968,127	1,285,863	632,136	455,454	318,742	1,288,616	428,986

State.	Furnace sand.		Paving sand.		Other sands.		Gravel.		Grand total.	
	Quantity.	Value.	Quantity.	Value.	Quantity.	Value.	Quantity.	Value.	Quantity.	Value.
Alabama			37,801	$14,997	(a)	(a)	497,832	$140,861	852,943	$268,111
Arizona									(a)	(a)
Arkansas			7,383	4,093	27,398	$7,438	915,674	272,908	1,217,740	393,639
California			19,767	11,554	100,354	37,521	1,652,397	293,728	2,189,432	518,516
Colorado			24,380	16,930			31,020	9,015	112,514	45,983
Connecticut					(a)	(a)			20,823	7,805
Delaware	(a)	(a)							129,157	62,047
Florida			(a)	(a)			97,394	11,922	115,450	21,050
Georgia			5,725	1,575	1,500	750	86,540	37,554	445,122	171,129
Hawaii					(a)	(a)	(a)	(a)	(a)	(a)
Idaho			(a)	(a)			(a)	(a)	(a)	(a)
Illinois			30,581	13,958	499,685	75,391	3,481,638	664,552	6,957,901	1,929,822
Indiana			93,346	39,152	232,180	40,610	2,252,065	574,292	4,701,005	1,175,370
Iowa			45,408	11,360	380,958	54,083	768,105	157,856	2,231,615	562,809
Kansas			274,492	57,996	139,049	31,092	18,420	3,744	1,381,586	287,352
Kentucky			16,754	11,822	10,329	12,311	282,906	131,105	778,241	391,477
Louisiana					112,625	89,102	722,266	313,559	933,617	417,041
Maine							(a)	(a)	34,372	26,961

Maryland			(a)	(a)			807,295	305,871	1,650,904	627,874
Massachusetts	(a)	(a)	11,499	5,610	3,027	3,036	230,179	74,966	424,375	162,208
Michigan			68,453	16,898	115,624	29,746	1,409,180	407,925	2,681,821	818,603
Minnesota			(a)	(a)	18,936	12,525	643,117	164,698	946,339	278,578
Mississippi			2,279	763	(a)	(a)	1,452,802	269,116	2,124,288	512,688
Missouri			60,814	16,897	189,632	58,766	1,193,667	253,911	3,687,380	1,088,279
Montana			(a)	(a)			(a)	(a)	11,506	4,881
Nebraska			13,271	1,858	30,569	4,495	86,348	19,561	887,823	257,597
Nevada					(a)	(a)	(a)	(a)	(a)	(a)
New Jersey			168,233	35,883	55,706	47,218	776,911	220,357	3,245,767	1,146,640
New Mexico							123,812	29,085	125,872	29,963
New York			195,869	88,520	206,640	78,145	2,076,573	742,273	7,237,303	2,561,516
North Carolina			(a)	(a)	(a)	(a)	132,317	15,268	161,198	38,487
North Dakota							11,100	8,082	31,803	16,514
Ohio			145,554	59,540	152,270	83,488	2,442,621	610,800	5,874,412	2,304,968
Oklahoma			5,590	2,605	(a)	(a)	193,342	54,684	492,858	163,298
Oregon			(a)	(a)	(a)	(a)	605,193	243,912	1,067,634	499,030
Pennsylvania			304,288	134,604	457,153	255,695	1,921,425	456,905	6,509,333	3,371,513
South Carolina					(a)	(a)	(a)	(a)	104,965	14,846
South Dakota			(a)	(a)			510,539	52,871	545,622	69,348
Tennessee			16,985	12,925	56,981	29,982	620,800	270,201	1,181,967	516,298
Texas			(a)	(a)	21,595	5,470	380,213	186,480	716,468	384,942
Utah			6,600	4,543	(a)	(a)	29,132	9,447	76,850	28,595
Vermont					(a)	(a)	(a)	(a)	97,476	13,296
Virginia			(a)	(a)	9,595	4,279	235,302	87,472	689,266	291,773
Washington			90,211	39,240	(a)	(a)	665,757	226,180	1,020,841	345,289
West Virginia			41,318	24,808	19,425	3,650	262,538	56,001	849,864	530,025
Wisconsin			12,535	8,367	696,106	50,994	1,305,015	270,911	3,051,819	664,327
Wyoming			(a)	(a)	(a)	(a)	629,085	47,674	639,031	56,753
Concealed totals	51,446	27,258	89,394	34,182	448,951	161,278	214,915	45,270	118,258	35,967
Total	51,446	27,258	1,788,530	670,680	3,986,288	1,177,065	29,771,585	7,741,017	68,354,561	23,113,208

a Included in "Concealed totals."

Statistics of the production of sand and gravel in the United States in 1912 and 1913, in short tons.

1913.

State.	Glass sand.		Molding sand.		Building sand.		Grinding and polishing sand.		Fire and furnace sand.		Engine sand.	
	Quantity.	Value.	Quantity.	Value.	Quantity.	Value.	Quantity.	Value.	Quantity.	Value.	Quantity.	Value.
Alabama			57,798	$23,368	288,346	$90,347	25,903	$11,118				
Arizona					(a)	(a)						
Arkansas			1,214	708	42,914	16,272						
California	(a)	(a)	(a)	(a)	321,777	122,278	35,520	8,880	4,958	$3,671	66,396	$13,096
Colorado			12,781	4,454	29,651	10,460	(a)	(a)			6,001	2,996
Connecticut			(a)	(a)	16,578	5,150						
Delaware			(a)	(a)	(a)	(a)			(a)	(a)		
District of Columbia												
Florida			(a)	(a)	(a)	(a)						
Georgia	(a)	(a)	6,500	4,919	355,289	132,381	(a)	(a)	(a)	(a)	2,700	650
Hawaii					(a)	(a)						
Idaho												
Illinois	350,229	$239,227	404,717	181,794	2,299,834	594,687	42,198	23,138	84,801	43,269	79,568	11,166
Indiana	1,842	1,861	189,446	88,140	1,756,596	418,418	43,020	6,008			57,040	9,878
Iowa			2,977	1,560	794,219	231,784			6,000	2,400	15,509	3,162
Kansas			(a)	(a)	649,646	175,387					(a)	(a)
Kentucky	(a)	(a)	32,981	25,316	391,021	187,993	1,131	873	7,679	4,351	4,177	2,785
Louisiana					185,769	29,177					(a)	(a)
Maine					(a)	(a)						
Maryland	(a)	(a)	10,086	5,276	421,538	192,670	(a)	(a)			20,723	18,224
Massachusetts	(a)	(a)	15,236	7,490	123,388	44,738	(a)	(a)	7,800	6,825		
Michigan	2,938	3,020	50,763	17,493	1,326,016	415,737	(a)	(a)	(a)	(a)	4,447	647
Minnesota			15,364	6,249	433,093	113,904	6,217	2,145			2,916	589
Mississippi			4,920	1,115	204,592	70,104					11,642	2,194
Missouri	130,676	91,284	132,415	63,695	1,585,168	526,912	124,583	63,665	34,800	11,076	21,100	3,700
Montana					(a)	(a)						
Nebraska					665,854	118,255					44,743	7,366
Nevada					(a)	(a)					(a)	(a)
New Hampshire												
New Jersey	108,560	82,577	503,648	285,677	1,666,057	369,973	21,379	14,803	95,889	87,580	57,133	22,626
New Mexico			(a)	(a)								
New York	35,514	21,416	507,263	427,721	4,842,073	1,341,257	55,591	22,767	27,596	14,407	19,806	8,358
North Carolina			(a)	(a)	74,650	25,166	(a)	(a)			(a)	(a)
North Dakota					7,815	5,354						
Ohio	73,154	65,892	731,706	494,342	1,771,233	658,227	21,781	25,948	116,563	90,881	73,031	31,731
Oklahoma					81,125	20,578					11,892	2,424
Oregon					232,959	132,407						
Pennsylvania	513,867	674,073	730,224	505,334	2,298,640	987,810	451,711	346,685	115,672	90,687	216,151	127,257
South Carolina	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)				

South Dakota					12,392	6,785					3,248	544
Tennessee	(a)	(a)	20,199	10,278	300,695	137,750	(a)	(a)	(a)	(a)	61,764	15,476
Texas			(a)	(a)	330,407	160,085					(a)	(a)
Utah					6,947	1,687	(a)	(a)	(a)	(a)	(a)	(a)
Vermont			(a)	(a)	(a)	(a)	(a)	(a)				
Virginia	(a)	(a)	21,225	11,350	359,484	112,854			(a)	(a)	18,694	4,355
Washington			(a)	(a)	141,385	57,808						
West Virginia	534,600	668,214	1,918	1,184	195,115	99,950			(a)	(a)	133,390	94,017
Wisconsin			76,537	37,432	985,988	294,349	(a)	(a)	(a)	(a)	51,955	8,597
Wyoming					(a)	(a)					(a)	(a)
Concealed totals	40,420	48,427	33,665	25,322	199,129	99,135	112,339	14,369	17,303	9,216	49,424	9,968
Total	1,791,800	1,895,991	3,563,583	2,230,217	25,397,383	8,007,949	941,373	540,399	519,061	364,363	1,033,450	401,806

State.	Paving sand.		Railroad ballast sand.		Other sands.		Gravel.		Total.	
	Quantity.	Value.	Quantity.	Value.	Quantity.	Value.	Quantity.	Value.	Quantity.	Value.
Alabama	2,750	$1,250			2,000	$400	1,028,271	$271,605	1,405,068	$398,088
Arizona									(a)	(a)
Arkansas	115,319	45,779			128,124	48,169	533,885	209,711	821,456	320,639
California	111,515	34,861			9,480	5,836	1,272,630	237,118	1,836,012	439,009
Colorado							42,043	10,294	90,578	28,306
Connecticut							(a)	(a)	24,252	7,272
Delaware	(a)	(a)							127,875	58,675
District of Columbia	(a)	(a)			(a)	(a)	(a)	(a)	(a)	(a)
Florida	(a)	(a)					66,835	11,104	87,061	21,194
Georgia	17,500	7,500			2,000	1,000	18,792	15,970	407,853	166,798
Hawaii							(a)	(a)	(a)	(a)
Idaho	(a)	(a)							(a)	(a)
Illinois	101,631	30,973	39,841	$10,849	132,057	66,403	4,457,264	868,985	7,992,140	2,070,491
Indiana	256,235	114,356	95,405	17,886	136,963	40,187	2,485,331	563,938	5,021,878	1,260,672
Iowa	153,789	40,519	777,486	44,694	19,183	3,923	928,869	200,024	2,698,032	528,066
Kansas	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	1,119,990	271,509
Kentucky	23,399	9,905	222,122	30,819	(a)	(a)	446,869	155,449	1,137,286	424,049
Louisiana	(a)	(a)	(a)	(a)	22,787	4,123	662,709	228,043	878,943	262,840
Maine							(a)	(a)	48,963	23,575
Maryland	(a)	(a)			(a)	(a)	861,928	281,371	1,821,214	622,567
Massachusetts	9,855	4,150	(a)	(a)	6,175	3,700	124,260	67,011	290,757	149,036
Michigan	533,261	108,328	358,105	33,823	113,318	20,342	3,930,224	915,455	6,424,168	1,529,142
Minnesota	52,286	10,350			133,283	14,680	1,451,751	134,965	2,094,910	282,882
Mississippi	8,100	1,200					1,662,409	345,788	1,891,663	420,401
Missouri	288,067	69,451	425,282	38,679	20,833	7,940	1,363,202	232,831	4,126,126	1,109,233
Montana							(a)	(a)	15,856	7,857
Nebraska	11,540	1,385					110,772	22,280	832,909	149,286
Nevada					(a)	(a)	(a)	(a)	14,905	3,729

Statistics of the production of sand and gravel in the United States in 1912 and 1913, in short tons—Continued.

1913.

State.	Paving sand.		Railroad ballast sand.		Other sands.		Gravel.		Total.	
	Quantity.	Value.	Quantity.	Value.	Quantity.	Value.	Quantity.	Value.	Quantity.	Value.
New Hampshire							252,000	$87,500	252,000	$87,500
New Jersey	175,543	$59,722			45,608	$22,485	1,222,604	216,587	3,896,421	1,162,050
New Mexico							(a)	(a)	(a)	(a)
New York	196,942	66,083			172,210	43,497	2,767,098	1,018,157	8,624,093	2,963,663
North Carolina	(a)	(a)			(a)	(a)	320,534	100,107	400,577	127,574
North Dakota							9,411	5,235	17,226	10,589
Ohio	192,770	57,047	218,586	$62,649	123,884	49,473	2,283,059	556,211	5,605,767	2,092,401
Oklahoma	(a)	(a)	(a)	(a)			48,037	13,538	157,628	39,457
Oregon	59,294	36,972	(a)	(a)	(a)	(a)	1,145,984	261,210	1,442,152	432,938
Pennsylvania	283,946	105,498			148,338	115,167	1,943,900	429,081	6,702,449	3,381,692
South Carolina					(a)	(a)	(a)	(a)	39,730	4,958
South Dakota	12,411	4,163	(a)	(a)			1,040,282	77,614	1,068,833	89,306
Tennessee					19,791	8,337	415,641	112,560	828,633	288,900
Texas	(a)	(a)	(a)	(a)			506,645	287,212	870,943	455,908
Utah	(a)	(a)			(a)	(a)	92,562	13,293	108,758	16,481
Vermont					(a)	(a)	(a)	(a)	116,765	15,045
Virginia	44,588	8,835	(a)	(a)	(a)	(a)	325,115	91,705	787,009	239,591
Washington	318,977	82,456	(a)	(a)			836,623	238,117	1,301,771	385,886
West Virginia	9,118	2,955			(a)	(a)	138,739	67,643	1,026,960	939,933
Wisconsin	93,950	27,688	(a)	(a)	218,087	40,123	2,612,020	362,440	4,044,754	772,125
Wyoming							754,829	60,813	771,139	63,577
Concealed totals	262,722	88,963	198,369	27,453	657,876	150,946	363,371	71,846	282,346	92,618
Total	3,335,508	1,020,389	2,335,196	266,852	2,111,997	646,731	38,526,498	8,842,811	79,555,849	24,217,508

[a] Included in "Concealed totals."

The production of gravel exceeded that of building sand by more than 13,000,000 tons. The total production of gravel in 1913 was 38,526,498 tons, valued at $8,842,811, or an increase in quantity of 8,754,913 tons and in value of $1,101,794 over the production of 1912. These figures show an average cost per ton of slightly less than 23 cents, or 3 cents less than the average value per ton of gravel in 1912. This large quantity of gravel was used for many purposes, including concrete, paving, filter beds, roofing, road making, and railroad ballast.

Molding sand, which in 1912 for the first time exceeded a production of 4,000,000 tons, seems to have had a severe setback in 1913, if the returns are as complete as in 1912. The production of molding sand reported for 1913 is 3,563,583 tons, valued at $2,230,217, a decrease in quantity of 921,797 tons, and in value of $488,509 from the production of 1912. Although New Jersey made a good increase in production, there was a very large decrease in Illinois, Indiana, Michigan, New York, Ohio, and West Virginia. Thus the depression in the iron and steel trades shows itself, or an overproduction in 1912 is counterbalanced.

Glass sand, on the contrary, was marketed in greater quantity than ever, the total quantity produced in 1913 being 1,791,800 tons, valued at $1,895,991. This is an increase in quantity of 326,414 tons and in value of $465,520 over the production of 1912. The average value per ton rose from 97 cents in 1912 to $1.05 in 1913. The revision of the tariff on glass seems to have had no effect on the production of glass sand, if we may judge by the quantity reported sold.

Grinding and polishing sand fell off 344,490 tons from the production of 1912, in which year the production exceeded that of 1911 by 347,235 tons. The value of the product in 1913 was $540,399, or $91,737 less than in 1912.

The production of fire and furnace sand remained practically the same, totaling about 519,000 tons, and the output of engine sand reported was about 255,000 tons less than in 1912.

Paving sand production nearly doubled in quantity in 1913. The production reported was 3,335,508 tons, valued at $1,020,389, as compared with 1,788,530 short tons, valued at $670,680 in 1912, an increase in quantity of 1,546,978 tons and in value of $349,709.

Railroad ballast sand is this year separately recorded for the first time. The reported production of 2,335,196 short tons, valued at $266,852, is not the total quantity of sand ballast used by the railroads in the United States in 1913, for the reason that some railroads keep no record of the quantity of sand produced and used by them in making cuts and ballasting their road beds, it being with them only a matter of moving material from one point on the right of way to another point. The quantity and value given above were actually reported.

The entire report of the production of sand and gravel is necessarily incomplete because it is impracticable to attempt to get or to estimate the quantity of sand produced by the thousands of individuals who each year dig a small quantity for their own use. This production, of which there is no count or accounting, may average less than a ton for the individual producer, but the aggregate may be hundreds of thousands of tons. The figures each succeeding year should be nearer the actual production, as the list of producers is added to annually.

The gravel figures for 1913 do not include a considerable quantity of chats or tailings from the Missouri zinc mines. The production of chats in Missouri and Kansas in 1913 was 2,028,889 tons, valued at $304,333. The gravel figures do include 125,897 tons of chert, valued at $52,883, used for road building in Alabama.

The unit of measurement given in the tables of production is the short ton. Much of the sand is reported as sold by the cubic yard, a cubic yard varying in weight from 2,300 to 3,000 pounds, according to the condition of the sand, according to the material of which the gravel is composed, and according to the custom of the locality. All of the glass sand is sold by the short ton, and also a considerable quantity of the molding, building, and other sand; hence the quantities reported were all reduced to this unit.

IMPORTS.

Sand valued at $172,257 was imported into the United States in 1913, as compared with imports valued at $141,690 in 1912 and at $147,268 in 1911. This is largely building sand brought to the United States as ballast, or from Canada as a near source of supply, but it includes a small quantity of French molding sand which comes to this country barreled in lump and is here ground and pulverized before marketing.

SAND FOR STEEL MOLDING.

The principal requirement of a sand for steel molding is a high degree of refractoriness, and therefore clean quartz sand containing more than 95 per cent silica is used. The size of the grain demanded varies with the weight of the casting and the place occupied in the mold. Steel molding sands are commonly white but may be yellow or light brown.

The specifications for sand bought by the Panama Canal Commission for use on the Isthmus in making steel castings were as follows:

Sand, silica, to be sharp, free from loam and other organic matter, and suitable for steel castings; shall show the following upon analysis:

SiO_2	95–100 per cent.
Fe_2O_3	under 1 per cent.
CaO	under 1 per cent.
MgO	under 1 per cent.

It will be noted that size of grain and color are not mentioned. A New Jersey sand which answered the requirements of these specifications and was shipped to the Panama Canal in hundreds of barrels is here compared with other steel-molding sands. The tests made by the writer were on samples in the Survey collection, which are contained in 3-ounce jars.

Sieve test of steel-molding sands.

Locality.	Retained on—			
	40-mesh.	80-mesh.	100-mesh.	Pan.
	Per cent.	*Per cent.*	*Per cent.*	*Per cent.*
Burlington, N. J	15	83	1.5	0.5
Lake Majella, Cal	11.5	87	1.5	....
Niles, Ohio	32	61	4	3
Millville, N. J	64	32	2	2
Ottawa, Ill., glass or silica	47	50	1.5	1.5
Ottawa, Ill., white steel	37.5	43.5	12.8	6.2
Ottawa, Ill., yellow steel	54	40	3	3
Pacific Grove, Mo	1	95.5	2	1.5

The sand from Burlington, N. J., was used on the Panama Canal. It is not known to the writer for what specific purposes it was used in steel molding. It is presumed to be adapted to general work. The test shows that it can be separated by screening into three different sizes. The coarse size, or 15 per cent, thus obtained appears to be a little larger in grain than glass or silica sand from Ottawa, Ill., and slightly smaller than steel sand from Millville, N. J. The bulk of this sand, or 83 per cent, which ranges from 40 to 80 mesh is comparable in size with many glass sands, while the remaining 2 per cent is almost a silica flour. Each of these three sizes would have its particular use in casting steel; the coarse sand is fitted for the body of a mold or parts where a smooth surface is not demanded; the medium sand for smooth surfaces, sharp corners where wear will come, and the throat of the mold through which a considerable quantity of molten metal will pass. The finest size could be used for facing parts of the mold. The raw sand is judged to be a high-grade sand for general use.

The sand from Burlington as shown by the test is practically identical in size with a steel molding sand dug at Lake Majella, near Pacific Grove, Cal. The most noticeable difference is that the former is a grayish white and the latter yellowish white. As the Lake Majella sand is a high-grade silica sand there would seem to be no reason for Pacific coast steel foundaries paying freight on steel sand from the Mississippi Valley. The deposit at Lake Majella is in dunes of considerable size and extent.

A grayish-white sand from Niles, Ohio, which is used by a steel company in Cleveland for green sand molding, is found by the sieve test to be one-third 20–40 mesh and two-thirds 40–80 mesh. This is just the opposite of two sands from Silver Run, Millville, N. J., which are two-thirds 20–40 mesh and one-third 40–80 mesh. The sands at Millville occur in the bank in distinct yellow and white bands, which may or may not be mixed in digging. These distinct differences in percentages of different sizes of component grains adapt them to different uses in refined molding.

Steel sands from Ottawa, Ill., vary in size of grain only slightly among themselves, and, so far as known to the writer, the white steel sand from this locality is identical with the best glass sand from Ottawa. The yellow sand, although not so valuable for glass making, probably is as good for steel molding as the clear white sand. These sands are derived from disintegrated St. Peter sandstone, as is also the sand from Pacific Grove, Mo. The latter has grains of the most uniform size of the sands tested. The 1 per cent coarse sand of the Missouri sample is identical with the 54 per cent of the yellow sand from Ottawa; and the 95 per cent of the sand from Missouri is only a shade less yellow than the 40 per cent of the yellow sand from Ottawa.

Sand made by crushing quartzite which analyzes over 95 per cent silica is also used in considerable quantities in casting steel. A sand of this kind which is produced in southeastern Pennsylvania and is said to be used in large quantities as a steel and fire sand varies in size from ⅛-inch grain to flour.

It is apparent that the size of grain varies considerably with the character of the work to be done. A sand suitable for making a mold in which steel pigs are to be cast is very different from a sand adapted to use in molding light weight, sharply detailed steel castings.

Steel molding sands vary in color, being commonly white, gray-white, yellowish, or light brown. Silica sand may be yellow and yet have less than 0.05 per cent of iron.

High-grade silica sand has no bond and a binder must be added to make a sand which can be molded. Some steel plants use a mixture of 5 parts old or burned sand, 5 parts fresh sand, and 1 part fire clay. Another mixture is approximately equal parts of old and fresh sand gaged with silica flour, molasses water, and fire clay. Some molders use 7 parts silica sand, 2 parts ground ganister or silica rock, and 1 part silica clay, bonded with molasses water. All these mixtures are changed to suit varying conditions.

Cores for steel molds are made of a variety of material, depending largely on the size of the space to be occupied. Small cores may be made of an open sand with a binder, and large cores are made of grit mixed with iron molding sand, and tempered with 1 shovelful of flour to 10 shovelfuls of grit and a thin vegetable oil.

SAND AND GRAVEL FOR FILTRATION PLANTS.

Clear, white, quartz sand of the proper size is the common material used in filter beds. The floor of filters may be made of broken trap, granite, or other rock screened to the proper size, or of clean, sized gravel.

The specifications for the filtration plant at Washington, D. C., which called for proposals for furnishing 140,200 cubic yards of filter sand and 42,300 cubic yards filter gravel, were as follows:

Filter gravel.—On the floor of the filters and surrounding the underdrains shall be placed gravel or broken stone having a maximum depth of 1 foot. Instructions will be given by the Engineer officer in charge as to the exact arrangement and positions of the various layers when the stone commences to be received upon the ground, but the arrangement will be approximately as follows: The lower 7 inches shall consist of broken stone or gravel which will remain upon a screen with a mesh of 1 inch, and which has but very few stones over 2 inches in diameter. Above this shall be placed 2½ inches of broken stone or gravel which has passed a screen with a mesh of 1 inch, and which remains upon a screen with a clear mesh of ⅜ inch, and above this shall be placed 2½ inches of broken stone or gravel, which has passed a screen with a mesh of ⅜ inch, and which is coarser than the ordinary sand, and entirely free from fine material.

The material for all of the layers may be broken trap rock or granite screened to the proper sizes, or gravel screened from sand and gravel banks of a sandy nature. Gravel screened from hardpan or clayey material can not be sufficiently cleaned. The gravel shall not contain more than a very small amount of shale or limestone. The gravel shall be washed entirely free from fine material, so that water passing through it or agitated in contact with it will remain substantially clean.

Filter sand.—The filter sand shall be clean river, beach, or bank sand, with either sharp or rounded grains. It shall be entirely free from clay, dust, or organic impurities and shall, if necessary, be washed to remove such materials from it. The grains shall, all of them, be of hard material which will not disintegrate and shall be of the following diameters: Not more than one-half of 1 per cent by weight shall be less than 0.13 millimeter; not more than 8 per cent less than 0.26 millimeter. At least 7 per cent by weight shall be less than 0.34 millimeter, at least 70 per cent less than 0.83 and at least 90 per cent less than 2.1 millimeters. No particle shall be more than 5 millimeters in diameter, and the sand shall be passed through screens or sieves of such mesh as to stop all such particles, and no screen or sieve shall be used containing at any point holes or passages allowing grains larger than the above to pass. The diameters of the sand grains will be computed as the diameters of spheres of equal volumes. The sand shall not contain more than 2 per cent by weight of lime and magnesia taken together and calculated as carbonates. In all other respects the sand shall be of a quality satisfactory to the Engineer officer in charge.

The filter sand shall be placed in the filters in three layers, each layer to be about 1 foot thick, and the sand shall not be dropped from a height into final position or otherwise unduly compacted. The first two layers may be filled in to only approximate depths and the surfaces need not be smoothed. The final layer shall be brought to a true and even grade, and the surface left smooth and uniform.

The specifications for the plants at Springfield, Mass., and Toronto, are practically identical, as follows:

The filter sand shall be clean sand, with either sharp or rounded grains. It shall be entirely free from clay, dust, or organic impurities, and shall, if necessary, be washed to remove such materials from it. The grains shall, all of them, be of hard material which will not disintegrate. The effective size shall not be less than 0.25 millimeter nor more than 0.35 millimeter. The uniformity coefficient shall not be more than 3.0. The sand shall be free from dust and shall not contain more than 1 per cent finer than 0.13 millimeter, and shall be entirely free from particles over 5 millimeters in diameter. The sand shall not contain more than 2 per cent by weight of lime and magnesia taken together as carbonates. In all other respects the sand shall be of a quality satisfactory to the engineer.

ASBESTOS.

By J. S. Diller.

PRODUCTION.

The production of asbestos in the United States is small, but in manufactured asbestos products the United States surpasses any other country. The total output of asbestos in this country for 1913 was about 1,100 short tons, and all of it came from 2 producers in Georgia and 1 in Arizona. For this reason exact figures can not be given without divulging confidential information.

Georgia produced asbestos of the amphibolite variety, anthophyllite. In 1913 the production of Georgia increased decidedly over the output of that State in 1912, and the Sall Mountain Asbestos Co. continues to be the largest producer.

The latest reports from Arizona indicate that the market is active for Arizona crude fiber at prices comparing favorably with No. 1 Canadian. A small initial production is accredited to 1913.

Annual marketed production of asbestos in the United States, 1890–1913, in short tons.

Year.	Production.			Year.	Production.		
	Quantity.	Value.	Average price per ton.		Quantity.	Value.	Average price per ton.
1890	71	$4,560	$64.23	1902	1,005	$16,200	$16.12
1891	66	3,960	60.00	1903	887	16,760	18.90
1892	104	6,416	61.69	1904	1,480	25,740	17.39
1893	50	2,500	50.00	1905	3,109	42,975	13.82
1894	325	4,463	13.73	1906	1,695	28 565	16.85
1895	795	13,525	17.01	1907	653	11,899	8.22
1896	504	6,100	12.10	1908	936	19,624	20.97
1897	580	6,450	11.12	1909	3,085	62,603	20.29
1898	605	10,300	17.02	1910	3,693	68,357	18.51
1899	681	11,740	17.24	1911	7,604	119,935	15.77
1900	1,054	16,310	15.47	1912	4,403	87,959	19.98
1901	747	13,498	18.07	1913	1,100	11,000	10.00

The largest annual production of asbestos in the United States was in 1911, when the output amounted to 7,604 short tons, valued at $119,935. In 1912 the output declined to 4,403 short tons, and the falling off continued throughout 1913. The cause of the sharp decline is the fact that the mill of the Chrysotile Asbestos Corporation of Vermont was closed during the entire year.

WORLD'S PRODUCTION.

The world's supply of asbestos is drawn largely from the Province of Quebec in Canada, although the rapid development of the Russian output is making that country an important factor in the world's supply, as is shown in the following table:

World's production of asbestos, 1907–1912, in short tons.[a]

Country.	1907	1908	1909	1910	1911	1912
United States	653	936	3,085	3,693	7,604	4,403
Africa:						
Cape Colony	604	1,267	1,674	1,403	1,253	(b)
Natal	....	....	....	3	13	(b)
Rhodesia	....	55	272	332	460	c 1,234
Transvaal	....	....	....	77	....	(b)
Australia	....	45	3	....	....	(b)
Canada:						
Asbestos	62,130	66,548	63,349	77,508	d 101,393	d 111,561
Asbestic	28,296	24,225	23,951	24,707	d 26,021	d 24,740
Cyprus	99	521	172	487	799	(b)
India	....	....	....	3	....	(b)
Italy	....	....	....	....	e 184	e 186
Russia	11,497	13,129	f 14,654	12,055	17,124	f 18,138

a Statistics taken from Mines and Quarries: General Report with Statistics, pt. 4, London, up to 1911.
b Statistics not available.
c The Mineral Industry, 1912, New York.
d Report on the mineral production of Canada, calendar year 1912, Ottawa.
e Revista del Servizio Minerario, Rome.
f Min. Jour., London.

PRICES.

Prices of asbestos in the United States are controlled by the Canadian market. Most of the mines have sold their output ahead for a considerable time. Prices in 1913 were higher than in 1912, as is shown in the accompanying table:

Range of New York prices per short ton for Canadian chrysotile fiber during 1912 and 1913.

	1912	1913
No. 1 crude	$300–$325	$320–$350
No. 2 crude	175– 200	200– 225
No. 1 fiber	....	100– 125
No. 2 fiber	....	75– 100
Shorter fibers	....	10– 30

The trade appears to expect prices to be advanced 10 or 15 per cent during 1914, owing to the increase in wages demanded. Recent offers for Arizona fiber indicate that it will rank with the Canadian in market value. The price of the amphibole variety of asbestos fiber averaged $10 a ton in 1913.

IMPORTS.

The imports given in the first of the accompanying tables are total imports for calendar years and are almost identical with the imports for consumption for the same period.

Canada is by far the most important source of the asbestos used in the United States. Unmanufactured asbestos, including ground, is admitted free, but manufactured asbestos is dutiable at from 25 to 40 per cent ad valorem.

The Canadian exports of asbestos during the 12 months ending December 31, 1913, are reported by the customs department of the Dominion[1] as 103,812 short tons, valued at $2,848,047. Of this quantity 86,564 short tons were shipped to the United States, that is, more than 83 per cent of all that was exported by Canada and more than 63 per cent of all that Canada produced in 1913.

As is shown in the accompanying table, the total imports of unmanufactured asbestos other than that from Canada amounted in 1913 to only 173 short tons, or about 0.2 per cent of the imports from Canada. The greater portion of this asbestos came from Russia, in part by way of Germany, and a few tons came from Italy.

The comparatively small imports of manufactured asbestos come mainly from Europe, in particular from England, Germany, and Austria-Hungary.

General imports of asbestos into the United States, calendar years 1912 and 1913, in short tons.

Country.	1912			1913		
	Unmanufactured.		Manufactures of.	Unmanufactured.		Manufactures of.
	Quantity.	Value.	Value.	Quantity.	Value.	Value.
Austria-Hungary			$72,772			$75,770
Belgium	6	$146	22,957			28,616
Canada	71,426	1,441,475	348	86,564	$1,897,611	7,456
England	3	510	173,095	1	1,546	176,413
France			1,366			4,202
Germany	29	4,684	84,742	17	3,547	88,526
Italy	6	918	7,661	5	694	6,937
Japan						215
Netherlands			119			
Russia in Europe	53	8,279		150	25,307	
Scotland			699			1,489
Switzerland						40
Total	71,523	1,456,012	363,759	86,737	1,928,705	389,664

The value of the manufactured and unmanufactured asbestos imported for consumption into the United States during the calendar years 1909 to 1913 is shown in the following table:

Value of asbestos imported for consumption into the United States, 1909–1913.

Year.	Unmanufactured.	Manufactured.	Total.
1909	$993,254	$240,381	$1,233,635
1910	1,235,170	308,078	1,543,248
1911	1,413,541	290,098	1,703,639
1912	1,456,012	363,759	1,819,771
1913	1,928,705	378,961	2,307,666

[1] Preliminary report on the mineral productions of Canada during the calendar year 1913: Canada Dept. Mines, p. 16, 1914.

ASBESTOS IN THE UNITED STATES.

ARIZONA.

Arizona has long been known for the peculiar occurrence as well as the high grade of its asbestos, although it has not been a producer. The asbestos occurs with serpentine in limestone. The serpentine, like the limestone in which it occurs, is derived from material of sedimentary origin and as to its original source is therefore in strong contrast with the serpentine derived from peridotite.

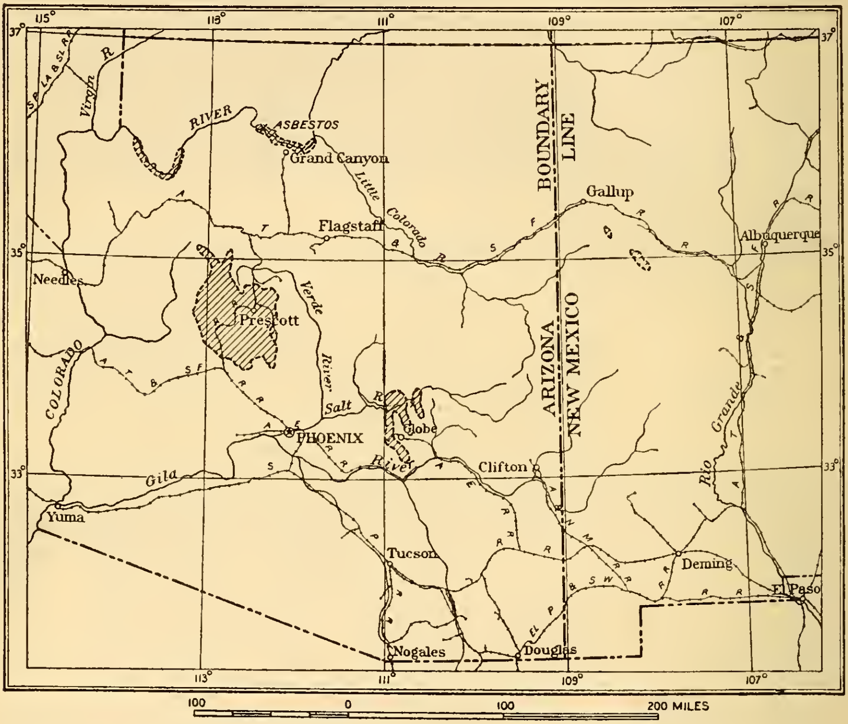

FIGURE 12.—Map showing asbestos prospects (X) in Arizona. Shading shows areas of pre-Cambrian rocks.

Chrysotile was discovered some years ago in the depths of the Grand Canyon under Grand View, as well as at Bass's, 30 miles farther west. Lately, however, chrysotile of the same sort and mode of occurrence has been found in the vicinity of Globe, on Ash Creek. Both localities are indicated in figure 12.

CHRYSOTILE ASBESTOS OF THE GRAND CANYON.

The asbestos of the Grand Canyon lies west of the mouth of the Little Colorado. The belt is a long, narrow strip lying at a definite geologic horizon among the Algonkian strata in the depths of the Grand Canyon of the Colorado about 4,000 feet below the rim and in places about 1,000 feet above the river. It has been studied at two localities in the canyon, one beneath Grand View[1] where the

[1] Pratt, J. H., U. S. Geol. Survey Mineral Resources, 1904, pp. 1137-1140, 1905.

serpentine-asbestos belt is exposed for nearly 2 miles with a width of only a few feet, and the other 30 miles farther west in the canyon beneath Bass's camp[1] where the same belt has a length of about three-fourths of a mile.

According to Noble the same asbestos belt outcrops for several miles in the canyon west of Powells Plateau. Owing to its inaccessibility the locality has not yet been examined.

The strata in which the chrysotile occurs are part of a thick series of Algonkian rocks which dip generally to the north or northeast at angles of 10° to 20° and are broken here and there by normal faults, generally of small displacement. These rocks form part of the north wall of the great gorge of the Colorado, where they are separated from both the overlying Cambrian and the underlying Archean by conspicuous unconformities. The strata, although deep seated and of great age, are as a body not crushed, fractured, or metamorphosed as are those of Canada and Vermont, where the chrysotile is contained in serpentine derived from the alteration of peridotite.

A section of the rocks with which the asbestos is associated in the Grand Canyon is given below, as measured by Noble[2] on Asbestos (Hakataia) Creek.

Section of asbestos-bearing rocks in Asbestos Creek Canyon.

	Feet.
Diabase.	
Layer of green serpentine	2
Pure white crystalline limestone	1½
White crystalline limestone with bands and nodules of serpentine	2
Serpentinous nodular and banded layer carrying veins of asbestos	1
Banded crystalline limestone with bands and nodules of serpentine	10
Nodular cherty limestone	4
Soft blue slate	5

The limestone above the diabase contains some serpentine and small veins of asbestos rather widely distributed, but on the whole this material appears to be much less abundant and persistent than that below the diabase.

The asbestos below the diabase is not absolutely constant in horizon, but may lie, according to Noble, anywhere from 3 to 15 feet below the contact.

The serpentine and asbestos occur in the limestones only where these strata are invaded by the diabase sill; where the diabase lies between shales there is no development of these minerals within the invaded strata. In no place in the area are they developed within the diabase itself. It is, therefore, clear that they are a contact-metamorphic phenomenon conditioned by the invasion of the limestones by the diabase. It seems probable, as suggested by Diller, that the serpentine which incloses the veins of asbestos is derived from some mineral in the limestones and not from the diabase. The limestones themselves are magnesian and locally siliceous in the form of chert bands and nodules. In another part of the area the conversion of the shales to jaspers where they are in contact with the diabase is evidence that the fumarolic action accompanying the injection of diabasic magma was manifested by aqueous and probably siliceous emanations and was fairly intense. It seems possible that the operation of the fumarolic action upon the elements already present in the magnesian limestones might have been sufficient to convert the more siliceous portions into serpentine. The occurrence of the asbestos in veins that cut both the nodules of serpentine and the limestones is evidence that the formation of the cross-fiber asbestos was itself a somewhat later phenomenon.[3]

[1] Noble, L. F., Am. Jour. Sci., 4th ser., vol. 29, pp. 520–522; 1910. Also personal letter dated June 21, 1910.
[2] Noble, L. F., op. cit., p. 520.
[3] Noble, L. F., op. cit., pp. 521–522.

THE ASBESTOS.

The serpentinous layer that carries the asbestos is usually from 12 to 14 inches in thickness, and the general trend of the asbestos veins within it is parallel to the bedding of the limestone. Locally the asbestos fiber is 4 inches in length from side to side of the vein, but generally the veins do not exceed 2½ inches and in many places they appear as a series of small parallel veins. The larger veins are remarkable for their continuity. According to Pratt,[1] below Grand View, where the outcrop of the serpentine-asbestos layer is in places as much as 18 or even 24 inches in thickness, there may be in it two or three large parallel veins of asbestos that continue for 150 feet. Within this thin layer containing the asbestos, cross-fiber veins more than an inch in width are common. The width of the veins at this horizon varies greatly from place to place, so that a 3-inch vein in one locality may be represented by a zone of numerous small veins in another; but, according to Noble, the actual continuity of the zone that carries the asbestos is rarely broken.

The asbestos veins have but few partings, and these are generally of chalcedonic quartz with rough borders instead of the smooth, sharp lines like those which generally mark the sides of the veins. The asbestos is generally of a beautiful golden-yellow color, though in places shading to pale green. It is finely fibrous, smooth, silky, and of great tensile strength, so that it compares favorably with the crude asbestos from any other country.

Locally as much as 40 per cent of the 12-inch layer may be Nos. 1 and 2 crude, with 10 per cent of lower grades, but in general the thin layer would probably not average more than 15 per cent of all grades.

The eastern area under Grand View has been most extensively prospected. A few years ago the Hance Asbestos Co. opened a number of cuts along the outcrops and ran tunnels down the dip, some of them for 75 feet.

The large proportion of crude to other grades in this Grand Canyon deposit is remarkable. Ordinarily such a deposit could be profitably mined, but the narrow limits of the asbestos belt, taken in connection with its attitude and the difficulties of getting the asbestos across the river and out of the canyon to the railroad, appear to render successful mining very problematical, except in a small way with donkeys for transportation. In any case, the development of this deposit would have to be on a small scale only and for high-grade material.

Whatever part the asbestos of the Grand Canyon may play in the industry of the country, it will ever be recognized as one of the most exceptional and interesting deposits yet discovered. The entire absence of rock crushing and the remarkable continuity of the asbestos veins approximately in the plane of stratification clearly indicate that the veins were not deposited in open fissures, but by the replacement of serpentine in the planes of weakness somewhat later than the development of the serpentine itself. Here, too, we have convincing evidence of the development of asbestos by igneous intrusion. We may, therefore, the more readily accord to the granite dikes in Canada and elsewhere a decided influence in the formation of the asbestos near their contacts.

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[1] Pratt, J. H., op. cit., pp. 1138–1139.

CHRYSOTILE OF ASH CREEK NEAR GLOBE.

The most important event during 1913 concerning the occurrence of asbestos in the United States was the discovery by T. D. West of an important deposit of chrysotile in the region of Globe, Ariz. Four-

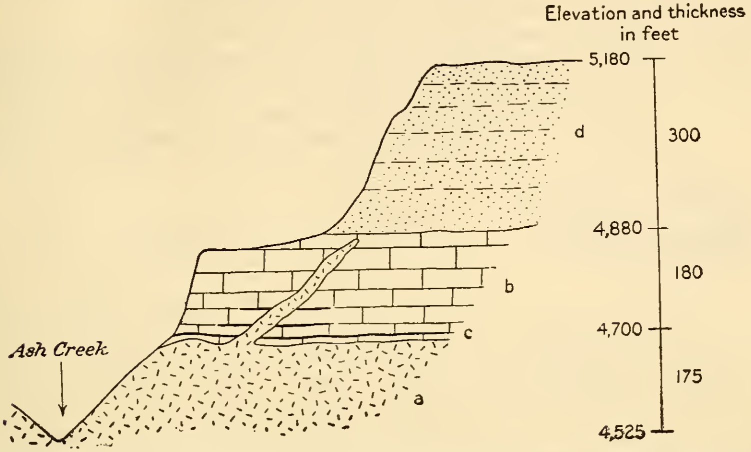

FIGURE 13.—Section of east slope of Ash Creek, 25 miles northeast of Globe, Ariz.; 220 miles S. 30° E. of Bass's Ferry in Grand Canyon. a, Diabase; b, gray limestone, in part cherty, locally banded and containing sheets and nodules of serpentine and some asbestos; c, three asbestos belts 12 to 24 inches in thickness lie parallel with the bedding in layers of gray to white limestone; d, mainly quartzite with some conglomerate. Nodules of serpentine occur here and there in the locally banded limestone near the asbestos belts.

teen claims were taken up by T. D. West and Fred Patee on Ash Creek, about 25 miles in a direct line N. 25° E. of Globe. Ash Creek is a short stream and carried about 4 miner's inches of cool clear water September 28, 1914. It heads against Sycamore Creek and flows north through a rugged canyon into Salt River. At the point where the asbestos occurs the canyon is about 600 feet deep and its eastern slope presents the general section shown in figure 13.

The asbestos belts contain cross-fiber veins of chrysotile, which constitutes in some places from 25 to nearly 50 per cent of the mineral matter of the belt. Most of the chrysotile fiber is from one-half inch to 1 or 2 inches in length. A generalized section showing the detailed structure of the asbestos belt is shown in figure 14.

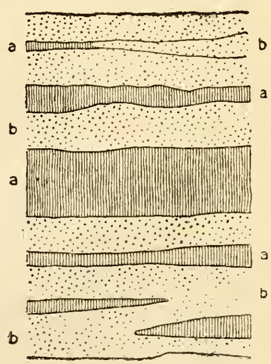

FIGURE 14.—Generalized detail section of asbestos belt. Cross-fiber veins of chrysotile (a), separated by pale-green to gray serpentine (b).

The asbestos belt, especially the one near the contact with the diabase, is more or less continuous for a mile, but varies greatly from place to place.

The bands of serpentine in the asbestos belt are generally of light-green color and compact, splintery, conchoidal fracture. In places the serpentine is gray like chalcedony but is easily distinguished by its softness.

The principal asbestos belt is the one nearest the contact with the diabase, although usually separated from the diabase by a few feet of limestone. Other belts, generally smaller, occur farther up in the limestone to a distance of about 30 feet. The higher-grade asbestos belts appear to be associated with a dike of diabase penetrating limestone from the main body of diabase below.

These nodules of serpentine with partial borders of asbestos, as shown in figure 15, occur in the white to gray limestones near the asbestos belts. The nodules are of various colors from brown to deep leek green. The quantity of serpentine and chrysotile is small as compared with that of the asbestos belts.

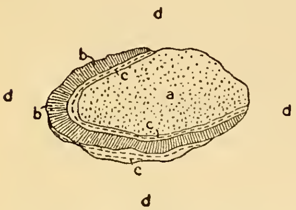

FIGURE 15.—Nodule of serpentine (a) with chrysotile (b), bordered mostly on both sides by serpentine (c), but partly by white limestone (d).

COMPOSITION AND QUALITY OF ARIZONA CHRYSOTILE.

The quality of the chrysotile is excellent. For electric insulation it has been tested by several large firms and pronounced better than the Canadian. This view is demonstrated by a comparison of the following chemical analyses, which show the Grand Canyon asbestos to contain only 0.51 per cent of iron oxide, while the best analyses of Canadian chrysotile yet reported from Thetford, Black Lake, and Danville, the three great centers of Canadian production, contain from 2.26 to 2.60 per cent of iron oxide.

Chemical analyses of chrysotile asbestos.

	SiO_2.	Al_2O_3.	FeO and Fe_2O_3.	MnO.	CaO.	MgO.	Na_2O.	K_2O.	H_2O-.	H_2O+.	Total.
1	43.68	0.34	0.51	0.17	0.09	40.64	0.14	0.11	1.18	13.12	99.98
2	39.05	3.67	2.41	......	......	40.07	......	......	....	14.48	99.68
3	39.36	......	3.31	......	......	42.15	......	......	....	14.50	[a] (99.32)
4	40.42	0.82	2.60	......	......	41.85	......	......	....	14.37	[a] (100.06)
5	39.22	3.64	2.26	......	......	40.27	......	......	....	14.37	[a] (99.76)
6	41.84	......	2.23	......	......	41.99	......	......	....	14.28	[a] (100.34)
7	42.64	......	3.66	......	......	39.54	......	......	....	14.31	[a] (100.15)
8	44.10	......	......	......	......	43.00	......	......	....	12.9	100.00

[a] Totals in parentheses by present writer.

1. Grand Canyon, under Grand View., Ariz. (Analyst, R. C. Wells, U. S. Geol. Survey).
2. Thetford. (Analyst, J. T. Donald, Montreal).
3. Black Lake, Amalgamated Asbestos Corporation, B. C. quarries. (Analyst, Milton Hersey, Montreal).
4. Black Lake, Amalgamated Asbestos Corporation, Standard quarries. (Analyst, Milton Hersey, Montreal).
5. Black Lake, Southwark mine. (Analyst, J. T. Donald).
6. Danville. (Analyst, J. T. Donald).
7. Danville. (Analyst, J. T. Donald).
8. Theoretical composition: Dana, E. S., A textbook of mineralogy, p. 477.

The chemical analyses of this table (Nos. 2 to 7, inclusive) are quoted from the monograph of Fritz Cirkel.[1] In moisture content as well as in magnesia the Grand Canyon chrysotile is close to the Canadian, but in silica it is somewhat higher, although a little less than the theoretical composition (8) of pure chrysotile.

[1] Chrysotile-asbestos: Its occurrence, exploitation, milling, and uses, 2d ed., p. 31. Dept. Mines, Ottawa, Canada, 1910.

The Grand Canyon type of chrysotile occurring at Ash Creek is remarkable (where not affected by weathering) for its silky luster, flexibility, and tensile strength.

To test the latter a number of samples were prepared of groups of fibers $1\frac{1}{2}$ to 2 inches in length and so numerous that when twisted three times they formed a yarn about $\frac{3}{100}$ of an inch in thickness. The average of a number of tests of chrysotile yarn made of Ash Creek, (Ariz.) fiber showed that it will support $15\frac{4}{5}$ pounds, while the Canadian chrysotile under the same conditions supported $15\frac{1}{2}$ pounds. The strength of the fiber is much impaired by weathering, and it is still difficult to get material at Ash Creek as fresh as that of the large quarries at Thetford.

Among the most valuable properties of asbestos are its heat resistance. Its melting point is high and its conduction is low. For this reason it is good for fireproofing and heat insulation. When heated, chrysotile gives off most of its water at red heat. In a blast-lamp flame having a temperature between 1,200° and 1,300° C. the Grand Canyon and the Ash Creek chrysotile, like the best grades of silky Canadian fiber, lose water and their threads apparently melt and change form to a somewhat glassy enamel-like substance which is not isotropic like glass but granular doubly refracting, owing to the fact that the chrysotile under high heat breaks up into olivine (Mg_2SiO_4) and enstatite ($MgSiO_3$), which do not fuse in the ordinary blast lamp. According to Brun [1] olivine fuses at 1,750° C., and some members of the pyroxene group as high as 1,350° to 1,410° C.

CALIFORNIA.

California contains much serpentine that has been crushed and penetrated by various dikes, so that it might well be regarded as good ground for the asbestos prospector. Numerous prospects have been reported but have not resulted in definite production. Hitherto the prospects reported have been in the Sierra Nevada, especially in Placer County near Towle and Iowa Hill, but in 1913 two other localities attracted attention, one on Mears Creek in Shasta County and the other in the southern part of Napa County. The samples submitted from Placer County are mainly of the slip-fiber type. Those from Shasta and Napa counties are for the most part of the cross-fiber type, but in quantity, size, and quality of fiber they do not warrant great expectations.

About the head of Mears Creek in Shasta County, west of Sims station (Hazel Creek post office), there is a large area of serpentine that was prospected in 1913. Much of the rock has completely changed to serpentine, but in places there is much olivine and pyroxene remaining to show the original character of the igneous rock from which the serpentine has been derived. It is cut by a variety of dikes in the vicinity of the asbestos deposits. Cross-fiber veins are common up to half an inch in thickness, but no large veins of high-grade chrysotile were observed. On the other hand, the property contains a remarkable deposit of slip fiber in which the fiber lies nearly horizontal parallel to the vein as if the motion producing it were horizontal comparable to that of the faulting connected with the San Francisco

[1] Econ. Geology, vol. 7, p. 4.

earthquake. This clear, white fiber softened by weathering on the outcrop but hard beneath has a variable thickness up to 3 or 4 feet. Lengthwise it has been traced more or less continuously for nearly a mile. The locality is on a steep, rocky slope from 3 to 7 miles west of the railroad, and Mears Creek running directly through the locality affords good water power.

GEORGIA.

The outlook in Georgia continues to grow slowly but steadily more encouraging. The output increased 53 per cent in 1913, as compared with that of 1912. There were two points of production, one near Asbestos station on the Gainesville & Northwestern Railroad, 3 miles southwest of Sall Mountain, in White County, and the other near Hollywood on the Tallulah Falls Railroad, in Habersham County.

The Sall Mountain Co. has been in continuous operation for many years. In 1913 it removed its mill from Sall Mountain to Gainesville on the main line of the Southern Railway, at its junction with the Gainesville & Northwestern Railroad, over which its raw material is transported from quarry to mill.

The mill and quarry at Hollywood began operations about December 1, 1913. The material and product is similar to that of the Sall Mountain Co.

Much of the Georgian asbestos is exported, but experiments now under way may result in its being used to advantage in the manufacture of asbestos wood and similar products.

Dr. Oliver B. Hopkins, of the Georgia Geological Survey, has recently prepared a paper concerning the asbestos deposits of Georgia and has kindly permitted the following abstract to be made from his manuscript:[1]

After a few general statements concerning (1) the history and importance of the asbestos industry, (2) the principal sources of raw material, and (3) the types and modes of occurrence of asbestos, Dr. Hopkins takes up the asbestos deposits of Georgia in particular.

The asbestos deposits of Georgia are associated with the crystalline schists of pre-Cambrian age and are limited in their distribution to the areas of basic igneous rocks which form a belt across the northwestern portion of the State from Rabun County to Harris County; this belt is relatively more important in Rabun and Habersham counties. Small quantities of slip fiber occur in the diorites and gabbros, but the more important deposits are those of mass fiber associated with peridotites and pyroxenites. The whole rock mass is fibrous, and Hopkins calls attention to the fact that usually as much as 95 per cent of the rock quarried in Georgia is realized as fiber, while in the case of the chrysotile deposits of Canada the average extraction of fiber for 1912 was only 6.45 per cent of the rock quarried. Although the extraction of the Canadian cross-fiber chrysotile is less than one-fourteenth that of Georgia mass-fiber asbestos, the price is nearly three times as great. This gives, according to Hopkins, a decided advantage to the Georgian product, especially since the mining can be done more economically and the milling is much more simple.

[1] This paper was read before Section E of the American Association for the Advancement of Science at Atlanta, and is to be published in a volume of papers read at that meeting concerning the mineral resources of the Southern States.

Owing to the slight demand, little Georgia asbestos is being put on the market at the present time. With a good demand for the material at from $8 to $12 a ton a number of deposits in the State could probably be worked with profit and a large amount of material could be put on the market.

The field relations and the microscopic study of the material indicate that the mass-fiber anthophyllite is derived from enstatite-olivine rock.

VERMONT.

The large area of peridotite and serpentine of the Province of Quebec in Canada, which furnishes so large a part of the world's supply of asbestos, extends southwest across the international boundary into Vermont and has long been regarded as one of the most promising asbestos fields in the United States.

The Lowell Lumber & Asbestos Co. began operations in Vermont in 1907, erected a mill on the southwestern slope of Mount Belvidere, and began the production of asbestos in 1908. The mill was enlarged and the output increased to its greatest yield in 1911. Owing to labor troubles and especially also, it is said, to the decline of trade in the countries affected by the Balkan War, the mill shut down during part of 1912, and in 1913 there was no production at all. In response to inquiries the president, W. G. Gallager, states:

> That the principal work done was getting ready for the installation of electric power and the enlargement of the plant, which we expect to have completed by the coming summer. We also expect to have the transportation problem solved by building a railroad either from Johnson, Vt., or Morrisville, Vt. This we also hope to have in operation before the snow flies next winter.

WYOMING.

Prospecting continues in the Casper and Wind River mountains of Wyoming, but there has been no definite production for the market. Some interesting experiments have been made in the use of Wyoming asbestos for boiler covering by the Chicago & North Western Railway Co. Vice President R. H. Aishton [1] reports that:

> A conductivity test was made, and the results show that the Wyoming asbestos contains better heat-resisting qualities than the two samples of Canadian asbestos compared with it.

The practical boiler covering test will not be completed for 12 or 18 months when the engine comes up for repair. Definite results are not yet available, but they appear to promise a line of utilization for Wyoming fiber.

QUARRYING ANG MINING ASBESTOS.

The mass-fiber asbestos of Georgia is obtained in quarries. The whole rock mass is fibrous, and after the removal of the soil almost the entire body of rock quarried may be milled into marketable product.

In Vermont, and especially also in Canada, where the chrysotile is associated with serpentine resulting from the alteration of peridotite, the chrysotile is quarried. The only exception to this statement is

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[1] Letter, Feb. 2, 1914.

that at Thetford, Canada, the material is removed from the Bell quarry by cars on rails through a 1,100-foot tunnel, which affords an opportunity for actual underground working, that is mining asbestos.

The chrysotile in Arizona is a product of contact metamorphism in limestone and outcrops, so far as is known, only in canyons. It occurs at Ash Creek in a narrow irregular belt, and the amount of chrysotile that can be removed from open cuts on the steep canyon slopes is limited. To obtain that which lies within the canyon walls, the limestone must be tunneled and the asbestos removed by regular mining methods. The bulk of it could be "hand cobbed" ready for the market. There is also much short but excellent fiber that should be carefully saved for more convenient transportation or manufacture at the mine. That this asbestos can be mined is considered feasible, but whether or not it can be mined at a profit has not yet been demonstrated by actual experience.

PROSPECTING FOR ASBESTOS.

Asbestos of the cross-fiber type of chrysotile is most commonly found in large areas of serpentine derived from the alteration of basic intrusive rocks, such as peridotite and pyroxenite. Large areas of serpentine, especially of much crushed rock masses, are therefore the most promising in which to search for asbestos. The purer the serpentine the better the prospect in Canada and elsewhere, especially if the serpentine is cut by dikes of fine-grained granitic rocks, such as occur in the great asbestos region of Thetford and Black Lake in the Province of Quebec.

In Arizona, which is just now attracting considerable attention, the case is very different. Although it is true that the chrysotile is associated with serpentine, the quantity of serpentine is small, and it occurs in beds of limestone near their contact with an intrusive mass of diabase, as illustrated in figure 13. The chrysotile and serpentine are due to the contact metamorphism of the limestone by the diabase. In some places, particularly in the Grand Canyon, the diabase cuts the limestone approximately parallel to the bedding, and chrysotile occurs along both the upper and the lower contacts, but the lower contact as far as yet seen has the largest amount of chrysotile. Both contacts should be prospected.

It is not yet certainly known whether or not the limestone containing chrysotile asbestos on Ash Creek is the same horizon as that containing the same material in the asbestos region of the Grand Canyon.

The limestone carrying chrysotile in the Grand Canyon region is known to be Cambrian. That of Ash Creek is believed to be either Cambrian or older, and below the "Globe limestone," Carboniferous and Devonian, described by Ransome in the Globe folio.[1] The horizon of the chrysotile on Ash Creek may be in the cherty dolomitic limestone, separated from the Devonian by 400 feet of quartzite.[2]

As the chrysotile is found only in limestone near the contact of diabase, such contacts should be thoroughly prospected throughout the country between Ash Creek and the Grand Canyon of the Colorado, for there may be other localities of importance.

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[1] Ransome, F. L., U. S. Geol. Survey Geol. Atlas, Globe folio (No. 111), p. 5, 1904.
[2] Ransome, F. L., Copper deposits near Superior, Ariz.: U. S. Geol. Survey Bull. 540, pp. 139–143, 1914.

Pre-Cambrian rocks are exposed at a number of points in northeastern Arizona and northwestern New Mexico. The general outlines of the areas as well as the localities at which asbestos is known to occur are shown in figure 12 and may serve as a suggestive guide to prospectors. Of the two asbestos localities in the Grand Canyon the one farthest west is Bass's and the other is Hance's. The locality northeast of Globe is on Ash Creek. Between the Grand Canyon and Ask Creek, a distance of about 175 miles, the pre-Cambrian rocks are so deeply covered by Paleozoic strata as to render them inaccessible, unless these rocks have been brought to the surface by great faults at places not now known. In the Globe area west of Ash Creek, as well as in the Prescott area and also in the westernmost area in the Grand Canyon, no asbestos has been found, but it should be looked for.

The conditions of mining and transporting asbestos in Arizona will necessarily limit its production, but as the material is of high grade it may, if economically handled, be made profitable. In getting the best fiber, much short fiber will accumulate that can be milled and manufactured later by hydroelectric power.

To the east, in New Mexico, the pre-Cambrian rocks come to the surface again. A small area of them about 20 miles southwest of Grant might contain asbestos deposits more advantageously located than in the other localities mentioned.

The apparently increasing demand for the mass-fiber type of asbestos, such as has been mined for years at Sall Mountain, Ga., is of interest. This type of asbestos occurs in thoroughly crystalline basic igneous rocks, such as pyroxenites bordering upon peridotites, and has been found in many places in the Appalachian Mountains in North Carolina and Georgia; but it has been successfully mined in Georgia alone. The grade of this asbestos being low, the possibility of its successful financial development is more limited than in the case of higher grades. If hard, fresh white asbestos rock of this type could be milled and separated by an air process the product might find extended application and larger demand in the manufacture of paper.

ASBESTOS IN FOREIGN COUNTRIES.

CANADA.

The asbestos mines of Canada are located in the eastern townships of the Province of Quebec. The most productive localities are at Thetford, Black Lake, and Danville.

The asbestos is chrysotile and occurs in thin irregular veins traversing masses of serpentine rock that have resulted from the alteration of peridotite. The veins vary from a mere film to 2 or 3 inches in thickness. The chrysotile fiber runs directly across the vein from side to side unless interrupted by partings, which may contain a bit of serpentine or oxide of iron.

The chrysotile veins traverse the serpentine in all directions, but do not continue for great distances. The whole mass of rock is quarried in open cuts and the veins of crude fiber are separated from milling rock by hand picking. The crude-fiber grades 1 and 2 containing fiber about an inch or more in length afford the best spinning material, and when broken from the rock and bagged this material is ready for the market.

The other rock material from which the crude grades have been separated and which is yet sufficiently rich in fiber is prepared for market by being dried, crushed, fiberized, and separated by a process of milling into various grades ranging from mill fiber to asbetic.

Canada is the world's chief source of asbestos. In 1909 Canada furnished 81 per cent of the world's output; in 1910, 85 per cent; and in 1911, about 82 per cent. The production of Canada is rapidly and rather uniformly increasing. The output of all other countries, except Russia, is relatively unimportant.

However small its domestic production of asbestos, the United States is the chief manufacturer of asbestos goods and draws its supply of raw material from Canada.

Canadian activity in the production of asbestos in 1913 [1] was confined to the districts of Black Lake, Thetford, and Danville, in Quebec. None of the quarries formerly operated at East Broughton were worked, although small shipments were made by one firm from stock.

The total output in 1913 was 132,564 [short] tons as against 102,759 tons in 1912, an increase of 29,805 tons, over 29 per cent. The sales and shipments of asbestos fiber in 1913 were 136,951 tons, valued at $3,830,909, or an average of $27.97 per ton, as against sales in 1912 of 111,561 tons, valued at $3,117,572, or an average of $27.95. Stock on hand at December 31, 1913, was reported as 20,786 tons as compared with stocks of 23,288 tons at the beginning of the year.

A new mill is in course of construction at Danville.

The output and sales of crude and mill stock separately is shown for 1912 and 1913 in tabulated statements following. The classification is based on valuation. Crude No. 1 comprises material valued at $200 per ton and upward, and crude No. 2, under $200; mill stock No. 1 includes mill fiber valued at from $30 upward; No. 2, from $15 to $30; and No. 3, under $15.

The total sales of crude in 1913 were 5,660.3 tons, valued at $989,162, or an average of $174.75, as against sales in 1912 of 5,662.9 tons, valued at $890,351, or an average of $157.22, practically the same quantity but at a higher average price.

The total sales of mill stock in 1913 were 131,291 tons, valued at $2,841,747, or an average of $21.64 per ton, as against 105,898 tons in 1912, valued at $2,227,221, or an average of $21.03 per ton, a large increase in quantity but at substantially the same average price.

There was a falling off in the amount of both crude and mill fiber in stock at the end of the year, indicating a revival of business and increasing demand.

Output, sales, and stocks of Canadian asbestos in 1913, in short tons.

[Subject to correction.]

	Output.	Sales.			Stock on hand Dec. 31.		
	Quantity.	Quantity.	Value.	Price per ton.	Quantity.	Value.	Price per ton.
Crude No. 1	2,015.4	1,853.3	$531,200	$286.62	880.5	$247,877	$281.52
Crude No. 2	3,010	3,807	457,962	120.29	1,522	178,789	117.47
Mill stock No. 1	23,444	26,198	1,229,908	46.95	6,755	350,165	51.84
Mill stock No. 2	58,592	60,164	1,201,215	19.97	4,809	108,285	22.52
Mill stock No. 3	45,503	44,929	410,624	9.14	6,820	54,604	8.01
Total asbestos	132,564.4	136,951.3	3,830,909	27.97	20,786.5	939,720	45.21
Asbestic		24,135	19,016	.79			

RUSSIA.

Next to Canada, Russia sends the largest importation of raw asbestos for manufacture in the United States. A brief account of the asbestos deposits of Russia was published [2] in this report

[1] McLeish, John, Preliminary report on the mineral production of Canada during the calendar year 1913; Canada Dept. Mines, pp. 14-16, 1914.
[2] U. S. Geol. Survey Mineral Resources, 1908, pt. 2, pp. 702-703, 1909.

for 1908. The asbestos field is a large one, lying on the eastern slope of the Ural Mountains, and the mining is chiefly in the district of Ekaterinburg. The country is flat, and the serpentine, derived apparently from pyroxenite, is deeply weathered, so that it can be easily worked in open cuts for the asbestos it contains. Owing to the strong industrial demand for asbestos, the production has been on the increase of late. It nearly doubled in the space of the five years from 1907 to 1912.

The asbestos produced annually in the Ural Mountains since 1902 is as follows: [1]

Production of asbestos in the Ural Mountains, 1903–1912.

	Short tons.		Short tons.
1903	5,785	1908	11,935
1904	8,244	1909	14,654
1905	7,985	1910	12,203
1906	8,815	1911	17,071
1907	9,741	1912	18,138

The total production of asbestos in the Ural Mountains during the 10 years ending with 1912 was 114,570 short tons. There were 20 quarries in operation in 1912.

The spot price of the Russian asbestos is between 2 rubles ($1.03) and 2 rubles and 20 kopeks ($1.18) per pood; that is, $57.21 and $65.56 per short ton.

An increasing quantity of asbestos is exported abroad, viz, 6,372 short tons in the first six months of 1913.[2]

RECENT INVESTIGATIONS CONCERNING ASBESTOS.

In studying the conduction of heat with reference to heating devices, C. P. Randolph, of the General Electric Co.'s research laboratory at Great Barrington, Mass., determined the efficiency of insulations containing asbestos and published his results in the following table: [3]

Thermal resistivity of insulations containing asbestos.

Material.	Density (pounds per cubic foot).	Temperature (° C.).	Resistivity (° C. per watt per cubic inch).
Diatomaceous earth and asbestos	20.7	400–0	550
85 per cent magnesia	13.5	400–0	600
35 per cent magnesia	29.8	0–400	480
Air-cell asbestos	15.6	0–200	400
Asbestos fire felt	7.18	200	740
	7.18	300	620
	7.18	400	430
Navy brand asbestos fire felt	19.8	500	465
	....	300	523
	....	100	793
Asbestos roll-fire fire felt	35.8	0–600	490
"C" fiber	22.9	100	518
	22.9	200	448
	22.9	300	395
	22.9	400	374
	22.9	500	358
Asbestos fiber	12.5–18.7	500	450–550
Asbestos sponge felt	34.4	100	1,020
	....	200	830

[1] Min. Jour. (London), Aug. 16, 1913, p. 778, given in poods.
[2] Chamber of Commerce Jour., London, December, 1913, p. 386.
[3] Gen. Elec. Rev., vol. 16, pp. 122-123, February, 1913.

The temperature given represents approximately the temperature of the side on which the heat flux enters, the temperature of the other side being always about 10° C.

Nature and composition of insulations containing asbestos listed in the table.—The "diatomaceous earth and asbestos" is the "nonpareil high-pressure covering" made by the Armstrong Cork Co., Pittsburgh, and is a mixture of kieselguhr (pure SiO_2) and asbestos, held together with a binder. The measurement given is the average of values found at five temperatures from 100° to 500° C., none of which vary from the mean by more than 8 per cent and which show neither a definite increase nor decrease with the temperature. The material withstands heating to 500° C., with only a slight tendency to crumble and may safely be used at the above temperature. It is self-supporting.

The material listed as "85 per cent magnesia" is made from magnesium carbonate and asbestos fiber by the Johns-Manville Co., Boston. It can not be used safely where it will be exposed continuously to temperatures above 300° C., as it disintegrates and carbon dioxide is evolved. If it is then subject to moisture, it will hydrate. It possesses no distinct temperature coefficient, and the value given for the resistivity is the average of five measurements at temperatures from 100° to 500° C. The deviation from the mean is not more than 8 per cent. The material is self-supporting.

The material listed as "35 per cent magnesia" was made by the Keasbey-Mattison Co., Ambler, Pa., and contains 35 per cent magnesium carbonate with 60 per cent fiber. It can safely be used continuously at temperatures not in excess of 300° C. It is self-supporting and is called "magnasbestos."

The "air-cell asbestos" (Johns-Mansville) is also known as "asbestocel corrugated fireproof paper." It is a self-supporting corrugated paper about $\frac{1}{32}$ inch thick, held in shape by a paper backing. The value given for the resistivity is accurate no closer than 10 per cent, as it varies greatly with different samples. This material can not be used at temperatures exceeding 200° C., as it apparently contains an organic binder.

The "asbestos fire felt" (Johns-Manville) is the lightest self-supporting material we have ever been able to secure. The manufacturer states that it is made of pure asbestos fiber loosely felted together. It has a tough outer shell and is essentially a molded material. It can be used continuously at temperatures not in excess of 300° C.

The "navy brand asbestos fire felt" is the same material as the above, except that the density is much greater, and, according to the manufacturer, it is constructed of specially selected long-fiber asbestos. It withstands temperatures of 500° C. perfectly, while heating at 500° C. for eight days does not affect appreciably the resistivity—increasing it slightly, in fact.

The "asbestos roll fire felt" (Johns-Manville) is an asbestos cloth, flexible and very tough. It is made of pure long-staple asbestos, can be used at temperatures up to 600° C., and has no distinct temperature coefficient.

The "C fiber" listed (Johns-Manville) consists of asbestos fiber with a small amount of some powdered material. It can be used at 500° C., but is not self-supporting.

The "asbestos fiber" figures relate to five samples from the Eimer-Amend Co., New York. They apparently do not change on heating to 500° C.

The "asbestos sponge felt" (Johns-Manville) consists of layers of asbestos paper each about 0.04 inch thick. The manufacturer states that it is made of asbestos fiber and finely ground sponge. It can not be used at temperatures exceeding 200° C., as it loses all strength above this [temperature]. It is a self-supporting material.

GYPSUM.

By Ralph W. Stone.

PRODUCTION.

The gypsum industry is growing at a healthy rate. In 1903 a little over 1,000,000 tons of crude gypsum were mined, in 1913 the production was well over 2,500,000 tons. In 10 years the production has fallen short of that of the preceding year only three times, the greatest setback being in 1904, when the production as reported was more than 100,000 tons less than that of 1903.

The number of short tons of raw gypsum mined in 1913 was 2,599,508, an increase of 98,751 tons over the 2,500,757 tons mined in 1912. The gypsum sold without calcining and used principally as an ingredient in Portland cement and in paint, and as land plaster, amounting to 463,136 short tons, valued at $697,066, showed an increase in quantity of 21,528 tons and in value of $73,544, as compared with 441,608 short tons, valued at $623,522, in 1912; and the material calcined for plaster increased in quantity 42,175 short tons and in value $137,370. The total value of gypsum and gypsum products produced in 1913 was $6,774,822, as compared with $6,563,908 in 1912, an increase of $210,914.

Gypsum was produced in 18 States and in Alaska. Eighty-two quarries or mines were worked. The total number of mills reporting in 1913 was 67. This includes mills using domestic material that calcined plaster as well as those that ground raw gypsum for land plaster and for other purposes. New York was the largest producer of raw gypsum; Iowa ranked second; and Michigan was third. Sales of gypsum products are credited to Illinois, Minnesota, Washington, and Wisconsin, although these States are not producers. This is rendered necessary by the trend of the gypsum industry toward assembling calcined gypsum, retarder, fiber, sand, etc., and preparing plasters for the market at local mixing mills from which they may be more readily and economically distributed to the trade territory. Sales made from mixing plants as reported to the Survey are credited to the State in which the warehouse is located.

The quantity of raw gypsum ground and sold for land plaster amounted to 54,815 short tons, valued at $95,953, in 1913, compared with 53,065 tons, valued at $107,058, in 1912, an increase in quantity of 1,750 short tons and a decrease in value of $11,105. The average price per ton at the mills received for land plaster was reported to be $1.75 in 1913, compared with $2.02 in 1912, $1.85 in 1911, and $2.05 in 1910. The quantity of raw gypsum sold for the manufacture of paint, for Portland cement, for bedding plate glass, and for various other purposes, amounted to 408,321 short tons, valued at $601,113, in 1913, compared with 388,543 short tons, valued at $516,464, in 1912, an increase in quantity of 19,778 tons and in value of $84,649. The average price of this class of products in 1913 was $1.47 per ton, compared with $1.33 in 1912, and with $1.47 in 1911. The average price of calcined gypsum products, including wall plasters, plaster of Paris, Keene's cement, and dental plaster was $3.43 per ton, the same as in 1912.

The following tables give the statistical data regarding the gypsum industry in 1912 and 1913, by States:

Production of gypsum in the United States in 1912 and 1913, by States and uses, in short tons.

1912.

State.	Number of mills reporting.	Total mined.	Sold without calcining.				Sold as calcined plaster.		Total value.
			Ground for land plaster.		For Portland cement, paint, bedding plate glass, and other purposes.				
			Quantity.	Value.	Quantity.	Value.	Quantity.	Value.	
Alaska, Arizona, Colorado, Georgia,[a] Illinois,[a] Minnesota,[a] Montana, New Mexico, South Dakota, Utah, Virginia, Washington,[a] and Wisconsin[a]	15	302,029	15,556	$40,995	46,902	$103,444	260,209	$1,170,136	$1,314,575
California	6	47,741	7,055	17,835	13,011	32,787	30,457	168,695	219,317
Iowa	6	411,186	(b)	(b)	42,443	40,824	273,116	804,804	845,628
Kansas	6	131,031	(b)	(b)	29,356	25,341	80,002	299,479	324,820
Michigan	8	384,297	10,103	9,375	53,716	52,470	243,656	559,702	621,547
Nevada	4	122,408	(b)	(b)	[c] 15,500	15,600	91,355	453,330	468,930
New York	12	506,996	10,498	23,248	170,448	224,704	274,155	993,562	1,241,514
Ohio	4	262,551	(b)	(b)	[c] 6,769	12,478	237,094	799,910	812,388
Oklahoma	8	135,074	(b)	(b)	[c] 17,334	20,904	86,741	247,714	268,618
Texas	4	160,863	(d)	(d)	(d)	(d)	[e] 131,033	356,579	356,579
Wyoming	3	36,581	....	....	....	....	26,773	89,992	89,992
Total	76	2,500,757	53,065	107,058	388,543	516,464	1,731,674	5,940,386	6,563,908

1913.

State.	Number of mills reporting.	Total mined.	Ground for land plaster: Quantity.	Value.	Portland cement, etc.: Quantity.	Value.	Calcined: Quantity.	Value.	Total value.
Alaska, Arizona, Colorado, Illinois,[a] Minnesota,[a] Montana, Nevada, Oregon, South Dakota, Utah, Virginia, Washington,[a] Wisconsin[a]	16	392,788	17,120	$35,624	54,839	$156,177	285,790	$1,335,074	$1,526,875
California	5	49,015	6,209	15,700	18,211	47,166	29,690	168,070	230,936
Iowa	5	456,031	8,757	10,266	43,300	35,285	333,357	1,112,388	1,157,939
Kansas	4	110,510	(b)	(b)	[c] 32,696	26,992	64,236	281,316	308,308
Michigan	8	423,896	9,604	10,222	51,102	45,747	278,368	665,356	721,325
New Mexico	3	43,180	....	....	(d)	(d)	[e] 39,532	102,564	102,564
New York	7	529,627	9,418	17,232	179,064	259,723	282,187	1,003,744	1,280,699
Ohio	4	254,863	(b)	(b)	[c] 7,174	11,793	208,421	683,356	695,149
Oklahoma	8	147,876	(b)	(b)	[c] 12,093	10,723	110,418	319,693	330,416
Texas	4	161,090	(d)	(d)	(d)	(d)	[e] 133,946	345,749	345,749
Wyoming	3	30,632	....	....	....	....	21,453	74,862	74,862
Total	67	2,599,508	54,815	95,953	408,321	601,113	1,773,849	6,077,756	6,774,822

[a] Produces no crude gypsum.
[b] Included with crude gypsum for Portland cement, etc.
[c] Includes some land plaster.
[d] Included with calcined gypsum.
[e] Includes some crude gypsum.

Crude gypsum mined in the United States, 1880–1913.

	Short tons.		Short tons.		Short tons.
1880	90,000	1892	256,259	1904	940,917
1881	85,000	1893	253,615	1905	1,043,202
1882	100,000	1894	239,312	1906	1,540,585
1883	90,000	1895	265,503	1907	1,751,748
1884	90,000	1896	224,254	1908	1,721,829
1885	90,405	1897	288,982	1909	2,252,785
1886	95,250	1898	291,638	1910	2,379,057
1887	95,000	1899	486,235	1911	2,323,970
1888	110,000	1900	594,462	1912	2,500,757
1889	267,769	1901	633,791	1913	2,599,508
1890	182,995	1902	816,478		
1891	208,126	1903	1,041,704		

The following table showing the marketed production of gypsum by uses in the United States from 1909 to 1913 should be of particular interest as it shows the trend of the trade. An increasing quantity of crude gypsum is being sold for Portland cement manufacture, and the average price per ton, which fell off 15 cents in 1912, increased 14 cents, making it $1.47 in 1913 or 1 cent lower than in 1911.

The quantity sold crude for land plaster has remained nearly the same for four years, but the average value per ton dropped 27 cents in 1913, or from $2.02 to $1.75. As 88 per cent of gypsum sold crude in 1913 was used for Portland cement, the average price per ton of all crude gypsum—$1.51—is close to that of the gypsum sold for Portland cement. The considerable decrease in the average price of land plaster is more than counterbalanced by the slight increase in value of the larger item.

Although the sale of calcined gypsum for dental plaster and to glass factories was 15,546 tons less in 1913 than in 1912, and that used as plaster of Paris, wall plaster, etc., increased only 1,740 tons, that sold for Portland cement and other purposes was 55,981 tons more than in 1912. The total increase in calcined gypsum sold in 1913 over that sold in 1912 was 42,175 tons. The average price per ton remained the same, $3.43. It is interesting to note that nearly 95 per cent of the calcined gypsum sold in the United States, or 1,680,157 tons, is used for wall plaster, Keene's cement, plaster of Paris, etc. About one and one-quarter million tons of this quantity represents mixed wall plaster.

Marketed production of gypsum in the United States, 1909–1913, by uses, in short tons.

Year.	Sold crude.														
	For Portland cement.			As land plaster.			For paint material.			For other purposes.			Total.		
	Quantity.	Value.	Average price per ton.	Quantity.	Value.	Average price per ton.	Quantity.	Value.	Average price per ton.	Quantity.	Value.	Average price per ton.	Quantity.	Value.	Average price per ton.
1909	260,433	$402,830	$1.55	49,581	$103,695	$2.09	(a)	(a)	....	a 31,841	$45,984	$1.44	341,855	$552,509	$1.62
1910	334,815	522,693	1.56	53,815	110,325	2.05	1,297	$2,386	$1.84	31,902	34,093	1.07	421,829	669,497	1.59
1911	327,953	484,373	1.48	52,880	97,573	1.85	(a)	(a)	....	a 6,647	7,533	1.13	387,480	589,479	1.52
1912	382,952	509,400	1.33	53,065	107,058	2.02	(a)	(a)	....	a 5,591	7,064	1.26	441,608	623,522	1.41
1913	408,221	600,913	1.47	54,815	95,953	1.75	(a)	(a)	....	100	200	2.00	463,136	697,066	1.51

Year.	Sold calcined.														
	As plaster of Paris, wall plaster, Keene's cement, etc.			For dental plaster.			To glass factories.			For Portland cement and other purposes.			Total.		
	Quantity.	Value.	Average price per ton.	Quantity.	Value.	Average price per ton.	Quantity.	Value.	Average price per ton.	Quantity.	Value.	Average price per ton.	Quantity.	Value.	Average price per ton.
1909	b 1,441,434	$5,143,934	$3.57	(b)	(b)	....	13,869	$35,208	$2.54	58,734	$175,087	$2.98	1,514,037	$5,354,229	$3.54
1910	b 1,483,046	5,599,353	3.78	115	$805	$7.00	15,943	29,185	1.83	84,565	224,189	2.65	1,583,669	5,853,532	3.70
1911	1,523,263	5,678,453	3.73	413	2,612	6.32	33,472	80,220	2.40	41,270	111,271	2.70	1,598,418	5,872,556	3.67
1912	1,678,417	5,805,999	3.46	c 3,190	15,564	4.88	21,159	52,741	2.18	25,908	66,082	2.55	1,731,674	5,940,386	3.43
1913	1,680,157	5,858,785	3.49	861	4,168	4.84	10,942	21,797	1.99	81,889	193,006	2.36	1,773,849	6,077,756	3.43

a Paint material included under "For other purposes."
b Some dental plaster and other gypsum products included with plaster.
c Includes some casting plaster.

Marketed production of gypsum in the United States, 1909–1913, in short tons.

Year.	Sold without calcining.			Sold as calcined plaster.			Total value.
	Quantity.	Value.	Average price per ton.	Quantity.	Value.	Average price per ton.	
1909	341,855	$552,509	$1.62	1,514,037	$5,354,229	$3.54	$5,906,738
1910	421,829	669,497	1.59	1,583,669	5,853,532	3.70	6,523,029
1911	387,480	589,479	1.52	1,598,418	5,872,556	3.67	6,462,035
1912	441,608	623,522	1.41	1,731,674	5,940,386	3.43	6,563,908
1913	463,136	697,066	1.51	1,773,849	6,077,756	3.43	6,774,822

IMPORTS.

Gypsum imported into the United States comes almost wholly from Nova Scotia and New Brunswick and enters the ports of the New England and North Atlantic States, over one-half of it entering the port of New York.

A marked advance in the quantity and value of imports was made in 1913. There was an increase of 34,686 tons of unground gypsum as compared with an increase of 22,283 tons in 1912, the total importation of unground gypsum in 1913 being 447,383 short tons, valued at $473,594. The figures give an average value per ton of unground gypsum of $1.058, or about 2 cents a ton higher than in 1912.

The quantity of ground or calcined gypsum imported is very small.

The following table gives such statistics concerning the imports of gypsum and gypsum products as are issued by the Bureau of Foreign and Domestic Commerce:

Gypsum imported and entered for consumption in the United States, 1909–1913, in short tons.

Year.	Unground.		Ground or calcined.		Value of manufactured plaster of Paris.	Total value.
	Quantity.	Value.	Quantity.	Value.		
1909	350,160	$376,790	3,437	$21,799	$26,548	$425,137
1910	415,321	444,263	2,414	15,072	42,776	502,111
1911	389,874	413,119	388	3,353	34,334	450,806
1912	412,697	430,183	3,702	19,709	38,589	488,481
1913	447,383	473,594	4,542	31,277	52,051	556,922

PRODUCTION IN OTHER COUNTRIES.

The following table gives the production of gypsum in the principal producing countries from 1910 to 1912, inclusive, so far as the figures are available:

Production of gypsum in principal producing countries, 1910–1912, in short tons.

Country.	1910		1911		1912	
	Quantity.	Value.	Quantity.	Value.	Quantity.	Value.
Algeria	55,751	$115,109	57,220	$119,264	(a)	(a)
Australia	19,092	47,278	15,110	37,584	(a)	(a)
Canada	b 525,246	934,446	b 518,383	993,394	b 578,458	$1,324,620
Cyprus	c 7,276	17,782	c 9,595	23,247	(a)	(a)
France	1,760,901	2,942,664	1,874,291	3,139,524	(a)	(a)
German Empire (Bavaria)	59,962	22,658	66,568	26,850	62,957	24,683
Greece	268	968	1,392	3,572	(a)	(a)
India	7,362	(d)	10,296	11,237	(a)	(a)
United Kingdom	286,226	478,095	309,886	507,191	319,526	538,191
United States	2,379,057	6,523,029	2,323,970	6,462,035	2,500,757	6,563,908

a Data not yet available. b Quantity marketed. c Exports. d Total value not stated.

TRADE AND MANUFACTURING CONDITIONS.

A number of producers reported business conditions as practically the same in 1913 as in 1912; a small number found trade poorer because of drought and poor crops; nine producers considered it better. The average price of raw gypsum throughout the country advanced 10 cents in 1913 over that of 1912, while the average price of calcined material remained the same. Four new mills were in operation in 1913, 1 each in California, New York, Oklahoma, and Oregon, and 3 new mills were reported under construction in 1913, 1 each in California, Colorado, and South Dakota.

There were 82 active gypsum mines, including quarries and pits, in the United States in 1913, 1 being in Alaska. These mines supplied 67 plants in the United States. Of these plants 45 used gypsum, 9 used gypsite, 12 used both gypsum and gypsite, and 1 reported the use of selenite crystals. Four plants produced ground gypsum only, and 63 plants calcined some of their product. Of these calcining plants 57 were equipped with kettles, 3 with rotary kilns, and 3 with stationary kilns. There were 181 calcining kettles in operation mainly 8 and 10 feet in diameter. The total daily capacity for all these kettles as reported was 14,344 short tons, giving an average of 79 tons per kettle.

On comparing these statistics with those of 1912, when there were 76 gypsum plants in operation, 69 of which were calcining plants and 63 of which were equipped with a total of 192 kettles, it is found from the producers' reports that there was a net loss of 9 plants, a loss of 6 calcining plants, and a net loss of 11 kettles. There was an apparent loss of 1,325 tons in the total daily capacity and a loss of 3 tons a day in the average daily capacity per kettle. The loss in number of calcining plants was due in part, particularly in New York, to the replacement of several small mills by one of larger capacity. These summaries do not include the equipment of several plants termed "mixing mills," which are auxiliary mills established at commercial centers, such as Chicago, Ill., Milwaukee and Superior, Wis., Minneapolis and St. Paul, Minn., and Cleveland, Ohio. These mills do no calcining, but receive the calcined plaster and prepare it for the market in various forms by the addition of fiber, retarder, and sand.

Keenes cement was made at 5 of the gypsum plants in 1913, a loss of 1 from the number of plants reporting the manufacture of this cement in 1912.

The fuel used at 43 calcining plants was coal; oil was used at 17 plants, wood at 1 plant, and coal and oil at 2 plants. The oil-burning plants are in Arizona, California, Kansas, Nevada, New Mexico, Oklahoma, Oregon, Texas, and Washington.

GYPSUM PRODUCTS.

The bulk of the gypsum produced in the United States, as well as in foreign countries, is manufactured by grinding and by partial or complete calcination into the various plasters, such as plaster of Paris, molding and casting plaster, stucco, so-called cement plaster or hard wall plaster, flooring plaster, hard-finish plaster, etc. Refined grades of gypsum plaster are used in dental work, also as cement for plate glass during grinding, for making pottery molds, stereotype molds, molds for rubber stamps, and as an ingredient in various patent cements. A steadily increasing quantity of gypsum is used in the raw state as a retarder in Portland cement. Considerable quantities are ground without burning and used as land plaster or fertilizer; smaller quantities are used in the manufacture of paint, wall tints, crayons, paper, imitation meerschaum and ivory, and as an adulterant. The pure white or tinted, fine-grained, massive form, known as alabaster, is much used by sculptors for interior ornamentation—less, however, in this country than abroad.

For plaster of Paris and for dental molding and casting plasters, a high grade of rock gypsum, ground very fine, is required, and the product is not mixed with any foreign substance or retarder, but is used in the pure or "neat" condition. Such plasters are quick setting and are usually white in color. Much of the so-called cement plaster is made directly from gypsite, an impure unconsolidated earthy or sandy form of gypsum, which in many places is found to contain a suitable percentage of foreign material, so that the addition of a retarder is not necessary to effect a slow set. Where gypsite deposits are not available, cement or hard wall plasters are made from rock gypsum by the addition of various mineral or organic retarders. A large part of the structural plaster now produced is used in specially prepared conditions that appeal to the builder on account of their convenience. A plaster board is pressed from plaster interlaminated with sheets of thin cardboard, felt, or wood. This plaster board is furnished in thin sheets of different sizes—as $\frac{1}{4}$, $\frac{3}{8}$, and $\frac{1}{2}$ inch thick by 32 by 36 inches, comprising 8 square feet of surface; $\frac{3}{8}$ inch thick by 27 by 48 inches, equivalent to 1 square yard; also 32 by 24 inches, 32 by 18 inches, and 24 by 18 inches. This board is designed to be nailed directly to the studding in place of lath and to receive a coat of wall plaster directly on its outer surface. Fibered plaster is molded into both solid and hollow blocks and tiles, which are used in partitions and interior construction, and these, as well as the plaster board, have been proved to be of value as fire retarders. Gypsum tile or partition blocks are commonly 12 inches wide, but vary in thickness from 2 to 8 inches. They are made 24 and 30 inches long, except 8-inch blocks, which are 15 inches long. Gypsum tiles are lighter than clay tiles; they are straight and true; they can be cut by a handsaw; and on account of light weight and large size they can be laid rapidly.

The employment of gypsum wall plasters has assumed noteworthy proportions in the last few years. Plaster manufacture represents the most important single application of gypsum in this country. Hard wall plasters consist of plaster of Paris and some fiber, like hair or wood fiber, with the addition of a retarder. They may contain either hydrated lime or clay to increase their plasticity and spreading properties. This is not necessary with plasters made from gypsite, because the raw material contains considerable quantities of clay. Hard wall plasters are of two general grades, one having a brown or gray coat, and the other a white or tinted finish coat. They are somewhat more expensive than lump lime and inferior to it in deadening sound, but the material is delivered to the work in a more convenient form to handle than lump lime, and by reason of its more rapid set it gives opportunity to complete a job in less time.

A number of hard-finish anhydrous plasters are also made from gypsum, the most prominent representative of the group being Keenes cement, which was originally manufactured under English patents that have expired. The name "Keenes" is now applied by several manufacturers in the United States to their product, made by calcining very pure rock gypsum in lump form at a red heat and adding to the resulting dehydrated lime sulphate a substance like alum or borax. Keenes cement makes a very white and very hard plaster. It is used as a backing and surface for artificial marble and for ornamental moldings and castings and is capable of taking a high polish. Its use as a wall plaster is increasing, but when so used it may be mixed with lime. Flooring plaster is another example of this type of plaster. Gypsum is used in the manufacture of calcimines, in water paint and tints, and, to a considerable extent, as an ingredient in dry colors, notably in Venetian reds. When used in excess in mixed paints, it is regarded as an adulterant. The unburned or the dead-burned forms of gypsum may be used to a certain extent with oil paints, because they are chemically inactive. The partly dehydrated form is not suitable for such use, but can be used with water.

The Government has not undertaken a thorough investigation of gypsum products nor made any extensive tests of gypsum plasters. It is hoped that when this is done by the Bureau of Standards definite data may be obtained regarding some of the properties which are now in doubt. It is maintained by some that the strength of gypsum plaster decreases with time. The change, if any, is probably so slight that it might be necessary to extend an inquiry on this point over several years to obtain definite results. So long as gypsum plasters properly applied have proved perfectly satisfactory after many years, this point would seem not to be of commercial interest. Whether gypsum plaster has an injurious effect on metal lath has not been demonstrated conclusively, so far as the writer is aware.

In a letter to the Survey, discussing certain properties of gypsum plaster and lime plaster, the Pittsburgh branch of the Bureau of Standards, Department of Commerce, says:

It is quite possible that some hard wall plasters containing a fiber retarder and a considerable percentage of clay or hydrated lime possess a greater spreading power than lime plaster; but the spreading power of a plaster, by which we assume is meant the number of square yards which can be covered per unit of weight, is not of particular importance, because, first, the spreading power should be based on unit of cost of material rather than on unit of weight; and second, the cost of application of a wall plaster being ordinarily four to five times the cost of the raw material, it follows that any slight variation in the cost of the material would not make any particular difference in the cost of the wall.

While it is true that hard wall plasters shrink less on drying than lime plasters, this can hardly be called a point in their favor, because lime plasters have proven entirely satisfactory.

The ability to unite with coloring agents, so as to produce any desired tint, while true of gypsum plaster, is equally true of lime, the facts of the matter being that the manufacturers of hard wall plaster have put on the market plasters already tinted, while the lime manufacturers have not. It will also be noted in this connection that with the lime plaster it is possible to obtain a glossy finish, which is not possible with the hard wall plaster. Moreover, on account of the quick setting of the ordinary hard wall plasters, it is difficult to obtain an even surface, which would add greatly to the beauty of the tint. For this reason a number of architects specify that tinted surfaces must be finished with a 7-foot straight edge, and it has been found impossible to use this on a hard wall plaster.

Although gypsum plaster is not suited to many kinds of masonry work, it is recommended by the producers for use as mortar in setting gypsum block and tile in interior partitions. Gypsum plaster has been used extensively for the exterior finish of temporary structures, such as exposition buildings; it should be used successfully for permanent exterior construction in arid climates; it is so used in southern California, and might be also in parts of Utah, Nevada, Arizona, and New Mexico. Gypsum blocks are used for exterior construction in places in Utah and Arizona.

OCCURRENCE OF GYPSUM AND GYPSITE IN THE UNITED STATES.

The following pages concerning the occurrence of gypsum in the various States have been extracted verbatim from Federal and State reports and other sources, or rewritten by the present writer to suit the needs of this report.

Alaska.—The following notes on gypsum mining in Alaska have been prepared by E. F. Burchard, of the United States Geological Survey, who visited the gypsum mines in October, 1912:

The only extensive gypsum deposit known in southeastern Alaska is operated by the Pacific Coast Gypsum Co. and is situated in the eastern part of Chichagof Island, about a mile from Iyoukeen Cove. The limits of the deposit have not yet been ascertained. At the surface the deposit is covered by gravel except near the shaft house, and no footwall nor hanging wall has been encountered in the mine workings. Several solution channels filled with gravel more or less cemented have been encountered in mining. The gravel is of the same character as that in the bed of Gypsum Creek. The gravel-filled channels extend below the 160-foot level. One channel has been tunneled for 35 feet without being cut through. Thin dikes of basaltic rock cut the gypsum beds, and a vein of anhydrite ranging in thickness from 6 inches to more than 10 feet has been encountered in the lower workings. This anhydrite is much harder to drill than the inclosing gypsum, and it is left in the mine. The gypsum is generally of a light bluish-gray color, although some is white, and occurs in massive beds, which dip 30°–60° NE. The main body of gypsum is of a high degree of purity.

The mine shaft is 160 feet deep, with a 26-foot sump. The first level is at 75 feet and the second at 160 feet. The general trend of the gypsum deposit is in a direction slightly north of west, and the levels extend for 750 feet east and west and 270 feet north and south, with the shaft near the middle of the exploited area. Altogether the underground workings are reported to measure probably 1 mile.[1] Overhand stoping is the method employed in mining, and considerable broken gypsum rock is stored in the stopes.

The gypsum is hoisted to rock bins of 1,200 tons capacity, from which it is dumped into tramcars and drawn by a steam locomotive to the wharf. Owing to a recent collapse of the old wharf, about 2,500 tons of gypsum rock which had been stored in the bunkers were lost. A new wharf was under construction in 1912. It will carry bunkers near the middle instead of at the outer end, as on the old one, but the tramway will extend the whole length of the wharf. The production of gypsum from this mine, which began in 1906, was slightly curtailed during 1912, owing to the difficulty in loading rock while the new wharf was under construction; but a much larger output is assured for 1913. Shipments of crude gypsum are made by barges to Tacoma, Wash., where the material is calcined and manufactured into wall plaster of various grades in the company's plaster mill.

Adjoining on the east the claims now being worked for gypsum by the Pacific Coast Gypsum Co. and extending to the shore of Chatham Strait are other claims which have been located on reported deposits of gypsum.

Arizona.—Gypsum occurs at several localities in southern Arizona, the following being noteworthy: Navajo County, Fort Apache Reservation, Snowflake, Winslow, and Woodruff; Cochise and Pinal counties, in the low hills along the course of San Pedro River, and at Douglas; Pima County, in the foothills of the Santa Catalina Mountains north of Tucson, and in Santa Rita Mountains southeast of Tucson. The gypsum deposits in the Santa Rita Mountains are of considerable thickness and extent. The occurrence on Fort Apache Reservation consists of large selenite crystals. Gypsum has been quarried at Douglas since 1908 and at Winslow since 1909.

Arkansas.—Large deposits of gypsum are said to exist at Tokie, in Pike County, but its fitness for plaster can not be definitely stated. Extensive beds 15 inches to 15 feet thick occur in Logan County in the bank of Little Missouri River in T. 8 N., R. 25 W.

Colorado.—Gypsum-bearing localities in Colorado occur at intervals from the northern to the southern border of the State along the eastern foothills of the Rocky Mountains and also near Arkansas River in Custer County, on Gunnison River in Delta and Montrose counties, along Grand and Eagle rivers in Eagle County, and along Frying Pan Creek in Eagle and Pitkin counties. The gypsum varies in thickness up to 30 feet; much of it is good quality; and the supply may well be regarded as very great. Beds have also been prospected on Bear Creek, near Morrison, and 8 miles southeast of Morrison on Deer Creek. Quarries have been worked in the past at Ruedi, near Perry Park, and at the Garden of the Gods, near Colorado City. In 1913 gypsum was quarried at Loveland, near Coaldale, and at Stone City. Two mills were operated, one at Loveland and one at Portland.

California.—Gypsum is widely distributed in the Tertiary rocks of California. It is found throughout nearly all the coast ranges, particularly south of San Francisco Bay, in the foothills of the Great Valley, in the valleys of southern California, and in the Palen and Maria mountains. In the Palen Mountains the deposits are probably of Paleozoic or earlier age. Deposits are known to occur in

[1] These approximate measurements were furnished to the Survey by Mr. T. H. George, superintendent of the mine.

the counties of Fresno, Ventura, Kings, Monterey, Kern, San Luis Obispo, Santa Barbara, Los Angeles, San Bernardino, Riverside, and Orange. They are generally shallow and of the variety known as gypsite.

The principal deposits are located on Santa Barbara Creek, French Point, Point Sal, Castaic, Palmdale, in the Pelen Mountains, in the Maria Mountains, at Mecca, and at other places in the Colorado Desert.

Gypsum has been quarried in Fresno County, at Coalinga and Mendota; Kern County near Fellows, Mohave, McKittrick, and Bakersfield; Los Angeles County at Palmdale and Castaic; Monterey County, King City; Riverside County, Corona; San Bernardino County, Amboy; and Ventura County, Fillmore.

In 1913 gypsum was ground for wall plaster or land plaster at five mills in California, as follows: One each at Amboy, Los Angeles, McKittrick, Bakersfield, and Fillmore.

Florida.—A deposit of soft gypsum, probably gypsite, occurs 6 miles west of Panasoffkee, Sumter County, in a low-lying area known as Bear Island. The gypsum is 6 to 7 feet thick and contains bowlders of impure limestone. It is not used.

Idaho.—Gypsum occurs in Washington County, Idaho, in the bluffs overlooking Snake River about 10 miles northeast of Huntington, Oreg., which is the nearest town. Short tunnels and prospect pits have shown that the material consists of lenticular masses of rock gypsum banded with grayish and greenish material, possibly chloritic. Development discloses thicknesses ranging from 6 to 30 feet or more. The hill slopes are too steep and there is too much stripping necessary to render extensive open quarrying practicable, but the material can be obtained by mining. A railroad that connects with the Oregon Short Line at Huntington passes down the Oregon side of Snake River within 2,000 feet of the gypsum outcrop and near enough for the rock to be carried across the river on an aerial cableway. The deposits here are apparently of the same series that occur on the Oregon side of Snake River, a few miles farther south. The Washington County gypsum deposits are held by the Northwest Gypsum Plaster Co., of Huntington, Oreg.

Iowa.—Gypsum in Iowa is confined mainly to a single area of 60 to 70 square miles near Fort Dodge, Webster County. It occurs in one bed, which varies from 10 to 25 feet in thickness, and is probably of Permian age. The bed is practically horizontal and at least 40 square miles of it may be regarded as available for use. The average thickness of the gypsum suitable for plaster is 10 feet, and the yield per acre of a bed of this thickness is 30,000 tons. Except immediately along Des Moines River and its tributaries, the bed is covered by a mantle of glacial drift 60 to 80 feet in thickness.

The first gypsum mill in Webster County was erected in 1872. Operators along the river strip off the drift and quarry the gypsum. Back on the prairie the bed is reached by shafts. The Iowa gypsum is extensively worked, 5 plaster mills being in operation in Webster County in 1913 and 1 paint mill that uses gypsum.

Gypsum of Mississippian age and associated with anhydrite occurs more than 500 feet below the surface at Centerville, Appanoose County. Whether or not it is of economic importance is undetermined.

Kansas.—The area in which gypsum is found in Kansas is an irregular belt extending northeast and southwest across the State. It is naturally divided into three districts, which, from the important centers of manufacture, may be named the northern or Blue Rapids area, in Marshall County; the central or Gypsum City area, in Dickinson and Saline counties; and the southern or Medicine Lodge area, in Barber and Comanche counties. A number of small intermediate areas have been developed, which connect the three main areas more or less closely.

The deposits in the northern area are in the lowest part of the Permian rocks, those of the central area are higher in the system, and those near Medicine Lodge are near the top of the Permian as exposed in Kansas. The beds in the southern area are the continuation of the gypsum hills of Oklahoma.

Both rock gypsum and gypsite or gypsum earth occur in extensive deposits. The rock-gypsum beds are so vast in extent as to be almost inexhaustible, and only those favorably situated with respect to transportation are developed. Near Blue Rapids the bed is 8 to 9 feet thick; near Gypsum City, 5 to 14 feet; at Dillon 18 feet; and in the Medicine Lodge area beds vary from 3 to 20 feet thick. Some of the rock gypsum is suited to the manufacture of fine grades of plaster of Paris.

Gypsite is found in low, swampy ground in central Kansas in deposits several acres in extent and up to 18 feet deep. It is particularly adapted to wall and cement plasters, but many of the gypsite deposits have been exhausted. The first gypsum mill in Kansas was erected at Blue Rapids in 1872. Four mills were operated in Kansas in 1913, 3 at Blue Rapids, and 1 at Medicine Lodge. The last-named plant produces Keene's cement.

Louisiana.—Thick beds of gypsum have been encountered in deep drill holes at St. Charles, Calcasieu Parish, associated with sulphur, and at Pine Prairie, St. Landry Parish. Gypsum also occurs at Rayburn's salt work, Bienville Parish.

Michigan.—The history of Michigan's gypsum industry begins at an early date. Rock gypsum was known to the Indians and fur traders and had been used for making plaster before the first gypsum mill was erected in 1841. This mill was on Plaster Creek between Grandville and Grand Rapids and in one of the areas that produces to this day.

The principal gypsum areas are: (1) In the vicinity of Grand Rapids near the western side of the Lower Peninsular, and (2) at Alabaster, north of Saginaw Bay on Lake Huron. The deposits occur in the Michigan formation, the lower formation of the Grand Rapids group, of Mississippian age, which outcrops as a ring around the interior coal basin. At Grand Rapids there is an upper ledge 6 feet thick separated by 1 foot of shale from a lower ledge 12 feet thick; and at Grandville, 5 miles southwest, two ledges 11 and 14 feet thick are separated by 4 feet of limestone. The gypsum is very pure and is taken from quarries and underground workings.

At Alabaster an extensive exposure of gypsum 23 feet thick has been worked back from its original outcrop on the shore of Lake Michigan for more than a quarter of a mile, the quarry now being very large. A 10-foot bowlder-clay cover is stripped and the rock is blasted from a horseshoe shaped face. The bottom of the quarry is about 15 feet above the lake level. Several thin beds underlie the quarry within a depth of 90 feet. Gypsum has been found in a number of wells in northern Arenac County and southeast Ogemaw County in the Monroe formation of the Silurian; in Mackinac County, near Point Aux Chenes, 7 miles west of St. Ignace, and in the vicinity of St. Martins Bay. Eight plants were operated in 1913 in Michigan, 7 being near Grand Rapids and 1 at Alabaster.

Montana.—Rock gypsum deposits occur in the eastern foothills of the main Rocky Mountain Range in Cascade, Carbon, and other counties of Montana. There are several beds of gypsum ranging from a few feet to as much as 50 feet in thickness. They occur intercalated with red and green shales and limestones of Mississippian age. Mills are located at Armington, Bridger, and Great Falls, but only at Great Falls was there any production in 1913. A gypsum claim has been developed at Limespur, Jefferson County. The rock is favorably situated with respect to transportation. In many places the undeveloped gypsum beds are within 5 miles of railroads. The supply far exceeds any demand that can be expected in many years.

Nevada.—The best-known gypsum deposits are in northwestern Nevada, near Moundhouse and Lovelocks. Large deposits also occur in southern Nevada, in the Spring Mountians and other ranges to the south. In Esmeralda County there are large bodies near Hawthorne, and an extensive bed is exposed at the Ludwig mine in the Yerington district, Lyon County.

The gypsum near Moundhouse lies on the east flank af the Virginia Mountains in the form of a thick bed standing nearly vertical. Its greatest width is 390 feet. The main deposit is cut off abruptly at one end by diorite and pinches out in the other direction in a few hundred yards. The gypsum and its inclosing limestone are entirely surrounded by diorite.

The deposit at Lovelocks is pure white or grayish white rock gypsum, which at its broadest outcrop covers a hill slope for some 1,200 feet. At the point of broadest exposure the gypsum is folded into an anticline and its measurement is difficult, but probably it nowhere exceeds 200 feet. At another place in the vicinity the gypsum is 130 feet thick.

Gypsum, in white and red lenticular masses ranging up to 75 feet in thickness, occurs in Carboniferous strata in the Spring Mountains, and as white granular layers it is found in lake beds of Tertiary or later age widely distributed in the State.

Three mills manufactured plaster in Nevada in 1913, 1 at Moundhouse, 1 at Reno, and 1 at Arden; and gypsum was quarried at Bouse, Clark County, for shipment to California.

New Mexico.—The "Red Beds," which contain rock gpysum in many places, occur in large areas in New Mexico. The largest area is in eastern New Mexico, principally in the valley of the Pecos, but it connects with the area entering the State along Canadian River from northern Texas, Oklahoma, and Kansas. The central division of the "Red Beds" area is drained by the Rio Grande and its tributaries, and there is also an area in western New Mexico in the region of the Zuni Mountains. Along the western base of Sierra Nacimiento in Sandoval County there are immense beds of massive gypsum. At Gallina the gypsum bed is over 40 feet thick, at Senorita it measures 54 feet, and at San Miguel copper mine the total thickness of massive white gypsum in a single bed is 60 feet. A bed of practically pure gypsum of this thickness extending for miles would be considered a practically inexhaustible resource, but at the head of a tributary to Rio Salado, about 3 miles southeast of Ojo del Espiritu Santo, the gypsum bed reaches a maximum thickness of about 100 feet. In addition to the areas of bedded gypsum there are accumulations of white gypsum sands in Otero County. These sands form dunes which cover an area of about 270 miles. They are deposited on a plain and so form a slightly elevated area. The highest dunes are about 50 feet. The sand is almost snow-white and the eastern edge of the deposit is sharp and abrupt like a snow drift. A small deposit of gypsum sands occurs about 10 miles north of Torrance near Pinoswells, Torrance County. Development of the vast resources of gypsum has been retarded by the limited markets and the long distances that the raw or manufactured materials must be transported. Railroad facilities are lacking to many of the gypsum deposits in this State. In 1913 plaster mills were operated at Acme, Chaves County, at Ancho, Lincoln County, and at Oriental, Eddy County; but the mill at White Sands was idle. Gypsum was quarried for use in Portland cement at El Rito.

New York.—The gypsum in New York State occurs as rock gypsum interbedded with shales and shaly limestones of the Salina formation. Several gypsum beds, separated by shale, usually occur in any given section. They are lenticular in shape, but of such horizontal extent that in any given quarry they are usually of practically uniform thickness. Those that are worked vary from 4 to 10 feet in thickness, but at Fayetteville a 30-foot bed is exposed. Underground mines furnish most of the gypsum in the western part of the State, but where the heavier beds outcrop near Syracuse they are quarried. The area in which the gypsum-bearing formations are found extends more than 150 miles through the central part of the State, the workable portion of the belt including parts of Madison, Onondaga, Cayuga, Ontario, Genesee, Monroe, Livingston, and Erie counties. The center of the industry is now in the western part of the State, and whereas the output was formerly marketed largely as raw gypsum, principally for agricultural purposes, it is now converted mainly into wall plasters, plaster board, and gypsum tile or partition blocks in plants operated in connection with the mines.

Large quantities of crude gysum are shipped to Portland cement mills in New York and Pennsylvania. Although the annual production is more than 500,000 tons, the exhaustion of the New York gypsum deposit can not be foreseen, as an area 150 miles long and 10 to 20 miles wide is underlain by at least 4 feet of rock gypsum.

Gypsum was quarried in 1913 at Union Springs, Cayuga County; Akron, Erie County; Oakfield, Genesee County; Caledonia, Livingston County; Garbutt, Monroe County; Jamesville and Fayetteville, Onondaga County. Seven mills reported production of gypsum in either the raw or the calcined condition in New York State in 1913. These mills are located as follows: One at Fayetteville, 2 at Garbutt, 1 at Jamesville, 2 at Oakfield, and 1 at Wheatland.

Ohio.—The gypsum deposits of Ohio which have been prospected or developed consist of beds of rock gypsum occurring in the northwestern part of the State in the Silurian system. Some of the deposits are exposed close to the level of the waters of Sandusky Bay, and have been known since the first settlements were made on its northern shore. An area of 1,500 to 2,000 acres of land has been thoroughly prospected with a drill, and it has been shown that there are from 150 to 200 acres of workable gypsum in beds 3 to 7 feet in thickness in Portage Township, Ottawa County. Considerable water is encountered in the workings, so that it is necessary to use pumps. Four plants were operated in Ohio in 1913, three of them being in the area north of Sandusky Bay, near Port Clinton. On the south shore of the bay, about 2½ miles northwest of the town of Castalia, another area of workable gypsum has been developed. Gypsum has been encountered also in many deep borings in northern and central Ohio.

Oklahoma.—The gypsum in Oklahoma may be considered as occurring in four regions: (1) The Kay County region; (2) the main line of gypsum hills, extending from Canadian County northwest through Kingfisher, Blaine, Major, Woodward, Woods, and Harper counties to the Kansas line; (3) the second gypsum hills, parallel with the main gypsum hills, and from 50 to 70 miles farther southwest, which extend from the Keechi Hills, in southeastern Caddo County, northwestward through Washita, Custer, Dewey, and Ellis counties; and (4) the southwestern region, occupying part of Greer, Jackson, Harmon, and Beckham counties. The deposits in Kay County consist of soft, earthy gypsum, or gypsite. In the other three regions rock gypsum predominates, although there are numerous localities where gypsite occurs in workable bodies. In the main line of gypsum hills there are three distinguishable beds of gypsum which extend for many miles. These vary from 4 to 30 feet in thickness, and one bed more than 50 feet thick of massive white gypsum, with only one parting 5 to 7 feet thick, has been found. In the second line of hills the gypsum beds are more irregular and are very thin in the northwestern and the southeastern portions of the area, but localities are known where 60 feet of massive gypsum are exposed.

The southwestern region contains beds of rock gypsum that maintain a fairly constant thickness of 18 to 20 feet for many miles. The reserves of rock gypsum in Oklahoma are enormous, but the gypsite deposits adjacent to the railways are limited. In this State materials for plaster are obtained from open quarries rather than from mines. The supply for wall plaster has been drawn largely from gypsite deposits which are comparatively soon worked out. New deposits are, however, being discovered from time to time. Some ledges of rock gypsum are being quarried, but gypsite, so long as it lasts, will probably be used for wall plasters because it costs less to quarry since it can be taken up rapidly by means of scrapers instead of requiring blasting and breaking, and because the material is often found to contain nearly, if not exactly, the right proportions of silica and other impurities to make a good wall plaster when calcined, and therefore does not require the addition of retarders. Gypsite that is unusually impure or that contains considerable surface soil may be brought up to the requisite standard by the addition of rock gypsum.

Eight plants produced gypsum, including that ground for land plaster, for wall plaster, and for plaster of Paris in Oklahoma in 1913 as follows: One each at Acme, Bickford, Eldorado, Homestead, Okarche, Okeene, Southard, and Watonga.

Oregon.—Gypsum occurs in Oregon in two localities. One is on the eastern border of the State near the middle point of the boundary line on a ridge dividing Burnt River and Snake River at Gypsum, about 6 miles north of Huntington. The gypsum occurs here as elongated lenses, in places 10 to 40 feet thick, interstratified in a sedimentary series of limestone and shale with a few intercalated strata of volcanic tuffs. The gypsum is in part white and crystalline, but contains in places thin strata and films of greenish chloritic mineral. It is worked at present by open quarrying. The rock is carried down to the calcining plant on Snake River by means of an aerial cableway 6,100 feet long. The weight of loaded buckets on the cableway develops 50 horsepower for operating an air compressor and pneumatic tools at the quarry. The kettles are fired with oil.

Another deposit of gypsum occurs in Crook County, near the town of Bend, but it has not yet been developed. It is reported that this material is in part gypsite and that it has been used as fertilizer.

South Dakota.—In the Black Hills uplift there is brought to the surface an elliptical outcrop of the "Red Beds" surrounding the high ridges and plateaus of the central portion of the Black Hills. The hook-shaped outcrop zone in South Dakota is over 140 miles long and has an average width of 3 miles, except in a few districts where the rocks dip deeply and where it is much narrower. The formation consists mainly of red, sandy shale, with included beds of gypsum at various horizons, some of which are continuous for long distances and others are of local occurrence. The thickness of the deposits varies greatly, but in some districts over 30 feet of pure white gypsum occur, and nearly throughout the outcrop of the formation the deposits are of sufficient thickness and extent to have commercial value. A bed at Hot Springs is 33½ feet thick, and north of Edgemont a 25-foot bed is continuous for many miles. The average thickness about Rapid is 10 feet. The gypsum beds are convenient of access from Hot Springs, Rapid, Spearfish, Newcastle, and Edgemont. A plaster mill was formerly operated at Hot Springs, but the only operators reporting in 1913 were one plant near Rapid and one at Black Hawk.

Texas.—The largest area in Texas containing deposits of gypsum lies east of the foot of the Llano Estacado, in northern Texas. The beds have an approximately northeast strike and extend from Red River to the Colorado in an irregular line, the sinuosities of which are produced by the valleys of the eastward-flowing streams. This belt is a continuation of the deposits in Oklahoma.

In the eastern part of El Paso County, to the east of the Guadalupe Mountains, there is an area of gypsum which extends beyond the border of the State northward into New Mexico. It lies north of the Texas & Pacific Railway and west of Pecos River. In a few localities this great plain of gypsum is overlain by beds of later limestone and conglomerate. The gypsum is conspicuously exposed along the course of Delaware Creek, a stream rising in the foothills of the Guadalupe Mountains and flowing eastward into the Pecos.

In the Malone Mountains, in El Paso County, there is a third area which contains notable deposits of rock gypsum. This locality has the advantage of being situated near the Southern Pacific Railroad. Extensive deposits of good alabaster in beds up to 4 feet thick are reported at Kiowa Peak in the northwestern corner of Stonewall County. The only area exploited for gypsum at present is in northern Texas. Four plants, 3 at Acme and 1 at Hamlin, were engaged in the manufacture of plaster in 1913. Keenes cement is made at one of these plants.

Utah.—The more important known deposits in Utah occur in the central and southern portions of the State. They are all of the rock-gypsum type, except the one near Fillmore, which is composed of selenite crystals and gypsum sand blown from dry lakes into dunes. Important localities are as follows: (1) Iron County, where enormous deposits are reported. (2) Emery and Wayne counties, along the west side of the San Rafael Swell, where gypsum beds 4 to 50 feet thick are continuous for many miles. The area contains within 2 miles of the outcrop about 10 billion tons of good rock gypsum. (3) Juab County, large deposits near Nephi and Levan. The Nephi gypsum deposit forms the entire mass of a prominent spur at the entrance to Salt Creek valley. Two beds, one 55 and the other 65 feet thick, are high-grade gypsum, and a 75-foot bed that separates them is only less pure. (4) Millard County, vast deposit at White Mountain near Fillmore. Mounds and dunes of gypsum and sand crystals which constitute this deposit are estimated to contain 450,000 tons. (5) Wayne County, in South Wash. The extensive deposit of rock gypsum and gypsum sand in Wayne County is said to extend unbrokenly for about 2 miles. Deposits are also known in Kane County, near Kanab; in Grand County, between Grand River and the La Sal Mountains; in Sanpete County, near Gunnison; in the eastern part of Washington County, between Duck Lake and Rockville; and at other places. In 1913, 3 mills produced plaster in Utah, 1 at Nephi and 2 at Sigurd. Keenes cement is made at one of the mills at Sigurd.

Virginia.—All the workable gypsum deposits of Virginia occur in Washington and Smyth counties in the valley of the North Fork of Holston River. The area within which the known deposits are located is a narrow belt 16 miles in length, extending from a short distance southwest of Saltville to a point about 3 miles west of Chatham Hill post office.

The material occurs as rock gypsum intimately associated with salt deposits and interbedded with shale and shaly limestone of Carboniferous age. The gypsum-bearing shales outcrop around a syncline, and the dip of the gypsum beds is so high as to require mining except at the surface. The bodies of gypsum are large masses and lenses interbedded with red and gray clays. The beds of gypsum average 30 feet in thickness at the localities at which they are now worked. The rocks of the district dip at a high angle, usually between 25° and 45°, so that certain wells which have been drilled are in the gypsum for long distances; and accordingly great thicknesses of gypsum have been erroneously reported, because the inclination of the deposits was not taken into account.

The development of the gypsum industry in this area has been governed almost entirely by transportation facilities. The deposits at Saltville and Plasterco, which are on a branch of the Norfolk & Western Railway, furnished the principal output up to 1907. Recently a railroad 4 miles long has been built to North Holston, and the gypsum deposits at this point have been developed by shaft mining.

In 1913 two plaster mills reported production from Virginia, one at North Holston and one at Plasterco.

Wyoming.—The gypsum deposits of economic importance in Wyoming occur in the "Red Beds," which consist largely of red sandstone and shale. This formation outcrops about the base of many mountain ranges or is exposed by erosion as the core of small or secondary folds. The areas where gypsum deposits are known to occur are the Rawlins uplift, Freezeout Hills, Grand Canyon of the Platte, Black Hills, and Laramie, Medicine Bow, Shirley, Seminoe, Ferris, Rattlesnake, Bighorn, Absaroka, Prior, Wind River, Gros Ventre, and Salt Creek mountains. In all there are about 1,500 miles of the gypsum-bearing formation exposed, and throughout this extent there are generally present beds of gypsum ranging from 5 to 20 feet thick, and in places reaching thicknesses of 30 to 50 feet. The material is generally found to be of excellent quality. Besides the rock gypsum, there are secondary surficial deposits of gypsite, which occur in depressions below the gypsum outcrops.

Three mills produced plaster in Wyoming in 1913. Two of them at Laramie utilized gypsite as raw material and one at Red Butte, 10 miles south of Laramie, worked rock gypsum and gypsite.

FLUORSPAR AND CRYOLITE.

By Ernest F. Burchard.

FLUORSPAR.

PRODUCTION.

One of the noteworthy features of the fluorspar industry in 1913 was the slight decrease both in the quantity of domestic spar sold and in the quantity of spar imported. The sales of gravel spar to open-hearth steel furnaces slightly exceeded those in 1912, but it is probable that, owing to the depression in the manufacture of iron and steel during the latter part of 1913, less spar was actually consumed than in 1912 and that considerable stocks were accumulated. This condition foreshadows a greater decrease in production in 1914. The first shipments were reported from a recently opened fluorspar vein at Wagon Wheel Gap, Colo., and shipments were reported for the first time since 1908 from Arizona. A considerable revival of activity in Kentucky fluorspar mines took place during 1913.

The total quantity of domestic fluorspar reported to the Survey as marketed in 1913 was 115,580 short tons, valued at $736,286, as compared with 116,545 short tons, valued at $769,163, marketed in 1912, a decrease in quantity of 965 short tons and in value of $32,877. This decrease represents only 0.83 per cent of the quantity but about 4.27 per cent of the value of the product marketed in 1912. The production and sales of fluorspar in 1912 were by far the greatest ever recorded, and those of 1913 make a close second. The average price per ton for the whole country, considering all grades of fluorspar—gravel, lump, and ground—was approximately $6.37 in 1913, as compared with $6.60 in 1912, a decrease of 23 cents a ton, or nearly 3.5 per cent. This value represents the selling price on board cars or barges at railroad or water shipping points; and, with reference to the product from Colorado, New Mexico, and New Hampshire, the price reported for much of the spar includes the cost of a long wagon haul—$1.50 to $3 a ton. In Illinois the principal producing mines are near river transportation and many of the mines reporting from Kentucky are near a railroad, so that the cost of long wagon hauls has not entered to an important extent into the reported value of the fluorspar from those States.

The total quantity of domestic gravel spar marketed in 1913 was 101,767 short tons, valued at $597,024, as compared with 99,285 short tons, valued at $578,294, in 1912, an increase in quantity of

2,482 tons and in value of $18,730. The average price per ton of domestic gravel spar was nearly $5.87 in 1913, as compared with $5.82 in 1912, an increase of about 5 cents a ton. The sales of domestic lump spar in 1913 were 5,676 short tons, valued at $39,059, as compared with 5,315 short tons, valued at $36,553, in 1912, an increase in quantity of 361 tons and in value of $2,506. The average price per ton of lump spar was approximately $6.88 in both 1912 and 1913. The sales of domestic ground spar in 1913 were 8,137 short tons, valued at $100,203, as compared with 11,945 short tons, valued at $154,316, a decrease in quantity of 3,808 tons and in value of $54,113. The average price per ton of ground spar was $12.31 in 1913 as compared with $12.92 in 1912, a decrease of 61 cents a ton. According to these statistics the entire decrease in both quantity and value of fluorspar marketed in 1913 was confined to the sales of ground spar, both the gravel and the lump spar marketed having shown actual increases in quantity and in value as compared with 1912.

Fluorspar was produced in 1913 in six States—Illinois, Kentucky, New Mexico, Colorado, New Hampshire, and Arizona—in the order named. Increases in sales were reported in Arizona, Colorado, Kentucky, and New Mexico, and decreases in Illinois and New Hampshire. Gravel spar was produced by all the States except Arizona; sales of lump spar were reported from Illinois, Kentucky, and Arizona, and of ground spar from Illinois and Kentucky. The product of the mines in New Hampshire and New Mexico is classed as gravel spar, since it is sold entirely for flux in steel making, but much of the spar shipped from these two States would yield an excellent grade of lump spar if it were hand picked.

It is impossible to give in detail the production of fluorspar from Illinois and Kentucky separately, because in publishing the statis ics of production of the various minerals it is the custom of the Survey to conceal the output of individuals; therefore the production of a single State is not given unless three or more producers report from that State, except when the producers interested have given express permission for the publication of their figures. Thus, while it is possible to give the total production of fluorspar in Illinois and Kentucky for 1913, it is not possible to give it by grades.

The total stocks of fluorspar reported at the mines or at shipping points December 31, 1913, were 15,252 short tons, as compared with 8,663 short tons on hand at the close of 1912, according to revised reports. Owing to inaccurate methods of estimating stocks, these figures can be regarded as only approximate; it is found, however, that the stocks on hand at the close of one year, together with the tonnage mined during the following year, less the tonnage marketed during that year, generally check reasonably well with the stocks reported on hand at the close of the second year.

The following table gives the quantity and value of the different grades of fluorspar marketed in the United States in 1912 and 1913:

Fluorspar marketed in 1912 and 1913, in short tons.

State.	Gravel.		Lump.		Ground.		Total quantity.	Total value.
	Quantity.	Value.	Quantity.	Value.	Quantity.	Value.		
1912.								
Illinois, Kentucky	97,150	$565,784	5,315	$36,553	11,945	$154,316	114,410	$756,653
Other States[a]	2,135	12,510					2,135	12,510
Total	99,285	578,294	5,315	36,553	11,945	154,316	116,545	769,163
1913.								
Illinois	91,663	525,456	5,676	39,059	8,137	100,203	85,854	550,815
Kentucky							19,622	113,903
Other States[a]	[b] 10,104	71,568	([b])	([b])			10,104	71,568
Total	101,767	597,024	5,676	39,059	8,137	100,203	115,580	736,286

[a] Includes, 1912: Colorado, New Hampshire, and New Mexico; 1913: Arizona, Colorado, New Hampshire, and New Mexico.
[b] Small quantity of lump spar from Arizona included with gravel.

The annual production of fluorspar from 1883 to 1913 is given in the following table. Beginning with the year 1906, the quantities reported represent marketed production.

Production of fluorspar in the United States, 1883–1913, in short tons.

Year.	Quantity.	Value.	Year.	Quantity.	Value.
1883	4,000	$20,000	1900	18,450	$94,500
1884	4,000	20,000	1901	19,586	113,803
1885	5,000	22,500	1902	48,018	271,832
1886	5,000	22,000	1903	42,523	213,617
1887	5,000	20,000	1904	36,452	234,755
1888	6,000	30,000	1905	57,385	362,488
1889	9,500	45,835	1906	40,796	244,025
1890	8,250	55,328	1907	49,486	287,342
1891	10,044	78,330	1908	38,785	225,998
1892	12,250	89,000	1909	50,742	291,747
1893	12,400	84,000	1910	69,427	430,196
1894	7,500	47,500	1911	87,048	611,447
1895	4,000	24,000	1912	116,545	769,163
1896	6,500	52,000	1913	115,580	736,286
1897	5,062	37,159			
1898	7,675	63,050	Total	918,904	5,692,551
1899	15,900	96,650			

Figure 16 shows graphically the course of fluorspar production in the United States from 1883 to 1913. Two periods of fluctuation in output—between 1889 and 1898 and between 1902 and 1908—are in strong contrast with the large and steady increase in production in the periods 1898 to 1902 and 1908 to 1912. For convenience of comparison the imports, beginning with the first full year for which records are available, 1910, are shown on the same diagram.

The total quantity of fluorspar reported to the Survey as mined in the United States in 1913 was 124,130 short tons, as compared with 117,282 short tons mined in 1912.

COMPOSITION OF GRAVEL SPAR MARKETED.

Fluorspar or fluorite, chemically, calcium fluoride (CaF_2), consists of calcium and fluorine in the proportion of 51.1 to 48.9. The mineral

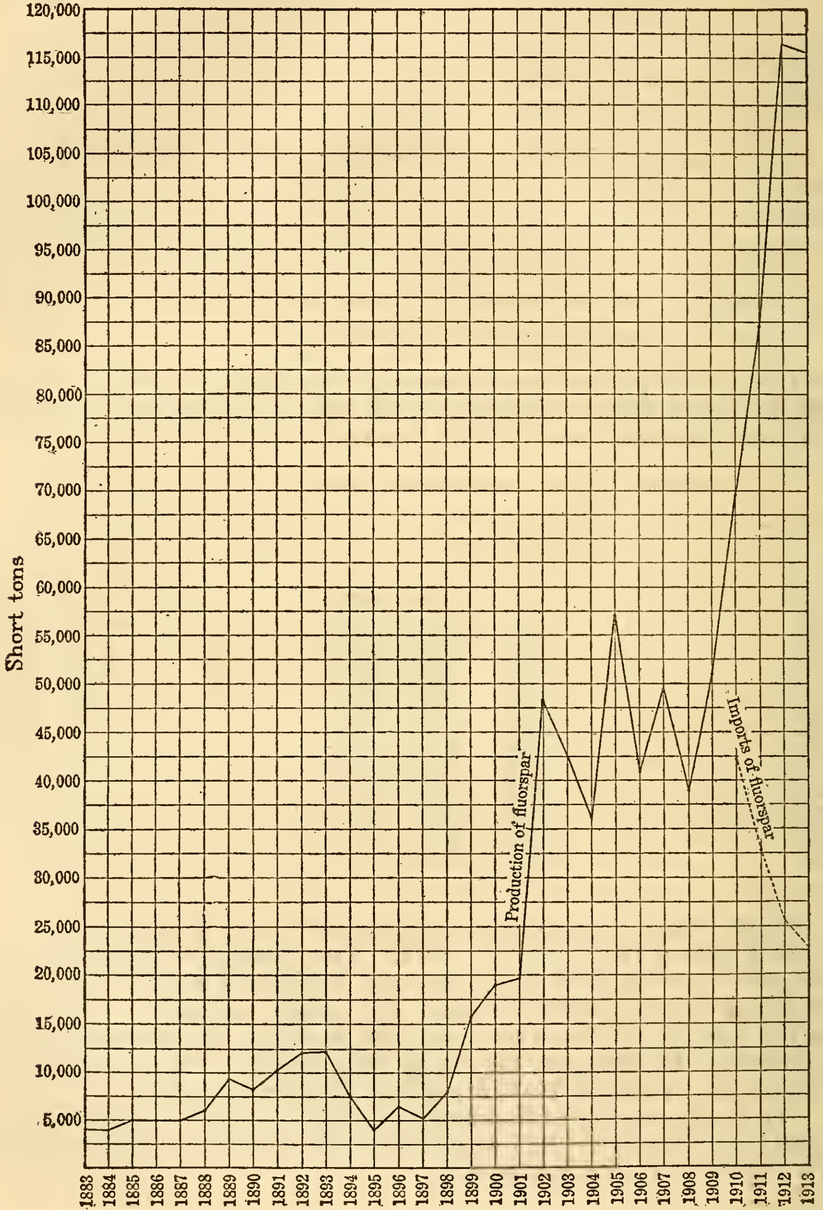

FIGURE 16. Production of fluorspar in the United States 1883–1913, and imports 1910–1913.

is crystalline, only slightly harder than calcite. It crystallizes in the isometric system and is found commonly in cubical crystals. In color the spar ranges according to purity from a clear, slightly bluish or green glasslike substance through various other brilliant colors to dark purple, although much of it is white and opaque. It is seldom, however, that absolutely pure spar is marketed, although lump spar used in the manufacture of chemicals is often found to contain less than 1 per cent of impurtity. A large number of chemical analyses made on receipts of gravel spar at the Minnequa works of the Colorado Fuel & Iron Co. during 1912 and 1913 indicate the percentages of the principal constituents as shown in the accompanying table. These percentages may be considered as only approximately the averages of monthly receipts, as the tonnages on which they are based are not in all cases equivalent.

Analyses of gravel fluorspar from Colorado, Illinois, and New Mexico.

	Calcium fluoride (CaF_2).	Silica (SiO_2).	Lime carbonate ($CaCO_3$).	Oxides, mostly iron (Fe_2O_3) and alumina (Al_2O_3).	Barium sulphate ($BaSO_4$).
1912.					
Colorado (unwashed spar):					
Jamestown	82.16	10.64	2.26	4.27	....
	79.38	11.12	2.80	4.49	....
	79.22	12.16	1.85	4.75	....
Morrison	71.65	23.26	1.52	2.04	....
Jefferson	68.34	28.33	1.34	1.69	....
Duffields	80.55	14.55	3.07	1.50	....
New Mexico (unwashed spar): Deming	92.31	5.28	1.19	1.07	....
Illinois (washed spar): Rosiclare	87.64	4.15	6.41	1.58	....
1913.					
Colorado (unwashed spar):					
Jamestown	80.32	10.32	2.58	6.46	....
	83.78	9.24	2.18	5.56	....
Morrison	72.21	21.93	2.78	3.08	....
	83.73	11.13	2.21	2.66	....
Jefferson	59.23	35.98	1.76	3.05	
Wagon Wheel Gap	90.08	2.21	1.17	2.14	Between 3.22 and 6.00
New Mexico (unwashed spar): Deming	88.94	8.35	1.34	1.29	....
Illinois (washed spar): Rosiclare	90.41	3.35	4.33	1.03	....

Comparisons of these analyses is of interest. Shipments from Jamestown, Colo., averaged nearly the same in the two years. From Morrison, they averaged a little better in 1913, but from Jefferson considerably lower in grade than in 1912. A new producer is reported from Wagon Wheel Gap, and the spar shipped appears to be of an excellent grade, the fact being considered that it probably has not been subjected to mechanical cleaning or concentration. The presence of barite, or barium sulphate, in this deposit is also of interest. Notes on this deposit are given on a later page.

USES OF FLUORSPAR.

It is estimated that about 80 per cent of the domestic fluorspar output, mainly in the form of gravel spar, and practically all of the imported fluorspar, is consumed as a flux in basic open-hearth steel furnaces. It is used also as a flux in blast furnaces, iron foundries, and silver, copper, and lead smelters; in the manufacture of fluorides of iron and manganese [1] for steel fluxing; in the manufacture of glass, enameled, and sanitary ware, and of hydrofluoric acid; in the pro-

[1] For notes on the uses of these fluorides see Goldmerstein, L., Prolonging the life of the Bessemer process: Iron Age, Jan. 22, 1914, pp. 250-251; and The fluorine process in the open hearth: Iron Age, Mar. 19, 1914, pp. 724-725.

duction of aluminum; in the electrolytic refining of antimony and lead; and for many other purposes.

Fluorspar for making iron and steel should carry at least 80 per cent of calcium fluoride, (CaF_2) and preferably it should be purer. For most other chemical purposes it should contain 95 per cent or more of calcium fluoride.

TRADE CONDITIONS.

The strong demand for American fluorspar that existed in 1911 and 1912 was slightly less active in 1913, especially during the latter part of the year. The demand in the eastern United States was supplied chiefly by 4 mines in Hardin County, Ill., 2 of which have important production and are equipped with large mills, and by 7 mines in Crittenden County and 1 in Caldwell County, Ky. Prices of gravel and lump spar remained about the same, but prices of ground spar dropped about 4.7 per cent. In Kentucky, conditions showed a decided improvement, the quantity of spar sold from this State in 1913 having increased more than 87 per cent over the marketed output of 1912. Two more mines produced spar and 1 more shipped spar in 1913, making 9 mines and 8 shippers in Kentucky. Shipments were limited, however, in both Illinois and Kentucky by the idleness of open-hearth steel plants during a portion of the year. The quantity mined in southern Illinois might have been greater had not the large mines at Fairview and Rosiclare been twice flooded by the Ohio River in the spring of 1913.

A small tonnage of high-grade spar was shipped from New Hampshire for flux in steel manufacture in Massachusetts. In Colorado 6 producers reported an output of fluorspar, and a considerable quantity was produced from 1 mine near Deming, N. Mex. The product from both of these States was shipped to the open-hearth steel plant of the Colorado Fuel & Iron Co., at Minnequa, Colo. The output of these States was adequate to the requirements of the steel plant in 1913. In Colorado the production was from the vicinity of Jamestown, Jefferson, Morrison, and Wagon Wheel Gap. Wagon Wheel Gap is a new producing locality. A small production of lump spar was reported from the Castle Dome district, Arizona, for the first time in several years.

Low-grade fluorspar imported from England is reported to control the market along the Atlantic Seaboard and to compete with domestic spar even as far inland as Pittsburgh. The imports, as noted on another page, showed a decrease of more than 13 per cent.

The following table shows the production during the last five years of open-hearth steel which has a most important bearing on the market for gravel spar:

Production of open-hearth steel in 1909–1913, in long tons.[a]

	Basic.	Acid.	Total.
1909	13,417,472	1,076,464	14,493,936
1910	15,292,329	1,212,180	16,504,509
1911	14,685,932	912,718	15,598,650
1912	19,641,502	1,139,221	20,780,723
1913	20,344,626	1,255,305	21,599,931

[a] Statistics from 1909 to 1911 according to Ann. Repts. Am. Iron and Steel Association, and since 1911 (1913 subject to revision) from report of Am. Iron and Steel Inst., both of Philadelphia, Pa.

IMPORTS.

Prior to August, 1909, fluorspar was imported into the United States duty free, and the full statistics of importation were not obtainable before that date. A duty of $3 a ton on imported fluorspar continued in force from August, 1909, until October, 1913, when it was reduced to $1.50 a ton. Large quantities of gravel spar produced at a low cost from the tailings of lead mines and from the gob in abandoned mines in England have been shipped to this country as ballast at a very low freight rate. The material thus produced is high in silica and is almost entirely consumed by makers of open-hearth steel. According to American producers spar from England at present competes with American fluorspar as far west as Pittsburgh and practically fixes the market price at that point, while in the Lehigh and Susquehanna valleys of Pennsylvania and other localities near the Atlantic seaboard English fluorspar can be purchased advantageously.

The imports of fluorspar entered for consumption into the United States in 1913 were 22,682 short tons, valued at $71,463, as compared with 26,176 short tons, valued at $71,616, in 1912. This represents a decrease in quantity of 3,494 short tons, or about 13 per cent, and in value of $153, or about 0.2 per cent. The value assigned to the material in 1913 averaged $3.15 a ton, as compared with $2.74 a ton in 1912, an increase of 41 cents a ton, or about 15 per cent. The imports of fluorspar in 1913 amounted to about 22.3 per cent of the domestic production of gravel spar, as compared with about 27 per cent in 1912. The reported average price of imported spar at dock, exclusive of the duty, amounted to about 53 per cent of the price of domestic gravel spar at mines or nearest shipping points in 1913. According to the prices reported, the average cost to the consumer, including the duty of $3 a ton, but excluding freight charges, was $5.74 a ton in 1912, as compared with $5.82 for domestic gravel spar, and in the latter part of 1913 the cost of the imported material, including the duty of $1.50 a ton, was $4.65, as compared with $5.87 for domestic gravel spar. The freight charges on domestic spar to points where it is consumed are generally higher than on foreign spar from the docks to eastern steel plants, so that the differences in cost to the consumer are relatively greater than are indicated. Foreign spar is, however, not of as high grade as the mechanically treated spar from Illinois and Kentucky, and, since fluorspar is of value chiefly according to its purity, purchasers find that the purer American spar is more efficient and consequently cheaper in the end.

The following table (see also fig. 16) shows the imports of fluorspar into the United States since August 1, 1909:

Fluorspar imported, 1909–1913, in short tons.

	Quantity	Value.	Average price per ton.
1909	6,971	$26,377	$3.78
1910	42,488	135,152	3.18
1911	32,764	80,592	2.46
1912	26,176	71,616	2.74
1913	22,682	71,463	3.15

APPARENT CONSUMPTION OF FLUORSPAR.

No accurate estimate of the annual consumption of fluorspar in the United States can be made without a knowledge of the stocks maintained by the consumers. These stocks are probably variable, but as the value of fluorspar as a flux in open-hearth steel making and in other metallurgical operations has become so generally appreciated, consumers are taking care to keep larger stocks in reserve. However, the sales of domestic spar plus the imports (there are no considerable exports at present) should give from year to year an index to the quantity entering into consumption and should indicate the relative increase or decrease in consumption. The apparent consumption of spar in 1913 was 138,262 short tons, as compared with 142,721 short tons in 1912, a decrease of more than 3 per cent.

The following table indicates the apparent consumption of fluorspar in the United States in the years 1910, 1911, 1912, and 1913:

Apparent consumption of fluorspar, 1910-1913, in short tons.

	Sales of domestic spar.	Imports.	Apparent consumption.
1910	69,427	42,488	111,915
1911	87,048	32,764	119,812
1912	116,545	26,176	142,721
1913	115,580	22,682	138,262

FLUORSPAR AT WAGON WHEEL GAP, COLO.

The fluorspar at Wagon Wheel Gap occurs in a fissure vein in rhyolitic tuffs and breccias. The relations of this vein to the local geology and to the hot springs have been described by Emmons and Larsen.[1] The vein is thin—2 to 5 or 6 feet thick, generally not more than 3 feet—and contains in addition to fluorite small quantities of other minerals, such as barite, calcite, quartz, and altered pyrite. The pyrite occurs mostly in the altered wall rock. The fluorite is comparatively pure. It occurs in tabular masses, in fibrous forms, in crusts, and in crystals. Some of the fluorite shows well-defined banding of varying shades of pink and white. The fluorite carries low values of precious metals, assays having shown, respectively, 0.007 ounce and 0.03 ounce gold, and 0.283 ounce and 4.55 ounces silver to the ton.[2]

There are three hot springs at Wagon Wheel Gap, the temperatures of which are 135° F., 150° F., and 140° F. Emmons and Larsen show that the hot springs and the fissure vein are undoubtedly connected, since the strike of the vein passes through one spring and close to the second. A deposit of travertine surrounds spring 1, and this deposit appears to be bisected by the vein (projected). A partial analysis of the travertine was made by George Steiger, of the United States Geological Survey, with the following results:

[1] Emmons, W. H., and Larsen, E. S., The hot springs and the mineral deposits of Wagon Wheel Gap, Colo.: Econ. Geology, vol. 8, No. 3, pp. 235-246. April-May, 1913.
[2] Assayed with unusual precautions by Edmund Newton, Minnesota Univ. School Mines.

Partial analysis of travertine from Wagon Wheel Gap, Colo., hot spring.

	Per cent.
Lead (Pb)	None.
Zinc oxide (ZnO)	0.007
Barium oxide (BaO)	0.045
Fluorine (F)	0.22
Copper (Cu)	None.

If these percentages be recalculated to a mineral basis they correspond to a content of 0.008 per cent of sphalerite (ZnS), 0.078 per cent of barite ($BaSO_4$), and 0.45 per cent of fluorite (CaF_2). It is thus evident that the fluorite has been deposited by the hot water, which probably has its source at considerable depth.

CANADA.

According to the revised mineral statistics Canada produced 40 short tons of fluorspar, valued at $240, or $6 a ton, in 1912, as compared with 34 tons, valued at $238, or $7 a ton, in 1911. No production was reported for 1913 in the preliminary report for that year recently issued.

GREAT BRITAIN.

The production of fluorspar in England has an important bearing on the industry in the United States, for practically all the competing material is imported from that country. Since 1903 the output of Great Britain has exceeded 10,000 tons annually, and except in 1908, 1911, and 1912, there has been a steadily increasing annual production of spar up to 1912, the latest year for which statistics are available. According to the official report of output of mines and quarries issued by the British home office at London, there were produced in 1912, a total of 47,246 long tons of fluorspar, valued at $84,010, or $1.78 a ton, as compared with 55,231 long tons, valued at $92,176, or $1.67 a ton, produced in 1911. In 1912, 23,862 tons were produced in Derbyshire, mostly from quarries and open workings (probably mine dumps) and 23,384 tons from mines and mine dumps in Durham. Of the 1911 output, 5,045 tons were produced from mines in Derbyshire, including large quantities produced from mine dumps and 23,644 tons from quarries in the same county, while 26,542 tons were produced from mines and mine dumps in Durham. When the output of fluorspar in England in 1912 is compared with the imports of fluorspar into the United States in that year, and in view of the fact that the imports are derived almost wholly from England, it appears that more than 55 per cent of the production of England was shipped to the United States in 1912, as compared with about 52 per cent in 1911.

CRYOLITE.

IMPORTS AND PRICES.

No cryolite is produced in the United States, the entire supply used in this country being imported from Ivigtut, an Eskimo hamlet on the southern coast of Greenland.

The quantity of cryolite reported to have been imported for consumption into the United States in 1913 was 2,559 long tons, valued at $52,557 as compared with 2,126 long tons, valued at $48,293, in 1912. The average price per ton declared in 1913 was apparently $20.54, as compared with $22.72 in 1912. Cryolite was imported free of duty in 1913.

PEAT.

By Charles A. Davis.

INTRODUCTION.

The peat deposits of the United States form one of the most important of the undeveloped resources of the country. Peaty swamps cover, in the aggregate, large areas in the region east of the Ninety-seventh meridian and north of Ohio River; they occur also along the Atlantic coast as far south as and including Florida. On the Pacific coast peat beds have been reported from southern California northward to the Canadian boundary. These potentially valuable swamp lands have for some years attracted the attention of those who have followed the progress which has been made in Europe in extending the use of peat for fuel and for various other purposes, but only in a limited degree and in a more or less speculative or often purely academic way.

The extent of the peat deposits of the United States is not yet well known. Very little systematic search for peat has been undertaken, but from what has been done it seems probable that a large percentage of the swamps and bogs which occur throughout the glaciated region of the country and on the poorly drained parts of the Atlantic Coastal Plain conta'n more or less peat of commercial value. A larger percentage of the swamps of the extreme northern part of the country along the Canadian border than of the Coastal Plain region will undoubtedly be found to contain peat of commercial value. In all cases, however, where peat is sought swamp land should be examined in attempting to locate deposits of this important raw material.

The most extensive use of peat in Europe has been for fuel. Most of the attempts which have been made to utilize peat deposits in the United States also have aimed at their development as sources of fuel. A chief reason for this has prabably been the fact that the best peat deposits in the United States lie almost entirely outside of the region of occurrence of known workable coal fields and in regions where the climate is so severe that there is need for large supplies of fuel for domestic use. In the same region there is also a constantly growing demand for cheap fuel for manufacturing.

The States in which the largest areas of swamp land are known are Minnesota, Wisconsin, Michigan, the northern parts of the States immediately south of them, New York, the New England States, Pennsylvania, New Jersey, and also parts of the States south, especially a narrow strip along the Atlantic border where the land is flat, poorly drained, and has a large annual rainfall. The fact that all these States, with the exception of northern Illinois, Indiana, Ohio, and Pennsylvania, receive their supplies of fuel from rather distant coal fields, largely by rail, has made fuel costly, especially in the last few years, and many attempts have been made to convert peat into fuel, both for domestic use and, to some extent, for manufacturing purposes. Up to the present time, however, practically none of these attempts at the production of a serviceable fuel from peat have been commercially successful.

It does not seem necessary in this place to go into the details of the causes of failure, but the whole matter may be summed up by stating that the lack of success has apparently not been caused by the peculiarities of the peat fuel itself, since in practically every case where the material has been offered for sale it has found a ready market and has been sold at prices which, while less than those paid for other fuels, were ample to have made the manufacturer of the material remunerative. Although failure has been the history of the production of peat for fuel in the United States, European countries in which peat is abundant have been increasing its production and use both for domestic fuel and for power until at the present time there are probably between 15,000,000 and 20,000,000 tons of peat produced and used annually for fuel in the countries of northern Europe. Because this steady increase in the use of peat for fuel and for other purposes goes on in European countries; because improvements are constantly being made there in methods of recovery and use which are adapted to utilization on a large scale; and because our peat deposits in the United States are not only neglected but also are often wastefully burned up to remove the peat from the surface of the ground, a brief review of the methods in use in northern Europe for the economical production and use of peat for fuel is given here.

EUROPEAN METHODS OF PRODUCING PEAT FOR FUEL.

The oldest and simplest method of preparing peat for fuel is that still extensively employed by the peasantry of Ireland and other countries of northern Europe. The peat deposit is drained as thoroughly as possible by open ditches, after which a special type of spade is used to cut the peat out from the beds in the form of bricks. The brick-shaped blocks thus formed are laid out on the surface of the bog and dried by exposure to sun and wind. Peat fuel made in this way is, however, very easily broken and very bulky, and the method is only adapted to very local production and consumption, and not to transportation. Peat fuel recovered in this way is called cut peat.

A second method by which a much more satisfactory product is obtained is coming into general use wherever peat fuel is made. The method is simple and, to a certain extent, resembles that just described, but differs from it in that the peat is reduced to a pulp by suitable machinery before being formed into bricks. The processes and the machinery for pulping and handling the raw peat have been greatly improved during the last 10 years until at the present time the necessary processes of digging, conveying, reducing to pulp, and spreading the pulp on the drying grounds are all mechanical and are carried on by machines which work together and are all operated by a single portable and generally self-propelling engine.

The most serious difficulty which has operated against the production and use of peat as fuel is the fact that, as it lies in the bog, it contains about 90 per cent of water. Long experience has shown this water content can not be reduced below 80 per cent, even by most careful and thorough draining; consequently, in the production of air-dried peat, in which form it is actually used as fuel, and which contains from 10 to 25 per cent of moisture, from 8 to 10 tons, depending on the actual water content, of raw material must be handled to produce a single ton of salable fuel. Thus the charges for excavating, transporting, reducing to pulp, spreading, and drying the raw material must be all charged against the very small proportion of the dry product. Even if this charge is very small per ton, the fact that it must be multiplied by at least eight times makes it a formidable matter in estimating the cost of the final product, which, to be commercially profitable, must be sold at a low price.

The processes of production of peat for fuel, after the peat deposit is ready to work, when reduced to the lowest possible terms are: (1) Digging, (2) elevating and transporting to the macerating machinery, (3) pulping or maceration, (4) forming the pulp and spreading it in some way so that it may be quickly and thoroughly dried, (5) tending the material during the process of drying, and (6) gathering and storing. In five of these operations first named, from 8 to 10 times the weight of the salable material must be handled in the form of water, which is eliminated in the course of drying. Hence, the less this waste material is handled and the shorter the distances and the more directly it is transported the greater the chance of final profit when the fuel which is the result of all the operations is ready for the market.

These facts have led to a large amount of experimental work on the part of mechanical engineers and other practical and trained men both abroad and, to a somewhat less extent, in the United States and Canada.

Within the last three years there have been several very compact and powerful machines or, better, combinations of machines developed which are self-moving and operate directly on the surface of the bog. In this way the inventors claim to eliminate all needless transportation of the wet material with its high percentage and great weight of waste water. These machines combine digging, macerating, and spreading devices in such a way that until the wet, thoroughly pulped peat is spread in brick form on the surface of the bog or on other drying grounds to dry there is no break in the forward movement. The several types of automobile machines or plants in use have been developed independently, and although they present fundamental likenesses in their construction each of them attains in a practical and simple way the same end, namely, they dig, move, pulp, and take to the drying grounds large quantities of raw material with an outlay of power and manual labor small in comparison with what was formerly used to attain the same actual tonnage of final product. Peat fuel prepared as described is called machine peat.

PRESSING WATER FROM PEAT.

It has long been realized by those who have given the matter attention that it is very desirable to avoid the uncertainties inherent in the method of drying peat by spreading in the open air, because weather and climatic conditions limit production. The most certain solution of the problem seemed to be the invention of some form of mechanical device for ridding the peat of water. With this in view, there have been attempts made for more than 50 years to invent presses having capacity and power enough to remove the water from peat on a commercial scale by mechanical pressure. During this time about every form of press that could be devised has been given experimental or even commercial trial, but without any commercial success up to the present time.

The difficulties which have been encountered have been due in part to the peculiar capacity which the peat itself has for holding the water, which is a part of it as it lies in the bog. This water is held in at least three ways: First, mechanically mixed with the particles of vegetable matter which make up the solid matter of the peat. (This water is termed by some writers "free water.") Second, the water is held in the minute cavities in and between the cells and fibers of the vegetable structures which the processes of decay have not thoroughly broken down. This water is held in the peat by capillarity and is more difficult to remove by pressure than the free water. Third, a certain percentage of the water present in the peat is held in the vegetable matter itself, in the walls of the cells, fibers, and tissues. This water is probably chemically combined with the fundamental organic substances of which the vegetable matter is composed. Water in such combination can not be removed by pressure, at least not until the chemical substances, of which it is a part, are decomposed, but can only be dried from the substances with which it is combined. There is also a fourth way in which water may be combined, and doubtless is combined, in most kinds of peat: This is what may be termed colloidal water, and is apparently in chemical combination with the substances with which it is associated. This water in whatever percentage it may be present is seemingly never removed by pressure, but must be removed by destroying the chemical bonds by which it is combined with the organic matter. This destruction can be brought about by heat or by evaporation, but the assumed union is not destroyed by pressure alone.

During the year 1913 reports were received from Europe of the development of a press which, although it has not yet been thoroughly tested on a commercial scale, apparently has made a very considerable reduction of the water content of a number of kinds of peat on an experimental scale. The results reported were such as to warrant the further development of the press to determine its value when tried with many kinds of peat, and late in 1913 a small machine of commercial size was finished and tested under conditions similar to those found in commercial operations. It is claimed for this press that, although it has a large capacity, it will be very cheaply operated and will require but little power. It reduces the water content of the material which is pressed to below

60 per cent. At the same time that this press was under construction two other machines were being constructed for the same purpose, but entirely independently, in the United States. No reports have been received from tests of these American machines.

BRIQUETTED PEAT.

Peat which has been thoroughly dried and reduced to a powder can be successfully briquetted without a binder, much as the brown coals are briquetted in various European countries. The heavy, thoroughly decomposed black peats are better for briquetting than the light-colored and bulky brown peats, but with a suitable press and with well-dried materials briquetting is practicable for almost any kind of peat, although the lighter kinds do not make as good briquets as those of greater specific gravity.

Briquetting as a means to make from peat a fuel that could be successfully transported was attempted early in the history of the process in various parts of Europe, especially in Germany and Holland, where brown coal briquets were received with enthusiasm by the consumers of fuel. For various reasons, however, only a single peat-briquet factory is known to be in operation in Europe at the present time. A chief cause of the lack of success in several of the peat-briquetting enterprises of Germany was the difficulty in securing enough dry peat to keep the briquetting plant in operation at full capacity for a sufficient number of days in the year to make the output of the plant normal. To prepare the peat for briquetting it has to be handled very much as is done in the production of machine peat until it is air dry; after it has reached as nearly as possible the air-dried state the peat bricks are gathered, crushed or ground into powder, and artificially dried in mechanical driers to a moisture content which has been found by experiment to be the optimum for the given peat and locality. After the powdered peat is dried and cooled, the briquetting is done by special presses, which are designed for the material which is to be briquetted. The briquetting plant is much more costly than the plant for producing air-dried machine peat. Some of the earlier peat-fuel factories which were established in the United States were briquetting plants, and these, without exception, were unsuccessful, never having reached the productive stage.

PEAT POWDER.

In 1911 it was announced from Sweden that peat powder was being produced on a large scale in a single plant at Back, the processes of preparing the material for use being almost identical in principle to those used in making briquets, the only difference being that when the peat powder was thoroughly dried it was burned and was not briquetted. Peat in powdered form and consumed in proper burners makes a very efficient fuel, and the factory at which it is produced in Sweden is reported to be turning out from 10,000 to 12,000 tons of dry peat powder per annum. It is also reported, as the result of carefully conducted tests, that peat fuel in this form is nearly as efficient, ton for ton, as the best English coal and that the cost to the consumer is considerably less. Late reports indicate that peat powder has been successfully used in railroad locomotives as well as in boiler furnaces of the ordinary stationary plant. Peat powder has also been used to some extent in the reduction of iron from its ores, and in other ways.

PEAT COKE OR CHARCOAL.

Peat, when thoroughly macerated and formed into thoroughly dried bricks, can be reduced to coke or charcoal by heating to high temperatures in properly constructed retorts. The residue obtained, although called peat coke, is not a true coke, but a charcoal, in that there is no fusion of particles or masses of the original peat. If the quality of the peat is good, the charcoal partakes of some of the characteristics of coke; it is hard and tough, withstanding considerable more pressure than ordinary wood charcoal and possessing all of the valuable properties for metallurgical work which wood charcoal has. The modern method of coking peat involves the use of large vertical iron and masonry retorts designed and fitted for the recovery of by-products which result from the condensation of the gases formed by the action of the heat on the peat. These by-products are: Fuel gas, which may be used for continuing the coking process after it is once started, or for running gas engines, or for any other purposes for which gas may be used. Next, the more easily condensible gases yield ammonia, which is generally recovered as the sulphate; acetic acid, which is obtained from the tar water, as it is called; acitone; and a certain quantity of methyl alcohol. The heavier tars obtained from the gases given off by the retorts may be made to yield illuminating and lubricating oils, creosote, and other similar products, paraffin, and a dense, heavy substance closely resembling asphalt, and having the same commercial uses as that substance. In other words, all of those products may be obtained which are recoverable from the dry distillation of wood. The successful operation of a peat-coking plant on a commercial scale depends chiefly upon the quantity and quality of the air-dried machine peat bricks which can be made at the locality where the plant is located. In order to get the best quality of coke the peat used must be low in mineral matter or ash, and in sulphur, and, after maceration, must dry into dense, hard bricks. The cost of installing and operating a plant for the production of peat coke is high.

PRODUCER GAS FROM PEAT.

During the last 10 years there has been great progress made in England, Germany, and Russia in the extent to which low-grade fuels are used in gas producers of different kinds. Among fuels of the bituminous class which have been thoroughly tried and proved successful in commercial operations is peat. This fuel has been successfully used not only in small installations in the European countries mentioned, but air-dried peat bricks also form the sole fuel employed in large central electric power plants. The most noteworthy of these installations are one at Schweger-Moor, near Osnabruck, in northwestern Germany, and two in Italy, where plants developing as much as 4,000 horsepower have been in commercial operation for some years. These plants develop producer gas by the Mond system, by which, in addition to the gas generated, ammonia in the form of sulphate is recovered to a very profitable extent in cleansing the gas. Profitable ammonia recovery from producer gas depends on the fact that peat, as compared with coal, contains a relatively high percentage of combined nitrogen, from which ammonia is formed during distillation. It is now possible by the improved methods of recovery which have been developed in the last few years to recover as ammonia as much as 70 or even 80 per cent of the entire quantity of the combined nitrogen in the fuel. This, with a percentage of nitrogen equal to 1½ per cent of the total dry weight of the peat, yields enough sulphate of ammonia to pay for running the entire plant, leaving the gas free for whatever use it may be put to. It will thus be seen that this is a most important way of utilizing peat as a source of power, the chief if not the only drawback being the difficulty of securing dry fuel enough to run the producer-gas plant to its capacity. This difficulty, if modern methods of handling the raw material are used, should not exist, since it is perfectly possible to keep the gas-producer plant fully supplied with satisfactory material throughout the year by taking the precaution to plan the production of peat for fuel on the right scale to allow for unfavorable seasons.

PEAT AS FUEL FOR STEAM PLANTS.

There now seems no question that it is entirely practicable to use peat as a fuel for steam boilers if the boilers used have furnaces properly designed for this particular type of fuel and if the raw supply is located where there is a market for power. In northern Germany, at the Wiesmoor, near Aurich, there is a very large central electric-power station entirely fired by peat fuel which distributes electricity over a radius of some 25 miles and which is reported to be entirely successful from every point of view. Moreover, in the regions of Germany where brown coal is mined it is common practice to burn the raw unconsolidated fuel as it comes from the mines, containing as high as 60 per cent moisture, under boilers having furnaces and grates of special construction. This fuel is only slightly different from half-dry, untreated peat in appearance and physical structure; and if the brown coal is successfully used, there is no reason apparent why partly dried crude peat could not be used to nearly as good advantage for generating steam if the boiler furnaces and grates were correctly designed.

The utilization of this type of fuel in some of the manufacturing regions of this country would materially improve the fuel situation in such districts. There would be apparently no difficulty in procuring a sufficient supply of the right sort of fuel as soon as the demand for it was made. However, in the present state of our fuel markets it is not to be expected, of course, that a large plant would be erected in the vicinity of a peat bog in the hope that some one would establish a peat-fuel industry to supply its needs. It would be necessary, in developing a plant of this type, to begin by making provision to dig and dry the requisite fuel and to have it ready for use when the plant was completed. With the machinery and methods already developed and in use, there seems to be no doubt that such a plant could be easily established for using commercially either steam or gas engines.

PEAT FUEL IN SPECIAL INDUSTRIES.

From Russia, in districts where coal and petroleum are now or have lately become very high in price as compared with the recent past, it has been reported during the last year that machine peat has been successfully used in glass factories. The reports also indicate that such factories have been able to sustain themselves against competition in other districts because of the low price at which their fuel could be obtained and because of the satisfactory results obtained by the use of this fuel. Peat fuel and the gas obtained from it have also been reported as used in glass manufacture in parts of Germany. It has long been the custom in parts of Germany and Russia where peat is abundant to use it in foundry work, as the fuel obtained from peat is very free from sulphur and gives a good melting heat when thoroughly dry and fired in properly constructed furnaces. Producer gas from peat is used in some German localities in foundry work. From Sweden reports have been received of the successful use of peat powder in the reduction of iron and other metals from the ores, and also in subsequent processes of refining. Peat coke or charcoal has an extensive use in making steel where a particularly high quality of material is desired. This special use consumes practically all of the peat charcoal which is manufactured in Europe.

OTHER COMMERCIAL USES OF PEAT IN EUROPE.

During the last year reports have been received again that the demand for the coarser and less decomposed types of peat for bedding for horses and cattle has largely increased. Some of the factories at which this material is prepared and baled have more than doubled their capacity in order to meet the constantly increasing demand for their output. The finer material, which is obtained in the course of shredding and sorting the raw cut-peat blocks from which litter is made, is sold under the name "peat mull" as packing material for glassware, perishable fruits, and so on. To a somewhat less extent the mull finds a market as a medium for mixing with and absorbing liquid foodstuffs, such as beet-sugar molasses, the mixture making a good and easily fed stock food, popular as a fattening ration for all kinds of live stock. Other and more digestible materials, however, are being substituted in some parts of Europe for the peat mull, but as packing material its use is reported to be increasing.

DOMESTIC USE OF PEAT IN 1913.

FUEL.

As already stated, peat has much less use in the United States than its merits, as judged by what has been accomplished in Europe, would seem to demand. The production of peat for fuel during the calendar year 1913 was entirely insignificant, so far as can be learned. The men who in previous years reported small outputs of machine peat reported that, for one reason or another, their production had been discontinued in the summer of 1913.

There were no new fuel plants at work, so far as known. There were in the course of construction, however, experimental peat-fuel plants in various parts of the country, which their builders expected to have in operation during the season of 1913, but which were delayed by unavoidable causes. These peat-fuel enterprises will doubtless be developed in another year.

FERTILIZER FILLER AND FERTILIZERS.

As in past years, domestic peat was produced in larger quantities for fertilizer filler and fertilizers than for all other purposes combined. So far as can be learned, this use of peat is peculiar to the United States, and apparently its continuance here has been possible because of the richness in combined nitrogen of the peats used for the purpose and because of their thorough decomposition. The whole number of plants for the manufacture of these materials was less than in 1912, as some of those operated in that year had suspended operations in 1913. The chief causes of the closing of these plants seem to have been a very unfavorable drying season combined with the low price at which their output had been contracted for prior to the beginning of the operating season.

All told, 7 plants reported the production and sale of peat for fertilizer and similar uses in 1913, instead of 11 as in 1912. Of the 7 which actually operated in 1913, only 2 were carried on by the same firms included in the list of 1912. It may be stated in explanation, however, that one large producer of the previous year was rebuilding the plant, which had been destroyed by fire; another company had sold its factory; so that the production appears as from new owners. There were 4 new plants established in 1913, all of which began production so late in the season that their output was much below their possible capacity, although all of these new plants reported satisfactory market conditions. The older plants reported some increased production for the year. The 7 factories making peat fertilizer products in 1913 were located by States as follows: Illinois, 2; Indiana, 1 (1 additional building); Massachusetts, New Jersey, Pennsylvania, and Florida, 1 each.

The total production of peat for fertilizer uses reported for 1913 was 28,460 tons, valued at $169,600. The average selling price reported was $5.95 a ton, ranging from $5 to $6 a ton, for carload lots shipped in bulk, to $8 a ton when sold in small lots shipped in burlap bags. The sales for fertilizer filler are reported to be made on the basis of the nitrogen and moisture content of the kiln-dried peat. When sold directly for fertilizer, the peat is sold in the "sun-dry" state, either with or without the addition of mineral salts.

STOCK FOOD.

A considerable quantity of kiln-dried peat was sold as the absorbent for mixing with liquid foodstuffs, especially refuse molasses, for feeding stock that is being fattened for market. It is reported by many users of this type of food that they get excellent results from its use, which seems to be increasing in parts of the country where sugar is made or refined. The production and sale of peat for this use was reported in 1913 at 4,800 tons, valued at $27,600.

PAPER STOCK.

The one factory in the country where peat is known to be used in making paper was being enlarged and extensively remodeled and was not in operation during the greater part of 1913; hence no report of the use of peat during the year has been received.

STABLE LITTER.

There was no production of peat for stable litter in the United States during 1913, but about the usual quantity was imported from Holland, which has been for many years the source of supply for this material for the United States. This material is imported and sold under the name of "peat moss." The quantity brought into the county in 1913 was 9,966 metric tons, or 10,983 short tons, valued at $55,719.

PRODUCTION OF PEAT IN 1913.

The following summary gives the quantity of peat products made and used in the United States in 1913 so far as these have been reported:

Production and consumption of peat in the United States in 1913, in short tons.

Use.	Production.		Imports.		Consumption.	
	Quantity.	Value.	Quantity.	Value.	Quantity.	Value.
Fertilizer	28,460	$169,600			28,460	$169,600
Stock food	4,800	27,600			4,800	27,600
Stable litter			10,983	$55,719	10,983	55,719
Total	33,260	197,200	10,983	55,719	44,243	252,919

MINERAL WATERS.

By R. B. Dole.

CHARACTER OF STATISTICS.

The following statistics on the production of domestic mineral waters have been compiled from individual reports furnished by the owners or operators of springs, and they are intended to include only statistics on natural waters that are bottled and sold in their natural state or only slightly altered from their natural state. Natural still waters that have been artificially carbonated and natural carbonated waters that have lost part of their carbon dioxide are included, and doubtless some waters from which iron has been removed are also included; but artificial waters and natural waters that have been flavored, concentrated, fortified, diluted, or otherwise essentially modified in chemical character are excluded in so far as available information permits such segregation. Waters that are sold by flat or meter rates or are delivered to consumers through pipes or that are otherwise obviously municipal supplies or adjuncts to them are excluded. This is the nearest that it is practicable to approach the commonly accepted definition of a natural mineral water. No distinction is made between mineral water flowing or pumped from a natural spring and that flowing or pumped from a dug, bored, driven, or drilled well. Many of the best known mineral waters in the United States come, not from springs as is popularly supposed, but from wells.

Distinction for practical purposes between table and medicinal waters is entirely arbitrary. In general, table waters are clear and sparkling and without distinct mineral taste or odor; many medicinal waters are highly mineralized or have a distinct taste and odor. Yet some table waters are more strongly mineralized than some medicinal waters and many medicinal waters contain less mineral matter than certain city supplies. A logical distinction between medicinal and other waters might be based on minimum contents of certain substances that cause physiologic reaction; practically, however, no such distinction is made in this country. The basis used in this report for separating medicinal from table waters is the report of the spring owner, and his separation is based in turn on his personal knowledge that some of his customers buy the water to use regularly on their tables as a beverage and that others buy it for an aid during illness.

A few strongly-mineralized waters are not sold as table waters and a few widely sold table waters are not used medicinally, but most waters are sold for both uses.

The statistics do not include the water given away or consumed at spring resorts, which constitutes a large part of the annual production.

MINERAL-WATER TRADE IN 1913.

OUTPUT AND VALUE.

The two following tables give the production and value by States of mineral waters produced in 1912 and 1913. The number of active springs, the average price per gallon, and the value both of medicinal and of table waters are given, together with the total quantity and value. The quantity of mineral water used in the manufacture of soft drinks is separately reported in a later table.

Production and value of mineral waters in the United States, 1912 and 1913, by States.

1912.

State.	Commercial springs.	Quantity sold.	Average price per gallon.	Value of medicinal waters.	Value of table waters.	Total value.
		Gallons.	*Cents.*			
Alabama	16	165,678	12	$9,610	$10,825	$20,435
Arkansas	11	1,396,032	10	63,902	68,355	132,257
California	41	2,089,951	26	174,620	358,351	532,971
Colorado	11	1,178,308	6	19,388	55,926	75,314
Connecticut	28	2,110,231	7	5,214	148,169	153,383
Florida	9	123,485	14	13,469	4,052	17,521
Georgia	16	861,365	6	11,632	43,399	55,031
Illinois	17	1,143,625	7	7,530	66,915	74,445
Indiana	15	993,163	68	658,681	19,037	677,718
Iowa	6	84,300	14	2,075	9,300	11,375
Kansas	16	428,677	18	63,078	12,841	75,919
Kentucky	13	477,341	12	28,152	28,403	56,555
Louisiana	4	561,660	6	5,545	27,800	33,345
Maine	31	1,179,192	37	115,039	317,726	432,765
Maryland	13	1,606,373	10	6,000	151,541	157,541
Massachusetts	54	4,502,806	6	23,829	223,568	247,397
Michigan	18	1,420,465	5	777	74,834	75,611
Minnesota	18	8,881,018	3	6,805	245,472	252,277
Mississippi	10	639,905	20	106,941	19,300	126,241
Missouri	30	608,385	13	54,782	26,332	81,114
Montana	3	160,150	8	810	12,388	13,198
New Hampshire	8	240,568	4	175	9,825	10,000
New Jersey	12	2,386,217	9	2,150	207,576	209,726
New York	57	10,008,801	10	106,407	928,070	1,034,477
North Carolina	16	144,708	16	17,881	4,504	22,385
Ohio	30	2,709,745	4	19,550	97,737	117,287
Oklahoma	10	1,015,512	3	3,067	29,904	32,971
Oregon	6	48,351	36	2,047	15,456	17,503
Pennsylvania	41	2,192,106	9	31,190	173,716	204,906
Rhode Island	7	466,893	6	0	29,126	29,126
South Carolina	15	360,404	20	39,926	30,422	70,348
Tennessee	21	796,568	7	41,951	11,609	53,560
Texas	34	1,292,992	12	149,600	1,795	151,395
Vermont	3	21,000	39	1,385	6,895	8,280
Virginia	45	2,762,319	13	162,380	186,875	349,255
Washington	5	156,171	11	8,008	9,534	17,542
West Virginia	11	309,245	20	28,819	31,626	60,445
Wisconsin	31	6,045,719	14	94,347	775,148	869,495
Other States [a]	14	711,772	8	2,470	52,087	54,557
Total	746	62,281,201	11	2,089,232	4,526,439	6,615,671

[a] Includes Delaware, District of Columbia, Nebraska, Nevada, New Mexico, South Dakota, Utah, and Wyoming.

Production and value of mineral waters in the United States, 1912 and 1913, by States—Continued.

1913.

State.	Commercial springs.	Quantity sold.	Average price per gallon.	Value of medicinal waters.	Value of table waters.	Total value.
		Gallons.	*Cents.*			
Alabama	15	169,687	11	$7,528	$11,815	$19,343
Arkansas	16	1,428,869	11	87,246	64,166	151,412
California	49	2,801,393	19	176,597	355,328	531,925
Colorado	11	1,053,429	9	11,008	78,812	89,820
Connecticut	43	2,458,327	6	1,566	135,312	136,878
Florida	10	343,123	11	20,290	17,184	37,474
Georgia	18	750,893	9	7,205	62,237	69,442
Illinois	21	1,216,442	6	6,872	61,677	68,549
Indiana	16	383,577	54	188,062	17,559	205,621
Iowa	5	48,665	15	1,495	5,874	7,369
Kansas	14	337,193	18	49,195	10,831	60,026
Kentucky	14	475,675	11	26,879	26,455	53,334
Louisiana	5	700,795	6	5,643	34,014	39,657
Maine	32	1,174,262	31	93,238	275,198	368,436
Maryland	12	1,390,437	9	6,000	120,883	126,883
Massachusetts	60	3,907,395	6	26,445	187,357	213,802
Michigan	20	884,893	6	3,605	49,037	52,642
Minnesota	16	4,802,053	4	5,682	178,077	183,759
Mississippi	12	346,652	24	70,855	10,945	81,800
Missouri	34	697,467	12	61,044	23,272	84,316
Montana	3	180,200	2	70	3,176	3,246
Nebraska	3	105,985	10	3,360	7,239	10,599
Nevada	3	4,897	32	0	1,584	1,584
New Hampshire	9	402,355	3	200	12,507	12,707
New Jersey	14	2,067,277	9	1,438	187,108	188,546
New Mexico	4	154,800	11	790	15,940	16,730
New York	64	9,801,255	9	67,705	803,896	871,601
North Carolina	17	176,068	14	18,006	5,871	23,877
North Dakota	5	582,356	3	2,003	12,400	14,403
Ohio	33	3,317,639	4	16,895	108,189	125,084
Oklahoma	12	502,439	5	3,370	22,861	26,231
Oregon	8	68,413	28	6,240	13,169	19,409
Pennsylvania	43	2,163,931	9	19,323	171,136	190,459
Rhode Island	7	444,036	6	0	28,535	28,535
South Carolina	15	261,412	19	36,681	12,518	49,199
Tennessee	23	1,088,034	6	44,762	20,143	64,905
Texas	38	1,187,612	11	127,361	5,127	132,488
Vermont	4	17,725	40	168	6,900	7,068
Virginia	49	2,873,288	10	105,498	192,975	298,473
Washington	6	150,498	13	9,175	9,659	18,834
West Virginia	10	316,749	17	21,659	30,600	52,259
Wisconsin	34	6,326,533	14	83,982	788,536	872,518
Wyoming	4	16,200	22	2,110	1,500	3,610
Other States [a]	7	286,470	6	754	15,784	16,538
Total	838	57,867,399	10	1,428,005	4,203,386	5,631,391

[a] Includes Delaware, District of Columbia, South Dakota, and Utah.

Though reports were received from a greater number of springs, the production and value of both medicinal and table water were less in 1913 than in 1912. The total quantity sold in 1913 was 57,867,399 gallons, valued at $5,631,391, whereas in 1912 the sales were 62,281,201 gallons, valued at $6,615,671. The decrease in total production was therefore 4,413,802 gallons, or 7 per cent, and the decrease in value was $984,280, or 15 per cent. An appreciable part of this apparent decline of output is caused by reclassification of the statistics, on account of which returns regarding certain waters hitherto included have been omitted from the compilation of production in 1913. If the excluded values were retained, however, there would still be shown a decrease in output. The slight falling off in average price per gallon from 11 to 10 cents is caused partly by the reclassification, but mostly by decrease in the sales of high-priced medicinal waters and increase in the sales of low-priced table waters rather than by essential reduction in price of individual waters.

The State of New York leads in the number of commercial springs, quantity of water sold, and value of table water, and nearly ties Wisconsin for first place in total value, though the value of medicinal water marketed from New York is relatively low. Indiana leads in the value of medicinal water sold, but takes seventh rank in total value of waters. The leaders in the number of commercial springs are New York and Massachusetts; California and Virginia are tied for third place and are closely followed by Connecticut and Pennsylvania, each of which had 43 active springs in 1913. In total output New York is followed by Wisconsin, and that State in turn by Minnesota. In value of medicinal water California comes close to Indiana and is followed by Texas and Virginia. The sales of table water in New York and Wisconsin are more than twice as great as those in any other State, though California and Maine also had notable sales. Wisconsin leads in total value of mineral waters, is closely followed by New York, and thereafter in order by California, Maine, Virginia, Massachusetts, and Indiana, the total values for all other States falling below the $200,000 mark.

The number of springs reporting in 1913 was 838, as compared with 746 in 1912, an increase of 92. The appreciable extension of the collection of these statistics is indicated by the fact that only from three States and the District of Columbia were reports for less than three active springs received, as compared with seven States and the District of Columbia in 1912. No reports of mineral water sales were received from Arizona and Idaho. Only two States, New York and Wisconsin, reported sales of more than 5,000,000 gallons of water, but 15 others reported large sales, ranging from Colorado, 1,053,429 gallons, to Minnesota, 4,802,053 gallons. In three States, Wisconsin, New York, and California, the total value of the mineral-water output exceeded $500,000.

The following table gives the annual production and total value of mineral waters in 1883, 1885, and each fifth year thereafter to 1905, with the production and value for each year since 1909, inclusive:

Production of mineral waters, 1883–1913.

Year.	Commercial springs.	Quantity sold (gallons).	Value.	Year.	Commercial springs.	Quantity sold (gallons).	Value.
1883	189	7,529,423	$1,119,603	1909	760	64,674,486	$6,894,134
1885	224	9,148,401	1,312,845	1910	709	62,030,125	6,357,590
1890	273	13,907,418	2,600,750	1911	732	63,788,552	6,837,888
1895	370	21,463,543	4,254,337	1912	746	62,281,201	6,615,671
1900	561	45,276,995	5,791,805	1913	838	57,867,399	5,631,391
1905	564	46,544,361	6,491,251				

CONDITION OF MINERAL-WATER TRADE.

The reported production and value of mineral waters reached the maximum in 1909. There was a decline in 1910, followed by an increase in 1911, but in 1912 and 1913 there has been a decrease in the volume of business in spite of the fact that the field of the statistics has been extended and reports have been received from an increasing number of operators. Not only has this change taken place, but there is also a tendency toward a lower price, which may be attributed to decreased sales of high-priced waters and increased sales of low-priced waters. The general tendency toward a decline in price is doubtless due to demand for good pure potable bottled waters at moderate cost in place of the former demand for waters reputed to possess exceptional curative properties. Detailed examination of the statistics for the last few years shows that the installation of municipal purification plants in several large cities has been followed by marked decrease in the sales of spring waters in the immediate vicinity, and doubtless general improvements in the quality of public water supplies in smaller municipalities throughout the country has similarly affected the mineral-water business and has contributed to the present lowered production.

Comparative production of mineral waters, 1912–1913.

State.	1912			1913			Increase (+) or decrease (—) in number of springs.	Increase (+) or decrease (—) in quantity sold.	Percentage of increase (+) or decrease (—) in quantity sold.	Increase (+) or decrease (—) in value of product.	Percentage of increase (+) or decrease (—) in value of product.
	Commercial springs.	Quantity sold.	Value.	Commercial springs.	Quantity sold.	Value.					
		Gallons.			*Gallons.*			*Gallons.*			
Alabama	16	165,678	$20,435	15	169,687	$19,343	— 1	+ 4,009	+ 2	— $1,092	— 5
Arkansas	11	1,396,032	132,257	16	1,428,869	151,412	+ 5	+ 32,837	+ 2	+ 19,155	+ 15
California	41	2,089,951	532,971	49	2,801,393	531,925	+ 8	+ 711,442	+ 34	— 1,046	— .2
Colorado	11	1,178,308	75,314	11	1,053,429	89,820	0	— 124,879	— 11	+ 14,506	+ 19
Connecticut	28	2,110,231	153,383	43	2,458,327	136,878	+15	+ 348,096	+ 16	— 16,505	— 11
Delaware	1	(a)	(a)	1	(a)	(a)	0	(a)	(a)	(a)	(a)
District of Columbia	2	(a)	(a)	2	(a)	(a)	0	(a)	(a)	(a)	(a)
Florida	9	123,485	17,521	10	343,123	37,474	+ 1	+ 219,638	+178	+ 19,953	+114
Georgia	16	861,365	55,031	18	750,893	69,442	+ 2	— 110,472	— 13	+ 14,411	+ 26
Illinois	17	1,143,625	74,445	21	1,216,442	68,549	+ 4	+ 72,817	+ 6	— 5,896	— 8
Indiana	15	993,163	677,718	16	383,577	205,621	+ 1	— 609,586	— 61	—472,097	— 70
Iowa	6	84,300	11,375	5	48,665	7,369	— 1	— 35,635	— 42	— 4,006	— 35
Kansas	16	428,677	75,919	14	337,193	60,026	— 2	— 91,484	— 21	— 15,893	— 21
Kentucky	13	477,341	56,555	14	475,675	53,334	+ 1	— 1,666	— .4	— 3,221	— 6
Louisiana	4	561,660	33,345	5	700,795	39,657	+ 1	+ 139,135	+ 25	+ 6,312	+ 19
Maine	31	1,179,192	432,765	32	1,174,262	368,436	+ 1	— 4,930	— .4	— 64,329	— 15
Maryland	13	1,606,373	157,541	12	1,390,437	126,883	— 1	— 215,936	— 10	— 30,658	— 20
Massachusetts	54	4,502,806	247,397	60	3,907,395	213,802	+ 6	— 595,411	— 13	— 33,595	— 14
Michigan	18	1,420,465	75,611	20	884,893	52,642	+ 2	— 535,572	— 38	— 22,969	— 30
Minnesota	18	8,881,018	252,277	16	4,802,053	183,759	— 2	—4,078,965	— 46	— 68,518	— 27
Mississippi	10	639,905	126,241	12	346,652	81,800	+ 2	— 293,253	— 46	— 44,441	— 35
Missouri	30	608,385	81,114	34	697,467	84,316	+ 4	+ 89,082	+ 15	+ 3,202	+ 4
Montana	3	160,150	13,198	3	180,200	3,246	0	+ 20,050	+ 13	— 9,952	— 75
Nebraska	2	(a)	(a)	3	105,985	10,599	+ 1	(a)	(a)	(a)	(a)
Nevada	1	(a)	(a)	3	4,897	1,584	+ 2	(a)	(a)	(a)	(a)
New Hampshire	8	240,568	10,000	9	402,355	12,707	+ 1	+ 161,787	+ 67	+ 2,707	+ 27
New Jersey	12	2,386,217	209,726	14	2,067,277	188,546	+ 2	— 318,940	— 13	— 21,180	— 10
New Mexico	2	(a)	(a)	4	154,800	16,730	+ 2	(a)	(a)	(a)	(a)
New York	57	10,008,801	1,034,477	64	9,801,255	871,601	+ 7	— 207,546	— 2	—162,876	— 16
North Carolina	16	144,708	22,385	17	176,068	23,877	+ 1	+ 31,360	+ 22	+ 1,492	+ 7
North Dakota	0	0	0	5	582,356	14,403	+ 5	+ 582,356	....	+ 14,403	....
Ohio	30	2,709,745	117,287	33	3,317,639	125,084	+ 3	+ 607,894	+ 22	+ 7,797	+ 7
Oklahoma	10	1,015,512	32,971	12	502,439	26,231	+ 2	— 513,073	— 51	— 6,740	— 20
Oregon	6	48,351	17,503	8	68,413	19,409	+ 2	+ 20,062	+ 42	+ 1,906	+ 11
Pennsylvania	41	2,192,106	204,906	43	2,163,931	190,459	+ 2	— 28,175	— 1	— 14,447	— 7
Rhode Island	7	466,893	29,126	7	444,036	28,535	0	— 22,857	— 5	— 591	— 2
South Carolina	15	360,404	70,348	15	261,412	49,199	0	— 98,992	— 28	— 21,149	— 30
South Dakota	2	(a)	(a)	2	(a)	(a)	0	(a)	(a)	(a)	(a)

Tennessee	21	796,568	53,560	23	1,088,034	64,905	+ 2	+ 291,466	+ 37	+ 11,345	+ 21
Texas	34	1,292,992	151,395	38	1,187,612	132,488	+ 4	− 105,380	− 8	− 18,907	− 13
Utah	2	(a)	(a)	2	(a)	(a)	0	(a)	(a)	(a)	(a)
Vermont	3	21,000	8,280	4	17,725	7,068	+ 1	− 3,275	− 16	− 1,212	− 15
Virginia	45	2,762,319	349,255	49	2,873,288	298,473	+ 4	+ 110,969	+ 4	− 50,782	− 17
Washington	5	156,171	17,542	6	150,498	18,834	+ 1	− 5,673	− 4	+ 1,292	+ 7
West Virginia	11	309,245	60,445	10	316,749	52,259	− 1	+ 7,504	+ 2	− 8,186	− 14
Wisconsin	31	6,045,719	869,495	34	6,326,533	872,518	+ 3	+ 280,814	+ 5	+ 3,023	+ 4
Wyoming	2	(a)	(a)	4	16,200	3,610	+ 2	(a)	(a)	(a)	(a)
Miscellaneous States [b]		711,772	54,557		286,470	16,538		− 143,420	− 20	− 5,496	− 10
Total	746	62,281,201	6,615,671	838	57,867,399	5,631,391	+92	−4,413,802	− 7	−984,280	− 15

[a] Included under Miscellaneous States.

[b] Includes in 1912, Delaware, District of Columbia, Nebraska, Nevada, New Mexico, South Dakota, Utah, and Wyoming; in 1913, Delaware, District of Columbia, South Dakota, and Utah.

Nearly half the trade was in the hands of a few very large producers. Five springs sold more than 1,000,000 gallons each and 20 springs more than 500,000 gallons each, or an aggregate of 23,408,057 gallons, valued at $2,090,126. Fifty-four springs did more than $20,000 worth of business each, selling a total of 28,769,596 gallons for $3,642,964. Yet though half the sales were made by a few producers, the business as a whole is one of numerous small producers supplying local demand; for besides the big dealers just mentioned there are 784 others whose annual sales range in value from $5 to $20,000 and whose individual fields of activity occupy every State in the Union except Arizona and Idaho.

Increase of production is reported from 20 States; the greatest proportionate growth was in North Dakota, which advanced from a reported nonproduction in 1912 to a production of 582,356 gallons, valued at $14,403, in 1913; the sales in Florida during 1913 were nearly treble those in 1912. Among the 17 States of the million-gallon class 8 report increase and 9 decrease of sales, though in 4 of the 17 States the change was practically nothing; the greatest relative increases were in Tennessee (37 per cent) and California (34 per cent) and the greatest relative decrease was in Minnesota (46 per cent).

RANGE OF PRICE.

The price for which mineral waters are sold is governed almost entirely by supply and demand, and the value of the containers in which they are sold constitutes an appreciable part of the value of the packages. These conditions give to mineral waters as a class a wider range of price than pertains to almost any other mineral product.

Some widely distributed waters are sold in bottles that are not returnable, and the cost of the containers is usually included in the net value of the waters ready for the market. Other waters, especially table waters in local demand, are sold in returnable carboys whose value is not usually included in the net value of the waters. Consequently State average prices may be greatly affected by one or two high-priced medicinal waters or by a large number of low-priced table waters. In these statistics effort has been made to eliminate freight and marketing charges and the value of returnable containers and thus to give the net value of the waters at their source.

Range of price per gallon of mineral water in 1913.

Price per gallon (in cents.)	Number of springs.	Quantity sold.	Value.	Percentage of number of springs.	Percentage of total quantity.	Percentage of total value.
		Gallons.				
Not more than 2	34	5,693,870	$91,631	4	10	2
More than 2 and not more than 5	215	17,563,048	673,467	26	30	12
More than 5 and not more than 10	280	22,601,519	1,875,768	34	39	33
More than 10 and not more than 20	146	7,559,012	1,191,177	18	13	21
More than 20 and not more than 30	59	1,828,538	440,667	7	3	8
More than 30 and not more than 50	62	1,762,602	689,389	8	3	12
More than 50 and not more than 100	19	812,787	610,085	2	2	11
More than 100	5	46,023	59,207	1	0	1
Total	[a] 820	57,867,399	5,631,391	100	100	100

[a] Exclusive of 18 springs whose waters are used exclusively for the manufacture of soft drinks.

The preceding table shows the number of springs and the quantity and value of mineral water sold within certain ranges of price during 1913. Practically four-fifths of the mineral water was sold at prices ranging from half a cent to 10 cents a gallon, and only 5 per cent at prices greater than 30 cents a gallon. The water from 529 springs was sold for 10 cents or less a gallon and the water from 5 springs was sold at prices ranging from about $1 to about $5 a gallon. This table shows strikingly the great effect of demand on the price of mineral water. As a general rule, most of the higher-priced waters are sold for medicinal use, though several high-priced spring waters that are widely sold are on the market chiefly as table waters. The summary indicates moreover that the great bulk of the mineral-water business is in supplying table water at relatively low price.

That the general trend is toward decrease in price is indicated by the following table, which shows the average price per gallon of mineral water for the last five years and for each five years from 1885 to 1905.

Price per gallon of mineral water, 1885–1913, in cents.

Year.	Price per gallon.	Year.	Price per gallon.
1885	14.4	1909	10.7
1890	18.7	1910	10.2
1895	19.8	1911	10.7
1900	12.8	1912	10.6
1905	13.9	1913	9.7

SOFT DRINKS.

Though the manufacture and sale of soft drinks is an important branch of the mineral-water industry, the statistics regarding it are yet somewhat incomplete because of difficulty in obtaining reports from all manufacturers. The returns show that 5,259,494 gallons of mineral water went into the manufacture of soft drinks during 1913, as compared with 5,139,527 gallons in 1912, an increase of 2 per cent. The figures in the following table indicate the trend of this consumption. It should be remembered that these data do not in any way represent the total production of soft drinks, by far the greater part of which are compounded with municipal or private supplies not classified as mineral waters.

Gallons of mineral water used in manufacture of soft drinks, 1913, by States.

Rank.	State.	Quantity.	Rank.	State.	Quantity.
		Gallons.			*Gallons.*
1	Wisconsin	749,763	8	Maryland	171,000
2	Massachusetts	729,777	9	New York	168,570
3	Connecticut	639,217	10	Colorado	163,787
4	Minnesota	420,672		Other States	1,489,292
5	Pennsylvania	342,639			
6	Ohio	194,684		Total	5,259,494
7	Michigan	190,093			

IMPORTS.

The total imports of natural and artificial mineral waters in 1913, as reported by the Bureau of Foreign and Domestic Commerce, Department of Commerce, amounted to 3,364,676 gallons, valued at the points of shipment at $955,788. The imports have decreased in quantity more than 100,000 gallons a year since 1911, though their value was about $26,000 greater in 1913 than in 1912. More than 1,000,000 gallons each was imported in 1913 from France and Germany and nearly 400,000 gallons from Austria-Hungary; in other words, two-thirds of the imported mineral water consumed in the United States came from Germany, France, and Austria-Hungary. The next largest, but much smaller, importations were from Spain, Italy, Belgium, and England.

Mineral water imported and entered for consumption in the United States, 1900, 1905, and 1909–1913, in gallons.

Year.	Quantity.	Value.	Year.	Quantity.	Value.
1900	2,382,410	$663,803	1911	3,604,703	$1,037,485
1905	3,150,030	926,357	1912	3,499,497	930,091
1909	3,464,524	1,085,177	1913	3,364,676	955,788
1910	3,306,303	983,136			

EXPORTS.

Large quantities of a few domestic waters are exported, but no statistics regarding such shipments are available. The quantity and the value of these waters are included in the statistics of production for the United States.

MINERAL-WATER TRADE BY STATES.

ALABAMA.

Returns from Alabama indicate that the mineral-water trade in 1913 was practically the same as in 1912. The sales amounted to 169,687 gallons, or 4,009 gallons more than in 1912, and the value of the output was $19,343, or $1,092 less than in 1912. The average price reported was 11 cents a gallon, against an average of 12 cents in 1912. Fourteen springs reported sales; one spring active in 1912 was idle in 1913, and one spring's output, which was not reported, was estimated on the basis of the sales in 1912. There was some decrease in the sale of medicinal waters, but an appreciable increase in the sale of table waters, so that trade in the latter formed the greater part of the business. Five bathing establishments and resorts accommodating nearly 1,500 guests at 9 springs were maintained. In addition to the quantity reported as sold, 70,000 gallons of mineral water was used in the manufacture of soft drinks.

The following 14 springs reported sales:

Alabama Mineral Springs, McWilliams, Wilcox County.
Bailey Springs, Florence, Lauderdale County.
Bladon Spring, Bladon Springs, Choctaw County.
Blount Springs, Blount Springs, Blount County.
Bromberg Gulf Coast Lithia Spring, Bayou La Batre, Mobile County.
Dixie Spring, Dixie Spring, Walker County.
Healing Springs, Healing Springs, Washington County.
Ingram Lithia Wells, near Ohatchee, Calhoun County.

Livingston Spring, Livingston, Sumter County.
Luverne Mineral Spring, Luverne, Crenshaw County.
MacGregor Spring, Spring Hill, Mobile County.
Matchless Mineral Wells, east of Greenville, Butler County.
Purity Spring, Spring Hill, Mobile County.
White Sulphur Wells, near Jackson, Clarke County

ARKANSAS.

The mineral water business in Arkansas increased somewhat during 1913, principally because of the operation of new springs, the total sales having increased from 1,396,032 gallons, valued at $132,257, in 1912 to 1,428,869 gallons, valued at $151,412, in 1913, an increase of 2 per cent in quantity and of 15 per cent in value. The average price per gallon rose from 10 to 11 cents.

The following table shows the record for the last five years:

Production and value of mineral waters in Arkansas, 1909–1913.

Year.	Commercial springs.	Quantity sold.	Value.	Average price per gallon.
		Gallons.		*Cents.*
1909	10	1,213,742	$153,163	13
1910	10	1,065,676	89,772	8
1911	8	1,560,157	118,994	8
1912	11	1,396,032	132,257	10
1913	16	1,428,869	151,412	11

Sales were reported this year from five more springs than in 1912 and the number of bathing establishments increased from two to three, accommodations for guests increasing from 4,000 to 5,500, exclusive of the capacity of Hot Springs. More than one-half the mineral water is sold for medicinal use.

The United States Government maintains under the direction of the Secretary of the Interior the Hot Springs Reservation of about 900 acres, including Hot Springs Mountain, North Mountain, West Mountain, Sugarloaf Mountain, and Whittington Lake Park. The springs are all grouped about the base of Hot Springs Mountain, their aggregate flow being somewhat more than 800,000 gallons a day. Twenty-three pay bath houses and the Army and Navy General Hospital are supplied with hot water from these springs. The majority of the active springs of Arkansas are at or near Hot Springs.

The 16 springs reporting sales are as follows:

Arkansas Lithia Springs, near Hope, Hempstead County.
Arsenic Springs, Hot Springs, Garland County.
Chewaukla Spring, Hot Springs, Garland County.
De Soto Springs, Hot Springs, Garland County.
Glenaqua Mineral Springs, Hot Springs, Garland County.
Happy Hollow Spring, Hot Springs, Garland County.
Imperial Spring, Hot Springs, Garland County.
Iron and Magnesia Springs, Hot Springs, Garland County.
Lithia and Sulphur Springs, Sulphur Springs, Benton County.
Mountain Blood Spring, near Hot Springs, Garland County.
Mountain Valley Springs, Mountain Valley, Garland County.
Oaklawn Mineral Well, Hot Springs, Garland County.
Ozarka Spring, Eureka Springs, Carroll County.
Park Springs, Bentonville, Benton County.
Potash Sulphur Springs, Hot Springs, Garland County.
Ravenden Springs, Ravenden Springs, Randolph County.

CALIFORNIA.

There was a large increase during 1913 in the mineral-water sales of California, 2,801,393 gallons having been reported, as compared with 2,089,951 gallons in 1912, an increase of 711,442 gallons, or 34 per cent. The total value of the product, however, remained practically the same, being $531,925 in 1913, as compared with $532,971 in 1912; this was chiefly because the greater part of the increased output was in a few table waters that were sold at lower prices than formerly. The average price per gallon fell from 26 to 19 cents. Though two-thirds of the total output was sold for table use, California ranked second in 1913, as in 1912, in the production of medicinal waters. The State also ranked third in number of active springs and in value of output. The record for the last five years is as follows:

Production and value of mineral waters in California in 1909–1913.

Year.	Commercial springs.	Quantity sold.	Value.	Average price per gallon.
		Gallons.		*Cents.*
1909	44	2,179,187	$444,230	20
1910	41	2,008,697	394,841	20
1911	40	2,310,237	578,439	25
1912	41	2,089,951	532,971	26
1913	49	2,801,393	531,925	19

Five new springs were added to the list of producers in 1913; five idle in 1912 reported sales in 1913; two other springs formerly active were idle; and the output of three that failed to report was estimated—the total number of active springs thus having been increased to 49, or 8 more than in 1912. Mineral-water baths and resorts accommodating a total of 4,800 guests were maintained at 23 springs. A total of 50,000 gallons was reported as having been used in the manufacture of soft drinks.

The 46 springs reporting are as follows:

Ætna Springs, Lidell, Napa County.
Alder Glen Spring, Cloverdale, Sonoma County.
Alhambra Spring, Martinez, Contra Costa County.
Alma Spring, Alma, Santa Clara County.
Barcal Springs, Preston, Sonoma County.
Bartlett Springs, Bartlett Springs, Lake County.
Boyes Hot Springs, Boyes Springs, Sonoma County.
Bythinia Springs, Santa Barbara, Santa Barbara County.
Caliente Mineral Spring, Agua Caliente, Sonoma County.
California Geysers, The Geysers, Sonoma County.
Castalian Water, Inyo County.
Castle Rock Spring, Eubanks, Shasta County.
Console Spring, Colton, Riverside County.
Cooks Springs, near Williams, Colusa County.
Crystal Spring, Los Angeles, Los Angeles County.
El Granito Spring, El Cajon, San Diego County.
Elliotta White Sulphur Spring, Riverside, Riverside County.
Elysian Spring, Los Angeles, Los Angeles County.
Fouts Springs, Fouts Springs, Colusa County.
Grizzly Spring, near Sulphur Creek, Colusa County.
Lepori Vichy Springs, near Napa City, Napa County.
Lytton Spring, Lytton, Sonoma County.
Mercey Spring, Fresno County, near South Dos Palos.
Mokelumne Hill Spring, Mokelumne, Calaveras County.
Napa Soda Springs, Napa Soda Springs, Napa County.
Paraiso Hot Springs, Paraiso Springs, Monterey County.

Paso Robles Hot Springs, Paso Robles, San Luis Obispo County.
Pinkham Spring, Santa Barbara, Santa Barbara County.
Purity Springs, Sausalito, Marin County.
Radium Sulphur Springs, Colegrove, Los Angeles County.
Redwing Springs, Middletown, Lake County.
Rose Spring, Los Angeles, Los Angeles County.
Samuel Soda Springs, Monticello, Napa County.
San Benito Spring, near Hollister, San Benito County.
Shasta Springs, Shasta Springs, Siskiyou County.
Soboba Lithia Hot Springs, San Jacinto, Riverside County.
Table Rock Spring, Little Shasta, Siskiyou County.
Tamalpais Spring, San Rafael, Marin County.
Tia Juana Springs, San Ysidro, San Diego County.
Tolenas Spring, near Suisun City, Solano County.
Upper Soda Spring, Dunsmuir, Siskiyou County.
Valley Springs, Valley Springs, Calaveras County.
Veronica Medicinal Springs, near Santa Barbara, Santa Barbara County.
Vito Nuevo Spring, Mono County.
Walters Springs, Pope Valley, Napa County.
Witter Medical Springs, Witter, Lake County.

COLORADO.

Returns from Colorado indicate a decrease in quantity of water sold in 1913, due chiefly to a falling off in the sales of one large producer. The sales reported are 1,053,429 gallons, valued at $89,820, as compared with 1,178,308 gallons, valued at $75,314, in 1912. Though the decrease in quantity amounts to 11 per cent, the total value of the product increased $14,506, or 19 per cent, this being accompanied by an increase in the average price from 6 to 9 cents.

The following is the record for the last five years:

Production and value of mineral waters in Colorado, 1909–1913.

Year.	Commercial springs.	Quantity sold.	Value.	Average price per gallon.
		Gallons.		*Cents.*
1909	15	1,077,820	$111,158	10
1910	14	1,638,984	115,289	7
1911	14	1,436,066	104,763	7
1912	11	1,178,308	75,314	6
1913	11	1,053,429	89,820	9

Reports were received from no new springs during 1913. Colorado mineral waters are sold chiefly for table use. The number of bath resorts has increased from three in 1912 to five in 1913. Besides the quantity reported sold 163,787 gallons was used in the manufacture of soft drinks.

The 11 springs reporting are as follows:

Boulder Springs, Crisman, Boulder County.
Canon City Soda Spring, Canon City, Fremont County.
Clark Magnetic Mineral Spring, Pueblo, Pueblo County.
Columbia Well, Denver, Denver County.
Crystal Springs, Fowler, Otero County.
Marshall's Magnetic Mineral Spring, Pueblo, Pueblo County.
Navajo, Shoshone, Manitou, and Cheyenne springs, Manitou, El Paso County.
Pueblo Mineral Spring, Pueblo, Pueblo County.
Ute Chief Spring, Manitou, El Paso County.
Ute Iron, Ouray, Little Chief, and Iron Springs Geyser springs, Manitou, El Paso County.
Yampah Spring, Glenwood Springs, Garfield County.

CONNECTICUT.

The mineral-water sales in Connecticut during 1913 amounted to 2,458,327 gallons, an increase of 348,096 gallons, or 16 per cent, over sales in 1912; but the value of the output dropped from $153,383 in 1912 to $136,878 in 1913, a decrease of 11 per cent. This decrease in value in spite of a marked increase in output is the result chiefly of general decrease in price but great increase in production of table waters and of decrease in sales of a few relatively high-priced medicinal waters. The average price per gallon dropped from 7 cents in 1912 to 6 cents in 1913. The record for sales for the last five years follows:

Production and value of mineral waters in Connecticut, 1909–1913.

Year.	Commercial springs.	Quantity sold.	Value.	Average price per gallon.
		Gallons.		*Cents.*
1909	22	691,296	$42,375	6
1910	24	1,608,775	109,853	7
1911	28	2,164,701	182,744	8
1912	28	2,110,231	153,383	7
1913	43	2,458,327	136,878	6

Fourteen new springs, all but two of which sell table water exclusively, reported, and the production of one delinquent spring was estimated on the basis of the previous year's business, the number of active springs having been thus increased to 43. Nearly all the water is sold for table use. No resorts or mineral-water baths were reported as having been in operation at any of the springs, but nearly 640,000 gallons was used in the manufacture of soft drinks.

The 42 springs reporting are as follows:

Althea Spring, Waterbury, New Haven County.
Ansantawae Spring, Milford, New Haven County.
Aspinock Spring, Putnam Heights, Windham County.
Bailey Spring, Mill Plain Road, Fairfield County.
Barcla Spring, Danbury, Fairfield County.
Berkshire Spring, Cornwall Bridge, Litchfield County.
Buttress Spring, Woodbridge, New Haven County.
Chalybeate Spring, Oxford, New Haven County.
Cherry Hill Spring, Highwood, New Haven County.
Colonial Spring, Danbury, Fairfield County.
Crystal Spring, near Little River, Middlesex County.
Crystal Spring, near Derby, New Haven County.
Diamond Spring, Cheshire, New Haven County.
East Hill Spring, Derby, New Haven County.
Elco Spring, Elco Springs, Hartford County.
Ellis Mountain Spring, Danbury, Fairfield County.
Foxhunter Spring, Salisbury, Littlefield County.
Granite Rock Spring, Higganum, Middlesex County.
Gra-Rock Spring, Canton, Hartford County.
Hallett Spring, Stratfield, Fairfield County.
Hermitage Spring, Monotowese, New Haven County.
Highland Spring, near Mount Higbee, Middlesex County.
Hillside Spring, West Meriden, New Haven County.
Hosmer Spring, Willimantic, Windham County.
Indian Spring, Shelton, Fairfield County.

Live Elm Spring, Meriden, New Haven County.
Live Oak Spring, Meriden, New Haven County.
Mammanasco Spring, Ridgefield County.
Mohawk Spring, Torrington, Litchfield County.
Mountain View Spring, Middletown, Middlesex County.
Mountainville Spring, Danbury, Fairfield County.
Oak Spring, Middletown, Middlesex County.
Park Spring, Willimantic, Windham County.
Pequabuck Mountain Spring, Bristol, Hartford County.
Pequot Spring, Old Mystic, New London County.
Red Rock Spring, Meriden, New Haven County.
Richardson Spring, Torrington, Litchfield County.
St. George Spring, Ridgefield, Fairfield County.
Shantok Spring, Uncasville, New London County.
Tonica Spring, Highland Park, Hartford County.
Varuna Spring, North Stamford, Fairfield County.
Venture Rock Spring, Stonington, New London County.

DELAWARE.

Reports have been received from only one spring in Delaware during the last three years, the water being used principally on the table by residents of Wilmington. The spring is:

Kiamensi Spring, near Wilmington, Newcastle County.

DISTRICT OF COLUMBIA.

As only two springs, whose water is sold for table use, mainly in Washington, reported sales from the District of Columbia in 1913, statistics on them have been included with those of other States having less than three reporting springs.

The same springs reported in 1911 and 1912 and are:

Gitchie Crystal Spring, Benning.
Red Oak Spring, near Langdon.

FLORIDA.

The addition of two new springs to the list of producers in Florida nearly trebled the output during 1913, when the total sales amounted to 343,123 gallons, valued at $37,474, as compared with 123,485 gallons, valued at $17,521, in 1912. The average price per gallon continued to fall, dropping from 14 cents in 1912 to 11 cents in 1913. About half the water was sold for medicinal use. Bathing establishments and resorts for about 900 guests were maintained at six springs. One water on the market in 1912 was not sold in 1913, but Purity Spring and Stomawa Well were added to the list, and thus the total number of commercial springs in the State has been increased by one.

The 10 springs reporting sales are:

Chumuckla Spring, McDavid, Santa Rosa County.
Espiritu Santo Spring, Safety Harbor, Pinellas County.
Lackawanna Spring, near Jacksonville, Duval County.
Newport Spring, Newport, Wakulla County.
Orange City Mineral Spring, Orange City, Volusia County.
Panacea Mineral Spring, Panacea, Wakulla County.
Purity Spring, Tampa, Hillsboro County.
Quisisana Spring, Green Cove Springs, Clay County.
Stomawa Well, near Tampa, Hillsboro County.
Wekiwa Springs, Wekiwa Springs, Orange County.

GEORGIA.

The returns from Georgia indicate a falling off in quantity during 1913, but a notable increase in value. This apparent anomaly was due mostly to increase in the sales of some rather high-priced table waters, because of which the average price per gallon increased from 6 to 9 cents. The total sales in 1913 amounted to 750,893 gallons, valued at $69,442, as compared with 861,365 gallons, valued at $55,031, in 1912, these figures corresponding to a decrease of 13 per cent in quantity and an increase of 26 per cent in value. A little more than 10 per cent of the water is sold for medicinal use. Two springs, Dalton Mineral and Holly, reported production for the first time. Resorts accommodating about 700 people were in operation at 7 springs and mineral-water baths were maintained at 4.

The 18 springs reporting sales are:

Benscot Lithia Springs, Austell, Cobb County.
Bowden Lithia Spring, Lithia Springs, Douglas County.
Catoosa Springs, Catoosa Springs, Catoosa County.
Chalybeate Spring, Chalybeate, Meriwether County.
Dalton Mineral Spring, near Dalton, Whitfield County.
Daniel Mineral Spring, Union Point, Green County.
Duke Spring, near Cedartown, Polk County.
Electric Lithia Spring, Hillman, Taliaferro County.
High Rock Magnesia Spring, near Atlanta, Fulton County.
Holly Springs, Holly Springs, Cherokee County.
Jay Bird Spring, near Helena, Dodge County.
Miller's Mineral Spring, Milledgeville, Baldwin County.
Murrow Spring, Tifton, Tift County.
Pine Mountain Spring, West Point, Harris County.
Swift Lithia Spring, Elberton, Elbert County.
Utoy-Flora Spring, Utoy, Fulton County.
White Elk Spring, Macon, Bibb County.
White Oak Spring, Macon, Bibb County.

ILLINOIS.

According to the returns received from Illinois 1,216,442 gallons of mineral water, valued at $68,549 was sold during 1913; the sales in 1912 amounted to 1,143,625 gallons, valued at $74,445. Thus in 1913 there was an increase of 6 per cent in quantity but a decrease of 8 per cent in value, with a drop in the average price from 7 to 6 cents per gallon. The value of the medicinal waters, which constituted about one-tenth of the trade, decreased a little, most of the falling-off being in the value of the table waters. The record of the State for the last five years is as follows:

Production and value of mineral waters in Illinois, 1909–1913.

Year.	Commercial springs.	Quantity sold.	Value.	Average price per gallon.
		Gallons.		*Cents.*
1909	14	639,460	$49,108	8
1910	16	1,117,620	83,148	7
1911	14	1,304,950	82,330	6
1912	17	1,143,625	74,445	7
1913	21	1,216,442	68,549	6

Reports were received from 21 active springs, of which one, Sulphur Lick Spring, is new, and three idle in 1912 reported production. About 130,000 gallons was used in the manufacture of soft drinks. Bathing establishments were operated at six and resorts for guests at four springs.

Sales were reported from the following 21 springs:

Abana Spring, Libertyville, Lake County.
Aqua Vitæ Mineral Spring, Maquon, Knox County.
Brady Spring, Joliet, Will County.
Central Park Sulphur Spring, Peoria, Peoria County.
Cumberland Mineral Spring, Greenup, Cumberland County.
Glen Flora Mineral Spring, Waukegan, Lake County.
Gravel Spring, near Jacksonville, Morgan County.
Indian Spring, Streator, Lasalle County.
Macinac Mineral Springs, near Carlock, Woodford County.
Mokena Mineral Spring, Mokena, Will County.
Montgomery Magnesia Spring, Montgomery, Kane County.
Namonomia and Old Ironsides springs, Dixon Springs, Pope County.
Pekin Mineral Spring, Pekin, Tazewell County.
Perry Spring, Perry, Pike County.
Ripley Mineral Spring, Cooperstown, Brown County.
Sanicula Spring, South Ottawa, Lasalle County.
Scott's Springs, Galatia, Saline County.
Sulphur Lick Spring, Wedron, Lasalle County.
White Diamond Spring, South Elgin, Kane County.
White Eagle Spring, Edgemont, St. Clair County.

INDIANA.

Statistics from Indiana show 383,557 gallons of mineral water sold in 1913 for $205,621, at an average price of 54 cents, as compared with 993,163 gallons sold for $677,718, in 1912, at an average price of 68 cents. This apparently enormous decline is caused, however, by the omission of reports from certain springs that were included in 1912, and not to any essential change in the business, and the change in price is accounted for in the same manner. One new spring reported in 1913, increasing the number of active springs to 16, and 1 delinquent has been considered idle. The greater part of the mineral water is sold for medicinal use. At eight springs there are resorts accommodating more than 2,000 people and at these springs the water is also used for bathing. Very little mineral water is used for the manufacture of soft drinks.

The following 16 springs have reported sales:

Blue Cast Magnetic Spring, Woodburn, Allen County.
Blue Lick Spring, Blue Lick, Clark County.
Bronson Spring, Terre Haute, Vigo County.
Carlson Mineral Springs, Laporte, Laporte County.
Cartersburg Mineral Spring, Cartersburg, Hendricks County.
Coats Spring, Littles, Pike County.
Colomagna Springs, Columbus, Bartholomew County.
Craig Spring, Greenwood, Johnson County.
Knott's Mineral Spring, Porter, Porter County.
McCullough Spring, Oakland City, Gibson County.
Mudlavia Lithia Spring, Kramer, Warren County.
Paoli Lithia Spring, Paoli, Orange County.
Pluto, Proserpine, and Bowles springs, French Lick, Orange County.
Reid Mineral Spa Lithia Spring, near Richmond, Wayne County.
West Baden Mineral Springs, West Baden, Orange County.
White Crane Spring, Dillsboro, Dearborn County.

IOWA.

The output of mineral water in Iowa during 1913 suffered appreciable decrease, chiefly because of a falling off in the sales of one large producer. The total sales amounted to 48,665 gallons, valued at $7,369, at an average price of 15 cents The sales reported in 1912 were 84,300 gallons, valued at $11,375, at an average price of 14 cents. The decrease in quantity was 42 per cent, and in spite of an increase of 1 cent in the average price, the decline in value was $4,006, or 35 per cent. One spring, active in 1912, was reported idle in 1913, and no new springs were reported. About four-fifths of the water was sold for table use. In addition to the quantity given above, about 100,000 gallons of mineral water was used in the manufacture of soft drinks. The five springs reporting sales are as follows:

Crystal Spring, Estherville, Emmet County.
Egralharve Spring, Montgomery, Dickinson County.
Fry's Spring, Colfax, Jasper County.
Heston's Spring, Fairfield, Jefferson County.
White Sulphur Spring, Linwood, Scott County.

KANSAS.

The output of mineral water in Kansas during 1913 showed a marked decrease, the total sales amounting to 337,193 gallons, valued at $60,026, as compared with 428,677 gallons, valued at $75,919, in 1912. This corresponds to a decrease of 21 per cent in both quantity and value. The average price per gallon remained 18 cents. As no new springs reported and two springs hitherto active were idle, the number of commercial springs was reduced to 14, the output of one of which was estimated from the output in 1912. Resorts for guests, with bathing establishments, were maintained at four springs, and accommodated about 170 guests.

The following 13 springs reported sales:

Abilena Spring, Abilene, Dickinson County.
Aganippe Spring, near Independence, Montgomery County.
Blasing's Mineral Spring, near Manhattan, Riley County.
California Spring, Ottawa, Franklin County.
Crystal Spring, Coffeyville, Montgomery County.
Geyser Mineral Springs, Rosedale, Wyandotte County.
Hiatts Crystal and Mineral Springs, Winfield, Cowley County.
Ke-Lo Artesian Well, Kingman, Kingman County.
Magnesium and Choteau springs, Independence, Montgomery County.
Phillip's Mineral Spring, Topeka, Shawnee County.
Riverview Spring, Winfield, Cowley County.
Sycamore Mineral Spring, Sabetha, Brown County.
Waconda Spring, Waconda Springs, Mitchell County.

KENTUCKY.

The mineral-water business in Kentucky during 1913 was about the same as in 1912. The reported sales were 475,675 gallons as compared with 477,341 gallons in 1912, a decrease of less than 1 per cent, and the value of the sales in 1913 was $53,334 as compared with $56,555 in 1912, a decrease of 6 per cent. The average price decreased less than a cent a gallon, being 11 cents in 1913. Reports were received from three new springs, Crystal Spring, Kentucky

Carlsbad Spring, and St. Patrick's Well. The output from two springs from which reports could not be obtained has been estimated on the basis of the production reported for 1912. The total output was about equally divided between table and medicinal waters. There were resorts at six of the springs with accommodations for about 2,300 people, and bath establishments were maintained at two of these resorts. In addition to the sales already reported, about 79,000 gallons of mineral water was used in making soft drinks.

The 12 springs from which reports were received are as follows:

Anita Springs, La Grange, Oldham County.
Blue Rock Spring, Fisherville, Jefferson County.
Crystal Spring, Pollard, Boyd County.
Glen Lily Spring, near Bowling Green, Warren County.
Hamby's Spring, Dawson Springs, Hopkins County,
Kentucky Carlsbad Spring, Dry Ridge, Grant County.
Kentucky Mineral Well, Lorain, Taylor County.
Lexington Lithia Springs, Lexington, Fayette County.
Robson Spring, Fort Thomas, Campbell County.
Royal Magnesian Spring, near La Grange, Oldham County.
St. Patrick's Well, Louisville, Jefferson County.
Sanders Lithia Springs, Sanders, Carroll County.

LOUISIANA.

Though the number of commercial springs in Louisiana is small the individual productions are large. Five springs reported in 1913 a total output of 700,795 gallons, valued at $39,657, or at an average price of 6 cents a gallon. The corresponding figures for 1912 are 561,660 gallons, valued at $33,345. The increased business in 1913 represents 25 per cent increased production and 19 per cent increased value. Nearly five-sixths of the water was sold for table use. The record of sales for the last five years is as follows:

Production and value of mineral waters in Louisiana, 1909–1913.

Year.	Commercial springs.	Quantity sold.	Value.	Average price per gallon.
		Gallons.		*Cents.*
1909	5	1,375,000	$103,850	8
1910	4	2,313,000	163,975	7
1911	5	1,520,550	110,998	7
1912	4	561,660	33,345	6
1913	5	700,795	39,657	6

The notable drop in production after installation of the new waterworks in New Orleans has apparently been followed by partial recovery of the trade. No new spring was reported, but one temporarily idle in 1912 reported sales in 1913. Resorts were operated at two springs.

The five springs that made returns are as follows:

Abita Springs, Abita Springs, St. Tammany Parish.
Geyser Spring, Hammond, Tangipahoa Parish.
Greenwell Spring, Magnolia, East Baton Rouge Parish.
Krotz Spring, Krotz Springs, St. Landry Parish.
Ozone Spring, Pearl River, St. Tammany Parish.

MAINE.

The production of mineral water in Maine during 1913 was practically the same as in 1912. The quantity sold amounted to 1,174,262 gallons, valued at $368,436, as compared with 1,179,192 gallons, valued at $432,765, in 1912. The decrease in value, $64,329, or 15 per cent, is equivalent to a decrease in average price from 37 to 31 cents a gallon.

The following table shows the record of sales for the last five years:

Production and value of mineral waters in Maine, 1909–1913.

Year.	Commercial springs.	Quantity sold.	Value.	Average price per gallon.
		Gallons.		*Cents.*
1909	33	1,515,541	$402,593	27
1910	29	1,238,171	404,539	33
1911	28	1,254,783	431,740	34
1912	31	1,179,192	432,765	37
1913	32	1,174,262	368,436	31

Two new producers reported—Arctic Spring, at Bangor, and Bartlett Artesian Well, at Lewiston. The output of one spring that failed to report was estimated on the basis of the production for 1912. In addition to the quantity above reported nearly 95,000 gallons was used in the manufacture of soft drinks. Two resorts for guests, but no mineral-water baths, were operated.

The names of the 31 springs reporting are:

Arctic Spring, Bangor, Penobscot County.
Bakers Puritan Spring, Pine Point, Cumberland County.
Bartlett Artesian Well, Lewiston, Androscoggin County.
Blue Hill Mineral Spring, Blue Hill, Hancock County.
Forest Springs, Litchfield, Kennebec County.
Glenrock Cold Spring, Greene, Androscoggin County.
Glenwood Spring, Augusta, Kennebec County.
Glenwood Mineral Spring, St. Albans, Somerset County.
Hanover Spring, Hanover, Oxford County.
Highland Mineral Spring, Lewiston, Androscoggin County.
Indian Hermit Spring, Wells Village, York County.
Kennebunk Mineral Spring, Kennebunkport, York County.
Keystone Mineral Spring, East Poland, Androscoggin County.
Littlefield Spring, Gardiner, Kennebec County.
Mount Desert Spring, Northeast Harbor, Hancock County.
Mount Zircon Spring, Milton Plantation, Oxford County.
Mystic Spring, Saco, York County.
Oak Grove Spring, Brewer, Penobscot County.
Paradise Spring, Brunswick, Cumberland County.
Pine Spring, Topsham, Sagadahoc County.
Pine Croft Spring, Freeport, Cumberland County.
Poland Spring, South Poland, Androscoggin County.
Purity Spring, West Scarboro, Cumberland County.
Redman Farm Spring, Belfast, Waldo County.
Rocky Hill Spring, Fairfield, Somerset County.
Seal Rock Spring, Saco, York County.
Skowhegan Crystal Spring, Skowhegan, Somerset County.
Thorndike Mineral Spring, near Thorndike, Waldo County.
Underwood Spring, Falmouth Foreside, Cumberland County.
Wawa Lithia Spring, Ogunquit, York County.
Windsor Spring, Lewiston, Androscoggin County.

MARYLAND.

The mineral-water business of Maryland decreased 10 per cent in quantity and 20 per cent in value during 1913, while the average price dropped from 10 to 9 cents a gallon. The sales totaled 1,390,437 gallons, valued at $126,883, mostly table water, whereas in 1912 the sales amounted to 1,606,373 gallons, valued at $157,541.

The following record for the last five years indicates a maximum production in 1911 followed by a decline:

Production and value of mineral waters in Maryland, 1909–1913.

Year.	Commercial springs.	Quantity sold.	Value.	Average price per gallon.
		Gallons.		*Cents.*
1909	7	938,496	$91,569	10
1910	8	1,163,828	102,371	9
1911	12	1,657,756	150,966	9
1912	13	1,606,373	157,541	10
1913	12	1,390,437	126,883	9

No new spring was reported, the output of one that failed to report was estimated, and one spring active in 1912 was reported out of business in 1913, these changes making the total number of commercial springs 12. Only one resort for guests was operated, but two mineral baths hitherto unreported were in operation, and in addition about 170,000 gallons of spring water was used in the manufacture of soft drinks.

The 11 springs reporting sales are as follows:

Altamont Spring, near Deer Park, Garrett County.
Buena Vista Spring, Edgemont, Washington County.
Carroll Springs, Forest Glen, Montgomery County.
Caton Spring, Catonsville, Baltimore County.
Chattolanee Spring, Chattolanee, Baltimore County.
Crystal Rock Spring, Berwyn, Prince Georges County.
Gneiss Rock Artesian Well, Ruxton Heights, Baltimore County.
Indian Spring, Hillsdale, Baltimore County.
Mardela Mineral Spring, Mardela, Wicomico County.
Rock Crystal Spring, Rognel Heights, Baltimore County.
Royal Spring, Franklintown, Baltimore County.

MASSACHUSETTS.

Returns from Massachusetts for 1913 indicate a decline of 13 per cent in production and 14 per cent in value of mineral water. The reported sales are 3,907,395 gallons, as compared with 4,502,806 gallons in 1912, the total value being $213,802 in 1913 and $247,397 in 1912. The average price, 6 cents a gallon, remained the same. The additional quantity used in the manufacture of soft drinks decreased from 900,000 gallons in 1912 to 730,000 gallons in 1913. In spite of these decreases the State ranks second in number of commercial springs and fourth in total production.

The following record shows a gradual decline in trade since 1909:

Production and value of mineral waters in Massachusetts, 1909–1913.

Year.	Commercial springs.	Quantity sold.	Value.	Average price per gallon.
		Gallons.		*Cents.*
1909	60	5,424,082	$228,067	4
1910	55	4,691,159	241,949	5
1911	56	4,610,474	218,870	5
1912	54	4,502,806	247,397	6
1913	60	3,907,395	213,802	6

Output was reported by six new springs and the production of two was estimated from the sales reported in 1912, so that there were in all 60 active springs. Two bathing establishments and two small resorts were reported. Practically eight-ninths of the trade was in table water. The 58 reporting springs are as follows:

Abbott Spring, Methuen, Essex County.
Avonia Spring, Weymouth, Norfolk County.
Ballardvale Spring, Ballardvale, Essex County.
Belmont Crystal Spring, Belmont, Middlesex County.
Belmont Hill Spring, Everett, Middlesex County.
Burnham Spring, Methuen, Essex County.
Cadwells Crystal and Los Altos springs, Woburn, Middlesex County.
Chapmans Crystal Spring, Stoneham, Middlesex County.
Cold Spring, South Braintree, Norfolk County.
Crescent Spring, Brockton, Plymouth County.
Crystal Spring, West Peabody, Essex County.
Deep Glen Spring, West Lynn, Essex County.
El-Azhar Spring, Tyngsboro, Middlesex County.
Goulding Spring, Whitman, Plymouth County.
Granite Rock Spring, Brockton, Plymouth County.
Highland Spring, West Abington, Plymouth County.
Holyoke Spring, West Lynn, Essex County.
Indian Spring, Brockton, Plymouth County.
King Philip Spring, Mattapoisett, Plymouth County.
Klines Spring, Lawrence, Essex County.
Leicester Polar Spring, Spencer, Worcester County.
Massasoit Spring, West Springfield, Hampden County.
Milton Spring, Milton, Norfolk County.
Moose Hill Spring, Swampscott, Essex County.
Mountain Park Spring, Swampscott, Essex County.
Mount Blue Spring, Hingham, Plymouth County.
Mount Holyoke Lithia Spring, South Hadley, Hampshire County.
Mount Pleasant Spring, Lowell, Middlesex County.
Mount Vernon Spring, Mount Vernon, Essex County.
Nemasket Spring, Middleboro, Plymouth County.
New Abbott Spring, Methuen, Essex County.
Nobscot Mountain Spring, Framingham, Middlesex County.
Norwood Spring, Norwood, Norfolk County.
Oak Hill Spring, Brockton, Plymouth County.
October Mountain Spring, Lenox, Berkshire County.
Paradise Spring, Rowley, Essex County.
Pearl Hill Mineral Spring, Fitchburg, Worcester County.
Pepperell Spring, Pepperell, Middlesex County.
Pequot Mineral Spring, North Natick, Middlesex County.
Pine Crest Spring, Pittsfield, Berkshire County.
Pocahontas Spring, Lynnfield Center, Essex County.
Puritan Spring, Andover, Essex County.
Purity Spring, Spencer, Worcester County.
Robbins Springs, Arlington Heights, Middlesex County.
Roberge Mineral Spring, Worcester, Worcester County.

Sand Spring, Williamstown, Berkshire County.
Shawmut Spring, West Quincy, Norfolk County.
Simpson Spring, South Easton, Bristol County.
Sippican Spring, Marion, Plymouth County.
Sterling Spring, West Lynn, Essex County.
Stevens Spring, Lawrence, Essex County.
Twin Elm Spring, Lexington, Middlesex County.
Valpey Spring, Lawrence, Essex County.
Wampanoag Spring, Williamstown, Berkshire County.
Whitman Spring, Whitman, Plymouth County.
Wilbraham Mountain Spring, Wilbraham, Hampden County.
Ye Cape Cod Pilgrim Spring, South Wellfleet, Barnstable County.

MICHIGAN.

Reported sales of mineral water in Michigan showed a marked decrease in 1913. The total production was 884,893 gallons, valued at $52,642, or at an average price of 6 cents a gallon, as compared with a production in 1912 of 1,420,465 gallons, valued at $75,611, or at an average price of 5 cents a gallon. These figures represent a decrease of 38 per cent in output and of 30 per cent in value.

The following is the record of sales for the last five years:

Production and value of mineral waters in Michigan, 1909–1913.

Year.	Commercial springs.	Quantity sold.	Value.	Average price per gallon.
		Gallons.		*Cents.*
1909	19	2,760,604	$104,454	4
1910	17	1,454,020	69,538	5
1911	19	1,713,401	72,253	4
1912	18	1,420,465	75,611	5
1913	20	884,893	52,642	6

Beaver, Giant Mineral, and Moorman springs reported sales for the first time, and the output of two that failed to report was estimated on the basis of sales in 1912. Two springs active in 1912 were idle in 1913 and one idle in 1912 was active in 1913; thus the number of commercial springs increased to 20. About 7 per cent of the water is sold for medicinal use. In addition to the sales reported 190,000 gallons was used in the manufacture of soft drinks.

The 18 springs reporting sales are:

Andrews Magnetic Mineral Spring, St. Louis, Gratiot County.
Arctic Spring, Grand Rapids, Kent County.
Beaver Springs, Bangor, Van Buren County.
Bromo-Hygeia Well, Coldwater, Branch County.
Charlevoix Mineral Spring, Charlevoix, Charlevoix County.
Cooper Farm Spring, Birmingham, Oakland County.
Crystal Springs, Grand Rapids, Kent County.
Eastman Springs, Benton Harbor, Berrien County.
Giant Mineral Spring, Springwells Township, Wayne County.
Lake Superior Mineral Spring, Marquette, Marquette County.
Moorman Spring, Ypsilanti, Washtenaw County.
Mount Clemens Crystal Springs, Mount Clemens, Macomb County.
Ogemaw Spring, Maltby, Ogemaw County.
Ponce de Leon Spring, Paris Township, Kent County
Sanitas Spring, Topinabee, Cheboygan County.
Sterling Spring, Crystal Falls, Iron County.
Victory Spring, Mount Clemens, Macomb County.
White Oak Spring, Battle Creek, Calhoun County.

MINNESOTA.

The marked decrease in 1913 in the sales of water from Minnesota springs is traceable to a decline in demand for spring water for table use in Minneapolis after the installation of a municipal filtration plant. The total sales were 4,802,053 gallons, valued at $183,759, as compared with 8,881,018 gallons, valued at $252,277, in 1912. This decrease is equivalent to 46 per cent in quantity and 27 per cent in value, the disproportion between these decreases being due to increase in the average price from 3 tc 4 cents a gallon.

The following table shows the record for the last five years:

Production and value of mineral waters in Minnesota, 1909–1913.

Year.	Commercial springs.	Quantity sold.	Value.	Average price per gallon.
		Gallons.		*Cents.*
1909	20	13,746,142	$614,291	5
1910	19	9,962,370	281,009	3
1911	17	8,703,319	270,039	3
1912	18	8,881,018	252,277	3
1913	16	4,802,053	183,759	4

No new springs were reported in 1912, and two springs formerly active were reported idle. With the exception of water valued at about $6,000 for medicinal use the water sold was for the table and no resorts or bathing establishments were maintained at the springs. More than 400,000 gallons of mineral water was reported as being used in the manufacture of soft drinks.

The 16 reporting springs are as follows:

Clear Spring, Excelsior, Hennepin County.
Deep Mineral Spring, Crookston, Polk County.
Donaldson Artesian Well, Minneapolis, Hennepin County.
Fifield Artesian Well, Winona, Winona County.
Glenwood-Inglewood Spring, Minneapolis, Hennepin County.
Highland Spring, St. Paul, Ramsey County.
Indian Medical Spring, Elk River, Sherburne County.
Mankato Mineral Springs, near Eagle Lake, Blue Earth County.
Owatonna Vichy Spring, Owatonna, Steele County.
Owens Spring, Glenwood, Pope County.
Pokegama Spring, near Detroit, Becker County.
Red Star Spring, Cold Spring, Stearns County.
Rock Spring, Shakopee, Scott County.
Silver Spring, Marshall, Lyon County.
Silver Spring, Ortonville, Bigstone County.
Swasteka Spring, Cold Spring, Stearns County.

MISSISSIPPI.

There was a marked decrease in the sales of mineral water in Mississippi during 1913 in spite of the inclusion of returns from five new springs. The reported production was 346,652 gallons, valued at $81,800, as compared with 639,905 gallons, valued at $126,241, in 1912. The average price per gallon increased, however, from 20 to 24 cents. These changes are equivalent to a decrease of 46 per cent in quantity and of 35 per cent in value. The output of one spring for which no report was made was estimated on the basis of the report for 1912, and three springs active in 1912 were reported idle or out of business in 1913. Seven resorts accommodating 1,650 guests and five mineral-water baths were operated.

The names of the 11 reporting springs are:

- Alkanasia Spring, Jackson, Hinds County.
- Allison's Wells, Way, Madison County.
- Browns Wells, near Hazlehurst, Copiah County.
- Butler Spring, near Oxford, Lafayette County.
- Castalian Spring, near Durant, Holmes County.
- Cooper's Well, Raymond, Hinds County.
- Madison Spring, Pocahontàs, Madison County.
- Red Springs, Stewart, Choctaw County.
- Robinson Springs, near Pocahontas, Madison County.
- Stafford Mineral Springs, Vosburg, Jasper County.
- Vosburg Lithia Spring, Vosburg, Jasper County.

MISSOURI.

According to statements received from spring owners in Missouri the output in 1913 was 697,467 gallons, valued at $84,316, or at an average price of 12 cents a gallon. The output in 1912 was 608,385 gallons, valued at $81,114, or at an average price of 13 cents a gallon. These figures indicate an increase of 15 per cent in quantity and of 4 per cent in value. The decided increase in quantity without corresponding increase in value is due chiefly to increase in sales of low-priced waters. About three-fourths of the total output is said to be used medicinally. Six new springs reported activity, and the total number of commercial springs was 34. Six resorts, exclusive of those at Excelsior Springs, and six mineral-water baths were operated during the year. In addition to the spring water reported sold, 91,000 gallons was used in the manufacture of soft drinks.

The following 34 springs made returns of sales:

- American Spring, St. Louis, St. Louis County.
- B. B. Springs, Bowling Green, Pike County.
- Belcher Artesian Well, St. Louis, St. Louis City.
- Blue Lick Springs, Blue Lick, Saline County.
- Bokert Springs, near De Soto, Jefferson County.
- Carrollton Spring, Carrollton, Carroll County.
- Chalybeate Springs, Paris Springs, Lawrence County.
- Chouteau Springs, near Boonville, Cooper County.
- Crystal Lithium Spring, Excelsior Springs, Clay County.
- Cusenbary Spring, Mount Washington, Jackson County.
- Excelsior Saline Spring, Excelsior Springs, Clay County.
- Grand River Mineral Spring, near Mercer, Mercer County.
- Haymaker Spring, Mercer County, near Lineville, Iowa.
- Jackson Lithia Spring, Mount Washington, Jackson County.
- Lithia No. 1 Spring, Excelsior Springs, Clay County.
- Livertone Spring, Pike County.
- Mee Soda Well, Excelsior Springs, Clay County.
- Musick Spring, Eldorado Springs, Clay County.
- Natrona Soda Spring, Excelsior Springs, Clay County.
- Old Orchard Spring, Old Orchard, St. Louis County.
- Peerless Spring, Excelsior Springs, Clay County.
- Regent, Siloam, Soterian, and Sulpho-Saline springs, Excelsior Springs, Clay County.
- Salax Spring, Excelsior Springs, Clay County.
- Salt Sulphur Well, Excelsior Springs, Clay County.
- Soda Saline spring, Excelsior Springs, Clay County.
- Sweet Springs, Sweet Springs, Saline County.
- Vaile Springs, Independence, Jackson County.
- White Springs, Independence, Jackson County.
- Windsor Spring, Windsor, Henry County.
- Wyaconda and La Grange springs, La Grange, Lewis County.

MONTANA.

Returns from Montana indicate an increase in the quantity of mineral water sold but a decrease in the value of the output. The total sales in 1913 were 180,200 gallons, valued at $3,246, or at an average price of 2 cents, whereas 160,150 gallons was sold in 1912 for $13,198, or at an average price of 8 cents. These figures represent an increase of 13 per cent in quantity sold, but a decrease of 75 per cent in value. The remarkable change in average price is, however, traceable to the omission of statistics for 1913 on one high-priced water, which is understood not to be sold now, and to the inclusion of statistics regarding another low-priced table water; consequently, the change in total value is robbed of much of its apparent significance. Bathing establishments are maintained at two of these springs and a small resort at one. Most of the water was sold for table use. No new spring was reported, but one hitherto idle had a large output.

The three springs reporting are as follows:

Lissner Mineral Spring, Helena, Lewis and Clark County.
Rock Creek Spring, Red Lodge, Carbon County.
White Sulphur Spring, White Sulphur Springs, Meagher County.

NEBRASKA.

The sales reported in Nebraska for 1913 were 105,985 gallons, valued at $10,599, or at an average price of 10 cents a gallon. About one-third of this was used medicinally and, in addition to the quantity just reported, about 120,000 gallons was used in the manufacture of soft drinks. Heretofore the details of production in Nebraska have been included in those of other States having less than three active springs. There was not a sudden increase in business in 1913, but reports were received from a spring concerning which data have hitherto been unavailable. At one of the springs a small resort and a bathing establishment are maintained.

The names of the three springs reporting are:

Brown Park Spring, South Omaha, Douglas County.
Curo Mineral Spring, South Omaha, Douglas County.
Shogo Lithia Spring, Milford, Seward County.

NEVADA.

One spring in Nevada idle in 1912, reported production in 1913, and one new spring also reported, making the number of active springs three. The total sales in 1913 amounted to 4,897 gallons of table water, valued at $1,584, or at an average price of 32 cents a gallon, in addition to which about 2,000 gallons of spring water was used in the manufacture of soft drinks. A resort for about 100 people and a bathing establishment are maintained at one of the springs.

Reports were received from the following three springs:

Diamond Spring, Reno, Washoe County.
Ruby Spring, Halleck, Elko County.
Shoshone Spring, Franktown, Washoe County.

NEW HAMPSHIRE.

There was a notable increase in the mineral-water business in New Hampshire during 1913, the sales reported being 402,355 gallons, practically all table water, valued at $12,707, as compared with 240,568 gallons, valued at $10,000, in 1912. These figures correspond to an increased production of 161,787 gallons, or 67 per cent, and an increased value of $2,707, or 27 per cent, in spite of a decrease of the average price from 4 to 3 cents. Laconia Spring reported for the first time, and the production for another spring from which statistics could not be obtained was estimated on the basis of the report for 1912, making in all nine active springs. No resorts or bathing establishments are maintained at any of the springs reporting, but about 85,000 gallons of spring water, in addition to that already noted, was used in the manufacture of soft drinks.

The eight springs reporting are:

Crystal Spring, East Concord, Merrimack County.
Granite State Springs, Plaistow, Rockingham County.
Laconia Spring, Weirs, Belknap County.
Lafayette Mineral Springs, Derry, Rockingham County.
Mount Madison Spring, Gorham, Coos County.
White Mountain Mineral Spring, Conway, Carroll County.
Willow Spring, South Nashua, Hillsboro County.
Wilton Spring, near Wilton, Hillsboro County.

NEW JERSEY.

According to the estimates from mineral-spring operators in New Jersey, the sales in 1913 decreased 13 per cent in quantity and 10 per cent in value. The total sales reported were 2,067,277 gallons, valued at $188,546. The corresponding figures for 1912 were 2,386,-217 gallons, valued at $209,726. The average price, 9 cents a gallon, remained the same.

The following table shows the output for the last five years:

Production and value of mineral waters in New Jersey, 1909–1913.

Year.	Commercial springs.	Quantity sold.	Value.	Average price per gallon.
		Gallons.		*Cents.*
1909	11	1,419,500	$127,025	9
1910	11	1,583,050	133,139	8
1911	12	2,233,627	210,123	10
1912	12	2,386,217	209,726	9
1913	14	2,067,277	188,546	9

Two new springs reported, the Great Notch and the Rock, and the output of one spring that failed to report was estimated on the production during 1912. Practically the entire output was sold for table use. No resorts or mineral-water baths were maintained at springs, but about 17,000 gallons of water was used in the manufacture of soft drinks.

The following 13 springs made returns of sales:

Alpha Mineral Spring, Springfield, Union County.
Culm Rock Spring, Pluckemin, Somerset County.
Great Notch Spring, Great Notch, Passaic County.
Grey Rock Spring, Trenton, Mercer County.
Indian Spring, near Rockaway, Morris County.
Indian Lady Hill Spring, Asbury Park, Monmouth County.
Kalium Spring, Collingswood, Camden County.
Kanouse-Oakland Spring, Oakland, Bergen County.
Pilgrim Spring, Ridgefield Park, Bergen County.
Rock Spring, West Orange, Essex County.
Trinity Springs, Ridgefield, Bergen County.
Washington Rock Spring, Plainfield, Union County.
Watchung Spring, North Plainfield, Somerset County

NEW MEXICO.

Four springs, or two more than in 1912, reported sales of mineral water during 1913, the total output being 154,800 gallons, valued at $16,730, or at an average price of 11 cents a gallon. Nearly all the water was sold for table use and no resorts or bathing establishments were reported.

The four reporting springs are:

Aztec Spring, Taylor Springs, Colfax County.
Coyote Springs, Albuquerque, Bernalillo County.
Macbeth Spring, near Las Vegas, San Miguel County.
Ojo Caliente Spring, Ojo Caliente, Taos County.

NEW YORK.

New York again led the States in total quantity of mineral water sold and nearly tied Wisconsin in value of the product. The total output during 1913 was 9,801,255 gallons, valued at $871,601, or at an average price of 9 cents a gallon. The sales for 1912 were 10,008,801 gallons, valued at $1,034,477, or at an average price of 10 cents a gallon. Comparison of these figures shows a decrease of 2 per cent in quantity and of 16 per cent in value.

The following record for the last five years indicates only a slight decline in production since 1911:

Production and value of mineral waters in New York, 1909–1913.

Year.	Commercial springs.	Quantity sold.	Value.	Average price per gallon.
		Gallons.		*Cents.*
1909	52	8,813,563	$948,325	11
1910	46	8,780,903	858,635	10
1911	51	10,245,261	939,003	9
1912	57	10,008,801	1,034,477	10
1913	64	9,801,255	871,601	9

Ten new springs were added to the list and three springs active in 1912 are understood to be idle, these changes increasing the number of commercial springs to 64. Less than one-tenth of the water was sold for medicinal use. It was reported that five resorts, exclusive of those at Saratoga Springs, accommodated 3,600 guests, and that four mineral-water baths were operated during 1913. In addition to this business nearly 170,000 gallons of mineral water was used in the manufacture of soft drinks. The list of 64 commercial springs in 1913 is as follows:

Arlington Spring, Arlington, Dutchess County.
Arondack Spring, Saratoga Springs, Saratoga County.
Arrowhead Spring, Weedsport, Cayuga County.
Artesian Lithia Spring, Ballston Spa, Saratoga County.
Baldwin Mineral Spring, Cayuga, Cayuga County.
Black Rock Spring, Rensselaer, Rensselaer County.
Breesport Spring, Breesport, Chemung County.
Briarcliff Spring, Briarcliff Manor, Westchester County.
Cascadian Spring, Nyack, Rockland County.
Chemung Spring, Chemung, Chemung County.
Clinton Spring, Franklin Springs, Oneida County.
Coesa Spring, Saratoga Springs, Saratoga County.
Cold Springs, Whitesboro, Oneida County.
Comstock Spring, Ballston Spa, Saratoga County.
Crystal Springs, near Oswego, Oswego County.
Deep Rock and Os-We-Go springs, Oswego, Oswego County.
Diamond Rock Spring, Lancaster, Erie County.
Eagle Spring, Edgewoode, Greene County.
Elixir Spring, Clintondale, Ulster County.
Elk Spring, Lancaster, Erie County.
Flint Spring, West Sand Lake, Rensselaer County.
Franklin Lithia Spring, Franklin Springs, Oneida County.
Garden City Spring, Garden City, Nassau County.
Garden White Sulphur Spring, Sharon Springs, Schoharie County.
Geneva and Red Cross Mineral springs, Geneva, Ontario County.
Glen Alex Spring, Washington Mills, Oneida County.
Gramatan Spring, Bronxville, Westchester County.
Granite Spring, Granite Springs, Westchester County.
Great Bear Spring, near Fulton, Oswego County.
Great White Sulphur Spring, Richfield Springs, Otsego County.
Greendale Crystal Spring, Hudson, Columbia County.
Hathorn No. 1 Spring, Saratoga Springs, Saratoga County.
Hathorn No. 2 Spring, Saratoga Springs, Saratoga County.
Keeseville Spring, Keeseville, Essex County.
Lithaca Spring, Ithaca, Tompkins County.
Lithia Polaris Spring, near Boonville, Oneida County.
Madrid Indian Mineral Spring, Madrid Springs, St. Lawrence County.
Mammoth and Ideal springs, North Greenbush, Rensselaer County.
Mohawk Springs, Amsterdam, Montgomery County.
Mohican Spring, Ballston Spa, Saratoga County.
Monarch Spring, Matteawan, Dutchess County.
Mount Beacon Spring, Beacon, Dutchess County.
Mount View Spring, Poughkeepsie, Dutchess County.
Oasis Cold Spring, Bergen, Genesee County.
Paris Spring, Sauquoit, Oneida County.
Real Rock Spring, Breesport, Chemung County.
Red Jacket Spring, Seneca Falls, Seneca County.
Red Rock Spring, Fine View, Jefferson County.
Richland Spring, Richland, Oswego County.
Sagamore Spring, Oyster Bay, Nassau County.
Saratoga Gurn Spring, Saratoga Springs, Saratoga County.
Saratoga Vichy and Victoria No. 2 springs, Saratoga Springs, Saratoga County.
Setauket Spring, Setauket, Suffolk County.
Shell Rock Spring, near Rensselaer, Rensselaer County.
Sparkling Spring, Buffalo, Erie County.
Split Rock Spring, Franklin Springs, Oneida County.
Standard Spring, Troy, Rensselaer County.
Sun-Ray Spring, Ellenville, Ulster County.
Trèspur Spring, McGraw, Cortland County.
Valley Spring, Omar, Jefferson County.
Vita Spring, Fort Edward, Washington County.

NORTH CAROLINA.

The returns from North Carolina show marked increase in the mineral-water business during 1913. The sales amounted to 176,068 gallons, valued at $23,877, as compared with 144,708 gallons, valued at $22,385, in 1912, an increase of 22 per cent in quantity and of 7 per cent in value. The average price per gallon decreased from 16 to 14 cents. Parks Spring reported production for the first time. One spring active in 1912 was idle during 1913, and the output from one spring from which no report was received was estimated on the basis of the production for 1912, these changes increasing the number of commercial springs to 17. Eleven resorts accommodating 1,600 guests were maintained at springs, together with five establishments for bathing in mineral water. A small quantity of water also was used in the manufacture of soft drinks.

The 16 springs reporting are:

All Healing Spring, Taylorsville, Alexander County.
Barium Rock Spring, Barium Springs, Iredell County.
Buckhorn Lithia Spring, Bullock, Granville County.
Connelly Springs, Connelly Springs, Burke County.
Derita Mineral Spring, Derita, Mecklenburg County.
Haywood White Sulphur Spring, Waynesville, Haywood County.
Huckleberry Spring, Durham, Durham County.
Jackson Springs, Jackson Springs, Moore County.
Midas Spring, near Huntersville, Mecklenburg County.
Moores Springs, Moores Springs, Stokes County.
Mount Vernon Springs, Mount Vernon Springs, Chatham County.
Panacea Spring, Warren County, near Littleton.
Parks Springs, Caswell County, near Danville, Va.
Seven Springs, Seven Springs, Wayne County.
Shelby Lithia Spring, Shelby, Cleveland County.
Smith Lithia Spring, Oxford, Granville County.

NORTH DAKOTA.

Five new springs in North Dakota reported total sales of mineral water during 1913 amounting to 582,356 gallons, valued at $14,403, in addition to which 42,000 gallons was used in the manufacture of soft drinks.

The names and locations of these five springs are as follows:

Granite Spring, Minot, Ward County.
Kenmare Spring, Kenmare, Ward County.
Saskawea Mineral Spring, Northwood, Grand Forks County.
Stony Creek Spring, Bowbells, Burke County.
Williston Spring, Williston, Williams County.

OHIO.

The mineral-water trade of Ohio again made a decided gain during 1913, the sales rising from 2,709,745 gallons in 1912 to 3,317,639 gallons in 1913, and the total value increasing from $117,287 in 1912 to $125,084 in 1913. The increase in quantity was 22 per cent and in value 7 per cent. There was a slight decrease in the sales of medicinal water, but a notable increase in the sales of table water.

The following table of sales during the last five years shows, contrary to conditions in most other States, a general increase in the mineral-water business since 1911:

Production and value of mineral waters in Ohio, 1909–1913.

Year.	Commercial springs.	Quantity sold.	Value.	Average price per gallon.
		Gallons.		*Cents.*
1909	31	2,709,060	$112,775	4
1910	30	2,226,188	95,989	4
1911	28	1,958,547	86,478	4
1912	30	2,709,745	117,287	4
1913	33	3,317,639	125,084	

Two new springs reported in 1913 for the first time, Puritas Spring and the Purity Spring. Nearly nine-tenths of the water was sold for table use. Five resorts accommodating 500 guests and three bathing establishments were operated during the year and in addition to the water reported as sold, 195,000 gallons was used in the manufacture of soft drinks.

The 33 springs reporting sales are as follows:

Alba Spring, Rockport, Cuyahoga County.
Beech Rock Spring, near Zanesville, Muskingum County.
Bellmore Springs, near Signal, Columbiana County.
Belmont Spring, Bridgeport, Belmont County.
Chalybeate Spring, Newark, Licking County.
Collingwood Springs, Toledo, Lucas County.
Crum Mineral Spring, Austintown, Mahoning County.
Crystal Fountain Springs, Plainville, Hamilton County.
Crystal Spring, Newark, Licking County.
Deerfield Spring, Deerfield, Portage County.
Fargo Mineral Springs, Ashtabula, Ashtabula County.
Fisher's Magnesia Spring, Clintonville, Franklin County.
Glenwood Spring, near Chillicothe, Ross County.
Highland Springs, Akron, Summit County.
Maple Grove Mineral Spring, near Chillicothe, Ross County.
Minnehaha Spring, Rockport, Cuyahoga County.
Norwalk Sulphur Spring, Norwalk, Huron County.
Oak Place Spring, Akron, Summit County.
Oak Ridge Springs, Greenspring, Sandusky County.
Painesville Mineral Spring, Painesville, Lake County.
Peerless and Puritas springs, West Park, Cuyahoga County.
Puritas Spring, West Park, Cuyahoga County.
Purity Spring, South Euclid, Cuyahoga County.
Quakerdale Spring, Colerain, Belmont County.
Reynold's Artesian Well, Greenspring, Sandusky County.
Ripley Bromo Lithia Spring, Ripley, Brown County.
Sandrock Spring, Canton, Stark County.
Spring Grove Lithia Spring, Springfield, Clark County.
Sulphur Lick Spring, Chillicothe, Ross County.
Tallewanda Spring, College Corner, Preble County.
Wheeler Mineral Spring, Youngstown, Mahoning County.
Woods Lithia Spring, Bridgeport, Belmont County.

OKLAHOMA.

According to returns from Oklahoma the output of mineral water during 1913 was 502,439 gallons, valued at $26,231, as compared with 1,015,512 gallons, valued at $32,971, in 1912. This apparent decrease of 51 per cent in quantity and of 20 per cent in value is accounted for chiefly by the omission for 1913 of reports from certain producers hitherto included. The trade in mineral waters therefore really suffered only a slight decline. Mineral-water baths were operated at four springs and considerable water was used in the manufacture of soft drinks.

The record for the last five years is as follows:

Production and value of mineral waters in Oklahoma, 1909–1913.

Year.	Commercial springs.	Quantity sold.	Value.	Average price per gallon.
		Gallons.		*Cents.*
1909	12	563,475	$35,194	6
1910	4	115,000	4,950	4
1911	10	497,074	14,290	3
1912	10	1,015,512	32,971	3
1913	12	502,439	26,231	5

Three new springs reported production for the first time, Excelsior Well, Living Spring, and Snow Mineral Well, all in or near Oklahoma City; the output of one spring for which no report was received was estimated on the basis of figures for 1912.

The 11 springs reporting sales are as follows:

Bromide Spring, Sulphur, Murray County.
Excelsior Well, Oklahoma City, Oklahoma County.
Guthriewell, Guthrie, Logan County.
Hercules Spring, Guthrie, Logan County.
Kalium Spring, Faxon, Comanche County.
Lewis Lithia Wells, Oklahoma City, Oklahoma County.
Living Spring, Oklahoma City, Oklahoma County.
Shanoan Spring, Chickasha, Grady County.
Snow Mineral Well, Oklahoma City, Oklahoma County.
Standard Well, Tulsa, Tulsa County.
Works Excelsior Spring, Comanche, Stephens County.

OREGON.

Sales of mineral water in Oregon amounted in 1913 to 68,413 gallons, valued at $19,409, as compared with 48,351 gallons, valued at $17,503, in 1912, an increase of 42 per cent in quantity and of 11 per cent in value. The average price decreased from 36 to 28 cents a gallon. The output of one spring that failed to report was estimated from the returns of 1912. Five resorts accommodating about 300 guests and five bathing establishments were operated. In addition to the business above reported, about 11,000 gallons was used in the manufacture of soft drinks.

The names of the seven reporting springs are:

Calapooya Spring, London, Lane County.
Cascade Mineral Spring, Cascadia, Linn County.
Colestin Spring, Colestin, Jackson County.
Klamath Spring, Klamath Falls, Klamath County.
Sam-O Spring, Baker City, Baker County.
Selah Spring, Silverton, Marion County.
Wilhoit Spring, Wilhoit, Clackamas County.

PENNSYLVANIA.

The record of the mineral-water trade of Pennsylvania during 1913 indicates practically the same condition as obtained during 1912. The total output amounted to 2,163,931 gallons, valued at

$190,459, as compared with 2,192,106 gallons, valued at $204,906, in 1912. The average price decreased one-half cent and this was accompanied by a decrease of 7 per cent in total value of the output.

The following record of sales during the last five years shows a gradual decline in production since 1910.

Production and value of mineral waters in Pennsylvania, 1909–1913.

Year.	Commercial springs.	Quantity sold.	Value.	Average price per gallon.
		Gallons.		*Cents.*
1909	42	2,177,967	$240,856	11
1910	44	2,536,337	221,685	9
1911	41	2,327,732	216,819	9
1912	41	2,192,106	204,906	9
1913	43	2,163,931	190,459	9

Five new springs were added to the list as follows: Duquesne Vichy, Minnequa, Plymouth Crystal, Quaill Farm, and Summer Hill. The output of two springs that failed to report production was estimated from previous reports and three springs hitherto active were temporarily idle, so that 43 represents the number of commercial springs during 1913. Eleven resorts accommodating 1,650 guests were operated and seven establishments for giving mineral water baths also were maintained. In addition to the water sold 340,000 gallons was used in the manufacture of soft drinks.

The following 41 springs reported sales in 1913:

Bartlett Spring, Cambridge Springs, Crawford County.
Bedford Mineral Springs, near Bedford, Bedford County.
Carnegie Alkaline and Lithia Mineral Spring, Carnegie, Allegheny County.
Chadwick Spring, Cambridge Springs, Crawford County.
Cloverdale Lithia Spring, near Newville, Cumberland County.
Cold Spring, Lotell, Lebanon County.
Colonial Spring, Montgomery County, near Valley Forge.
Colvin White Sulphur Spring, Sulphur Springs, Bedford County.
Crystal-Cray Spring, Warren, Warren County.
De Profundus Spring, Saegertown, Crawford County.
Duquesne Vichy Spring, Swissvale, Allegheny County.
East Mountain Lithia Spring, near Factoryville, Wyoming County.
Franklin Lithia Spring, Cambridge Springs, Crawford County.
Glen Crystal Spring, Harbour Creek, Erie County.
Glen Summit Spring, Glen Summit Springs, Luzerne County.
Gray Mineral Spring, Cambridge Springs, Crawford County.
Harrison Valley Mineral Spring, Harrison Valley, Potter County.
Hutchinson's Spring, East Brook, Lawrence County.
Kecksburg Artesian Mineral Spring, Kecksburg, Westmoreland County.
Keystone Spring, near Taylorsville, Bucks County.
Massassauga Mineral Spring, Erie, Erie County.
Minnequa Spring, Canton, Bradford County.
Mount Laurel Spring, Temple, Berks County.
Original Magnesia Springs, Cambridge Springs, Crawford County.
Pavilion Spring, Wernersville, Berks County.
Petticord Spring, Cambridge Springs, Crawford County.
Plymouth Crystal Spring, Plymouth, Luzerne County.
Pocono Mineral Spring, near Wilkes-Barre, Luzerne County.
Polar Springs, Morrisville, Bucks County.
Prospect Rock Spring, Laurel, Luzerne County.
Pulaski Natural Mineral Spring, Pulaski, Lawrence County.
Puritas Spring, near Erie, Erie County.
Quaill Farm Spring, Bellevue, Allegheny County.
Ross Common Spring, Ross Common, Monroe County.

Sizerville Spring, Sizerville, Cameron County.
Springfield Spring, Springfield Township, Delaware County.
Summer Hill Spring, Pittsburgh, Allegheny County.
Thurston's Carbonate Spring, Meadville, Crawford County.
Tuckahoe Mineral Spring, near Northumberland, Northumberland County.
Unamis Mineral Spring, Unamis, Somerset County.
Whann Lithia Spring, Franklin, Venango County.

RHODE ISLAND.

The mineral-water trade in Rhode Island during 1913 was nearly the same as in 1912. The same springs reported a production of 444,036 gallons, valued at $28,535, as compared with 466,893 gallons, valued at $29,126, in 1912. This water was sold exclusively for table use, and no resorts or bathing establishments were maintained.

The names of the seven springs reporting are as follows:

Berry Spring, Pawtucket, Providence County.
Girard Spring, North Providence, Providence County.
Gladstone Spring, Narragansett Pier, Washington County.
Hermit Spring, East Providence, Providence County.
Holley Mineral Spring, East Woonsocket, Providence County.
Ochee Spring, Johnston, Providence County.
Prophet Spring, Johnston, Providence County.

SOUTH CAROLINA.

The returns for South Carolina indicate a marked decrease in the mineral-water business during 1913. The total sales in 1913 were 261,412 gallons, valued at $49,199; the total sales in 1912 were 360,404 gallons, valued at $70,348; these figures show a decrease of 28 per cent in quantity and of 30 per cent in value. The average price a gallon decreased from 20 to 19 cents. Practically three-fourths of the water is said to be sold for medicinal use. Three new springs were added to the list—Big, Mosely, and Shelton—but three springs active in 1912 were idle in 1913, so that the number of commercial springs remains unchanged. Six resorts, accommodating about 800 guests, and two bathing establishments were maintained. About 130,000 gallons of mineral water also was used in the manufacture of soft drinks.

The following 15 springs reported sales:

Big Springs, Bethune, Kershaw County.
Buffalo Lick Springs, Carlisle, Union County.
Cherokee Springs, Cherokee, Spartanburg County.
Chick Springs, Chick Springs, Greenville County.
Clementia Spring, Clementia Springs, Colleton County.
Crystal Carbon Spring, Spartanburg, Spartanburg County.
Glenn Spring, Glenn Spring, Spartanburg County.
Harris Spring, Harris Springs, Laurens County.
Mosely Spring, Loris, Horry County.
Piedmont Spring, Kings Creek, York County.
Shelton Spring, near Shelton, Fairfield County.
Shivar Spring, Shelton, Fairfield County.
Steele Mineral Spring, Rock Hill, York County.
Turner Magnalithia Spring, Mayo, Spartanburg County.
Verner Spring, Greenville, Greenville County.

SOUTH DAKOTA.

South Dakota reported production from two springs in 1913. The water was sold principally for table use, and a large additional quantity was consumed in the manufacture of soft drinks. The details of production are included with those of other States having less than three active springs. The names of the two springs are:

Culbert Spring, Aberdeen, Brown County.
Minnehaha Springs, Sioux Falls, Minnehaha County.

TENNESSEE.

Returns from Tennessee show a decided gain in the mineral-water trade in 1913 as compared with 1912. The sales amounted to 1,088,034 gallons, valued at $64,905, as compared with 796,568 gallons, valued at $53,560, in 1912. These figures correspond to an increase of 37 per cent in quantity and of 21 per cent in value, the price having decreased from 7 to 6 cents a gallon.

The following table is the record of sales during the last five years:

Production and value of mineral waters in Tennessee, 1909–1913.

Year.	Commercial springs.	Quantity sold.	Value.	Average price per gallon.
		Gallons.		*Cents.*
1909	18	934,912	$76,185	8
1910	18	950,511	71,129	8
1911	19	1,073,115	72,475	7
1912	21	796,568	53,560	7
1913	23	1,088,034	64,905	6

Four new springs are included in the list—Bright Sunrise, Bush Epsom Lithia, Eagle Bluff, and Faulkner—but two springs hitherto active are understood to have been idle in 1913, so that the total number of commercial springs is 23. Fourteen resorts, accommodating 2,300 guests, were operated and the water at four springs is reported to have been used for bathing. A small quantity of water also was used in the manufacture of soft drinks.

The following 23 springs reported sales:

Bright Sunrise Spring, near Ashland City, Cheatham County.
Bush Epsom Lithia Spring, near Nolensville, Williamson County.
Eagle Bluff Springs, near Jacksboro, Campbell County.
Eastbrook Spring, Eastbrook, Franklin County.
Epperson Spring, Macon County, near Westmoreland.
Faulkner Springs, near McMinnville, Warren County.
Galbraith Epsom Lithia Springs, Mooresburg, Hawkins County.
Gammons Spring, near Tate Spring, Grainger County.
Hamilton Spring, near Lebanon, Wilson County.
Horn Springs, Horn Springs, Wilson County.
Idaho Springs, near Clarksville, Montgomery County.
Larkin Spring, Madison, Davidson County.
Neubert Spring, Neubert, Knox County.
Paris Wells, near Paris, Henry County.
Pioneer Lithia Spring, near Nashville, Davidson County.
Red Boiling Springs, Red Boiling Springs, Macon County.
Rhea Springs, Rhea Springs, Rhea County.
Richardsons Lockeland Spring, near Nashville, Davidson County.
Tate Spring, Tate Springs, Grainger County.
Thompson Spring, near Nashville, Davidson County.
Whittle Spring, Whittle Springs, Knox County.
Willow Brook Spring, Craggie Hope, Cheatham County.
Wright's Epsom-Lithia Spring, Mooresburg, Hawkins County.

TEXAS.

Returns from Texas during 1913 indicate a slight decline in the mineral-water trade. The output reported was 1,187,612 gallons, valued at $132,488, as compared with 1,292,992 gallons, valued at $151,395, in 1912. There was thus a decrease of 8 per cent in quantity and of 13 per cent in value of water sold. The average price per gallon dropped one-half cent.

The following table of production during the last five years shows in common with several other States a decline in trade since 1911:

Production and value of mineral waters in Texas, 1909–1913.

Year.	Commercial springs.	Quantity sold.	Value.	Average price per gallon.
		Gallons.		*Cents.*
1909	34	1,033,476	$98,499	10
1910	31	1,241,248	128,549	10
1911	40	1,637,932	158,367	10
1912	34	1,292,992	151,395	12
1913	38	1,187,612	132,488	11

Beauchamp's Well, Hefner Spring, Hanna Springs, Southland Spring, and Wootan Wells reported production for the first time, and the output of one producer who did not report was estimated, so that statistics are included for 38 commercial springs. Practically the entire output is said to be used medicinally. Six resorts, accommodating 600 guests, were operated, exclusive of those at Mineral Wells, and the water of eight springs was used for bathing. Besides this consumption, more than 100,000 gallons of mineral water was used in the manufacture of soft drinks.

The following is the list of the 37 springs reporting sales in 1913:

Aqua Vitae Wells, Nacogdoches, Nacogdoches County.
Austin Well, Mineral Wells, Palo Pinto County.
Beauchamp's Well, Blossom, Lamar County.
Brock Mineral Well, near Denton, Denton County.
Capp's Wells, Longview, Gregg County.
Carlsbad Well, Blossom, Lamar County.
Crazy Well, Mineral Wells, Palo Pinto County.
Crystal Spring, Terrell, Kaufman County.
Dalby Spring, Dalby Springs, Bowie County.
Georgetown Mineral Wells, Georgetown, Williamson County.
Gibson Well, Mineral Wells, Palo Pinto County.
Hanna Springs, Lampasas, Lampasas County.
Hefner Spring, Blossom, Lamar County.
High Island Mineral Well, High Island, Galveston County.
Hubbard Hot Well, Hubbard City, Hill County.
Hume Sour Water Well, Sutherland Springs, Wilson County.
Indian Spring, Mineral Wells, Palo Pinto County.
Lamar Spring, Mineral Wells, Palo Pinto County.
Lonestar Mineral Well, Texarkana, Bowie County.
Mangum Wells, Mangum, Eastland County.
Marlin Hot Wells, Marlin, Falls County.
Maurice Wells, Mangum, Eastland County.
Olympia Well, Mineral Wells, Palo Pinto County.
Orono Spring, Oran, Palo Pinto County.
Overall Mineral Well, Franklin, Robertson County.
Putnam Mineral Well, Putnam, Callahan County.
Riviere Wells, Tyler, Smith County.
Roach Well, near Mount Pleasant, Titus County.

Rosborough Spring, Marshall, Harrison County.
St. Mary's Mineral Well, near Hallettsville, Lavaca County.
Sour Wells, Sulphur Springs, Hopkins County.
Southland Spring, Duffan, Erath County.
Star Well, Mineral Wells, Palo Pinto County.
Texas Carlsbad Spring, Mineral Wells, Palo Pinto County.
Tioga Mineral Wells, Tioga, Grayson County.
Weatherby Spring, Garrison, Nacogdoches County.
Wootan Wells, Wootan Wells, Robertson County.

UTAH.

Only one mineral spring in Utah reported production during 1913 and the production of another was estimated, as no report could be obtained. Statistics regarding them are included with those of other States having less than three operating springs.

The name and location of the spring reporting is:

Deseret Lithia Spring, Deseret, Millard County.

VERMONT.

Returns from Vermont indicate a decline in the mineral-water trade during 1913 of 16 per cent in quantity and of 15 per cent in value. The output was 17,725 gallons, valued at $7,068, as compared with 21,000 gallons, valued at $8,280, in 1912, the average price having increased from 39 to 40 cents a gallon. Practically all the water is sold for table use, and in addition to the reported sales, 31,000 gallons was used in the manufacture of soft drinks. Resorts for nearly 500 guests were operated at three springs and the water of two springs was used for bathing. One new spring, Alburg, was added to the list of active producers, which is as follows:

Alburg Spring, Alburg Springs, Grand Isle County.
Brunswick Mineral Spring, North Stratford, Essex County.
Clarendon Spring, Clarendon Springs, Rutland County.
Equinox Spring, Manchester, Bennington County.

VIRGINIA.

Virginia's output of mineral water during 1913 was slightly greater than that of 1912, but its value was considerably less, chiefly because of decline in the sales of certain high-priced medicinal waters and of increase in the sales of low-priced table waters. Reports from operators in 1913 showed a total output of 2,873,288 gallons, valued at $298,473, as compared with an output of 2,762,319 gallons, valued at $349,255, in 1912. In other words, there was an increase of 4 per cent in quantity but a decrease of 17 per cent in value, and the average price dropped from 13 to 10 cents a gallon.

The following record of the trade during the last five years shows a steady increase in production but notable fluctations in value:

Production and value of mineral waters in Virginia, 1909–1913.

Year.	Commercial springs.	Quantity sold.	Value.	Average price per gallon.
		Gallons.		*Cents.*
1909	49	1,504,530	$203,455	14
1910	40	2,441,923	301,523	12
1911	43	2,474,918	298,701	12
1912	45	2,762,319	349,255	13
1913	49	2,873,288	298,473	10

Five new springs were added to the list of those reporting, as follows: Abbevanna Ponce de Leon, Carter, Coyner's, Eaglewood, and Granite; and the number of springs reporting production has thus been increased to 49, the figure attained in 1909. Resorts accommodating a total of 1,800 guests were reported at 13 springs and the water at 6 springs was used for bathing. In addition to the quantity reported sold, 25,000 gallons was used in the manufacture of soft drinks.

The 49 springs reporting sales are as follows:

Abbevanna Ponce de Leon Spring, Scottsville, Fluvanna County.
Alleghany Spring, Alleghany Spring, Montgomery County.
Bear Lithia Spring, near Elkton, Rockingham County.
Beaufont Spring, near Manchester, Chesterfield County.
Berry Hill Mineral Spring, Elkwood, Culpeper County.
Blue Ridge Springs, near Blue Ridge Springs, Botetourt County.
Alkaline Lithia Spring, near Staunton, Augusta County.
Broad Rock Mineral Spring, near Richmond, Chesterfield County.
Brugh Spring, Nace, Botetourt County.
Buckhead Spring, Buckhead Springs, Chesterfield County.
Buffalo Lithia Spring, Buffalo Lithia Springs, Mecklenburg County.
Burnett Spring, Culpeper, Culpeper County.
Campfield Lithia Well, near Richmond, Chesterfield County.
Carper Lithia Springs, Radford, Montgomery County.
Carter Springs, Danville, Pittsylvania County.
Como Lithia Spring, East Richmond, Henrico County.
Coppahaunk Mineral Springs, Waverly, Sussex County.
Coyner's Spring, near Roanoke, Botetourt County.
Crockett Arsenic Lithia Spring, Crockett Springs, Montgomery County.
Eaglewood Spring, near Danville, Pittsylvania County.
Farmville Lithia Springs, Farmville, Cumberland County.
Fonticello Mineral Spring, near Manchester, Chesterfield County.
Granite Spring, Chesterfield County.
Harris Anti-Dyspeptic Spring, Burkeville, Nottoway County.
Healing Springs, Healing Springs, Bath County.
Jeffress Spring, Jeffress, Mecklenburg County.
Jordan White Sulphur Spring, Stephensons, Frederick County.
Kayser Lithia Springs, Staunton, Augusta County.
Landale Spring, Norfolk, Norfolk County.
Lithia Magnesia Spring, Rocky Mount, Franklin County.
Magee Chlorinated Lithia Spring, Clarksville, Mecklenburg County.
Massanetta Spring, near Harrisonburg, Rockingham County.
Mecklenburg Spring, Chase City, Mecklenburg County.
Mico Well, Alexandria, Alexandria County.
Mulberry Island Artesian Well, Mulberry Island, Warwick County.
Nye Lithia Springs, Wytheville, Wythe County.
Otterburn Lithia Spring, near Amelia, Amelia County.
Paeonian Spring, Paeonian Springs, Loudoun County.
Pickett Spring, Worsham, Prince Edward County.
Rockbridge Alum Springs, Rockbridge Alum Springs, Rockbridge County.
Rubino Healing Springs, Healing Springs, Bath County.
Seawright Spring, near Staunton, Augusta County.
Shoal Bay Iodine Vichy Spring, Smithfield, Isle of Wight County.
Stribling Springs, Stribling Springs, Augusta County.
Trepho Mineral Spring, Claremont, Surry County.
Virginia Etna Springs, Vinton, Roanoke County.
Virginia Magnesian Alkaline Spring, near Staunton, Augusta County.
Wallawhatoola Springs, Millboro, Bath County.
Wyrick Mineral Spring, Crockett, Wythe County.

WASHINGTON.

Washington returns show a slight decrease in the quantity but an increase in value of mineral water sold during 1913. The sales amounted to 150,498 gallons, valued at $18,834, whereas the sales in

1912 amounted to 156,171 gallons, valued at $17,542, these figures representing a decrease of 4 per cent in quantity and an increase of 7 per cent in value. The average price increased from 11 to 13 cents a gallon. Slightly more water was sold for table than for medicinal use.

Solduc Hot Springs reported production for the first time. Private hotels and bathing establishments were maintained at two springs and nearly 25,000 gallons of water was used in the manufacture of soft drinks.

The names of the six reporting springs are:

Diamond Mineral Spring, Auburn, King County.
Klickitat Spring, Klickitat, Klickitat County.
Olympia Hygeian Spring, Tumwater, Thurston County.
Solduc Hot Springs, Soleduck, Clallam County.
Yakima Artesian Mineral Spring, North Yakima, Yakima County.
Yakima Soda Spring, near North Yakima, Yakima County.

WEST VIRGINIA.

Returns from West Virginia for 1913 show a slight increase in the quantity of mineral water sold, but a notable decrease in its value. The total sales were 316,749 gallons, as compared with 309,245 gallons in 1912, an increase of 2 per cent; the value of the production in 1913 was $52,259, as compared with $60,455 in 1912, a decrease of 14 per cent. The average price decreased from 20 to 17 cents a gallon. The decrease occurred especially in the production and value of medicinal waters. Sales were reported for the first time from Madeira Spring, and the output of one spring from which no report could be obtained was estimated on the basis of the figures for 1912. Resorts that accommodated 3,000 guests were maintained at four springs, and the water of two springs was used for bathing, in addition to which a small quantity was used in the manufacture of soft drinks.

The following are the names of the nine commercial springs reporting in 1913:

Borland Springs, Borland, Wood County.
Madeira Spring, Morgantown, Monongalia County.
Man-A-Cea Irondale Spring, Independence, Preston County.
Pence Spring, Pence Springs, Summers County.
Saline-Chalybeate and Vigoro springs, Woodsdale, Ohio County.
Walnut Hill Spring, near Charleston, Kanawha County.
Webster Springs, Webster Springs, Webster County.
White Sulphur Springs, White Sulphur Springs, Greenbrier County.

WISCONSIN.

Wisconsin led the States in value of mineral water sold in 1913 and was second only to New York in quantity of output. The total sales were 6,326,533 gallons, valued at $872,518, and nine-tenths of the output was sold for table use. The sales in 1912 amounted to 6,045,719 gallons, valued at $869,495; thus there was in 1913 an increase of 5 per cent in quantity and of less than 1 per cent in value. The average price decreased about one-half cent a gallon.

The following record of the sales for the last five years indicates a notable annual increase in quantity since 1911:

Production and value of mineral waters in Wisconsin, 1909–1913.

Year.	Commercial springs.	Quantity sold.	Value.	Average price per gallon.
		Gallons.		*Cents.*
1909	34	6,101,882	$1,132,239	19
1910	36	6,400,812	974,366	15
1911	31	5,716,162	955,988	17
1912	31	6,045,719	869,495	14
1913	34	6,326,533	872,518	14

Resorts accommodating 1,600 guests were operated at two springs, but none of the waters was used for bathing. In addition to the quantity reported as sold, 750,000 gallons was used in the manufacture of soft drinks.

Three new springs were added to the list during 1913; Crystal, Deep Rock, and Famous, so that the total number of active springs was increased to 34, as follows:

Allouez Spring, Green Bay, Brown County.
Anderson Spring, Waukesha, Waukesha County.
Arbutus Mineral Spring, Oconto, Oconto County.
Arcadian Spring, Waukesha, Waukesha County.
Bay City Spring, Ashland, Ashland County.
Bethania Spring, Osceola, Polk County.
Bethesda Spring, Waukesha, Waukesha County.
Castalia Spring, Wauwatosa, Milwaukee County.
Chippewa Spring, Chippewa Falls, Chippewa County.
Clysmic Spring, Waukesha, Waukesha County.
Crystal Spring, Sheboygan, Sheboygan County.
Crystal Springs, Waupaca, Waupaca County.
Crystal Rock Springs, Waukesha, Waukesha County.
Darlington Mineral Springs, Darlington, Lafayette County.
Deep Rock Spring, Palmyra, Jefferson County.
Elysian Spring, Prairie du Chien, Crawford County.
Famous Springs, Menominee Falls, Waukesha County.
Fontana Lithia Spring, Fontana, Walworth County.
Glenn Rock Spring, Waukesha, Waukesha County.
Hiawatha Springs, Janesville, Rock County.
Horeb Spring, Waukesha, Waukesha County.
Kusche Spring, Oshkosh, Winnebago County.
Lebenswasser Spring, Green Bay, Brown County.
Maribel Mineral Spring, Maribel, Manitowoc County.
Nee-Ska-Ra Spring, Wauwatosa, Milwaukee County.
Sheboygan Mineral Spring, Sheboygan, Sheboygan County.
Sheridan Mineral Springs, near Lake Geneva, Walworth County.
Silurian Spring, Waukesha, Waukesha County.
Silver Spring, Madison, Dane County.
Solon Springs, Solon Springs, Douglas County.
Waukesha Fox Head Spring, Waukesha, Waukesha County.
Waukesha Roxo Spring, Waukesha, Waukesha County.
White Rock Spring, Waukesha, Waukesha County.
Willnette Spring, Cooper Station, Racine County.

WYOMING.

Four mineral springs in Wyoming reported sales during 1913 amounting to 16,200 gallons, valued at $3,610. More than half this water is said to be used medicinally. The average price per gallon was 22 cents. The water of three springs was used for bathing, and resorts for guests were operated at two springs. In addition to the two springs that reported in 1912, two new ones have been added to the list, the names of the four active springs being as follows:

Big Horn Hot Springs, Thermopolis, Hot Springs County.
De Maris Spring, Cody, Park County.
Paulson Well, Saratoga, Carbon County.
Saratoga Hot Springs, Saratoga, Carbon County.

PUBLISHED ANALYSES OF AMERICAN MINERAL WATERS.

So many requests for information regarding the chemical composition of waters of American springs are received by the United States Geological Survey that the following list of publications has been prepared to meet this demand. The list is not by any means exhaustive, hundreds of analyses of mineral waters having been published elsewhere; it mentions only reports that are notable for the number of analyses of mineral waters in them and reports on especially well-known springs. Those seeking analyses of water that are not mentioned in the following publications are advised to consult published reports of the United States Geological Survey, of State geological surveys, of State boards of health, and of agricultural experiment stations.

Haywood, J. K., Mineral waters of the United States: U. S. Dept. Agr. Bur. Chem. Bull. 91, 1905. Analyses are given of 55 American spring waters, including 13 Saratoga waters.

Skinner, W. W., American mineral waters; The New England States: U. S. Dept. Agr. Bur. Chem. Bull. 139, 1909. This pamphlet contains analyses of New England spring waters and the results of bacteriological examinations of them.

Cohen, S. S. [editor], System of physiologic therapeutics, vol. 9, P. Blakiston's Sons & Co., Philadelphia, 1902. This volume contains a chapter by Dr. A. C. Peale on the classification of mineral waters with special reference to those of the United States, and the composition of many waters is discussed.

Peale, A. C., Geographical distribution of the mineral springs of the United States: Internat. Med. Mag., Nov., 1895.

——— Natural mineral waters of the United States: U. S. Geol. Survey Fourteenth Ann. Rept., pt. 2, pp. 49–88, 1894. This report contains a general discussion of the origin, flow, geologic relations, and utilization of mineral waters, and a list of several hundred American mineral spring resorts. (Out of stock for free distribution; Part II, which includes several other papers, can be purchased from the Superintendent of Documents, Washington, D. C., for $2.10, payable in advance.)

——— Lists and analyses of the mineral springs of the United States: U. S. Geol. Survey Bull. 32, 1886. About 2,800 mineral springs are listed and about 800 analyses are quoted. (Out of print; available for consultation in certain libraries.)

Mineral waters, foreign and domestic, with analyses, use, and source, P. Scherer & Co., New York. Analyses of many foreign and domestic mineral waters are quoted.

Haywood, J. K., Analyses of the waters of the Hot Springs of Arkansas: U. S. Dept. Interior, 1912. (Purchasable from the Superintendent of Documents, Washington, D. C., for 10 cents payable in advance.) Analyses of 46 waters are given. The same report contains a geologic sketch of Hot Springs, Ark., by W. H. Weed.

Gooch, F. A., and Whitfield, J. E., Analyses of waters of the Yellowstone National Park: U. S. Geol. Survey Bull. 47, 1888. The methods of analysis are described and analyses of the waters of the geysers, pools, and hot and cold springs are given. (Out of print; available for consultation in certain libraries.)

Milford, L. R., Analyses of the Saratoga mineral waters: Jour. Ind. and Eng. Chemistry, vol. 4, p. 593, 1912; vol. 5, pp. 24 and 557, 1913; vol. 6, p. 207, 1914. This series of four articles gives new analyses of all the important Saratoga waters.

First bulletin of the commissioners of the State Reservation at Saratoga Springs, Albany, N. Y., October, 1913. Analyses of 20 Saratoga waters are given and the properties of the waters are described.

Waring, G. A., Springs of California: U. S. Geol. Survey Water-Supply Paper 338, 1914. Analyses of practically all California mineral waters are included. (In press.)

Pratt, J. H., The mining industry in North Carolina during 1907 with a special report on the mineral waters: North Carolina Geol. and Econ. Survey Econ. Paper 15, 1908. Analyses of 90 mineral waters are given.

Bailey, E. H. S., Special report on mineral waters: Kansas Univ. Geol. Survey, vol. 7, 1902. Analyses of 115 ground waters are given, including the well-known mineral waters of the State. Analyses of many other noted waters are quoted, among which may be mentioned analyses of Crab Orchard, Hunjadi Janos, Carabana, Kissingen, Sprudel, and Pullna waters. Special chapters deal with the classification of mineral waters and their therapeutic action.

Schweitzer, Paul, A report on the mineral waters of Missouri: Missouri Geol. Survey, vol. 3, 1892. About 80 analyses of Missouri ground waters are given. Analyses of Vichy, Sprudel, Kreutzbrunnen, Spa, St. Moritz, Aix-les-Bains, and other foreign waters are quoted. The classification of mineral waters and their therapeutic action are discussed.

Blatchley, W. S., The mineral waters of Indiana: Indiana Dept. Geol. and Nat. Res. Ann. Rept., vol. 26, pp. 11–158, 1901. Descriptions of more than 100 mineral springs are given and analyses of the waters of many of them are quoted. The same volume (pp. 159–226) contains a discussion of the medicinal properties and uses of Indiana mineral waters by Dr. Robert Hessler.

Hare, R. F., and Mitchell, S. R., Composition of some New Mexico waters: New Mexico Coll. Agr. and Mech. Arts Agr. Exp. Sta. Bull. 83, 1912. In a collection of miscellaneous analyses reports on the composition of the waters of Carlsbad (N. Mex.) Mineral Springs, Mimbres Hot Springs, San Antonio Springs, Aztec Mineral Springs, and some others are given.

Froehling and Robertson, Mineral waters and spring resorts of Virginia: A handbook on the minerals and mineral resources of Virginia, pp. 97–159, Richmond, 1907. This handbook was published for distribution at the Jamestown Exposition, Norfolk, Va., 1907. About 60 resorts are described and analyses of the waters at most of them are quoted.

Bartow, Edward, and others, The mineral content of Illinois waters: Illinois Water Survey Bull. 4, 1908. Analyses of many ground waters are given and special chapters deal with the geological occurrence and classification of the waters and the medicinal springs of Illinois.

Sellards, E. H., A preliminary report on the undergound water supply of central Florida: Florida Geol. Survey Bull. 1, 1908. Analyses of 14 large springs are given.

Shepard, J. H., The artesian waters of South Dakota: South Dakota Agr. Coll. and Exp. Sta. Bull. 41, 1895. Analyses of about 50 deep waters are given.

The United States Geological Survey has issued as water-supply papers and bulletins many reports on the geology and ground-water resources of various parts of the United States, and most of these contain analyses of the spring waters in the territory covered by them. Among these may be mentioned the following water-supply papers, copies of which may be obtained as long as the edition for free distribution lasts by application to the Director, United States Geological Survey, Washington, D. C.:

223, on southern Maine.
233, on the Blue Grass region of Kentucky.
254, on north-central Indiana.
256, on southern Minnesota.
273, on Kansas.
293, on Iowa.

RADIOACTIVITY OF MINERAL WATERS.

By R. B. Dole.

INTRODUCTION.

The radioactivity of mineral waters has attracted much attention during the last decade, and it is now widely believed that the therapeutic value of many waters is largely due to their content of radioactive substances. For many years the beneficial effects attending the use of certain natural waters were attributed to the common mineral ingredients determined by chemical analysis, and several elaborate systems have been devised for classifying such waters on the basis of their chemical composition. Though many natural waters unquestionably cause physiologic reactions because of their great content of common mineral substances, a large proportion of the well-known waters of the United States do not differ essentially in concentration and composition from supplies of city water used daily by thousands of people without apparent physiologic reaction other than that following the use of water itself. Tests have shown that many of these slightly mineralized waters have various degrees of radioactivity, and consequently, as radium compounds have been found to cause marked physiologic reactions, the improvement in health following sojourn at springs has very naturally been attributed to the radioactive properties of the waters. There are yet too few experimental data to settle this point definitely, but it is perhaps not out of place to call attention to the facts that in radiotherapy as in all other branches of medicine the curative agent must be present in a certain strength in order to exert any healing influence, and that most of the radiotherapeutic reactions thus far investigated have been effected by means of radioactive compounds whose strength is far greater than that of natural mineral waters. Therefore owners should not be led into making strong claims for the radiotherapeutic value of the waters of their springs without careful investigation of the subject.

MEASUREMENT OF RADIOACTIVITY.

The radioactivity of water and of the gases contained in water is measured by the effect produced on a charged electroscope by radium emanation (niton), a gas that is given off by radium-bearing minerals in proportion to their content of radium. The general opinion that most spring waters do not contain radium itself but radium emanation derived from contact with radium-bearing minerals is logically based on the fact that nearly all spring waters gradually lose their radioactivity after being removed from the source, whereas a solution of a radium salt, after having once reached equilibrium, continues to give off radium emanation. The sample of water is boiled to drive off the emanation, which is dried and then swept by a current of air into an air-tight electroscope. The latter instrument consists essentially of a jar from the cover of which is suspended a rod supporting at its lower extremity a metal strip and a leaf of aluminum foil. When the system is electrically charged the aluminum foil is deflected from its vertical position, to which it normally returns very slowly as the charge is dissipated. If, however, radium emanation is present in the jar the rate of leakage and consequently the rate of fall of the foil are greatly accelerated. The rate of leakage in the presence of the emanation from a measured quantity of water is therefore observed and compared with the rate of leakage similarly measured on the emanation from a solution of a weighed portion of a mineral whose content of radioactive substance has been determined. From these data the radioactivity of the sample of water can be calculated. The results of such measurements have unfortunately been expressed in a great variety of units, and as a natural consequence it is impossible to compare some reports of radioactivity with others. In England and America it is customary to express radioactivity as an equivalent of radium or of uranium, a radioactive substance; on the Continent it is customary to express the results in electrostatic units. It is quite general, irrespective of the unit, to report the radioactivity per liter of water or per liter of the gas in the water. The quantity of emanation in equilibrium with 1 gram of radium is known as a curie of emanation,[1] but as this is a very large unit estimates are expressed in fractional parts of a curie; thus, 22.9×10^{-9} curie per liter means that one liter of the water contains 229 ten-billionths of the quantity of emanation in equilibrium with 1 gram of radium. The mache unit, frequently encountered in reports of radioactivity, is defined as the saturation ionization current due to the radium emanation, free from decay products, from a liter of water or gas, expressed in electrostatic units (i) multiplied by 1,000;[2] and 1 curie of emanation per liter equals a concentration of 2,670 million mache units.[2]

RADIOACTIVITY OF SOME WELL-KNOWN WATERS.

The following table gives the results of measurements of the radioactivity of several well-known European mineral waters and of a few American waters. Many of these waters also contain radioactive gases. Reports of different observations on the same spring indicate that the waters and the gases in them vary greatly in radioactivity. Because of differences in the methods of measurement and in allowances for disintegration products and also because of the uncertain or arbitrary nature of some of the units of expression the figures have not been reduced to a common unit for direct comparison. The most powerful water listed contains per liter a quantity of emanation equivalent to that in equilibrium with 7×10^{-8} gram of radium, or, to state it differently, 3,800 gallons of the water would contain the quantity of emanation in equilibrium with 1 milligram of radium. The slight strength of the tabulated activities can be comprehended when it is noted that most of the waters are only one-hundredth to one-half as strongly radioactive as the most powerful water.

[1] Makower, Walter, and Geiger, Hans, Practical measurements in radioactivity, p. 110, London, 1912.

[2] Viol, C. H., Some units and terminology used in radium and emanation therapy: Radium, vol. 1, p. 7, 1913.

Radioactivity of spring waters in Europe and in the United States.

Source.	Location.	Observer.	Radioactivity per liter.				
			Electrostatic units ($i \times 10^3$).	Mache units.	Millemicrocuries (10^{-9} curie).	Equivalent in radium (10^{-11} gram).	Equivalent in uranium (10^{-4} gram).
Friederichsquellen	Baden, Germany	Engler and Sieveking.[a]	6.9				
Murquelle	do	do	27.3				
Büttquelle	do	do	108.8				
Eisenquelle	Karlsbad, Bohemia.	do	54.5				
Sprudelquelle	do	do	.2				
Schlossbrunnen	do	do	8.9				
Rudolfstollen	Bad-Gastein, Austria.	do	68.8				
Chorinskiquelle	do	do	121.9				
Elisabethquelle (N.)	do	do	20.9				
Nebenquelle	Marienbad, Bohemia.	Mache and Meyer.[b]	6.78				
Marienquelle	do	do	1.74				
Ferdinandsbrunnen	do	do	.66				
Riesenquelle	Teplitz-Schönau, Bohemia.	do	8.73				
Augenquelle	do	do	3.13				
Mine water	Joachimsthal, Bohemia.	do	185.0				
Pluto Spring	French Lick, Indiana.	Schlundt[c]		1.35			
Proserpine Spring	do	do		1.96			
Bowles Spring	do	do		4.45			
Apollinaris Spring	Yellowstone National Park.	Schlundt and Moore.[d]	22.1				31.9
Firehole Lake	do	do	5.9				8.5
Three Crater Spring	do	do	4.1				5.9
Nymph Spring	do	do	4.8				6.9
Imperial Spring	Hot Springs, Ark.	Boltwood[e]					266
Twin Spring (north)	do	do					65.4
Arsenic Spring (north)	do	do					23.9
Liver Spring	do	do					17.4
Dripping Spring	do	do					7.7
Cave Spring	do	do					3.7
Tonnelet Spring	Spa, Belgium	Girard and Chauvin.[f]		4.08			
Prince de Condé Spring No. 1.	do	do		3.51			
Delcor Spring	do	do		3.54			
Marie-Henriette Spring (right orifice).	do	do		.34			
Kochbrunnen	Wiesbaden, Prussia.	Henrich[g]		1.2			
Adlerquelle	do	do		.9			
Schützenhofquelle	do	do		6.9			
Mauritius Spring	St. Moritz, Switzerland.	Schweitzer[h]		1.13			
St. Placidus Spring (upper).	Disentis, Switzerland.	do		47.7			
St. Placidus Spring (lower).	do	do		46.7			
Strong iron spring No. 1.	Villnöss, Tyrol.	Bamberger and Krüse.[i]		32.7–43.0			
Strong iron spring No. 2.	do	do		78.2–95.3			
Célestins Spring	Vichy, France.	Laborde and Lepape.[j]			0.653		
Chomel Spring	do	do			.653		
Hôpital Spring	do	do			.022		

[a] 1. Cong. int. étude de la radiologie et de l'ionization Compt. rend., p. 201, Brussels, 1905.
[b] Idem, p. 18.
[c] Cited by Barnard, H. E., The radioactive content of certain Indiana mineral waters: Indianapolis Med. Jour., vol. 16, p. 228, 1913.
[d] U. S. Geol. Survey Bull. 395, p. 31, 1909.
[e] Am. Jour. Sci., 4th ser., vol. 20, p. 128, 1905; quoted by Schlundt and Moore, U. S. Geol. Survey Bull. 395, p. 31, 1909.
[f] Compt. Rend., vol. 157, p. 302, 1913.
[g] Chem. Abstracts, vol. 4, p. 714, 1910 (abstracted from Zeitschr. anorg. Chemie, vol. 65, p. 117, 1910).
[h] Arch. sci. phys. nat., 4th ser., vol. 27, p. 256, 1909.
[i] Monatsh. für Chemie, vol. 34, p. 403, Vienna, 1913.
[j] Compt. Rend., vol. 155, p. 1202, 1912.

Radioactivity of spring waters in Europe and in the United States—Continued.

Source.	Location.	Observer.	Radioactivity per liter.				
			Electrostatic units ($i \times 10^3$).	Mache units.	Millemicrocuries (10^{-9} curie).	Equivalent in radium (10^{-11} gram).	Equivalent in uranium (10^{-4} gram).
Choussy Spring	La Bourboule, France.	Laborde and Lepape.[a]			22.9		
Vauquelin Spring	Plombières, France.	Brochet[b]			4.8		
Dames Spring	do	do			10.7		
Lambinet Spring	do	do			15.9		
Kings Well	Bath, England	Ramsay[c]				173	
Pump well No. 4	State Reservation, Saratoga Springs, N. Y.	Moore and Whittemore.[d]				[e] 23.1	
Hathorn No. 2	do	do				[e] 16.1	
Emperor	do	do				[e] 7.0	
Geyser	do	do				[e] 3.9	

[a] Compt. Rend., vol. 155, p. 1202, 1912.
[b] Idem, vol. 150, p. 423, 1910.
[c] Chem. News, vol. 105, p. 133, 1912.
[d] Moore, R. B., and Whittemore, C. F., Report on the radioactivity of the waters of Saratoga Springs, N. Y.: Unpublished report communicated by the Director, Bureau of Mines.
[e] The cessation of pumping of Saratoga waters since these tests were made has been followed by substantial modification of the flow and hydrostatic head of the springs; consequently it is quite possible that waters have developed that are different from those on which the report here cited was made.

THERAPEUTIC USES OF RADIOACTIVE WATERS.

Radioactive waters are applied to the body in practically every manner that mineral waters have heretofore been used; baths, douches, and local applications of every description are employed, and the waters are also drunk and injected. In addition to these methods of administration, rooms or closets, called inhalatoria and emanatoria, are so arranged that patients may breathe the radium emanation in the gases that escape from the waters. The more completely equipped watering places have arrangements for combination of radium treatment with electric, muscular, aqueous, and other kinds of massage, hot-air baths, mud baths, and X-ray and violet-ray treatment. At some sanatoriums these treatments are given by means of waters, muds, packings, and compresses that have been rendered artificially radioactive. A great variety of diseases are treated, among which may be mentioned especially croupous pneumonia, bronchitis, bronchial asthma, articular rheumatism, tuberculosis, syphilis, gout, diabetes, and obesity. In reference to the physiologic reactions following treatment by the radioactive waters of Bath, Atkins and Harrison are quoted by Low [1] as saying that radium increases diuresis, excretion of uric acid, and exhalation of carbon dioxide; lowers the pressure of the blood and decreases its viscosity; increases the rate of decomposition of uric acid; inhibits inflammation; increases sexual vitality; and has considerable influence over sympathetic affections. As a concluding comment on this topic, it is well to repeat that there is much conflicting testimony on the therapeutic value of radioactive waters and that the physiologic effects of relatively strong solutions of radium salts may not necessarily be duplicated by weakly radioactive natural waters.

[1] Low, T. P., Radium emanation in mineral waters: Lancet, April 20, 1912; abstract in Med. Record, vol. 81, p. 912, 1912.

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RUTHERFORD, E., Radioactive transformations, Charles Scribner's Sons, New York, 1906.

MAKOWER, WALTER, and GEIGER, HANS, Practical measurements in radioactivity, London, 1912. The methods and instruments for measuring the radioactivity of minerals, waters, and gases are fully described.

LE RADIUM, a monthly journal published in Paris. It contains chiefly articles of scientific and theoretical interest on the character of radioactive bodies, the effects of radioactive substances, the properties of rays, the theory of electrons, ions, and radiations, and on atomic and cosmic phenomena. The earlier numbers contain references to articles in current literature on the radioactivity of various mineral springs.

Radiotherapy.

LAZARUS, PAUL, and others, Handbuch der Radium Biologie und Therapie, 521 pp., 153 text figs., 2 tables, J. F. Bergmann, Wiesbaden, 1913. This volume contains articles by authorities on the physical, chemical, and biologic properties of the radioactive elements, their general therapeutic uses, and the treatment of special diseases, with a general bibliography including more than a thousand references to articles on radiobiology and radiotherapy.

Comptes rendus de la premier Congrès international pour l'étude de la radiologie et de l'ionization, L. Severeyns, Brussels, 1905. Many papers covering divers phases of radiotherapy and the physical properties of radium are included, among which may be mentioned articles on the physiologic action of very feeble radioactivity, by Dr. E. S. London; medical applications of radium, by Dr. A. Darier; radioactivity applied to the histology of the nervous system, by Prof. Madrid Moreno; and the radioactivity of Austrian thermal waters, by H. Mache and St. Meyer.

BURNHAM, A. C., Radioactive waters in the treatment of gout: Med. Record, vol. 81, p. 117, 1912. The author recommends the use of artificially prepared and tested radioactive waters as the content of American waters is usually insignificant. He outlines the treatment for gout, giving doses.

KOHLRAUCH, F. L., and MAYER, KARL [Radioactive baths]: Zeitschr. exper. Pathologie, vol. 6, p. 186, 1910. The apparatus used in radium-bath treatment is described and clinical observations are given.

HATTON, JOHN [compiler], Notes on the therapeutics of radium in the Bath waters, Bath Corporation, Bath, England. This pamphlet contains the results of investigations of the hot springs of Bath, conducted by Sir William Ramsay; an article by a committee of the Bath branch of the British Medical Association on radioactivity as a factor in the efficacy of the Bath mineral waters; extracts from medical journals on radiotherapy; and a description of the methods of using the radioactive Bath waters.

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ROLLINS, WILLIAM, Some principles involved in the therapeutic applications of radioactivity. Boston Med. Jour., vol. 149, p. 542, 1903.

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METZENBAUM, MYRON, Radium, its known medical value: Med. Record, vol. 69, p. 17, 1906.

BERGELL, PETER, and BICKEL, ADOLF [Experimental investigations of the physiologic significance of the radioactivity of mineral waters]: 22. Kong. für inn. Medizin Verh., p. 157, 1905.

LOEWENTHAL, S. [Methods of measurement and units in biologic research with radium]: Deutsche med. Wochenschr., vol. 36, p. 2096, 1910.

Radioactivity of waters.

RAMSAY, SIR WILLIAM, Report on the mineral waters of Bath: Chem. News, vol. 105, p. 133, 1912.

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BROCHET, ANDRÉ, [Relation between the radioactivity and the quantity of soluble salts in the thermal waters of Plombières]: Compt. Rend., vol. 150, p. 423, 1910.

HENRICH, F., [Radioactivity of the thermal waters of Wiesbaden]: Zeitschr. anorg. Chemie, vol. 65, p. 117, 1910.

BOLTWOOD, B. B., The radioactive properties of the waters of the springs on the Hot Springs Reservation, Hot Springs, Ark.: Am. Jour. Sci., 4th ser., vol. 20, p. 128, 1905. Waters from 44 hot springs and samples of tufa and gas were examined.

SCHLUNDT, HERMAN, and MOORE, R. B., Radioactivity of the thermal waters of Yellowstone National Park: U. S. Geol. Survey Bull. 395, 1909. The methods and apparatus for measurement of the radioactivity of waters and gases are described and quantitative tests of 80 waters, 40 gases, and 50 solids are reported.

MOORE, R. B., and WHITTEMORE, C. F., The radioactivity of the waters of Saratoga Springs, New York: Jour. Ind. and Eng. Chemistry, vol. 6, p. 552, 1914.

MAGNESITE.

By Charles G. Yale and Hoyt S. Gale.[1]

PRODUCTION.

The magnesite produced and sold or treated in the United States in 1913 was 8.37 per cent less in quantity than in 1912, the total output marketed in 1913 being 9,632 short tons, valued at $77,056, compared with 10,512 tons, valued at $84,096, in 1912.

The only production in this country was from California, as has always been the case, the material having been derived in 1913 from 3 mines—1 in Fresno County, 1 in Riverside County, and 1 in Tulare County. The small output reported in 1912 from the deposit on the Eckert ranch, in Sonoma County, has not been followed by further production; and the deposits on Red Mountain, in Santa Clara County, which yielded a few hundred tons in 1912, were unproductive in 1913.

At the close of the year 1913 there was only 1 productive mine in operation in California, the others having been temporarily closed down. Since the close of the year 6 mining properties have started operations—1 in Alameda County, 1 in Kern County, 1 in Placer County, 1 in Santa Clara County, and 2 in Sonoma County. The mines in Sonoma County are both old ones reopened, but all the others have become productive for the first time, mainly, however, on a small scale. The distribution of the magnesite deposits in California is shown on Plate I.

Protest has been received that the description of the deposit in Placer County, published in Survey Bulletin 540,[2] does not include all the development or exposures represented in that general locality. The outcrops examined were carefully identified both in description and on the map given with the report, so that there can be no mistake as regards the deposits that have been so described; but it is entirely likely that more deposits in the same general vicinity may exist, which were not then examined and are not included in that report. As was there stated, "The area is thickly timbered, and it is possible that not all the known outcrops were found." It is desirable, however, that the matter may be clearly understood, and it is hoped and expected that a further examination of these deposits can be arranged for the field season of 1914, and that the matter may then be put more completely on record.

[1] The statistics concerning domestic production, together with most of the data relating to development in the California fields, have been gathered by Mr. Yale; the statements concerning eastern markets, prices, discussion of imports, uses, cements, and the bibliography are compiled by Mr. Gale.

[2] Gale, H. S., Late developments of magnesite deposits in California and Nevada. U. S. Geol. Survey Bull. 540, pp. 501-503, 1913.

By far the greater part of the domestic product is consumed in calcined form as a digester for wood pulp in paper manufacture. Some, however, is used in making plastic material for flooring, tiles, wainscoting, artificial marble, paint, and fireproofing.

None of the magnesite mined is sold crude, but it is all calcined before shipment from the mines. The California manufacturers of carbon dioxide who have been using limestone for making their gas are making comparative experimental tests with the intention, if desirable, of resuming the use of magnesite as a source of the gas, as was formerly done.

At one of the new mines recently opened in Alameda County a 5-ton calcining furnace has been completed, and the owners have entered into contract with a local steel company to furnish dead-burned refractory material for furnace linings.

In the toilet and bathrooms of the larger buildings of the Panama Pacific Exposition at San Francisco magnesite flooring is being laid, about 5,000 square feet having been put down in each of the main buildings. The domestic product is used in this work. A number of manufacturers in Los Angeles and San Francisco are engaged in work of this class, the magnesite compounds being given different names, such as artolite and litholite. With the near approach of the opening of the Panama Canal, renewed interest is being taken in the investigation and prospecting of the California magnesite deposits, as it is expected that the surplus output above the normal annual consumption of the Pacific coast product may be shipped much more cheaply than is possible at the present time.

A new company, which since the close of 1913 has purchased and is reopening the largest of the Sonoma County deposits, is building a short branch railroad to connect with the main line to tidewater. It is understood that it is the intention of this company to ship its entire output through the canal to New York, where it is reported to have contracts for monthly delivery of several thousand tons of calcined magnesite.

Notwithstanding the fact that California is the only State in which magnesite is produced in commercial quantities, a considerable quantity of imported calcined and ground magnesite is sold in the Pacific coast markets, particularly in California. This magnesite is sold finely ground and in packages of convenient size and form, and it brings a higher price generally than the domestic product, which is equally good, if not superior, because of its freshness, if for no other reason. Generally speaking, the California mine owners sell only carload lots in clacined lump form, and this is shipped in sacks and reduced to powder in the grinding mills at points of greatest consumption, such as Los Angeles and San Francisco. The manufacturers of flooring, tiling, and wainscoting usually buy in small lots of 1 or 2 tons, or even less, in order to fill pending contracts, and thus have to pay higher prices than if they purchased in larger quantities. The importers are able to meet this retail demand by disposing of their product in small wooden packages. Those who grind the domestic material are also following this plan. This domestic calcined and ground magnesite has been selling at an average of about $40 a ton, but as high as $50 and $55 a ton has been paid for the imported material in Los Angeles and San Francisco.

MAP OF A PART OF CALIFORNIA, SHOWING DISTRIBUTION OF MAGNESITE DEPOSITS.

The various magnesite mines and "prospects" in California have been described both in United States Geological Survey bulletins and in those of the California State Mining Bureau. In the opening and development of these mines their nearness to railroad transportation seems to be of more importance than the character or extent of the deposits. Certain deposits, notably in Santa Clara and San Benito counties, are known to be large in extent and of good character of material, but they lie idle owing to the distance the mineral must be hauled to a railroad, while smaller mines close to railroad stations are being worked. Investors looking for deposits of magnesite to be developed are not disposed to investigate even promising mines from which a long haul by team is necessary before the mineral can be placed on the cars.

The following table shows the quantity and value of the domestic output of magnesite from 1891 to 1913, inclusive:

Quantity and value of crude magnesite produced in the United States, 1891–1913, in short tons.

	Quantity.	Value.		Quantity.	Value.
1891	439	$4,390	1903	3,744	$10,595
1892	1,004	10,040	1904	2,850	9,298
1893	704	7,040	1905	3,933	15,221
1894	1,440	10,240	1906	7,805	23,415
1895	2,220	17,000	1907	7,561	22,683
1896	1,500	11,000	1908	6,587	19,761
1897	1,143	13,671	1909	9,465	37,860
1898	1,263	19,075	1910	12,443	74,658
1899	1,280	18,480	1911	9,375	75,000
1900	2,252	19,333	1912	10,512	84,096
1901	3,500	10,500	1913	9,632	77,056
1902	2,830	8,490			

PRICES DURING 1913.

The prices of magnesite of the various classes, and grades of magnesite and magnesia products, have fluctuated somewhat during 1913. The price of Grecian material rose markedly about the middle of the year, owing, it is said, to the scarcity of labor at the mines as a result of the Balkan wars, which limited production for a time. Since the close of the wars the prices have not been reduced to quite their former level.

The following summary represents approximately the wholesale prices per short ton current during 1913 for the products as usually marketed:

New York market:
- Grecian (Eubœan) calcined "caustic," fine-ground (in paper-lined barrels) .... $25 to $35
- Grecian (Eubœan) calcined "caustic," not ground (in sacks) .... $17.50 to $20
- Grecian (Eubœan) crude (bulk) .... $7 to $8
- Austrian, calcined, dead-burned, crushed or fine ground (bulk) .... $16.15 to $16.25

Pacific coast, San Francisco or Los Angeles markets:
- Domestic, calcined "caustic" fine ground (in paper-lined barrels) .... $30 to $35
- Domestic, calcined, not ground, dead-burned (in sacks) .... $20 to $25
- Norwegian, calcined, dead-burned, crushed or fine ground .... $22.50.

The value assigned to the domestic production is based on the figure $17.50 a ton for ordinary run calcined, unground magnesite at the mine or point of shipment, which is assumed to be approximately equivalent to $8 a ton for the raw magnesite.

IMPORTS.

The following statistics concerning imports of magnesite are obtained from the Bureau of Foreign and Domestic Commerce, Department of Commerce. The statistics include imports for consumption for the calendar years 1911 to 1913, inclusive, and also imports for the fiscal years 1910 to 1913, inclusive, under which are two statements relative to the imports of magnesite, calcined not purified—one showing the countries of shipment or nominal origin and the other the ports and customs districts into which imported; there is but one statement with regard to imports of the crude magnesite by the fiscal year, data as to the countries from which imported not being available.

Imports, for consumption, of magnesite into the United States from 1911 to 1913, in pounds.

	1911		1912		1913	
	Quantity.	Value.	Quantity.	Value.	Quantity.	Value.
Magnesia:						
Calcined, medicinal	91,029	$13,694	104,106	$16,326	54,915	$10,034
Carbonate of, medicinal	50,490	2,867	62,404	2,812	70,823	4,880
Sulphate of (Epsom salts)	5,950,861	22,559	10,703,209	41,739	8,121,677	32,884
Magnesite:						
Calcined, not purified	244,149,581	1,109,770	250,503,372	1,265,339	345,181,246	1,727,848
Crude	25,948,797	76,097	35,810,752	104,326	26,479,109	84,911

Imports of magnesite calcined, not purified, for fiscal years ending June 30, 1911–1913, by countries, in short tons.

Country.	1911	1912	1913
Europe:			
Austria-Hungary	143,392	99,104	163,715
Belgium	33	25	....
Germany	1,426	689	2,412
Greece	....	114	1,605
Italy	28	....	....
Netherlands	2,974	2,410	4,508
Norway	121	163	....
United Kingdom (England)	2	61	1
North America:			
Canada	296	234	350
Mexico	....	81	....
Asia: East Indies, British	....	57	....
Total	148,272	102,938	172,591

Imports of magnesite, showing ports of receipt during the fiscal year, ended June 30, 1913, by customs district, in short tons.

Customs district.	Crude.[a]	Calcined.	Customs district.	Crude.[a]	Calcined.
New York, N. Y.	12,454	8,418	Puget Sound, Wash	....	29
Boston and Charleston, Mass	....	95	Los Angeles, Cal	1	394
Champlain, N. Y	198	40	San Francisco, Cal	69	....
Buffalo Creek, N. Y	18	....	Other	417	249
Vermont	91	118			
Newport News, Va	2,089	....	Total	15,337	172,591
Philadelphia, Pa	....	119,682			
New Orleans, La	....	43,566			

[a] Imports for consumption.

TARIFF REGULATIONS.

The tariff act of October 3, 1913, contains the following provisions relating to magnesia materials and magnesite:

DUTIABLE LIST.

Schedule A.—Chemicals, oils, and paints. Magnesia: Calcined, 3½ cents per pound; carbonate of, precipitated, 1½ cents per pound; sulphate of, or Epsom salts, $\frac{1}{10}$ cent per pound.

Schedule B.—Earths, earthenware, and glassware. Firebrick, magnesite brick, chrome brick, etc., * * * not glazed, enameled, painted, vitrified, ornamented, or decorated in any manner, 10 per centum ad valorem.

Schedule C.—Metals and manufactures of. * * * Barium, calcium, magnesium, * * * and alloys of which said metals are the component material of chief value, 25 per centum ad valorem.

FREE LIST.

Magnesite, crude or calcined, not purified.

USES OF MAGNESITE.

Magnesite is marketed and used in various forms for different purposes, either raw or crude as mined, or calcined, which results principally in the expelling of the carbon dioxide and moisture of the original carbonate, the residue or calcined magnesite being chiefly the oxide, also known as magnesia.

The calcined magnesites are either the so-called "caustic" or the "dead-burned." The "caustic" magnesite intended for plastic or cement uses is burned at somewhat lower temperatures than the dead-burned, and usually retains a small percentage of carbon dioxide, which permits the material to react with the chloride salts used in cement. The "dead-burned" is roasted beyond the point at which all carbon dioxide would be extracted, heating being carried to incipient fusion, whereby practically all shrinkage is taken up, so that forms moulded of this crushed material and held by a satisfactory binder will shrink but little more with further heating.

The principal uses of magnesite are summarized as follows: (1) Various refractory uses, as brick, furnace hearths, crucibles, etc.; (2) as magnesium sulphite for the digestion and whitening of wood-pulp paper; (3) in crude form for the manufacture of carbon-dioxide; (4) calcined and ground for oxychloride or Sorel cement; (5) miscellaneous applications in crude or calcined form; (6) miscellaneous uses of refined magnesia salts.

Refractory uses.—The refractory uses of calcined magnesite constitute probably its most important application. Made into refractory bricks it finds an important use as the linings of basis steel furnaces. In "dead-burned" calcined form either as brick or as originally burned, the magnesia is used as a refractory lining for open-hearth furnaces and converters in the steel industry, for rotary kiln linings in Portland cement manufacture, for furnace hearths, for crucibles, and for cupels.

It is commonly assumed that the most refractory magnesite is the "dead-burned" product derived from magnesite containing little or no lime, silica, oxide of iron, or alumina. The presence of lime in magnesite bricks used for high temperatures is said to cause them to disintegrate more readily, and in basic steel furnaces the lime is believed "to cause the phosphorus to pass into the hearth instead of the slag, the hearth thereby becoming rotten." Silica, oxide of iron, and alumina are supposed to have a tendency to lower the fusing point. On the other hand, there is a decided preference in refractory uses for the magnesites carrying a certain percentage of iron, as do the Austrian and Hungarian products for use in the manufacture of brick. The iron probably does lower the fusing point but with the result that the shrinkage of the material after calcining is very much less and the bricks made from it are more satisfactorily burned and hold their shape better. It is generally admitted that the whiter and purer grades of magnesite are more refractory, but they require a much greater heat for calcining, in fact it is exceedingly difficult to burn them to a point where they will not shrink further. The calcined, dead-burned Austrian magnesite is reported to contain within a maximum of 3 to 4 per cent silica, 6 to 8 per cent iron, and 4 per cent lime.

Use in the paper-manufacturing industry.—The availability of magnesite in the California deposits has led to its considerable use in the manufacture of wood-pulp paper on the Pacific coast. Magnesia, in the form of the bisulphite, is said to have a more solvent action on the free resins of the wood than lime, and it also has an additional advantage in that the residues left in the paper stock are not afterwards injurious to sizing agents.

The process of making paper [1] in which magnesite is used is known as the sulphite process. The wood (mostly from coniferous trees) is boiled with a disintegrating agent so that it breaks down into a mass of pulp, which is afterward rolled into paper. The disintegrating agent in the sulphite process is sulphurous acid, or common bisulphite of calcium or magnesium. Magnesium bisulphite is more stable and it dissolves the noncellulose matter even more completely than calcium bisulphite. Sodium bisulphite gives a better product than either of the two mentioned, and strong liquors can be made from it, but it is too expensive for general use.

It is known that the greater part of the California magnesite is now used in the manufacture of paper by this process. The Portersville deposits, which have been for years the largest producers, have been worked primarily for the use of paper makers.

Manufacture of carbon dioxide.—The manufacture of carbon dioxide from raw magnesite consists in the decomposition of the magnesium carbonate by roasting with the recovery, purification, and compression of the carbon dioxide gas, the residual magnesia being also available as one of the important products of the process. The operation of this process is described by Hess [2] with a diagram showing details of one of the plants. It is understood that the use of magnesite for this purpose has now been chiefly or wholly abandoned on the Pacific coast, as the gas can be produced more cheaply as a by-product in other processes—as, for instance, as one of the products of a distillery and also from limestone. Carbon dioxide is, however, manufactured in this way from the imported magnesites in the eastern part of the country, in which case the magnesia is sometimes considered as a

[1] Thorp, F. H., Outlines of industrial chemistry, pp. 522–523, 1909.
[2] Hess, F. L., U. S. Geol. Survey Bull. 355, pp. 8, 9, 1908.

by-product in the manufacture of the gas. In other cases, however, the imported product is calcined for the sake of the magnesia alone without any attempt to save the gas.

Oxychloride or Sorel cement.—The use of magnesite for the manufacture of cement is apparently a promising field, and the product is likely to find an increasing use. This product is known as oxychloride or Sorel cement. Its manufacture is based on the fact that a mixture of finely ground calcined magnesite when wet with a solution of magnesium chloride of a certain strength will set as an exceedingly strong cement. This mixture is generally modified by the addition of various filler materials, such as wood flour, cork, talc, silex, asbestos, clay, marble dust, sand, and other materials, besides coloring matter. The cement thus produced is put out under many trade names, espepecially referred to as sanitary flooring. When well laid, magnesite cement flooring has some decided advantages over other cements for this purpose. It produces a smooth, even floor, which when successfully put down may be laid in large areas without cracking. It takes colors advantageously, and is susceptible of good polish by oiling or waxing. It is thus laid in a plastic state on wood, steel, or concrete. Its surface seems to have a resilience not given by ordinary cement, and it does not pulverize or grind to dust. This cement is said to have found a very extensive use abroad as flooring and to be gradually coming into more extended use in this country. It has also found a use in the manufacture of artificial marble and fine tiles.

It appears, however, that there are practical difficulties to be encountered in the manipulation of magnesia cements, which are not yet wholly understood and which have at times led to criticism and dissatisfaction with the material, possibly not always merited. (See review of this subject in subsequent pages.)

Miscellaneous applications in crude or calcined form.—Magnesia finds numerous miscellaneous applications in both crude and calcined form, among which may be mentioned its use in pipe covering as a nonconductor of heat, where it is commonly mixed with asbestos fiber. For this the light carbonate is used which is understood to be obtained from domestic sources, being manufactured from dolomite by a precipitation process. Magnesia, doubtless the light carbonate, is said to be used as an absorbent in the manufacture of dynamite. It is said to be used also as an adulterant in paint, and to prevent scale in boilers in which sulphurous waters are used. It has been tried with some success as a binder for briquetting coal, where it has the disadvantage common to all inorganic binding materials, namely, that they increase the ash without adding to the combustible portion of the fuel.

The use of fine-ground magnesia in a fireproof or fire-retarding paint is also reported to be coming to the fore. Wood or burlap coated with a paint made of magnesia and a magnesium chloride solution are said to resist fire, so that, although they can be burned by direct application of heat and flame, the fire will not spread beyond the areas actually exposed to the flame.

Miscellaneous uses of refined magnesia salts.—Among the miscellaneous uses as refined magnesia salts may be suggested those for medicinal and toilet purposes. The commercial preparation known as magnesia alba is a basic carbonate of slightly varying composition, according to the conditions of production. It is usually prepared by precipitation of either the commercial sulphate or chloride of magnesium with sodium carbonate. Epsom salts (magnesium sulphate) is derived from the deposits at Stassfurt and is imported on a considerable scale; but it is also manufactured by chemical treatment of magnesite. Its principal use is said to be in warp sizing or weighting in cotton mills. Very considerable quantities of magnesium chloride are also imported from the German fields for use in the oxychloride cement and for other purposes. The hydrate is used in sugar manufacture. A considerable quantity of magnesia, quoted as "calcined, medicinal," is imported annually, probably representing a purified product for medicinal or other uses.

UTILIZATION OF THE PRODUCT, DOMESTIC AND FOREIGN.

DOMESTIC.

Although the workable deposits of magnesite in this country are confined to the Pacific coast so far as known, all the important deposits being in the State of California alone, magnesite is very widely distributed throughout the world. Owing to high cost of transportation and possibly to a certain extent to difference in costs of labor in our own country and in foreign lands, the California magnesite has not yet been able to enter the Middle or Eastern States in competition with the imported products. As the largest markets in this country are in the Eastern States the total quantity of the imported product exceeds by many times the home production.

The magnesite of California is consumed principally in the paper-manufacturing trade. There is a limited demand in the West for magnesite for refractory uses, which is partly supplied by importation of foreign products even in that market, and also a limited, though probably growing demand for ground "caustic" magnesite for plastic or cement uses, which now seems to be in a fair way to be supplied by the domestic material as far as the west coast markets are concerned.

FOREIGN.

As suggested, however, the great bulk of the magnesite used in this country passes through our eastern markets and is derived from foreign sources. Ninety-five per cent or more of the magnesite imported into the United States comes from Austria and Hungary and is of the iron-bearing variety used for refractory purposes. This is received chiefly at the port of Philadelphia, where is it delivered in sacks in calcined form and goes into the manufacture of refractory brick. Some of the Grecian magnesite imported raw is calcined and manufactured into refractory brick in a similar way. The greater part of the magnesite that goes into the plastic or cement uses comes from the island of Eubœa, Greece, and is imported in both raw and calcined forms. Much of this product has been shipped raw from the mines to Hamburg and Rotterdam, where the material is calcined and sacked and reexported. Thus most of the product reported as received from Germany and Netherlands is actually Grecian magnesite. According to the statistics given herewith it may be noted that after Austria-Hungary, these are the two largest sources of our imports, each one much exceeding our imports from Greece direct.

A small quantity received from England doubtless comes in the same way. New York is the principal port of receipt of the Grecian material, whence it is distributed by the various importing chemical firms. Of the product thus received in the raw state, a part is used primarily for the manufacture of carbon dioxide, the calcined magnesia (a by-product) being disposed of as a secondary matter, and a part is calcined primarily for the magnesia with no attempt to save the carbon dioxide.

It would seem that there should be a decided advantage in the use of freshly calcined and ground material for the cement trade and that there is room for development along this line. As already stated, the greater part of the Grecian magnesite received here has been shipped raw in bulk from the mines to northern Germany or Holland, there to be calcined and in part ground, and being repacked either in sacks or (if ground) in barrels, is reexported to this country to be again handled by the brokers. In view of the fact that there is a marked tendency in calcined magnesite to deteriorate—especially if, after grinding, it be long kept in storage and particularly if it be exposed at all to dampness—either by absorption of moisture or of carbon dioxide from the air, it would seem that there should be a field for the calcination and grinding in our own country of this material, whether of the raw Grecian rock or of our own product from California. It is possible that the latter may be obtainable shortly at competing rates through the Panama Canal, but this is a matter which is still the subject of speculation. Much dissatisfaction is expressed with the variable quality of the magnesite that is furnished to the magnesia cement trade. Whether this variability is the result of actual differences in the original product, or in its condition of freshness or possible deterioration, or in the manner of the calcining and grinding of the original product has not been determined, and these points are apparently a source of equal uncertainty even within the trade itself. At least one point seems assured, namely, that calcined magnesite does deteriorate markedly with exposure to air and dampness, and that the ground calcined magnesia deteriorates rapidly, so that even with the best of packing in paper-lined boxes or barrels it should not be held in storage long before it is used, probably not more than a year under the most favorable conditions.

A certain quantity of magnesia, in the form of the light carbonate, is made from dolomite in Pennsylvania by precipitation and is used in the preparation of magnesia asbestos fireproofing and insulating materials. This has not been taken into account in the present report.

FOREIGN OCCURRENCES.

A summary of the foreign occurrences is given here chiefly by abstract from the review by Hess.[1]

Foreign occurrences of magnesite.

North America:

Canada: Quebec, in township of Grenville, Argenteuil County. British Columbia, at town of Atlin, in Pine Creek valley, and at 108-mile house on the Cariboo road, 93 miles north of Ashcroft, Lillooet district.

Mexico: Lower California, on island of Santa Margarita and on Cedros Island, in Magdalena Bay.

[1] Hess, F. L., U. S. Geol. Survey Bull. 355, 1908.

South America:
- Venezuela: Island of Margarita.

Europe:
- Austria: Styria (mines at Veitsch).
- Hungary: Nyustya, Jolsva, and Hizsuya, Gomor County; Ochtina, Martonhaza
- Germany: Near Frankenstein, Silesia.
- Greece: On island of Eubœa; near Mariki, close to Thebes (Bœotia); at Hermioni, in Argolis.
- Italy: At Casellette, in Val di Susa, and at several other places in the Turin district; on the island of Elba.
- Macedonia: Near the coast not far from the Greek border, and on the Chalkidike Peninsula.
- Norway: Two fields near Snarum, in the Modums division of Buskerud bailiwick, on the Kroderline, a spur of the Drammen Randsfjord line, 56 kilometers (35 miles) from Drammen, the nearest city or port.
- Russia: In the Uphim Mountain district of the Urals.

Africa:
- Transvaal: Extensive deposits between Kaapumiden and Malelane, 2 miles south of the Pretoria-Delagoa Bay Railway, 87 miles from Lorenzo Marquez, and 300 miles from Johannesburg.
- Rhodesia.

Asia:
- India: Madras, Chalk Hills, 4 miles northeast of Salem, Madras Presidency, in the southern part of the Indian Peninsula. Mysore: Occurrences at a number of points near Mavinhalli and Kadakola, in the south-central part of the Indian Peninsula.
- Ceylon: Hydromagnesite reported.

Australia:
- Queensland: In the Normanton district in the Gulf country; in the Rockhampton district on Dumer, Sawpit, and Stewart creeks; at Stanwell, Islapot, Moonmera, and the Pointer, near Yamba; in other districts at Clermont, Toorwomba, Ipswich, Kilkivan, and Newellton.
- New South Wales: Near Fifield; minor occurrences at other localities.
- South Australia: Large deposits reported.
- Tasmania: At Parson's Hood Mountain; Trial Harbor, in the Meredith Range; Dundas and Hazlewood.
- Victoria: Heathcote.

Oceania:
- New Caledonia: At the north end of the west coast, particularly between Koumac and Voh.

MAGNESIA CEMENT; A REVIEW.

A recent publication [1] on the subject of magnesia cement, generally termed oxychloride or Sorel cement, opens a discussion in this country on a subject which seems involved in a great deal of obscurity. As this paper gives information that will probably be of interest to the magnesite trade generally, the following summary is given, to which are added some other data on this general subject.

The basic idea, namely, the use of finely powdered magnesia and a solution of magnesium chloride to produce a cement, originated with Stanislas Sorel of Paris, who took out patents covering the idea in 1866. This cement has the special distinction as compared with other cements, of a considerable degree of elasticity to which probably may be ascribed its ability to withstand cracking caused by warping in the cement or its foundation, or by expansion or contraction. Its principal use in construction is for adding finishing surface either exterior or interior, but chiefly in the interior, especially for floors. Such surfaces are applied in a plastic form, usually about half an inch thick, which sets in a few hours as a tough seamless

[1] Hooker, H. M., Composition flooring, Eng. Soc. Western Pennsylvania Proc., vol. 29, pp. 305-338, 418-444, 1913.

surface. It has also a very strong bonding power, and will hold firmly to wood, metal, or concrete as a base. It may be finished with a very smooth even surface, which will take a good wax or oil polish. As ordinarily mixed there is added a certain proportion of wood flour, cork, or other filler, thereby adding to the elastic properties of the finished product. Its surface is described as "warm" and "quiet" as a result of the elastic and nonconducting character of the composite material. The cement is usually colored by the addition of some mineral pigment to the materials before mixing as cement. The colors used most commonly are red, buff, or gray. This cement is coming into very general recognition under many trade names, generally with particular reference to what are called its sanitary qualities. Its freedom from cracking where successfully laid favors cleanliness.

The desirable qualities of any flooring material (cost not considered) are listed for purposes of analysis or comparison under 18 heads, as follows: Cleanliness (sanitary qualities), quietness, immunity from abrasion (surface wear), resilience, immunity from slipperiness, appearance, waterproof character, plasticity, warmth (thermal insulation), life (immunity from deterioration with age), acid-proof character, alkali-proof character, fire resistance, elasticity, crushing strength, structural strength (rupture), immunity from expansion and contraction, and lightness. The importance of these various qualities varies with the varying requirements to be met; for instance, in some places, as in hospitals, cleanliness is one of the prime considerations; in other places immunity from abrasion might be one of the principal requisites. However, an attempt is made in the discussion of this subject to estimate quantitatively the values of these different properties and to compare magnesite flooring in this way with many other materials now in common use as flooring. As to most of these qualities the conclusion is reached that the magnesia cement affords one of the most satisfactory flooring materials for many purposes such as in kitchen, laundry, toilet, and bathrooms, corridors, large rooms or halls in public or other buildings, including hospitals, factories, shops, and restaurants.

There is no doubt that the material is steadily coming into more general recognition and favor for these uses. For a few special uses it is more or less disqualified; as an instance, it is not suited for construction of swimming tanks or for conditions of permanent wetness, since under constant immersion it gradually softens, although it is said to withstand intermittent wetting and drying and is recommended for shower baths. Naturally it is not acid-proof and not wholly alkali-proof, which might be a disadvantage in use for laboratory floors and tables; but these are rather special requirements. Its cost per square foot is given as 25 to 33 cents, depending on area, which is estimated to be lower than marble, cork, rubber, clay or mosaic tile, slate, or terrazzo, although more expensive than wood, asphalt, linoleum, or Portland cement.

After the consideration of properties and cost, methods of installation, preparation of foundation, delivery and character of materials are considered, in which the materials are, of course, assumed to be obtained ready prepared from a manufacturer. A feature must be called to attention which has not yet been satisfactorily provided for, namely, that there still remains an element of uncertainty in the practical application of these cement flooring materials which has not yet been successfully obviated. Although the general advantages of the material over most other floorings for many uses may readily be granted, there still exists the element of uncertainty as to whether a floor when laid will be satisfactory or, possibly, will be an entire failure. The real difficulty is that the true causes for the failure are generally not understood, and so can not be readily obviated. Some of these points are brought out in the discussion of Mr. Hooker's paper. It is admitted that in certain cases many floors have had to be replaced. The uncertainty as to what the result would be not only adds to the cost of such floors but acts as a decided deterrent to the more general use of this material.

In the discussion of the subject the causes of failure are ascribed to uncertain climatic changes, lack of uniformity in the mixtures used, lack of care on the part of those handling the materials, possible deterioration of materials used through exposure (either before or after mixing), lack of proper preparation of foundations on which the material is to be laid, and, as a very important factor, experience or nonexperience in the manipulation or actual laying and troweling of the material. Colors used may fade for various reasons, or an efflorescent salt may appear on the floor surface. In summary, the principal point in the argument, as presented for obtaining good results, seems to be in urging dependence on those responsible firms who may gain or have gained a reputation for preparing and laying the materials in a satisfactory way.

The trend of the foregoing argument is obvious. Investigation of the raw materials involved might serve to establish more completely than has yet been done the nature of the chemical reactions involved, and possibly some chemical causes for the failures. Data concerning the percentages of magnesium chloride and of ground calcined magnesia and data concerning the character and quantity of filler and color added to the commercial preparations are naturally guarded as trade secrets by the firms already in the business. A chemical investigation of the finished product, however, would probably not be very satisfactory, as magnesia limestone or dolomite, talc, asbestos, and other inert magnesian fillers are used in the mixture and the magnesia in them could not be readily distinguished from the reacting portion of the cement by ordinary analysis. The examination and standardization of the raw materials used, and of acceptable filler materials, and the establishment of standard proportions for the mixtures would seem to be about the only satisfactory way of attacking such a problem.

Inquiries have been received at the Survey from time to time as to the proportions used in such mixtures for magnesia cement. Of course, there is much variation in the compositions of the natural calcined magnesia to start with, and only certain materials are actually suited for the plastic or cement uses as distinguished from the general refractory and other uses to which magnesite is put. Probably the the best known "caustic" magnesia is the Grecian. The Canadian as well as, locally, the domestic product in our own Western States, is used in this way, although the Canadian is generally reported to contain a high percentage of lime. These magnesites are calcined, but not dead-burned, thereby retaining a small per cent of the original CO_2 in their composition. The condition of their calcination for cement uses is important, as the same material may undoubtedly be very greatly varied in its reacting properties by differing treatment in the kiln. It is generally agreed that the magnesite for cement use must be comparatively free from lime, as lime has a greater tendency to reabsorb water and carbon dioxide than the magnesia, thereby causing swelling. and is therefore not so permanent in the completed cement as a pure magnesia material. The magnesium chloride used is obtained by import from the German potash salt regions in the Stassfurt-Egelen region, where it is produced as a by-product in the potash industry. A limited supply might be, or may be, produced in our own salt refinery business. The fillers used may constitute 10 to 40 per cent of the whole cement, and commonly consist of ground marble, sand, or various sawdust, cork, or other materials. As an example of the formulas used in mixing such cements the following are quoted.[1]

Mixtures for the underlying or coarser layer.

[Parts by weight.]

1. 15 parts magnesia.
   10 parts magnesium chloride solution, 20° Baumé.
   10 parts moist sawdust.
   (Sets in 36 hours.)
2. 10 parts magnesia.
   10 parts magnesium chloride solution, 28° Baumé.
   5 parts sawdust.
   (Sets in 16 hours.)
3. 20 parts magnesia.
   15 parts magnesium chloride solution, 20° Baumé.
   4 parts ground cork.
   (Sets in 24 hours.)
4. 5 parts magnesia.
   3 parts magnesium chloride solution, 20° Baumé.
   5 parts ashes.
   (Sets in 24 hours.)

Mixtures for overlying or surface layers.

[Parts by weight.]

1. 40 parts magnesia.
   33 parts magnesium chloride solution ,19° Baumé.
   10 parts asbestos powder.
   5 parts wood flour.
   1 part red ocher.
   (Sets in 24 hours.)
2. 25 parts magnesia.
   25 parts magnesium chloride, 21° Baumé.
   4½ parts wood flour, impregnated with 4½ parts Terpentinharzlösung.
   15 parts yellow ocher.
   (Sets in 30 hours.)

The magnesite used is, as explained, the fine ground calcined (not dead-burned) of certain specified kinds or place of derivation regularly sold for the plastic purposes. This material commonly comes in paper-lined casks, barrels, or boxes, in which form it is fairly permanent, but it deteriorates by exposure, absorbing carbonic acid and moisture from the air. If carefully handled it can probably be kept unopened a year or more, but it should be used within a few weeks after being opened, even under most favorable conditions.

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[1] Scherer, Robert, Der Magnesit, sein Vorkommen, seine Gewinnung und technische Verwertung, pp. 216–217, A. Hartleben's Bibliothek, Wien und Leipzig, 1908.

PUBLICATIONS.

The following are a few important publications on magnesite:

Hanks, Henry G., A history and description of magnesia and its base and compounds with particular reference to magnesite, etc., 27 pp., San Francisco, C. A. Murdock & Co., 1895.

Hess, F. L., Some magnesite deposits of California: U. S. Geol. Survey Bull. 285, pp. 385-392, 1906.

———, The magnesite deposits of California: U. S. Geol. Survey Bull. 355, 67 pp., 1908.

Scherer, Robert, Der Magnesit, sein Vorkommen, seine Gewinnung und technische Verwertung, pp. viii+256, figs. 22, A. Hartleben, Vienna and Leipzig, 1908.

Dains, H. H., Indian magnesite industry: Soc. Chem. Ind. Jour., May 31, 1909, 2 pp.

Gale, H. S., Magnesite: U. S. Geol. Survey Mineral Resources, 1911, pt. 2, pp. 1113-1127, 1912.

Hooker, H. M., Composition flooring: Eng. Soc. Western Pennsylvania Proc., vol. 29, pp. 305-338, 418-444, 1913.

Gale, H. S., Late developments of magnesite in California and Nevada: U. S. Geol. Survey Bull. 540, pp. 483-520, 1914.

COKE.[1]

By Edward W. Parker.

INTRODUCTION.

In the manufacture of coke in the United States the cause of conservation has been as signally and materially advanced during the last few years, through the development of retort-oven practice, as has been evinced in any branch of mining and its collateral industries. The new era in coke making had its modest beginning in 1893 in the construction at Syracuse, N. Y., of 12 Semet-Solvay by-product retort ovens which were operated in connection with the chemical works of the Solvay Process Co. Progress at first was slow, for among furnace men a strong prejudice existed against the product of the retort oven which lacked certain physical characteristics, particularly the silvery luster and musical "ring" of the beehive coke, to which for many years they had been accustomed. It required a decade for the young rival of beehive coke to establish a firm hold, for, although production increased each year from the time the first plant was constructed, by 1902 the total quantity of retort coke produced was less than 1,400,000 tons, whereas in the same period the production of beehive coke had increased nearly 15,000,000 tons.

The second by-product coking plant to be erected in the United States was one of 60 Otto-Hoffmann (now known as "United-Otto") ovens built for the Cambria Iron Co. at Johnstown, Pa., in 1895, and it was the enlargement of this plant to 160 ovens in 1899 that probably exercised a considerable influence in convincing furnace men that the luster and ring of beehive coke were not essential qualities in the manufacture of iron.

During the last two or three years the progress in the manufacture of by-product coke has been marked, not only in the number of ovens built and under construction but in the size and capacity of the ovens themselves. The original Semet-Solvay ovens at Syracuse, N. Y., were 30 feet long, 16 inches wide at one end, 17 inches wide at the other, and 5 feet 8 inches high. They had a charging capacity of 4.4 short tons of coal. The original Otto-Hoffmann ovens at Johnstown were 33 feet 6 inches long, 6 feet high, and 17 to 21 inches wide, with a charging capacity of 5.5 tons. Many of the retort ovens constructed at the present time are over 36 feet long and nearly 12 feet high but without much additional width, and they have a charging capacity of from 12 to 16 tons.

The number of retort ovens in the United States in 1902, the end of the first decade in the era of by-product coke manufacture, was

[1] The product obtained from the distillation or partial combustion of bituminous coal in ovens or retorts which constitutes a fuel suitable for the blast furnace or foundry is the only coke considered in this series of reports. "Gas-house" coke is not included.

1,663; in 1912, at the end of the second decade, there were 5,211 such ovens, and in 1913 they numbered 5,688. The increase in the number of retort ovens from 1912 to 1913 was 477, whereas the total number of ovens increased 420, from 102,230 to 102,650. As will be shown later, however, many thousands of the beehive ovens were idle in 1913, more than half of them probably for the whole time, whereas all but 157 of the completed retort ovens were in operation. There were 1,321 new ovens building at the close of 1913, of which 504 were of the by-product type. The output of the by-product ovens in 1913 represented 27.5 per cent of the total coke production of the United States. In 1912 it represented a little more than 25 per cent, and in 1911 22.1 per cent.

The evolution in coke making which is shown to be in process of accomplishment by the figures presented in the following pages is not only in the steady substitution of the retort oven, and its recovery of the valuable contents of the coal other than coke, for the wasteful beehive; it means also the shifting of the coke-making industry from the vicinity of the mines to the centers of manufacture and population, where the gas may be utilized and the other by-products disposed of at a profit. The extent to which this shifting of the coke-making industry has already taken place is evinced by the statistics of production in West Virginia where there are few coke consuming enterprises. From the time the industry was first started in that State the larger part of the product has been shipped to furnaces in other States. The production of coke in West Virginia in 1913 showed an insignificant gain over 1912, and the industry has not only shown no progress during the last 10 years but has materially declined. The quantity of West Virginia coal used in the manufacture of coke, however, has materially increased, but the ovens at which the coal is used are at points in other States, and most of them are of the by-product or retort type. Returns to the Survey for 1913 show that the quantity of West Virginia coal made into coke outside of the State in that year was 7,546,674 tons, or nearly twice as much as the coal made into coke at ovens within the State. Another evidence of this marked change is that of the 17,826 ovens in West Virginia in 1913, 9,129 were idle the entire year and many others for a portion of the year.

In spite of the progress made in the last few years in the manufacture of coke in by-product ovens the United States is still much behind some European countries in this regard. In Germany and Belgium the retort oven is the only one used, the beehive having been discarded years ago. One of the reasons for the somewhat tardy development in the United States is peculiar, being nothing less than the well-grounded apprehension as to the early exhaustion of the Connellsville coal. Because of the limited span of life yet remaining to the Connellsville region, the owners and operators in that district have not felt disposed to throw away the capital already invested in the beehive ovens that have made the Connellsville district notorious and the coke famous.

PRODUCTION.

STATISTICS OF PRODUCTION IN 1913.

The production of coke in the United States in 1913 exceeded all previous records in both quantity and value, and amounted to 46,299,530 short tons, valued at $128,922,273. Compared with 1912, when the production was 43,983,599 short tons, valued at $111,-805,113, the output in 1913 showed an increase of 2,315,931 tons, or 5.3 per cent, in quantity and of $17,117,160, or 15.3 per cent, in value. The statistics for 1913 established a new record not only in quantity and value of output but in the average value per ton for the product. In 1907, when the prolonged strike in the anthracite region of Pennsylvania created a fuel famine in the Eastern States, the prices for coke were advanced and the average value per ton for the year was $2.74, the highest figure reached since this series of reports has been published until 1913, when the average value was $2.78 per ton. The reasons for the higher value in 1913 were two-fold. The first was that the revival which developed in the latter part of 1912 continued into January and contracts for delivery during the rest of the year were made at prices double those at the same period in 1912. The second and more stable reason for the higher value in 1913 was the notable increase in the production of retort oven coke, which, however, for reasons explained later on, does not necessarily involve any increased cost to the consumer. Nor did the higher value in 1913 even for beehive coke represent an equivalent increase of profit to the producers. The total value of the product in 1913, as already stated, showed a gain of $17,117,160 over 1912, and of this amount $6,004,922 was the increase in the value of retort coke. The value of the coal made into coke in 1913 exceeded the value of the coal used in 1912 by $13,642,487, the difference between the value of the coke made in 1913 and the coal used being $3,474,673, and as the increase in the quantity of coke produced was 2,315,931 short tons, it appears that the actual returns to the producers were relatively less in 1913 than in 1912. The value of the coal per ton of coke produced was $1.98 in 1912 and $2.17 in 1913. Of the 46,299,530 tons of coke made in 1913 in the United States, 33,584,830 tons were beehive or "oven" coke, valued at $80,284,421, and 12,714,700 tons, valued at $48,637,852, were by-product or "retort" coke. In 1912 the production of oven coke was 32,868,435 tons, valued at $69,172,183, and that of retort coke was 11,115,164 tons, valued at $42,632,930. From this it appears that nearly 70 per cent of the entire increase in the quantity of coke produced in 1913 was in the output of retort coke.

The increase in the production of retort coke in 1913 was 1,599,536 short tons, or 14.4 per cent; the beehive output increased 716,395 short tons, or 2.2 per cent. The production of beehive coke in 1913, although exceeding that of 1912 by 716,395 short tons and that of 1911 by 5,881,186 tons, was still nearly 1,000,000 tons short of the maximum production in 1910. The output of retort coke in 1913, however, exceeded that of 1910 by over 5,500,000 tons, or nearly 80 per cent.

With the exception of one year (1908) the production of by-product coke has increased each year since the first ovens were completed at Syracuse, N. Y., in 1893. The percentage of by-product coke to the total in 1901 was 5.4; in 1910 it was 17.1; in 1912 it was 25.3; and in 1913 it was 27.5. The value of the oven coke in 1913 exceeded that of 1912 by $11,112,238, or 16.1 per cent, while the increase in the value of the retort coke was $6,004,922, or 14.1 per cent.

The average value per ton for oven coke in 1913 was $2.39 against $2.10 in 1912. The average price for retort coke was $3.82 in 1913 as compared with $3.84 in 1912. As explained in previous reports, the higher value of retort coke is due not to the superior quality of that product but to the fact that the retort ovens are located at considerable distances from the coal mines and at or near the centers of consumption where markets for the gas and other by-products as well as for the coke are available. In such cases the expenses of transportation are borne by the coal and are added to the value of the coal as charged into the ovens. An equivalent value is necessarily added to the coke. The beehive and similar types of ovens are, on the other hand, located in the immediate vicinity of the mines and the expenses of transportation are borne by the coke, and the ultimate consumer pays as much for his beehive coke as for the apparently higher-valued retort coke.

Connellsville coke has for many years been the standard furnace coke of the United States and the Connellsville region is the only one for which weekly reports as to the trade conditions are made to the technical journals. The Connellsville Courier presents each week a comprehensive review of conditions affecting the demand and the prices for the commodity which has been the mainstay of the region. From its weekly reviews the following summary of the trade in 1913 has been extracted.

The year opened with the market quiet but firm, with spot furnace coke quoted at $4 a ton, though a few sales were made early in January at $4.15 and $4.25. Contracts for future delivery were made at $3.25 to $3.50 for the first six months, and at $3 to $3.25 for the second half of the year. Production was heavy during the month, and before the first of February prices for prompt delivery had dropped 50 cents a ton, though contract prices were held firm. Early in February, with a decided dullness in the iron trade in evidence, production was still maintained at high-water mark, and the price for prompt furnace coke dropped to $2.50, a decline of $1.50 in less than a month. Contract purchasers were conspicuous by their absence, though prices for future delivery were quoted nominally at $2.25 to $2.50. Prices for foundry coke were held a little more firmly, though this grade, which early in the year sold at from $4.25 to $4.50 for prompt delivery, was quoted at $3.25 to $3.50 by the end of February. Notwithstanding the declines in price, production held up until the last half of March, when the unprecedented floods in the Ohio Valley caused a sharp reduction in output. In April both spot and contract furnace coke were quoted at $2.25, and foundry coke at $3 to $3.50. In the latter half of April, when the railroads had effected the repairs to their roadbeds and tracks, production returned to normal figures and prices assumed a firmer tone, but without any advances. During May there was a temporary slump in the trade and producers experienced some difficulty in maintaining the price at $2.25 for spot coke; and in June some coke was sold as low as $2.10 while buyers were trying to beat it down to $2. Contract furnace coke was firmly held at $2.50, with foundry coke at $2.75 to $3. During the summer months production was kept down to market requirements and the price for spot furnace coke was maintained at $2.50, contracts for delivery during the last half of the year being made at the same figure until October, when a depression in the iron trade developed which continued through the rest of the year and in sympathy with which coke prices rapidly declined until in November prompt furnace coke was quoted as low as $1.85. From then until the end of the year spot furnace coke was quoted at $1.75 to $2, and producers were fighting as hard for $2 on contracts for delivery in the first half of 1914 as they were six months before for $2.50 on contracts for the last half of 1913.

A considerable proportion of the coke production of the United States is made in ovens or retorts operated by large corporations which not only mine the coal and make the coke but also operate blast furnaces and steel mills, which consume the entire product of the ovens. In such cases the fixing of a value upon the coke and upon the coal consumed in its making is purely arbitrary. By some corporations the coke is charged to the furnace department at cost, while by others a percentage of profit is added or the reported value is based on what it would cost if purchased. As the beehive ovens are gradually replaced by the retorts the proportion of the coke upon which the arbitrary values are fixed will increase, as the retort ovens are for the most part constructed by or for furnace operators and the product of the ovens does not go to the general markets. It must not be considered, therefore, that the values as stated in this and other reports of the series represent the actual selling value of all the coke, but they are sufficiently exact for statistical comparison.

The coal consumed in the manufacture of coke in 1913 was 69,239,190 short tons, valued at $100,561,439, against 65,577,862 short tons, valued at $86,918,952, in 1912. The value of the coke made in 1913 was $128,922,273, the difference between the value of the coal and the coke made from it being $28,360,834, which, less the cost of manufacture and expenses of administration, represents the profit on the coke-making operations. In 1912 the value of the coke was $111,805,113, and the difference between that and the value of the coal was $24,886,160. The difference between 1913 and 1912 of the excess in the value of the coke over the value of the coal used was $3,474,673, but as the quantity of coke produced in 1913 over 1912 was 2,315,931 tons it might be said that the excess in product in 1913 was valued at only about $1.50 per ton, whereas the average value for all the coke produced was $2.78.

At the close of 1912 there were fewer ovens in existence in the United States than at the beginning of that year, the number of ovens abandoned having exceeded the number of new ovens constructed. During that year there were 22 entire plants with a total of 1,529 ovens abandoned, in addition to which there were 2,648 ovens, portions of other plants that were torn down. All but 26 of the 4,177 ovens abandoned in 1912 were of the beehive type. The 26 exceptions were Rothberg ovens, 1 in New York and 25 in Ohio, which were really experimental installations and did not produce satisfactory results. At the close of 1913 there was a net increase of 420 in the total number of ovens in existence, although 2,833 ovens, all of the beehive type, had been abandoned during the year. There were 477 retorts constructed during the year, so that the new installations of the beehive or partial combustion type aggregated 2,776 ovens. These do not include a few small installations which were built in 1913 but not put into blast. The total number of ovens and retorts in operation in the United States increased from 102,230 to 102,650, a net gain of 420. As the retorts show an increase of 477, there was a net decrease of 57 in the number of beehive ovens in existence during 1913 as compared with 1912. Most of the new ovens of the partial combustion type added in 1913 were the Mitchell or rectangular ovens which have met with considerable favor, particularly in the Lower Connellsville district of Pennsylvania. In addition to the ovens abandoned during 1913 (and most of these had been idle for a number of years) there were 30,642 idle, of which 157 were retorts and 30,485 were beehive ovens, most of which had not been in operation for several years. The 30,485 idle beehive ovens included 11,347 which were the entire equipment of 107 idle establishments. All of the idle retorts were portions of plants which were in operation during the year and were idle largely because of the making of necessary repairs and alterations. The statement regarding the number of idle ovens refers only to those which were idle during the entire year. It does not include any ovens which were idle during a portion of the time only and which contributed to the output in 1913. The number of ovens and retorts in blast during the whole or a portion of 1913 was 72,008, as compared with 73,058 active ovens and retorts in 1912. The 72,008 active ovens and retorts in 1913 included 5,531 retorts and 66,477 of the beehive or partial combustion type. As the 5,531 retorts produced a total of 12,714,700 tons of coke, the average production for each retort was therefore practically 2,300 tons. The 66,477 active beehive ovens produced a total of 33,584,830 tons of coke, or an average of 505 tons per oven. In 1912 there were 5,211 retorts which produced an average of 2,133 tons per oven, and 67,847 beehive or partial combustion ovens which produced an average of 484 tons per oven. The average value per oven of the coke produced in active beehive ovens in 1913 was $1,208, and the average value per oven of the coke and by-products produced at retort ovens was $11,854, or nearly 10 times the average value of the beehive production. The new ovens in course of construction at the close of 1913 were 1,321, of which 504 were retorts and 817 beehive.

The tendency to consolidation into larger units is exhibited in the manufacture of coke as in other branches of industry, and the number of coke-making establishments has shown a steady decrease since 1909, when, on December 31, there were 579 coke-making establishments in the United States. At the close of 1910 the number of establishments had decreased to 578, at the close of 1911 to 570, and in 1912 to 559, and a further decrease to 551 on December 31, 1913, is shown. Some of these establishments have been entirely abandoned, and some, fewer in number, have been consolidated with others All of the establishments gone out of existence are relatively small and the ovens have not been in operation in the last few years. There were 6 new plants with a total of 434 ovens under construction at the close of 1913. Three of the new establishments, with a total of 214 ovens, were retort-oven plants.

The statistics of production of coke in 1912 and 1913 are presented, by States, in the following table:

Manufacture of coke, by States, in 1912 and 1913.

1912.

State.	Establishments.	Ovens. Built.	Ovens. Building.	Coal used (short tons).	Yield of coal in coke (per cent).	Coke produced (short tons).	Total value of coke.	Value of coke per ton.
Alabama	46	10,208	100	4,585,498	64.9	2,975,489	$8,098,412	$2.72
Colorado	15	3,588	0	1,473,112	66.0	972,941	3,043,994	3.13
Georgia	2	251	0	87,300	50.0	43,158	161,842	3.75
Illinois	6	594	40	2,316,307	76.2	1,764,944	8,069,903	4.57
Indiana	4	642	169	3,198,874	81.8	2,616,339	12,528,685	4.79
Kentucky	9	1,049	291	307,162	62.4	191,555	513,734	2.68
Montana	4	451	3	0	0	0	0	0
New Mexico	4	1,030	0	679,209	60.9	413,906	1,356,946	3.28
New York	4	555	0	1,095,198	72.6	794,618	3,203,133	4.03
Ohio	7	471	119	561,426	69.2	388,669	1,365,905	3.51
Oklahoma	2	260	0	0	0	0	0	0
Pennsylvania	277	53,756	1,887	41,268,532	66.5	27,438,693	56,336,255	2.05
Tennessee	15	2,584	0	685,861	54.0	370,076	951,853	2.57
Virginia	18	5,408	0	1,555,969	62.2	967,947	1,815,975	1.88
Washington	6	313	0	78,693	62.6	49,260	279,105	5.67
West Virginia	129	19,064	0	4,061,702	60.7	2,465,986	4,692,393	1.90
Kansas Maryland Massachusetts Michigan Minnesota New Jersey Utah Wisconsin	11	2,006	174	3,623,019	69.8	2,530,018	9,386,978	3.71
Total	559	102,230	2,783	65,577,862	67.1	43,983,599	111,805,113	2.54

1913.

State.	Establishments.	Ovens. Built.	Ovens. Building.	Coal used (short tons).	Yield of coal in coke (per cent).	Coke produced (short tons).	Total value of coke.	Value of coke per ton.
Alabama	46	10,284	20	5,218,323	63.6	3,323,664	9,627,170	2.90
Colorado	15	3,588	0	1,349,743	65.1	879,461	2,815,134	3.20
Georgia	2	251	0	82,871	51.5	42,747	186,304	4.35
Illinois	4	568	58	2,481,198	74.9	1,859,553	8,593,581	4.62
Indiana	5	749	41	3,535,136	77.1	2,727,025	13,182,136	4.83
Kansas	1	2	0	0	0	0	0	0
Kentucky	9	1,049	100	512,245	61.9	317,084	753,897	2.38
Missouri	0	0	56	0	0	0	0	0
Montana	3	351	0	0	0	0	0	0
New Jersey	1	150	0	339,351	75.4	255,792	695,041	2.72
New Mexico	4	1,030	0	788,172	59.4	467,945	1,548,536	3.31
New York	4	555	0	1,067,207	71.1	758,486	3,301,400	4.35
Ohio	7	471	119	507,417	69.3	351,846	1,231,554	3.50
Oklahoma	2	260	0	0	0	0	0	0
Pennsylvania	276	55,058	582	43,195,801	66.6	28,753,444	67,929,864	2.36
Tennessee	15	2,427	0	694,085	52.5	364,578	925,430	2.50
Virginia	18	5,695	100	2,015,259	64.7	1,303,603	2,840,275	2.18
Washington	6	331	0	118,786	64.2	76,221	432,770	5.68
West Virginia	124	17,826	35	4,034,251	61.3	2,472,752	5,504,416	2.23
Maryland Massachusetts Michigan Minnesota Utah Wisconsin	9	2,005	210	3,299,345	71.1	2,345,329	9,354,765	3.99
Total	551	102,650	1,321	69,239,190	66.9	46,299,530	128,922,273	2.78

PRODUCTION IN PREVIOUS YEARS.

The earliest use of coke in the United States of which there is any record is reported by the late James M. Swank[1] as having been made in a refinery at Plumsock, Fayette County, Pa., as early as 1817. This

[1] Iron in all ages, p. 201, 1892.

however does not seem to have awakened much interest in coke as a fuel, as in 1835 an offer of a gold medal was made by the Franklin Institute to anyone who would make iron with bituminous coal or coke made from bituminous coal. The medal was never claimed. In 1837 it appears that the manufacture and use of coke was attempted at a number of different but somewhat widely separated points in the United States, namely, by the Creek Coal Co. in the Richmond Basin of Virginia; at Tallmadge in Summit County, Ohio,[1] for use in the blast furnaces at Akron, and at Coke Oven Hollow, Parke County, Ind., for use in local foundries. According to Fulton[2] 100 tons of pig iron were made in the same year with coke as fuel by F. H. Oliphant at Fairchance in Fayette County. Mr. Swank states also that William Fernstone was the first to succeed in making iron with coke at the Mary Ann furnace in Huntingdon County, Pa. Another authority [3] states that the Lonaconing furnace in Maryland in 1837 was the first in the country to use coke with entire commercial success. This furnace continued in operation for many years. In 1841 two carpenters, Provence McCormich and James Campbell, learned that coke might be made from the coal in what is now the Connellsville region. They succeeded in interesting with them John Taylor, a stone mason, who owned a tract of coal land and who was engaged in mining. The three formed a partnership, the mason to build the coke ovens and the two carpenters to build boats to float the coke down the river to Cincinnati, and in the spring of 1842 they with the two arks reached Cincinnati safely with about 40 tons of coke. Here, to their disappointment, they found that the furnacemen were unfamiliar with coke as a furnace fuel and would not use it. The partners traded a large part of their cargo at an unprofitable rate and shipped the remainder by canal boat to Dayton, where Judge Gebhardt used the new fuel and discovered its superiority for iron making.[4] The use of coke did not grow rapidly in favor and did not begin to exert an appreciable influence on the manufacture of pig iron until the latter half of the nineteenth century. The Seventh Census of the United States, 1850, reported 4 establishments engaged in the manufacture of coke, but gave no information regarding the quantity or value of the coke produced. At the Eighth Census in 1860 there were 21 coke-making establishments, and in 1870, according to the Ninth Census, there were 25 establishments, but in neither of these, as at the taking of the Seventh Census, were any figures of production given. Mr. Swank is authority for the statement that it was not until 1875 that the quantity of pig iron made with coke exceeded that made with anthracite, the latter having held the supremacy for 20 years, or since it exceeded charcoal in 1855. At the present time the use of anthracite for blast-furnace fuel is negligible; when used at all it is usually mixed with coke. Some bituminous, also mixed with coke, is used in blast furnaces in Ohio and Indiana, but the quantity compared with the use of coke alone is small. Charcoal is still used to a limited extent for the manufacture of special irons, but even for this purpose its use is steadily decreasing.

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[1] Ohio Geol. Survey First Ann. Rept., 1838.
[2] Fulton, John, Treatise on coke.
[3] Ninth United States Census, Industry and Wealth, p. 77.
[4] Am. Inst. Min. Eng. Trans., vol. 13, p. 330.

The first record of the quantity of coke made in the United States was in 1880, when, according to the report of the Tenth United States Census, the production is stated to have been 3,338,300 short tons. The annual production since 1880 has been published in this series of reports, the present chapter completing the record of 34 years, which is shown in the following table:

Quantity of coke produced in the United States, 1880–1913, in short tons.

1880	3,338,300	1892	12,010,829	1904	23,661,106
1881	4,113,760	1893	9,477,580	1905	32,231,129
1882	4,793,321	1894	9,203,632	1906	36,401,217
1883	5,464,721	1895	13,333,714	1907	40,779,564
1884	4,873,805	1896	11,788,773	1908	26,033,518
1885	5,106,696	1897	13,288,984	1909	39,315,065
1886	6,845,369	1898	16,047,209	1910	41,708,810
1887	7,611,705	1899	19,668,569	1911	35,551,489
1888	8,540,030	1900	20,533,348	1912	43,983,599
1889	10,258,022	1901	21,795,883	1913	46,299,530
1890	11,508,021	1902	25,401,730		
1891	10,352,688	1903	25,274,281		

Of the 15 coke-producing States for which the statistics may be separately published, there were 9 in which the production increased in 1913 and 6 in which the output decreased. Somewhat more than half the total increase was in Pennsylvania, which showed an increase of 1,314,751 short tons out of a total gain of 2,315,931 tons. The largest percentage of increase in 1913, as in 1912, was in Kentucky, whose output showed a gain of 125,529 short tons, or 65.5 per cent, largely due to the operations of the new plant of Semet-Solvay ovens at Ashland. The second in quantity of increase was Alabama, which gained 348,175 short tons, or 11.7 per cent, and here also the gain was altogether in the output of by-product coke. Virginia, whose production is entirely from beehive ovens, showed a gain of 335,656 short tons, or 34.7 per cent. Second in percentage of increase was the State of Washington, whose production in 1913 showed a gain of nearly 55 per cent over 1912. West Virginia, next to Pennsylvania in the quantity of coking coal produced, barely escaped a decrease in the production of coke in 1913, with a gain over 1912 of 4,766 short tons, or a very small fraction of 1 per cent. The principal decreases in the production of coke in 1913 were shown by Colorado and Ohio, the former being due to labor disturbances in Las Animas County, and the second to floods in the spring and droughts in the summer and early fall.

In the following table is shown the production of coke by States during the last five years, with the increase and decrease in 1913 as compared with 1912:

Quantity of coke produced in the United States, 1909–1913, by States, in short tons, with increase and decrease in 1913.

State.	1909	1910	1911	1912	1913	Increase (+) or decrease (—) in quantity of coke produced.	
						1912-13	Percentage.
Alabama	3,085,824	3,249,027	2,761,521	2,975,489	3,323,664	+ 348,175	+11.7
Colorado	1,251,805	a 1,346,211	951,748	972,941	879,461	— 93,480	— 9.6
Georgia	46,385	43,814	37,553	43,158	42,747	— 411	— 0.9
Illinois	1,276,956	1,514,504	1,610,212	1,764,944	1,859,553	+ 94,609	+ 5.4
Indiana	(b)	(b)	916,411	2,616,339	2,727,025	+ 110,686	+ 4.2
Kansas		(b)	(b)	(b)	0	0	0
Kentucky	46,371	53,857	66,099	191,555	317,084	+ 125,529	+65.5
New Jersey	(b)	(b)	(b)	270,429	255,792	— 14,637	— 5.4
New Mexico	373,967	401,646	381,927	413,906	467,945	+ 54,039	+13.6
New York	(b)	652,459	686,172	794,618	758,486	— 36,132	— 4.5
Ohio	222,711	282,315	311,382	388,669	351,846	— 36,823	— 9.5
Pennsylvania	24,905,525	26,315,607	21,923,935	27,438,693	28,753,444	+1,314,751	+ 4.8
Tennessee	261,808	322,756	330,418	370,076	364,578	— 5,498	— 1.5
Utah	(c)	(c)	(c)	(b)	(b)	(b)	(b)
Virginia	1,347,478	1,493,655	910,411	967,947	1,303,603	+ 335,656	+34.7
Washington	42,981	59,337	40,180	49,260	76,221	+ 26,961	+54.7
West Virginia	3,943,948	3,803,850	2,291,049	2,465,986	2,472,752	+ 6,766	+ 0.3
Other States	2,509,306	2,169,772	2,332,471	2,259,589	2,345,329	+ 85,740	+ 3.8
Total	39,315,065	41,708,810	35,551,489	43,983,599	46,299,530	+2,315,931	+ 5.3

a Includes Utah.
b Included with other States having less than three producers.
c Included with Colorado.

In the table following is given a statement of the establishments, the number of ovens built and building, the quantity of coal used, the percentage yield of coal in coke, the quantity and value of the coke produced, and the average value per ton for the years 1880, 1890, 1900, 1910, and from 1911 to 1913, inclusive:

Statistics of the manufacture of coke in the United States in 1880, 1890, 1900, 1910, 1911–1913.

Year.	Establishments.	Ovens.		Coal used (short tons).	Percentage yield of coal in coke.	Coke produced (short tons).	Total value of coke at ovens.	Value of coke at ovens per ton.
		Built.	Building.					
1880	186	12,372	1,159	5,237,741	63.0	3,338,300	$6,631,267	$1.99
1890	253	37,158	1,547	18,005,209	64.0	11,508,021	23,215,302	2.02
1900	396	58,484	5,804	32,113,553	63.9	20,533,348	47,443,331	2.31
1910	578	104,440	2,567	63,088,327	66.1	41,708,810	99,742,701	2.39
1911	570	103,879	2,254	53,278,248	66.7	35,551,489	84,130,849	2.37
1912	559	102,230	2,783	65,577,862	67.1	43,983,599	111,805,113	2.54
1913	551	102,650	1,321	69,239,190	66.9	46,299,530	128,922,273	2.78

VALUE OF COKE PRODUCED.

As has already been indicated prices for coke during 1913 averaged higher than in any of the 33 preceding years covered by this series of reports, and values in every State, with the exceptions of Kentucky, Ohio, and Tennessee, showed a large percentage of gain or less percentage of loss than in the quantity of coke produced. There were five States that showed decrease in production in 1913 as compared with 1912, but in two of these, Georgia and New York, the value showed a gain. A part of the larger increase in value in 1913 was due to the larger production of retort coke, notwithstanding that in this item itself there was a slight falling off in the unit value, due to a greater proportionate increase in production from retort ovens nearer the coal mines than from those more distant. Aside from the larger production of retort coke, however, there was a substantial advance in values for beehive coke, particularly during the first part of the year, and, although prices steadily and persistently declined after January, enough coke had been contracted for in that month to make the average for the year the best on record. The average value for beehive coke in 1913 was higher than in any year prior to 1902, or before the output of retort coke began to influence the general averages.

The total value of the coke produced in the United States increased from $111,805,113 in 1912 to $128,922,273 in 1913, a gain of $17,117,-160, or 15.3 per cent. The percentage of increase in production was 5.3. Two-thirds of the total increase in value was made in Pennsylvania, whose production in 1913 was valued at $11,593,609 more than that of 1912. Alabama was second in the amount of increased value, with a gain of $1,528,758, practically all of it being due to the larger production of retort coke. West Virginia, with a negligible increase in quantity, showed a gain of $812,023, or 17.3 per cent, in value. The value of Virginia's production increased $1,024,300, or 56.4 per cent (the largest percentage of gain in value for any of the States); the value of Indiana coke increased $650,000; and Illinois showed a gain of nearly $525,000. Next to Virginia the largest percentage of increase was in the State of Washington, the value of whose coke production in 1913 showed a gain of 55 per cent. Kentucky ranked third in this regard, with a gain of 46.7 per cent. The value of the retort coke produced in 1913 was $48,637,852, a gain of $6,004,922, or 14.1 per cent over 1912, and that of oven, or beehive coke, was $80,284,421, a gain of $11,112,238, or 16.1 per cent. In quantity retort coke showed a gain of 14.4 per cent and oven coke increased 2.2 per cent.

In the following tables are presented statements showing the value of the coke produced in the several States for the last five years, with the amount and percentage of increase and decrease in 1913 as compared with 1912, and the total value of the coke produced in the United States in each year since 1880:

Total value, at the ovens, of the coke made in the United States, 1909–1913, by States, with increase and decrease in 1913.

State.	1909	1910	1911	1912	1913	Increase (+) or decrease (−) in value of coke produced.	
						1912–13	Percentage.
Alabama	$8,068,267	$9,165,821	$7,593,594	$8,098,412	$9,627,170	+$1,528,758	+18.9
Colorado	a 4,135,931	a 4,273,579	2,903,811	3,043,994	2,815,134	− 228,860	− 7.5
Georgia	159,334	173,049	135,190	161,842	186,304	+ 24,462	+15.1
Illinois	5,361,510	6,712,550	6,390,257	8,069,903	8,593,581	+ 523,678	+ 6.5
Indiana	(b)	(b)	3,598,195	12,528,685	13,182,136	+ 653,451	+ 5.2
Kansas	....	(b)	(b)	(b)	....	....	....
Kentucky	101,257	120,554	134,862	513,734	753,897	+ 240,163	+46.7
New Jersey	(b)	(b)	(b)	690,368	695,041	+ 4,673	+ .7
New Mexico	1,099,694	1,306,136	1,240,963	1,356,946	1,548,536	+ 191,590	+14.1
New York	(b)	2,635,873	2,883,990	3,203,133	3,301,400	+ 98,267	+ 3.1
Ohio	683,155	911,987	961,904	1,365,905	1,231,554	− 134,351	− 9.8
Pennsylvania	50,377,035	55,254,599	43,053,367	56,336,255	67,929,864	+11,593,609	+20.6
Tennessee	667,723	959,104	797,758	951,853	925,430	− 26,423	− 2.8
Utah	(c)	(c)	(c)	(b)	(b)	(b)	(b)
Virginia	2,415,769	2,731,348	1,615,609	1,815,975	2,840,275	+ 1,024,300	+56.4
Washington	240,604	347,540	216,262	279,105	432,770	+ 153,665	+55.1
West Virginia	7,525,922	7,354,039	4,236,845	4,692,393	5,504,416	+ 812,023	+17.3
Other States	9,129,282	7,796,522	8,368,242	8,696,610	9,354,765	+ 658,155	+ 7.6
Total	89,965,483	99,742,701	84,130,849	111,805,113	128,922,273	+17,117,160	+15.3

a Includes value of Utah coke.
b Included in other States having less than three producers.
c Included with Colorado.

Total value, at the ovens, of the coke made in the United States, 1880–1913.

1880	$6,631,265	1892	$23,536,141	1904	$46,144,941
1881	7,725,175	1893	16,523,714	1905	72,476,196
1882	8,462,167	1894	12,328,856	1906	91,608,034
1883	8,121,607	1895	19,234,319	1907	111,539,126
1884	7,242,878	1896	21,660,729	1908	62,483,983
1885	7,629,118	1897	22,102,514	1909	89,965,483
1886	11,153,366	1898	25,586,699	1910	99,742,701
1887	15,321,116	1899	34,670,417	1911	84,130,849
1888	12,445,963	1900	47,443,331	1912	111,805,113
1889	16,630,301	1901	44,445,923	1913	128,922,273
1890	23,215,302	1902	63,339,167		
1891	20,393,216	1903	66,498,664		

In the following table is shown the average price per ton, by States, during the last five years and the general average price per ton in the United States for each year since 1880. These averages are not the averages of the prices themselves, but are obtained by dividing the total quantity of coke produced into the total value in each State, with the same method for the total for the United States. The figures represent, therefore, the average values obtained rather than the averages of prices, and accordingly represent more accurately the returns obtained by the producers. As has already been explained, the values of the product as reported to the Survey do not always represent actual cash or its equivalent received by the coke producers, as some of the largest operations are carried on in connection with blast furnaces or other manufacturing enterprises, and the placing of value upon the coke produced by them is purely arbitrary. As the same methods of valuation at any one point are, however, employed each year, they would not affect materially the changes due to market conditions, and the statement of value per ton may be accepted as indicating pretty closely the relations of supply and demand.

The average value of coke, by States, from 1909 to 1913, inclusive, is shown in the following table:

Average value per short ton, at the ovens, of the coke made in the United States, 1909–1913, by States.

State.	1909	1910	1911	1912	1913
Alabama	$2.61	$2.82	$2.75	$2.72	$2.90
Colorado	[a] 3.30	[a] 3.17	[a] 3.30	3.13	3.20
Georgia	3.44	3.95	3.60	3.75	4.35
Illinois	4.20	4.43	3.97	4.57	4.62
Indiana	(b)	(b)	(b)	4.79	4.83
Kentucky	2.18	2.24	2.04	2.68	2.38
New Jersey	(b)	(b)	(b)	2.55	2.72
New Mexico	2.94	3.25	3.25	3.28	3.31
New York	(b)	4.04	4.20	4.03	4.35
Ohio	3.07	3.23	3.09	3.51	3.50
Pennsylvania	2.02	2.10	1.96	2.05	2.36
Tennessee	2.55	2.97	2.41	2.57	2.50
Utah	(c)	(c)	(c)	(b)	(b)
Virginia	1.79	1.83	1.77	1.88	2.18
Washington	5.60	5.86	5.38	5.67	5.68
West Virginia	1.99	1.93	1.85	1.90	2.23
Other States	3.64	3.53	3.75	3.71	3.99
Average	2.29	2.39	2.37	2.54	2.78

[a] Includes Utah.
[b] Included in other States having less than three producers.
[c] Included with Colorado.

The following table, showing the general average value per ton during a period of 34 years, is of particular interest as indicating the higher values that have obtained since the beginning of the present century. In only three years prior to 1901 did the general average value of coke per ton exceed $2, and one of these was the last year of the nineteenth century. In the other two years the average value per ton exceeded $2 by 1 cent and 2 cents, respectively. On the other hand, in only one year since and including 1901 has the average value of coke per ton fallen below $2 and in five years it has exceeded $2.50 per ton, reaching a maximum of $2.78 in 1913. From 1880 to 1890 the mean average value of coke per ton was $1.71, from 1891 to 1900 it was $1.76, and from 1901 to 1913 it was $2.41.

Average value per short ton, at the ovens, of the coke made in the United States, 1880–1913.

1880	$1.99	1892	$1.96	1904	$1.95
1881	1.88	1893	1.74	1905	2.25
1882	1.77	1894	1.34	1906	2.52
1883	1.49	1895	1.44	1907	2.74
1884	1.49	1896	1.84	1908	2.40
1885	1.49	1897	1.66	1909	2.29
1886	1.63	1898	1.59	1910	2.39
1887	2.01	1899	1.76	1911	2.37
1888	1.46	1900	2.31	1912	2.54
1889	1.62	1901	2.04	1913	2.78
1890	2.02	1902	2.49		
1891	1.97	1903	2.63		

The higher values shown in the later years were due in part, but not entirely, to the influence exerted by the increasing production of retort coke. The average price of beehive coke, which is more of a commercial product than the retort coke, has been much better maintained in the last few years than in the preceding century, and since 1908 the average value for beehive coke has not fallen below $2 per ton. Since 1908 the average value per ton for retort coke has ranged from $1.17 to $1.74 higher than beehive, this difference representing the transportation expenses on the coal from the mines to the ovens. In 1913 for the first time in eight years there was a decline in the average value of retort coke, but the decline was negligible—from $3.84 to $3.82. The average value per ton for beehive coke advanced from $2.10 to $2.39 and the mean average advanced from $2.54 to $2.78.

Comparative average values of beehive (oven) and by-product (retort) coke, 1908–1913, per short ton.

Year.	Beehive.	By-product.	Mean average.
1908	$2.20	$3.44	$2.40
1909	2.10	3.27	2.29
1910	2.17	3.47	2.39
1911	2.05	3.48	2.37
1912	2.10	3.84	2.54
1913	2.39	3.82	2.78

NUMBER OF COKE WORKS AND OVENS IN THE UNITED STATES.

In compiling the statistics of coke manufacture each bank of ovens is considered as a separate establishment, although in many cases these different establishments form a part only of one property and are reported from a central office. Different plants controlled or operated by one company are considered as much separate establishments as are the individual banks of ovens owned and operated by one firm or corporation. In 1913, notwithstanding the largely increased production of coke, the number of establishments and of ovens abandoned exceeded the number of plants and of ovens of new construction. There were 22 establishments abandoned and 14 new plants built, reducing the total number of plants from 559 to 551. The 22 dismantled plants had a total of 1,978 ovens. Most of these plants, it should be stated, had been idle for several years, and as they had an average of less than 90 ovens to a plant they were for the most part small plants. In addition to the 1,978 ovens contained in the 22 abandoned plants, there were 855 ovens, portions of operating plants, that were dismantled, making a total of 2,833 ovens abandoned during 1913. Of the 22 establishments abandoned 7 were in Pennsylvania, 6 in West Virginia, 2 each in Illinois, Kentucky, and Oklahoma, and 1 each in Indiana, Maryland, and Montana. There were 107 establishments with a total of 11,504 ovens that were idle during the year, and 19,138 ovens, portions of other plants, that were not in blast, making a total of 30,642 idle ovens. In 1912 there were 120 idle establishments and a total of 29,172 idle ovens. The number of plants in operation in 1913 was 444 against 439 in 1912, and the number of active ovens was 72,008 against

73,058. The number of active ovens for each plant was 162 in 1913 and 166 in 1912. The 107 idle plants in 1913 averaged 108 ovens to the plant. The 444 active establishments in 1913 produced 46,299,530 tons of coke or an average of a little over 100,000 tons to the plant. The concentration of the coking industry into comparatively large units has progressed markedly in recent years, as indicated by the fact that in 1880 there were 186 establishments which produced a total of 3,338,300 tons, an average of 17,948 tons to an establishment; the average production of each establishment in 1913 was more than six times the average of 1880. In 1880 there were 12,372 ovens in existence, an average of 67 to the establishment; in 1913 the average number of ovens to the establishment, including idle as well as active ovens, was 186. If instead of the number of plants the number of operating firms and corporations were considered as the unit, the concentration would appear to have been even more pronounced. An essential feature, however, in the increase in the average production per establishment and per oven during recent years has been the output from the growing number of by-product plants. In 1913 there were 5,531 active retort ovens in operation, with an average of 2,299 tons of production per oven.

The total number of establishments manufacturing coke in the United States at the end of each decade from 1850 to 1910, and at the end of each year since 1910, is shown in the following table. The numbers reported in 1850, 1860, and 1870 are for the census years; the others are for calendar years.

Number of coke establishments in the United States since 1850.

1850 (census year)	4	1890, Dec. 31	253	1911, Dec. 31	570
1860 (census year)	21	1900, Dec. 31	396	1912, Dec. 31	559
1870 (census year)	25	1910, Dec. 31	578	1913, Dec. 31	551
1880, Dec. 31	186				

The following table shows the number of coke ovens in existence in each State on December 31 for each of the last five years:

Number of coke ovens in each State at close of each year, 1909–1913.

State.	1909	1910	1911	1912	1913
Alabama	10,061	10,132	10,121	10,208	10,284
Colorado	3,846	3,611	3,606	3,588	3,588
Georgia	350	350	225	251	251
Illinois	468	508	506	594	568
Indiana	96	90	586	642	749
Kansas	67	71	53	3	2
Kentucky	494	495	577	1,049	1,049
Maryland	200	200	200	200	200
Massachusetts	400	400	400	400	400
Michigan	162	162	162	165	205
Minnesota	50	50	50	50	50
Missouri	4	4	....	....	....
Montana	551	451	451	451	351
New Jersey	150	150	150	150	150
New Mexico	1,030	1,030	1,030	1,030	1,030
New York	556	556	556	555	555
Ohio	447	496	496	471	471
Oklahoma	536	408	410	260	260
Pennsylvania	54,506	55,656	54,904	53,756	55,058
Tennessee	2,729	2,792	2,547	2,584	2,427
Utah	854	854	854	650	726
Virginia	5,469	5,389	5,496	5,408	5,695
Washington	285	285	235	313	331
West Virginia	20,283	19,912	19,876	19,064	17,826
Wisconsin	388	388	388	388	424
Total	103,982	104,440	103,879	102,230	102,650

The following table shows in a succinct statement the number of idle establishments and ovens, the number of establishments and ovens abandoned in 1913, and the number of establishments and ovens in course of construction at the end of the year:

Number of coke establishments idle, abandoned, and in course of construction at the end of 1913.

State.	Idle.			Abandoned.			Building.		
	Establishments.	Ovens.	Total number of ovens idle.	Establishments.	Ovens.	Total number of ovens abandoned.	Establishments.	Ovens.	Total number of ovens building.
Alabama	20	3,447	5,449	0	0	0	0	0	20
Colorado	6	726	1,706	0	0	0	0	0	0
Georgia	1	50	100	0	0	0	0	0	0
Illinois	0	0	0	2	26	26	0	0	58
Indiana	0	0	6	1	10	10	0	0	41
Kansas	1	2	2	0	0	0	0	0	0
Kentucky	2	220	220	2	104	104	0	0	100
Maryland	0	0	0	1	200	200	0	0	120
Minnesota	0	0	0	0	0	0	1	90	90
Missouri	0	0	0	0	0	0	1	56	56
Montana	3	351	351	1	100	100	0	0	0
New Mexico	1	50	50	0	0	0	0	0	0
Ohio	0	0	29	0	0	0	1	68	119
Oklahoma	2	260	260	2	150	150	0	0	0
Pennsylvania	19	1,895	9,432	7	424	740	3	320	582
Tennessee	6	768	1,138	0	0	160	0	0	0
Virginia	0	0	2,406	0	0	1	0	0	100
Washington	3	100	100	0	0	0	0	0	0
West Virginia	41	3,371	9,129	6	964	1,342	0	0	35
Wisconsin	2	264	264	0	0	0	0	0	0
Total	107	11,504	30,642	22	1,978	2,833	6	434	1,321

Number of coke ovens in the United States on Dec. 31 of each fifth year, from 1880 to 1913.

1880	12,372	1900	58,484	1911	103,879
1885	20,116	1905	87,564	1912	102,230
1890	37,158	1910	104,440	1913	102,650
1895	45,565				

A statement of the number of ovens in course of construction at the end of each year since 1907 is shown in the following table. It is not intended by this to show the increase in the number of new ovens from year to year, nor does it include the number of new ovens completed during any one year. It merely exhibits the condition of the industry as shown by plants under construction at the close of each year.

Number of coke ovens building in the United States at the close of each year, 1907–1913.

1907	2,546	1910	2,567	1912	2,783
1908	2,241	1911	2,254	1913	1,321
1909	2,950				

RANK OF COKE-PRODUCING STATES.

The record of coke production in 1913 effected few changes in the relative importance of the States in connection with that industry. Virginia superseded Colorado as sixth in rank, but with that exception the first 12 States held the same position in 1913 as in 1912. Pennsylvania, of course, stands preeminently first, with Alabama second, Indiana third, and West Virginia fourth, but if all the coke made from West Virginia coal were produced in that State it would be well fixed in second place, as by far the larger part of the coke manufactured in Ohio, Indiana, and Illinois is from West Virginia coal. As, however, the production of coke in retort ovens at or near the points of consumption is likely to continue to increase in greater proportion and the beehive ovens to disappear gradually from the mining regions, it is not probable that West Virginia will again assume its former importance as a coke-producing State. The quantity of coke made in West Virginia in 1913 was less than one-half of that made from West Virginia coal in ovens outside the State.

Among the less important States, Ohio gave place to Tennessee as thirteenth in rank, Kentucky advanced from eighteenth to sixteenth place, and Maryland, because of alterations in the plant of the Maryland Steel Co., at Sparrows Point, dropped from sixteenth to eighteenth place. The only other change was the dropping of Kansas from the list. The positions held by the coke-producing States are shown in the following table:

Rank of the States in production of coke, 1909–1913.

State.	1909	1910	1911	1912	1913	State.	1909	1910	1911	1912	1913
Pennsylvania	1	1	1	1	1	Tennessee	13	13	14	14	13
Alabama	3	3	2	2	2	Ohio	15	14	15	13	14
Indiana	22	17	6	3	3	Utah	16	16	17	15	15
West Virginia	2	2	3	4	4	Kentucky	19	20	19	18	16
Illinois	5	4	4	5	5	New Jersey	14	15	16	17	17
Virginia	4	5	7	7	6	Maryland	12	12	13	16	18
Colorado	6	6	5	6	7	Minnesota	17	18	18	19	19
New York	7	7	8	8	8	Washington	20	19	20	20	20
Wisconsin	8	8	9	9	9	Georgia	18	21	21	21	21
Massachusetts	9	9	10	10	10	Kansas	......	24	22	22	......
Michigan	11	11	12	11	11	Montana	21	22	......	......	......
New Mexico	10	10	11	12	12	Oklahoma	......	23	......	......	......

COAL CONSUMED IN THE MANUFACTURE OF COKE.

The following tables present a statement of the quantity of coal consumed in the manufacture of coke in the several States during the last five years and the total quantity used each five years since 1880. In former years the determination of the quantity of coal consumed was largely a matter of estimate, and there were few establishments where that factor was accurately ascertained; but in the making of coke, as in other branches of industry, greater exactness is now demanded, and there are relatively few large plants where the coal is not carefully weighed before being charged into the ovens, and the yield thus determined. At the retort ovens it is doubtful if any coal is charged without being first weighed or measured.

A considerable quantity of the coal which is not run directly from the mines to the ovens is crushed and washed before coking. In such cases it has been the practice to ascertain for this report the quantity of cleaned coal obtained from washing operations, and to consider that as the oven charge. As explained in previous reports of this series, the quantity of coal consumed in making coke stated in this chapter is at considerable variance with the quantity reported as made into coke in the chapter on the production of coal. The reason for this discrepancy is that in the chapter on the production of coal the quantity made into coke takes into account only that coal which is coked at the mines. The coal shipped to ovens at a distance is included in the shipments, and not in the quantity made into coke. The total quantity of coal made into coke in 1913 was 69,239,190 short tons. The coal-mine operators reported 49,458,320 tons made into coke at the mines.

The quantity of coal used in the manufacture of coke, as obtained for this report from the several States, from 1909 to 1913, and the quantity used during each fifth year since 1880, are shown in the following tables:

Quantity of coal used in the manufacture of coke in the United States, 1909–1913, by States, in short tons.

State.	1909	1910	1911	1912	1913
Alabama	5,080,764	5,272,322	4,411,298	4,585,498	5,218,323
Colorado	[a] 1,984,985	[a] 2,069,266	[a] 1,810,335	1,473,112	1,349,743
Georgia	86,290	80,019	72,677	87,300	82,871
Illinois	1,682,122	1,972,955	2,087,870	2,316,307	2,481,198
Indiana	(b)	(b)	(b)	3,198,874	3,535,136
Kentucky	89,083	104,103	118,255	307,162	512,245
New Jersey	(b)	(b)	(b)	344,749	339,351
New Mexico	694,390	651,494	620,639	679,209	788,172
New York	(b)	910,293	955,067	1,095,198	1,067,207
Ohio	340,735	413,059	456,222	561,426	507,417
Pennsylvania	36,983,568	39,455,785	32,875,655	41,268,532	43,195,801
Tennessee	493,283	597,658	628,118	685,861	694,085
Utah	(c)	(c)	(c)	(b)	(b)
Virginia	2,060,518	2,310,742	1,425,303	1,555,969	2,015,259
Washington	69,708	94,223	60,201	78,693	118,786
West Virginia	6,361,759	6,226,234	3,754,561	4,061,702	4,034,251
Other States	3,427,732	2,930,174	4,002,047	3,278,270	3,299,345
Total	59,354,937	63,088,327	53,278,248	65,577,862	69,239,190

[a] Included coal coked in Utah.
[b] Included in other States having less than three producers.
[c] Included with Colorado.

Quantity of coal used in the manufacture of coke in the United States each fifth year, 1880–1913.

	Short tons.		Short tons.		Short tons.
1880	5,237,741	1900	32,113,543	1912	65,577,862
1885	8,071,126	1905	49,530,677	1913	69,239,190
1890	18,005,209	1910	63,088,327		
1895	20,848,323	1911	53,278,248		

VALUE OF COAL USED IN MAKING COKE.

The statistics of coke production presented in the earlier pages of this report show that the value of the coke made in 1913 exceeded that of the preceding year by $17,117,160, or 15.3 per cent, and as the increase in the quantity of coke produced was 2,315,931 short tons, or only 5.3 per cent, it appears at first sight that the industry in 1913 was much more profitable than in 1912. In making these comparisons, however, the value or cost of the coal used should also be given consideration, and when that is done for 1913 the vision of larger profits fades away. The quantity of coal consumed in the manufacture of coke in 1913 was 69,239,190 short tons, valued at $100,561,439, against 65,577,862 tons, valued at $86,918,952, in 1912. The coal used in 1913, therefore, cost the coke producers $13,642,487 more than in 1912, so that the actual gain in the value of the coke over and above the increase in the value of the coal used was only $3,474,673, or at the rate of $1.50 per ton for the amount of increase in coke. The average value per ton of the coal used in 1913 was $1.45, against $1.33 in 1912. The value of the coal per ton of coke produced was $2.17 in 1913, and $1.98 in 1912. The cost of the coal charged into the ovens in 1913 was accordingly 19 cents more per ton of coke produced than it was in 1912, and the average value per ton of coke produced showed a gain of 24 cents, indicating a net gain of 5 cents per ton for the product of 1913.

The total quantity and value of the coal consumed in the manufacture of coke in 1912 and 1913, with the quantity and value of the coal consumed per ton of coke produced, by States, are shown in the following table:

Quantity and value of coal used in the manufacture of coke in the United States in 1912 and 1913, and quantity and value of same per ton of coke, by States.

1912.

State.	Coal used (short tons).	Total value of coal.	Value of coal per ton.	Quantity of coal per ton of coke (short tons).	Value of coal to a ton of coke.
Alabama	4,585,498	$6,177,876	$1.35	1.541	$2.080
Colorado	1,473,112	2,307,660	1.57	1.514	2.377
Georgia	87,300	130,950	1.50	2.023	3.035
Illinois	2,316,307	6,568,003	2.84	1.312	3.726
Indiana	3,198,874	9,689,756	3.03	1.223	3.706
Kentucky	307,162	254,205	.83	1.600	1.328
New Mexico	679,209	1,098,332	1.62	1.641	2.658
New York	1,095,198	2,648,981	2.42	1.378	3.335
Ohio	561,426	1,085,040	1.93	1.444	2.787
Pennsylvania	41,268,532	43,228,909	1.05	1.504	1.579
Tennessee	685,861	672,075	.98	1.762	1.727
Virginia	1,555,969	1,241,995	.80	1.607	1.286
Washington	78,693	166,227	2.11	1.598	3.372
West Virginia	4,061,702	3,403,589	.84	1.647	1.383
Other States	3,623,019	8,245,354	2.28	1.432	3.265
Total	65,577,862	86,918,952	1.33	1.491	1.983

1913.

State.	Coal used (short tons).	Total value of coal.	Value of coal per ton.	Quantity of coal per ton of coke (short tons).	Value of coal to a ton of coke.
Alabama	5,218,323	$7,609,963	$1.46	1.570	$2.292
Colorado	1,349,743	2,158,120	1.60	1.535	2.456
Georgia	82,871	162,439	1.96	1.939	3.800
Illinois	2,481,198	7,225,925	2.91	1.335	3.885
Indiana	3,535,136	11,006,033	3.11	1.296	4.031
Kentucky	512,245	584,684	1.14	1.615	1.841
New Jersey	339,351	868,346	2.03	1.327	2.694
New Mexico	788,172	1,085,239	1.38	1.684	2.324
New York	1,067,207	2,640,679	2.47	1.407	3.475
Ohio	507,417	977,990	1.93	1.442	2.783
Pennsylvania	43,195,801	52,374,986	1.21	1.502	1.817
Tennessee	694,085	668,255	.96	1.904	1.828
Virginia	2,015,259	1,772,837	.88	1.546	1.360
Washington	118,786	295,402	2.40	1.558	3.739
West Virginia	4,034,251	3,615,901	.90	1.631	1.468
Other States [a]	3,299,345	7,514,640	2.28	1.407	3.208
Total	69,239,190	100,561,439	1.45	1.496	2.169

[a] Includes Maryland, Massachusetts, Michigan, Minnesota, Utah, and Wisconsin.

The following table shows approximately the quantity of coal (given in tons and pounds) required to produce a ton of coke in 1880, 1890, 1900, and annually since 1901. It will be observed that up to 1903 the quantity of coal required to produce a ton of coke exceeded 3,100 pounds; from 1904 to 1910, inclusive, it was between 3,000 and 3,100 pounds, and for the last three years it has been less than 3,000 pounds, the lowest figure (2,982 pounds) being in 1912.

Coal required to produce a ton of coke, in tons and pounds.

Year.	Tons.	Pounds.	Year.	Tons.	Pounds.
1880	1.57	3,140	1906	1.531	3,062
1890	1.56	3,120	1907	1.519	3,038
1900	1.57	3,140	1908	1.515	3,030
1901	1.57	3,140	1909	1.510	3,020
1902	1.56	3,120	1910	1.513	3,026
1903	1.56	3,120	1911	1.499	2,998
1904	1.544	3,088	1912	1.491	2,982
1905	1.537	3,074	1913	1.496	2,992

YIELD OF COAL IN COKE.

With the decrease since 1903 in the quantity of coal required to produce a ton of coke, shown in the preceding table, the yield of coal in coke has correspondingly increased. In present practice the quantity of coal required per ton of coke is about 160 pounds, or 5 per cent, less than was necessary 10 or 12 years ago, before the operations of retort ovens began to exert any marked influence on the coke-making industry. The yield of coal in coke, to 1901, was generally less than 64 per cent and reached as high as 65 per cent in one year only. It is, indeed, doubtful if in the earlier years the yield of coal in coke was much, if anything, in excess of 60 per cent, as much of the coal used in making coke, particularly at beehive plants, was not accurately weighed, but was frequently estimated from the cubical contents of the larry used in charging the ovens or by the even less reliably accurate method of the number of mine cars sent to the coking plant. In such cases the operators were quite apt to underestimate rather than overestimate the quantity of coal used. Modern practice in beehive as well as in retort ovens is much more exact, and probably more coal is now actually weighed before charging into the ovens than was previously estimated. At the begining of the present century the production of retort or by-product coke became a factor of some importance in the coke-making industry, and it has continued to exercise an increasing influence each year as the proportion of retort coke to the total output has steadily grown. The increasing yield of coal in coke since 1901 is one of the evidences of the influence of retort coke on the trade. From 1902 to 1904, inclusive, the yield of coal in coke was over 64 per cent; in the next three years another 1 per cent was added to the yield; and since 1908 the yield has been 66 per cent or more. In 1912 it reached its maximum of 67.1 per cent, and in 1913 it was 66.9 per cent. Reports to the Survey as to the source of the coal used in retort ovens indicate that the slightly smaller yield in 1913 was due to a smaller proportion of West Virginia coal and a larger proportion of Illinois or Indiana coal at some of the retort-oven plants in those States.

The effect produced on the yield of coal in coke by the retort ovens already constructed is clearly shown in the following table. The entire output of coke in Illinois, Indiana, Maryland, Massachusetts, Michigan, New Jersey, New York, and Wisconsin is from retort ovens, and the yield of coal in coke in 1913 ranged from 69.4 per cent in Maryland to 77.1 per cent in Indiana, whereas the yield in beehive ovens ranged from 51.5 per cent in Georgia to 66.6 per cent in Pennsylvania. An interesting comparison is also exhibited in the increase in the yield of Alabama coal from 60.7 per cent in 1909 to 64.9 per cent in 1912. In the earlier year 17.3 per cent of Alabama's coke was made in retorts, and in 1913 retort coke constituted 60 per cent of the State's total. The average yield of retort coke in the United States in 1913 was 74.4 per cent, and that from beehive ovens was 64.4 per cent. In 1912 the retort coke yield averaged 75.3 per cent and the beehive, 64.7 per cent.

The following tables show the percentage yield of coal in coke in each State during the last five years; and in the United States in each tenth year since 1880, and annually since 1901:

Percentage yield of coal in coke, 1909–1913, by States.

State.	1909	1910	1911	1912	1913
Alabama	60.7	61.6	62.6	64.9	63.6
Colorado	64.9	66.6	66.6	66.0	65.1
Georgia	53.8	54.8	51.7	50.0	51.5
Illinois	75.9	76.8	77.1	76.2	74.9
Indiana	44.4	78.3	80.6	81.8	77.1
Kansas	0	75.2	70.0	70.0	0
Kentucky	52.0	51.7	55.9	62.4	61.9
Maryland	67.9	65.6	66.2	65.8	69.4
Massachusetts	77.7	77.3	77.4	75.5	76.3
Michigan	74.1	75.7	74.2	75.4	76.2
Minnesota	67.7	68.0	67.6	69.6	66.9
Montana	44.7	44.7	0	0	0
New Jersey	77.7	76.1	76.2	78.4	75.4
New Mexico	53.9	61.6	61.5	60.9	59.4
New York	72.0	71.7	71.8	72.6	71.1
Ohio	65.4	68.3	68.2	69.2	69.3
Oklahoma	0	45.0	0	0	0
Pennsylvania	67.3	66.7	66.7	66.5	66.6
Tennessee	53.1	54.0	52.6	54.0	52.5
Utah	53.7	54.9	59.0	56.8	56.9
Virginia	65.4	64.6	63.9	62.2	64.7
Washington	61.7	63.0	66.6	62.6	64.2
West Virginia	62.0	61.1	60.4	60.7	61.3
Wisconsin	76.1	77.4	74.9	69.6	76.2
Total average	66.2	66.1	66.7	67.1	66.9

Percentage yield of coal in coke, 1880–1913.

1880	63.0	1904	64.8	1910	66.1
1890	64.0	1905	65.1	1911	66.7
1900	63.9	1906	65.3	1912	67.1
1901	63.7	1907	65.8	1913	66.9
1902	64.1	1908	66.0		
1903	64.1	1909	66.2		

CONDITION IN WHICH COAL IS CHARGED INTO THE OVENS.

In the following table is to be found a statement of the condition in which the coal is charged into the ovens in the several States for the last two years and for each of the five-year periods since 1890. In a number of the coking districts the principal oven fuel is the slack coal produced in the mining operations. By far the larger quantity, however, is run of mine, some of which is crushed before being charged into the ovens, as in many cases it is found that a better and more uniform quality of coke is obtained when the coal is crushed before coking. Considerable quantities of both mine-run and slack coal are washed before being coked, in order to remove the impurities, consisting of slate, pyrite, etc. In 1913, 19.8 per cent of all the coal charged into the coke ovens was washed and 80.2 per cent was used without other preparation than, in some instances, crushing. The mine-run coal that is crushed before coking is considered as mine-run coal and not as slack.

In Pennsylvania and West Virginia and in the by-product coke-producing States that draw their coal supplies chiefly from Pennsylvania and West Virginia the larger part of the coal used is unwashed. In West Virginia most of the coal used in making coke is unwashed slack, as a majority of the ovens in that State were constructed for the purpose of utilizing the slack. In Pennsylvania and the other States in which unwashed coal is used the greater part of it is run of mine. In Alabama most of the coal used is washed, and nearly two-thirds of the total coal used in the State is washed slack. All of the coal used in Georgia, New Mexico, and Washington is washed, and in the first two it is slack exclusively. In Colorado the larger part of the coal used is washed run of mine, and in Virginia the quantity of coal is nearly evenly divided between run of mine and slack, all of it being unwashed.

In 1913 the total quantity of coal used for making coke was 69,239,190 short tons, of which 54,359,773 tons (49,566,720 tons unwashed and 4,793,053 tons washed) were run of mine and 14,879,417 tons (5,958,173 tons unwashed and 8,921,244 tons washed) were slack. The total quantity of unwashed coal used was 55,524,893 tons and of washed coal was 13,714,297 tons.

The following table shows the quantity of run-of-mine and of slack coal, unwashed and washed, charged into the ovens in 1912 and 1913, by States, with the percentage of each:

Character of coal used in the manufacture of coke, by States, in 1912 and 1913, in short tons.

1912.

State.	Run of mine.		Slack.		Total.			
	Unwashed.	Washed.	Unwashed.	Washed.	Unwashed.	Percentage.	Washed.	Percentage.
Alabama	747,305	896,421	18,793	2,922,979	766,098	16.7	3,819,400	83.3
Colorado	680	1,061,917	43,310	367,205	43,990	3.0	1,429,122	97.0
Georgia	0	0	0	87,300	0	0	87,300	100.0
Illinois	2,279,974	36,333	0	0	2,279,974	98.4	36,333	1.6
Indiana	3,167,766	108	31,000	0	3,198,766	100.0	108	0
Kentucky	172,020	0	63,880	71,262	235,900	76.8	71,262	23.2
New Mexico	0	0	0	679,209	0	0	679,209	100.0
New York	849,029	200,554	43,360	2,255	892,389	81.5	202,809	18.5
Ohio	506,883	23,541	15,598	15,404	522,481	93.1	38,945	6.9
Pennsylvania	35,344,633	2,493,661	1,098,392	2,331,846	36,443,025	88.3	4,825,507	11.7
Tennessee	0	189,887	86,678	409,296	86,678	12.6	599,183	87.4
Virginia	793,019	0	762,950	0	1,555,969	100.0	0	0
Washington	0	76,611	0	2,082	0	0	78,693	100.0
West Virginia	1,146,620	143,309	2,433,229	338,544	3,579,849	88.1	481,853	11.9
Other States[a]	2,552,043	0	1,070,976	0	3,623,019	100.0	0	0
Total	47,559,972	5,122,342	5,668,166	7,227,382	53,228,138	81.1	12,349,724	18.9

1913.

State.	Run of mine.		Slack.		Total.			
	Unwashed.	Washed.	Unwashed.	Washed.	Unwashed.	Percentage.	Washed.	Percentage.
Alabama	868,659	684,223	0	3,665,441	868,659	16.6	4,349,664	83.4
Colorado	13,267	1,015,099	48,952	272,425	62,219	4.6	1,287,524	95.4
Georgia	0	0	0	82,871	0	0	82,871	100.0
Illinois	2,348,526	111,762	0	20,910	2,348,526	94.7	132,672	5.3
Indiana	3,485,232	0	49,904	0	3,535,136	100.0	0	0
Kentucky	440,480	0	0	71,765	440,480	86.0	71,765	14.0
New Jersey	339,351	0	0	0	339,351	100.0	0	0
New Mexico	0	0	0	788,172	0	0	788,172	100.0
New York	835,600	222,364	6,259	2,984	841,859	78.9	225,348	21.1
Ohio	479,286	7,726	7,417	12,988	486,703	95.9	20,714	4.1
Pennsylvania	36,621,183	2,191,944	1,199,859	3,182,815	37,821,042	87.6	5,374,759	12.4
Tennessee	0	202,014	24,327	467,744	24,327	3.5	669,758	96.5
Virginia	916,808	0	1,098,451	0	2,015,259	100.0	0	0
Washington	0	118,786	0	0	0	0	118,786	100.0
West Virginia	916,068	239,135	2,525,919	353,129	3,441,987	85.3	592,264	14.7
Wisconsin	847,469	0	0	0	847,469	100.0	0	0
Other States[b]	1,454,791	0	997,085	0	2,451,876	100.0	0	0
Total	49,566,720	4,793,053	5,958,173	8,921,244	55,524,893	80.2	13,714,297	19.8

[a] Includes Kansas, Maryland, Massachusetts, Michigan, Minnesota, New Jersey, Utah, and Wisconsin.
[b] Includes Maryland, Massachusetts, Michigan, Minnesota, and Utah.

In the following table are given the statistics of the character of the coal used in making coke each fifth year since 1890, and annually from 1910 to 1913, inclusive:

Character of coal used in the manufacture of coke in the United States, 1890–1913, in short tons.

Year.	Run of mine.		Slack.		Total.
	Unwashed.	Washed.	Unwashed.	Washed.	
1890	14,060,907	338,563	2,674,492	931,247	18,005,209
1895	15,609,875	237,468	3,052,246	1,948,734	20,848,323
1900	21,062,090	1,369,698	5,677,006	4,004,749	32,113,543
1905	31,783,314	3,187,994	8,196,226	6,363,143	49,530,677
1910	42,554,324	5,178,915	6,842,078	8,513,010	63,088,327
1911	36,362,875	4,918,520	5,460,689	6,536,164	53,278,248
1912	47,559,972	5,122,342	5,668,166	7,227,382	65,577,862
1913	49,566,720	4,793,053	5,958,173	8,921,244	69,239,190

COKE MAKING IN BY-PRODUCT OVENS.

In May, 1913, the by-product branch of the coke-making industry in the United States entered its twenty-first year. The first ovens of the retort or by-product recovery type built in this country comprised a plant of 12 Semet-Solvay retorts with recovery apparatus at Syracuse, N. Y. The initial production of coke from that plant, from May to December, 1893, was 12,850 tons. The second by-product plant constructed was one of 60 Otto-Hoffmann ovens, completed in the latter part of 1895, at Johnstown, Pa. The Semet-Solvay plant at Syracuse, which is operated in connection with the chemical works of the Solvay Process Co., has been enlarged three times, 13 ovens being added in 1896, 5 in 1901, and 10 more in 1903. The plant at Johnstown has also been enlarged three times, to 160 ovens in 1899, to 260 in 1904, and to 372 in 1907. Since the first installations at Syracuse and Johnstown the by-product coking industry has grown steadily, the output each year showing a gain in its percentage to the total quantity of coke produced, and in only one year, 1908, showing a decrease in quantity. The decreased output of retort coke in that exceptional year was less in proportion than the decrease in the production of beehive coke. At the close of 1913 there were 38 by-product coke-making establishments distributed among 14 States and having a total equipment of 5,688 retorts. The production of retort coke in 1913 amounted to 12,714,700 short tons, or 27.5 per cent of the total, an increase of 1,599,536 tons, or 14.4 per cent over 1912, when the output of retort coke was 11,115,164 tons, or 25.3 per cent of the total. As shown in the following table, the percentage of by-product coke to the total in 1893 was 0.01 per cent; in 1901 it was 5.4 per cent; and in 1910 it was 17.1 per cent. In addition to the increase in the number of retorts, the installations of the present day are of much larger dimensions and of greater capacity than formerly. The original ovens at Syracuse, N. Y., were 30 feet long, 16 inches wide at one end, 17 inches wide at the other end, and 5 feet 8 inches in height. Their charging capacity was 4.4 short tons of coal and the time required for coking was 24 hours. Even at that time a gain of 50 per cent in coking time was obtained as compared with beehive practice, which requires 48 hours for the production of furnace coke and 72 hours for the production of foundry coke. The present installations of Semet-Solvay ovens are 36 feet 3 inches long, 20 inches wide at one end and 22 inches at the other, and 11 feet 10 inches high, holding at the average about 16 tons of coal. The exact capacity depends, of course, upon the specific gravity of the coals used. The original 60 Otto-Hoffmann ovens erected at Johnstown, Pa., were 33 feet 6 inches long, 6 feet high, 17 inches wide at one end, expanding to 21 inches at the other. These ovens had a charging capacity of about 5½ tons. The latest installations of United-Otto ovens constructed at Mayville, Wis., in 1912 are 34 feet long, 9 feet 1½ inches high, and 17 to 20 inches wide. They have an average capacity of 10.33 tons of coal. The coking time has been materially reduced, so that excellent furnace coke is now made in 16 to 18 hours. The development of modern mechanical appliances has done much to forward the efficiency of the retort oven and to reduce the labor necessary per unit of output. The same crew of men which was required to handle 25 of the small ovens 20 years ago and which were carbonizing, say, 110 tons of coal a day, is now able, with modern equipment, to handle 50 or more of the larger ovens coking 1,000 tons of coal a day. This represents an increase of about ninefold in the tonnage carbonized per man employed. These developments have been accompanied by marked improvements in by-product recovery, in the manufacture of ammonia, etc. Twenty years ago the only ammonia recovered was in the form of crude liquor running from 12 to 15 per cent ammonia. At the present time coking plants are producing ammonia liquor from crude through the different grades required for the manufacture of flameless powder, etc., to the production of almost chemically pure aqua ammonia at one operation. Other plants are manufacturing sulphate either by the old or indirect process or by some of the more direct processes which have lately come into use where the gas itself is first scrubbed in sulphuric acid to recover ammonia after the tar has been removed. Still another marked development in by-product oven practice is in the adaptation of the surplus gas to the illumination of cities and towns. In the earlier days the ovens produced only a small and irregular quantity of surplus gas, which was also irregular in quality. To-day by-product ovens in the United States are selling from 40,000,000 to 50,000,000 cubic feet of gas per day for illuminating purposes. Almost the entire supply of gas in some cities is from retort ovens. Among these cities may be specially mentioned Boston, Mass.; Camden, N. J.; Indianapolis, Ind.; Hamilton, Ohio; Baltimore, Md.; Duluth, Minn.; South Chicago, Ill.; and Milwaukee, Wis.

The 5,088 retorts in existence in the United States at the close of 1913 consisted of 2,186 United-Otto (including Otto-Hoffmann and Schniewind types), 1,537 Semet-Solvay, 1,361 Koppers, 281 Rothberg, 300 Didier, 22 Klönne, and 1 Roberts-Mass. The one Roberts-Mass oven is an experimental retort built at Gary, Ind., by the American Coal & By-products Coke Co. for the purpose of testing the coking qualities of western coals.

For the first 15 years after the first retorts were built at Syracuse the Semet-Solvay and United-Otto (Otto-Hoffmann) ovens held a practically undisputed field in retort-oven practice, the only other installation being a plant of 282 Rothberg ovens built by the Lackawanna Steel Co. in 1904. In 1908 a new contestant for retort-coke business entered the lists by the construction of 140 Koppers ovens at Joliet, Ill., by the Illinois Steel Co. The patentee of this oven, the H. Koppers Co., has pushed the business with all the vigor of youth, and at the end of the first five years after the first plant was completed there were 1,361 of this type of ovens completed, with 334 under construction. Other uncompleted retorts at the close of 1913 were 152 Semet-Solvay and 18 Wilputte, the latter a modification of United-Otto type.

The eventual total displacement of the wasteful beehive oven by the more conservational retort, with the saving of the valuable by-products, is forecasted by the history of the last 21 years. In 1912 there was an actual decrease of 2,236 ovens of the beehive type, compared with 1911, and although there were 2,576 ovens of the beehive or partial-combustion type built in 1913, there were 2,633 abandoned, so that with an increase of 477 in the total number of retort ovens the net increase in the total number over 1912 was only 420 and the number of beehive ovens decreased by 57. Moreover, of the 96,962 ovens of beehive type in existence in 1913, 30,485, or 31.4 per cent, were idle throughout the entire year, and many (probably more than half) of those might as well be reported abandoned, as it is doubtful if they will ever again be put in blast. A large part of the partial-combustion ovens added in 1913 and building at the close of the year consisted of Mitchell or rectangular ovens, which have achieved considerable popularity in the Lower Connellsville district of Pennsylvania, where the greatest activity in that kind of construction had place. In the rectangular oven the process is the same as in that of the beehive, but the coking chamber, instead of being round is, as the name implies, rectangular in shape and oblong, so that the coke may be pushed, as from a retort oven, and does not have to be drawn, as in the case of the beehive. The rectangular oven is, therefore, included with the beehive type. Some reason exists for the persistence of this type of oven in the Connellsville and the Lower Connellsville regions. The coal is an ideal beehive-oven fuel; the ovens are quickly and cheaply constructed, as compared with the outlay in time and money necessary for the construction of by-product retorts and recovery apparatus; the coking districts are within a short distance of the greatest iron-producing center of the world; and the cost of transportation is not an important factor. Moreover, the life of the Connellsville district proper is drawing to an end, and coke-oven owners are not favorably disposed to the sacrifice of the capital invested in them, nor to undertaking the expense of substituting retorts, for the 25 or 30 years left to the region. With the exception of Alabama, which has shown exceptional progress in the substitution of retort for beehive ovens, most of the by-product oven construction has been at points distant from the mines; and if all of the beehive ovens in the Connellsville district were abandoned, the retorts to take their places would be built at the points of consumption and not at Connellsville.

The increase in the production of retort-oven coke compared with that of beehive coke since 1893 is shown in the following table. In the last 10 years, or from 1903 to 1913, the increase in beehive coke has amounted to 33 per cent; that of retort-oven coke has amounted to 575 per cent.

Production of by-product coke, compared with that of beehive coke, with percentage of quantity and value to the total, 1893–1913.

Year.	By-product coke.				Beehive coke.				Total.	
	Quantity.	Percentage to total.	Value.	Percentage to total.	Quantity.	Percentage to total.	Value.	Percentage to total.	Quantity.	Value.
	Short tons.				*Short tons.*				*Short tons.*	
1893..	12,850	0.01	....	....	9,464,730	99.99	....	....	9,477,580	$16,523,714
1901..	1,179,900	5.41	$2,894,077	6.51	20,615,983	94.59	$41,551,846	93.49	21,795,883	44,445,923
1907..	5,607,899	13.75	21,665,157	19.42	35,171,665	86.25	89,873,969	80.58	40,779,564	111,539,126
1908..	4,201,226	16.14	14,465,429	23.15	21,832,292	83.86	48,018,554	76.85	26,033,518	62,483,983
1909..	6,254,644	15.91	20,434,689	22.71	33,060,421	84.09	69,530,794	77.29	39,315,065	89,965,483
1910..	7,138,734	17.12	24,793,016	24.86	34,576,076	82.88	74,949,685	75.14	41,708,810	99,742.701
1911..	7,847,845	22.07	27,297,897	32.45	27,703,644	77.93	56,832,952	67.55	35,551,489	84,130,849
1912..	11,115,164	25.27	42,632,930	38.13	32,868,435	74.73	69,172,183	61.87	43,983,599	111,805,113
1913..	12,714,700	27.46	48,637,852	37.73	33,584,830	72.54	80,284,421	62.27	46,299,530	128,922,273

Distributed by States, the production of beehive and retort coke in 1912 and 1913 was as follows:

Statistics of the production of coke in beehive and retort ovens in the United States, 1912 and 1913, by States, in short tons.

1912.

State.	Beehive coke.		By-product coke.		Total.	
	Quantity.	Value.	Quantity.	Value.	Quantity.	Value.
Alabama	1,625,692	$4,623,996	1,349,797	$3,474,416	2,975,489	$8,098,412
Colorado	972,941	3,043,994	0	0	972,941	3,043,994
Georgia	43,158	161,842	0	0	43,158	161,842
Illinois	0	0	1,764,944	8,069,903	1,764,944	8,069,903
Indiana	0	0	2,616,339	12,528,685	2,616,339	12,528,685
Kentucky	191,555	513,734	0	0	191,555	513,734
New Mexico	413,906	1,356,946	0	0	413,906	1,356,946
New York	0	0	794,618	3,203,133	794,618	3,203,133
Ohio	(a)	(a)	(a)	(a)	388,669	1,365,905
Pennsylvania	25,464,074	50,315,872	1,974,619	6,020,383	27,438,693	56,336,255
Tennessee	370,076	951,853	0	0	370,076	951,853
Virginia	967,947	1,815,975	0	0	967,947	1,815,975
Washington	49,260	279,105	0	0	49,260	279,105
West Virginia	(a)	(a)	(a)	(a)	2,465,986	4,692,393
Kansas Maryland Massachusetts Michigan Minnesota New Jersey Utah Wisconsin	b 2,769,826	b 6,108,866	b 2,614,847	b 9,336,410	2,530,018	9,386,978
Total	32,868,435	69,172,183	11,115,164	42,632,930	43,983,599	111,805,113

a Included with other States. b Includes Ohio and West Virginia.

1913.

State.	Beehive coke.		By-product coke.		Total.	
	Quantity.	Value.	Quantity.	Value.	Quantity.	Value.
Alabama	1,300,705	$4,401,216	2,022,959	$5,225,954	3,323,664	$9,627,170
Illinois	0	0	1,859,553	8,593,581	1,859,553	8,593,581
Indiana	0	0	2,727,025	13,182,136	2,727,025	13,182,136
Kentucky	248,061	589,225	69,023	164,672	317,084	753,897
New Jersey	0	0	255,792	695,041	255,792	695,041
New Mexico	467,945	1,548,536	0	0	467,945	1,548,536
New York	0	0	758,486	3,301,400	758,486	3,301,400
Ohio	115,814	364,124	236,032	867,430	351,846	1,231,554
Pennsylvania	26,124,764	59,690,940	2,628,680	8,238,924	28,753,444	67,929,864
Tennessee	364,578	925,430	0	0	364,578	925,430
Virginia	1,303,603	2,840,275	0	0	1,303,603	2,840,275
Washington	76,221	432,770	0	0	76,221	432,770
West Virginia	2,336,600	5,069,837	136,152	434,579	2,472,752	5,504,416
Colorado Georgia Maryland Massachusetts Michigan Minnesota Utah Wisconsin	1,246,539	4,422,068	2,020,998	7,934,135	3,267,537	12,356,203
Total	33,584,830	80,284,421	12,714,700	48,637,852	46,299,530	128,922,273

Of the 5,688 retorts which in 1913 produced coke 157 were idle during the entire year, leaving 5,531 retorts that were in operation a whole or a part of the year. As the total production amounted to 12,714,700 short tons, the average production per oven was 2,299 tons of coke, compared with 2,133 tons in 1912, 1,817 tons in 1911, and 1,762 tons in 1910, which shows that the productive capacity of the ovens has increased regularly during the last four years. The average production per active beehive oven was 505 tons in 1913, 484 tons in 1912, 468 tons in 1911, and 376 tons in 1910. The average production from each retort in 1913 was 4.5 times that of the average production from the beehive type. The value of the coke alone considered, the average yield from each retort in 1913 was $8,794, as compared with $8,143 as the average coke value from each retort oven in 1912, and with $1,208 as the average value of the coke produced in the beehive ovens in 1913. If to the value of the coke is added that of the by-products recovered, the average yield from each retort in 1913 was $11,854, compared with $11,265 in 1912. The average total yield in value from each retort in 1913 was 9.8 times the average value of the yield of coke from beehive ovens in 1913. The quantity of coal consumed in the manufacture of coke in retort or by-product ovens was 17,095,369 short tons, which yielded 12,714,700 short tons of coke, indicating an average yield of coal in coke of 74.4 per cent. This was a slight decrease in the percentage of yield as compared with 1912, and appears to have been owing to a larger proportion of Illinois or Indiana coals used in the ovens in those States in 1913 than in 1912. The usual charge at the plants using principally West Virginia coal is 4 parts of West Virginia coal to 1 part of Illinois or Indiana coal. In 1912 the average yield per ton of coal in coke in retort ovens was 75.3 per cent; in 1911 it was 75.1 per cent; in 1910, 74.9; and in 1909, 74.5 per cent—a steady increase from 1909 to 1912 when, for the reasons stated, it dropped to 74.4 per cent in 1913. The average yield of coal in coke in beehive ovens in 1913 was 64.4 per cent, the difference in favor of the retort ovens being 10 points, or 15.5 per cent. The value of the 17,095,369 short tons of coal consumed in coke retorts in 1913 was $41,511,495, or an average of $2.43 per ton, as compared with $2.41 in 1912. The quantity of coal consumed in beehive ovens in 1913 was 52,143,821 short tons, valued at $59,049,944, an average of $1.13 per ton. The difference in the value of the coal used at retort ovens is due to the location of the plants. In beehive practice the ovens are in the vicinity of the mines, from which the coal is delivered directly to the larries, and no transportation expenses are added to the cost of the coal. The retort-oven plants are located at a distance from the mines and near the points of consumption, so that the transportation expenses are added to the value of the coal charged into the ovens.

The value of the by-product coke produced in 1913 was $48,637,852, or an average value per ton of $3.82. In 1912 the average value per ton of retort coke produced was $3.84. As shown in the preceding paragraph, the cost of the coal consumed advanced from $2.41 per ton in 1912 to $2.43 in 1913, and the average value for the coke declined from $3.84 to $3.82. The value of the coal used per ton of coke produced in retorts in 1913 was $3.28, the difference between the value of the coke produced and the coal used being $0.54 per ton, The value of the coal used in beehive ovens per ton of coke was $1.76. the difference between that and the value per ton of coke produced being $0.63. From this it appears that in 1913 the advantage was with the beehive coke. To the value of the coke produced in retort ovens, however, should be added the value of the by-products recovered. This factor in 1913 amounted to $16,925,941, or 35 per cent of the value of the coke produced. In 1912 the value of the by-products was $14,343,795, or 34 per cent of the value of the coke.

The value of the by-products is nearly $1 per ton of the coal used. The by-products consisted in 1913 of 64,553,941 thousand cubic feet of surplus gas, valued at $5,694,691; 115,145,025 gallons of tar; valued at $2,830,158; ammonia in the form of sulphate, ammoniacal liquor, and anhydrous ammonia to a total value of $7,997,513. In addition there were other by-products, principally coke braize, to the value of $403,579.

The total value of the coke, gas, tar, ammonia, and other products produced at by-product recovery ovens during the last three years is shown in the following table:

Value of products obtained in manufacture of coke in retort ovens in 1911, 1912, and 1913.

Product.	1911		1912		1913	
	Quantity.	Value.	Quantity.	Value.	Quantity.	Value.
Gas.............M cubic feet..	33,274,861	$3,781,218	54,491,248	$4,650,517	64,553,941	$5,694,691
Tar.................gallons..	69,410,599	1,638,314	94,306,583	2,310,900	115,145,025	2,830,158
Ammonia, sulphate or reduced to equivalent in sulphate, pounds....................	72,920,056	1,943,761	95,275,545	3,649,144	173,342,349	5,324,444
Ammonia liquor.....gallons..	4,660,596	548,824	5,502,403	735,120	4,102,448	537,413
Anhydrous ammonia, pounds..	23,180,118	1,847,929	[a]26,672,474	[a] 2,387,562	[a]28,663,936	[a] 2,135,656
Other by-products...........	....	273,915	....	610,552	....	403,579
Total value of by-products..................	....	10,033,961	....	14,343,795	....	16,925,941
Coke.............short tons..	7,847,845	27,297,897	11,115,164	42,632,930	12,714,700	48,637,852
Grand total............	....	37,331,858	....	56,976,725	....	65,563,793

[a] Mainly ammoniacal liquor sold on pound basis of NH_3.

The gas included in the foregoing statement is the "surplus" not consumed in the coking process, which is either used at manufacturing establishments operated in connection with the coke-oven plant or sold. At some plants where the surplus gas is consumed by the producing or an affiliated company both the quantity and the value of the surplus gas become a matter of estimate, but the figures as presented are believed to be sufficiently accurate for statistical purposes. The value of the gas furnished to domestic consumers varies from 10 to 50 cents a thousand cubic feet. When the gas is consumed at industrial works operated in connection with the ovens the value is sometimes placed as low as 3 cents a thousand cubic feet. The average value of all the surplus gas in 1913 was 8.8 cents a thousand cubic feet. The lower value of gas produced since 1909, as compared with the preceding years, is due largely to the operations of ovens connected with iron and steel works at Corey, Woodward, and Ensley, in Alabama, Joliet in Illinois, Gary in Indiana, Ashland in Kentucky, Sparrows Point in Maryland, Buffalo and Solvay in New York, Dunbar, South Sharon, Steelton, and Lebanon in Pennsylvania, and Benwood in West Virginia. This factor represented about 70 per cent of the total production.

At the close of 1912 there were 5,211 retort ovens in operation, and 793 were building. The completed ovens consisted of 2,100 United-Otto ovens (including the Otto-Hoffmann and Schniewind types), 1,443 Semet-Solvay, 281 Rothberg, 1,215 Koppers, 150 Didier, and 22 Klönne ovens. At the close of 1913 there were 5,688 ovens in blast, an increase of 477 over 1912. There were 504 ovens building. The new construction added in 1913 consisted of 54 Semet-Solvay ovens, 66 Koppers, and 150 Didier ovens. There were 200 United-Otto ovens abandoned. The ovens building included 334 Koppers ovens, 152 Semet-Solvay ovens, and 18 Wilputte ovens.

The statistical history of by-product coke making in the United States since the first ovens were completed in 1893 is shown in the table following.

Record of by-product coke making, 1893–1913.

Year.	Ovens.		Production (short tons).	Year.	Ovens.		Production (short tons).
	Built.	Building.			Built.	Building.	
1893	12	0	12,850	1904	2,910	832	2,608,229
1894	12	60	16,500	1905	3,103	417	3,462,348
1895	72	60	18,521	1906	3,547	112	4,558,127
1896	160	120	83,038	1907	3,684	330	5,607,899
1897	280	240	261,912	1908	3,799	240	4,201,226
1898	520	500	294,445	1909	3,989	949	6,254,644
1899	1,020	65	906,534	1910	4,078	1,200	7,138,734
1900	1,085	1,096	1,075,727	1911	4,624	698	7,847,845
1901	1,165	1,533	1,179,900	1912	5,211	793	11,115,164
1902	1,663	1,346	1,403,588	1913	[a] 5,688	[b] 504	12,714,700
1903	1,956	1,335	1,882,394				

[a] Includes 1,537 Semet-Solvay, 2,186 United Otto, 281 Rothberg, 1,361 Koppers, 300 Didier, 22 Klönne, and 1 Roberts-Mass ovens.
[b] Includes 334 Koppers, 152 Semet-Solvay, and 18 Wilputte ovens.

The record of by-product ovens for the last five years, by States, is shown in the following table:

Record of by-product ovens, by States, 1909–1913.

State.	Dec. 31, 1909.		Dec. 31, 1910.		Dec. 31, 1911.		Dec. 31, 1912.		Dec. 31, 1913.	
	Built.	Building.	Built.	Building.	Built.	Building.	Built.	Building.	Built.	Building.
Alabama	280	0	280	340	340	280	620	100	700	20
Illinois	440	40	480	0	480	48	568	40	568	58
Indiana	50	560	50	560	540	70	632	169	749	41
Kentucky	0	0	0	0	0	0	0	41	54	0
Maryland	200	0	200	0	200	0	200	6	[a] 0	120
Massachusetts	460	0	400	0	400	0	400	0	400	0
Michigan	162	0	162	0	162	0	165	40	205	0
Minnesota	50	0	50	0	50	0	50	92	50	90
Missouri	0	0	0	0	0	0	0	0	0	56
New Jersey	150	0	150	0	150	0	150	0	150	0
New York	556	0	556	0	556	0	555	0	555	0
Ohio	125	49	174	0	174	0	149	119	149	119
Pennsylvania	1,296	[b] 300	1,296	300	1,292	[c] 300	1,442	150	1,592	0
West Virginia	120	0	120	0	120	0	120	0	120	0
Wisconsin	160	0	160	0	160	0	160	36	196	0
Total	3,989	949	4,078	1,200	4,624	698	5,211	793	[a] 5,488	504

[a] At the close of 1913, 200 ovens at Sparrows Point works of the Maryland Steel Co., which were operated during the year, were being torn down to be replaced by 120 ovens of larger dimensions.
[b] Contracted for; construction begun in 1910.
[c] One-half (150) completed in latter part of 1912.

The retort ovens under construction at the close of 1913 were as follows:

Retort ovens under construction at the close of 1913.

State.	Kinds of ovens.		
	Semet-Solvay.	Wilputte.	Koppers.
Alabama	20	0	0
Illinois	40	18	0
Indiana	41	0	0
Maryland	0	0	120
Minnesota	0	0	90
Missouri	0	0	56
Ohio	51	0	68
Total	152	18	334

The distribution, by States and by kinds, of by-product ovens built and building in the United States at the close of 1913 is shown in the following table:

Kinds of by-product ovens built and building in the United States, by States, at the close of 1913.

State.	United Otto,[a] built.	Semet-Solvay, built.	Koppers, built.	Roth-berg, built.	Klönne, built.	Didier, built.	Roberts-Mass., built.	Total.	
								Built.	Building.
Alabama	0	280	420	0	0	0	0	700	[b] 20
Illinois	0	253	315	0	0	0	0	568	[c] 58
Indiana	100	0	626	0	22	0	1	749	[b] 41
Kentucky	0	54	0	0	0	0	0	54	0
Maryland	[d] 200	0	0	0	0	0	0	200	[e] 120
Massachusetts	400	0	0	0	0	0	0	400	0
Michigan	30	175	0	0	0	0	0	205	0
Minnesota	50	0	0	0	0	0	0	50	[e] 90
Missouri	0	0	0	0	0	0	0	0	[e] 56
New Jersey	150	0	0	0	0	0	0	150	0
New York	188	86	0	281	0	0	0	555	0
Ohio	100	49	0	0	0	0	0	149	[f] 119
Pennsylvana	932	360	0	0	0	300	0	1,592	0
West Virginia	0	120	0	0	0	0	0	120	0
Wisconsin	36	160	0	0	0	0	0	196	0
Total	2,186	1,537	1,361	281	22	300	1	5,688	504

[a] Includes the Otto-Hoffmann and Schniewind types.
[b] Semet-Solvay ovens.
[c] Includes 40 Semet-Solvay and 18 Wilputte ovens.
[d] Operated for a part of the year, but being torn down at the end of the year in order to be replaced by new ovens.
[e] Koppers ovens.
[f] Includes 51 Semet-Solvay and 68 Koppers ovens.

In the following table is presented a list of the by-product retort oven plants in the United States as they existed on January 1, 1914, with the dates the plants were put in operation, the number of ovens to each installation, and the uses to which the coke and surplus gas are put.

Complete list of retort coke-oven plants of the United States Jan. 1, 1914, by States.

State.	Town.	System.	Name of company owning plant.	Number of installments.	Date put in operation.	Number of ovens.	Uses of coke.	Uses of surplus gas.	Remarks.
Ala.	Ensley (near Birmingham).	Semet-Solvay	Tennessee Coal, Iron & R. R. Co.	First	Oct., 1898	120	Blast furnace	Fuel	
				Second	Mar., 1902	120	do	do	
	Tuscaloosa	do	Central Iron & Coal Co.	First	Feb., 1906	40	do	do	
	Woodward	Koppers	Woodward Iron Co.	do	1911	60	do	Fuel and power	
	do	do	do	Second	1913	80	do	do	
	Fairfield	do	Tennessee Coal, Iron & R. R. Co.	First	1912	280	do	do	
Ill.	Joliet	do	Coal Products Manufacturing Co.	do	do	35		Illuminating, domestic heating, and industrial.	
	do	Wilputte	do	Second	Began construction 1913.	18			
	do	Koppers	Illinois Steel Co.	First	Completed in 1908.	140	Blast furnace	Fuel and power	
	do	do	do	Second	Mar., 1909	140	do	do	
	South Chicago, on Calumet River.	Semet-Solvay	By-products Coke Corporation.	First	Dec., 1905	120	Blast furnace, foundry, and domestic.	Illuminating	
				Second	Dec., 1906	40			
				Third	1910	40			
	do	do	do	Fourth	1912	40	do	do	
	do	do	do	Fifth	Began construction 1912.	40	do	do	
	Waukegan	do	North Shore Gas Co.	First	Sept., 1912	13	do	do	
Ind.	Gary	Koppers	Illinois Steel Co.	do	490 completed in 1911.	560	Blast furnace	Fuel	
	Indiana Harbor	do	Inland Steel Co.	do	1913	66	do	do	
	Muncie	Klönne	Central Indiana Gas Co.	do	1912	22	Domestic and industrial.	Illuminating	
	Gary	Roberts-Mass	American Coal & By-products Coke Co.	do	1913	1			Experimental plant to test western coals; no by-products obtained.
	Indianapolis	United-Otto	Citizens Gas Co	do	Completed 1909.	50	Blast furnace and foundry.	Fuel and illuminating gas for Indianapolis.	
	do	do	do	Second	1913	50	do	do	
	do	Semet-Solvay	Indianapolis Gas Co.	First	Began construction 1912.	41	Foundry and domestic.	Illuminating, domestic heating, and industrial.	Leased to Citizens Gas Co.
Ky.	Ashland	do	Kentucky Solvay Co.	do	1913	54	Blast furnace and foundry.	Fuel	
Md.	Sparrows Point	United-Otto	Maryland Steel Co.	do	Mar., 1903	200	Blast furnace	Illuminating gas for city of Baltimore, 11 miles distant; 4,000,000 cubic feet daily.	Abandoned during 1913. Koppers ovens to be substituted.

	do	Koppers	do	do	Began construction 1912.	6	do	Illuminating, domestic heating, and industrial.	
	do	do	do	Second	Began construction 1913.	114	do	do	
Mass.	Everett	Otto-Hoffmann	New England Gas & Coke Co.	First	June, 1899	400	Domestic, industrial, and locomotive in about equal proportion.	Illuminating gas and fuel gas; 6,500,000 to 7,500,000 cubic feet daily of illuminating gas.	First illuminating-gas system installed.
Mich.	Detroit	Semet-Solvay	The Solvay Process Co.	do	Sept., 1901	30	Furnace, foundry, domestic, and lime burning.	Illuminating and fuel	
				Second	Nov., 1902	30			
				Third	Mar., 1906	60			
				Fourth	1909	12			
				Fifth	1913	43			
	Wyandotte	United-Otto	Michigan Alkali Co.	First	Oct., 1902	15	Burning limestone.	Fuel	Use the by-products in their works.
	do	do	do	Second	Aug., 1906	15			
Minn.	Duluth	do	Zenith Furnace Co.	First	July, 1904	50	Blast furnace	Illuminating gas for Duluth.	
	do	Koppers	Minnesota Steel Co.	do	Began construction 1912.	90	do	Fuel	
Mo.	St. Louis	do	Laclede Gas Light Co.	do	Began Construction 1913.	56			
N. J.	Camden	Otto-Hoffmann	Camden Coke Co.	do	About Jan., 1903.	100	do	Illuminating gas and fuel gas 2,500,000 to 3,000,000 cubic feet. Illuminating gas pumped daily under 10 pounds pressure to Trenton, 38 miles distant. In 1906 extended delivery of illuminating gas to New Brunswick and Plainfield, 83 miles from Camden. Towns now included: Camden, Bordentown, Woodbury, Trenton, New Brunswick, Plainfield, and smaller towns.	First to install enrichment by benzol transfer.
	do	United-Otto	do	Second	July, 1906	50	Foundry and domestic (domestic coke crushed and sized for sale).		
N. Y.	Syracuse	Semet-Solvay	Solvay Process Co.	First	Jan., 1893	12	Burning limestone; also iron foundry.	Fuel	First by-product plant in United States. Main purpose originally to obtain ammonia for alkali works.
				Second	1896	13			
				Third	Bet. 1900 and 1903.	15			
	Border City	do	The Empire Coke Co.	First	Aug., 1904	30	Foundry and domestic.	Illuminating	
				Second	1909	16			
	Buffalo	United-Otto	Lackawanna Steel Co.	First	May, 1904	188	Blast furnace	Fuel	First used stamped coal, but changed to top-charging, 1907.
	do	Rothberg	do	do		281	do	do	

Complete list of retort coke-oven plants of the United States Jan. 1, 1914, by States—Continued.

State.	Town.	System.	Name of company owning plant.	Number of installments.	Date put in operation.	Number of ovens.	Uses of coke.	Uses of surplus gas.	Remarks.
Ohio	Hamilton	Otto-Hoffmann	Hamilton Otto Coke Co.	First	Apr., 1901	50	Mostly domestic; some foundry. Installed crushing outfit 1905.	Illuminating gas for Hamilton; also power gas and fuel gas.	
	do	United-Otto	do	Second	1909	50	Blast furnace	do	
	Cleveland	Semet-Solvay	Cleveland Furnace Co.	First	1910	49	do	Illuminating and fuel	Originally 80 Rothberg ovens; now operated by the Semet-Solvay Co.
	do	do	do	Second	Began construction 1912.	51	do	do	
	Youngstown	Koppers	Republic Iron & Steel Co.	First	do	68	do	Fuel	
Pa	Dunbar	Semet-Solvay	Dunbar Furnace Co	do	Aug., 1896	50	do	do	
	do	do	do	Second	July, 1903	60	do	do	
	Chester	do	The Philadelphia Suburban Gas & Electric Co.	First	Apr., 1904	40	Blast furnace	Illuminating and fuel	
	South Sharon	United-Otto	Carnegie Steel Co	do	July, 1903	212	do	Fuel	
	Glassport	Otto-Hoffmann	Pittsburgh Gas & Coke Co.	do	Feb., 1897	120	Blast furnace and domestic. Installed a crushing outfit in 1905.	Illuminating gas and fuel gas to McKeesport.	
	Johnstown	do	Cambria Steel Co	do	Nov., 1895	60	Blast furnace	Fuel and power	
	do	United-Otto	do	Second	Mar., 1899	100	do	do	
	do	do	do	Third	Sept., 1904	100	do	do	
	do	do	do	Fourth	Feb., 1907	112	do	do	
	Lebanon	Semet-Solvay	Pennsylvania Steel Co.	First	July, 1904	90	do	Semet-Solvay Co. delivers surplus gas to Pennsylvania Steel Co., which sells it to American Iron & Steel Mfg. Co. for use in heating furnaces and gas engine. Also 4 gas engines, 1,200 H. P. each, furnishing power for generating electricity to operate Cornwall Ore Banks, at Lebanon, Pa.	This last gas-engine installation is the largest one in the United States using coke-oven gas.

	do	Otto-Hoffmann	Lackawanna Iron & Steel Co.	do	Mar., 1903	228	do	Fuel	Went back to top-charging since resumption in September, 1905.
	Steelton	Semet-Solvay	Pennsylvania Steel Co.	do	Jan., 1907	120	Blast furnace	Fuel	
	South Bethlehem.	Didier	Lehigh Coke Co	do	1912	150		do	
	do	do	do	Second	1913	150			
W. Va	Benwood	Semet-Solvay	National Tube Co	First	Oct., 1898	60	Blast furnace	Fuel	
				Second	Mar., 1901	60	do	do	
Wis	Milwaukee	do	Milwaukee Coke & Gas Co.	First	Mar., 1904	80	Blast furnace, foundry, and domestic.	Illuminating and fuel	
	do	do	do	Second	Mar., 1906	80			
	Mayville	Otto-Hoffmann	Northwestern Iron Co.	First	Began construction 1912.	36			

NOTE.—Of the 15 active plants of Semet-Solvay ovens in the United States in 1913, 2 were operated by the owners, and the other 13 were operated by the Semet-Solvay Co., the coke produced being turned over to the company whose name appears as owner.

IMPORTS AND EXPORTS.

IMPORTS.

The following table gives the quantity and value of coke imported and entered for consumption in the United States from 1908 to 1913, inclusive. In the reports of the Bureau of Foreign and Domestic Commerce, Department of Commerce, from which these figures are obtained, the quantities are expressed in long tons of 2,240 pounds. These have been reduced to short tons in order to make them conform to the standard unit of this report.

Coke imported and entered for consumption in the United States, 1908–1913, in short tons.

Year.	Quantity.	Value.	Year.	Quantity.	Value.
1908	147,427	$606,294	1911	77,923	$254,455
1909	191,253	736,120	1912	123,614	488,398
1910	172,716	625,130	1913	101,212	435,157

EXPORTS.

The quantity of coke exported from the United States increased steadily from 1900 to 1907. Since 1907 the value of the exports has alternately increased and decreased each year, although, with slight fluctuations, they have remained practically stationary during the last five years. The exports in 1913 were slightly greater than in 1912, which in turn were a little less than those of 1911. The exports during the last six years are shown in the following table, the quantities being reduced to short tons:

Coke exported from the United States, 1908–1913, in short tons.

Year.	Quantity.	Value.	Year.	Quantity.	Value.
1908	695,434	$2,161,032	1911	1,023,727	$3,215,990
1909	1,002,916	3,232,673	1912	912,576	3,002,742
1910	984,618	3,053,293	1913	987,395	3,309,930

IMPORTS OF COAL-TAR PRODUCTS.

It has been contended that the development of the by-product coking industry would have shown more rapid progress if markets for the by-products were assured. This contention pertains principally to the coal tar and its products, as there is no difficulty in disposing of the surplus gas, and there is practically at all times a fair demand for ammonia. The total value of domestic coal tar produced in 1913 from retort coke ovens was $2,830,158. No information is available regarding the quantity and value of the products obtained from this tar, as in going to the distillers it becomes mixed with the coal tar from gas-house retorts, and even if the total quantity and value of coal-tar products were obtainable, it would be practically impossible to differentiate those obtained from retort-oven tar from those obtained from gas-house tar. It is interesting to note, however, that the coal-tar products imported into the United States amount to approximately $10,000,000 annually. In 1913 the total value of coal-tar products imported into the United States was $10,962,828, of which colors and dyes made up nearly 80 per cent. On the entire imports duty was obtained to the amount of $2,323,729, making a total value at the port of entry, exclusive of ocean freights, commissions, and other expenses, of $13,286,557. The value of these importations by the time they are in the hands of the consumer is probably between $18,000,000 and $20,000,000. The kinds of coal-tar products imported, the value thereof, and the amount of duty paid on each during the last five years are shown in the following table:

Coal-tar products imported into the United States, 1909–1913.

Year.	Salicylic acid.		Alizarin and colors or dyes, natural and artificial.		Aniline salts.		Coal-tar colors or dyes, not specially provided for.	
	Value.	Duty.	Value.	Duty.	Value.	Duty.	Value.	Duty.
1909			$1,191,874	Free.	$553,503	Free.	$6,431,767	$1,929,530
1910			430,393	Free.	501,369	Free.	5,867,331	1,760,098
1911	$3,480	$915	996,794	Free.	410,193	Free.	6,444,595	1,933,379
1912	9,543	2,469	1,514,344	Free.	354,226	Free.	7,204,453	2,161,336
1913	2,969	613	1,493,840	Free.	323,420	[a] $4,034	7,253,788	2,176,136

Year.	Coal tar, all preparations, not colors or dyes.		Coal-tar products, not medicinal, not dyes, known as benzol, toluol, etc.		Total.	
	Value.	Duty.	Value.	Duty.	Value.	Duty.
1909	$693,608	$138,768	$960,724	Free.	$9,831,476	$2,068,298
1910	594,252	118,849	962,232	Free.	8,355,577	1,878,947
1911	659,407	131,881	1,128,409	Free.	9,642,878	2,066,175
1912	659,305	131,861	998,767	Free.	10,740,638	2,295,666
1913	702,721	131,268	1,186,090	[b] $11,678	10,962,828	2,323,729

[a] Dutiable on and after Oct. 4, 1913.
[b] All products in this class became dutiable on Oct. 4, 1913, except naphthaline, phenol, and cresol.

PRODUCTION BY STATES.

ALABAMA.

The production of coke in Alabama increased from 2,975,489 short tons, valued at $8,098 412, in 1912 to 3,323,664 tons, valued at $9,627,170, in 1913. The gain was 348,175 tons, or 11.7 per cent, in quantity, and $1,528,758, or 18.9 per cent, in value. All of the increased production, and more, was in the output of retort oven or by-product coke. There are in Alabama four retort oven establishments with a total of 700 ovens, and in 1913 those establishments produced 2,022,959 tons of coke, or a little more than 60 per cent of the total output, whereas 22 active beehive plants with an aggregate of 4,135 ovens in blast produced 1,300,705 tons, or a little less than 40 per cent of the total. The average production per oven in the by-product plants was 2,890 tons, and the average production for each beehive oven was 315 tons.

The increase in the production of by-product coke in 1913 over 1912 was 673,162 tons, or nearly double the total increase. The output of beehive coke decreased 324,987 tons. The value of the by-product coke showed an increase of $1,751,538, or $222,780 more than the total increase, the difference representing the decrease in the value of beehive coke. Moreover, the average yield of coal in coke from the retort ovens was 71.4 per cent, whereas the average yield in the beehive ovens was 54.5 per cent. There is not the marked difference in the values of retort and beehive cokes (and in favor of the former) in Alabama as is shown in some States, for in Alabama the retort ovens, like the beehive, are located near the mines, and the two in that respect are somewhat on a parity, whereas in most of the States where retort coke is made the ovens are at considerable distances from the mines, and the transportation charges assessed against the coal are added to the value of the coke. In fact, the Alabama beehive coke had a higher value per ton in 1913 than the retort coke, the averages per ton being $3.38 for beehive coke and $2.58 for retort coke. The explanation of this seeming inconsistency lies in the fact that all of the retort coke is used by the producers in their own furnaces, and the coke is charged to the furnaces at little more than cost, whereas the greater part of the beehive product is commercial coke, some of it for foundry use, and profits are included in the value.

That the beehive oven has had its day in Alabama and is on the decline is evinced by the facts that no new ovens of that type have been built in the last four years and that 20 establishments, with a total of 3,447 ovens, out of a total of 42 establishments, with 9,584 ovens, were idle in 1913, not counting the ovens out of blast at plants that produced some coke in 1913. There were fewer beehive ovens in existence in Alabama in 1913 than in 1908, five years before. The number of retort ovens increased from 620 in 1912 to 700 in 1913, 80 of the 100 ovens of that type reported as in course of construction at the close of 1912 having been completed and put in blast. The 700 completed ovens include 280 Semet-Solvay ovens (240 at Ensley and 40 at Tuscaloosa) and 420 Koppers ovens (280 at Fairfield, formerly known as Corey, and 140 at Woodward). The only new ovens in course of construction at the close of 1913 were 20 Semet-Solvay ovens which were being added to the Tuscaloosa plant.

The production of coke in Alabama in 1880, 1890, 1900, and annually from 1909 to 1913, is shown in the following table:

Statistics of the manufacture of coke in Alabama, 1880–1913.

Year.	Establishments.	Ovens.		Coal used (short tons).	Yield of coal in coke (per cent).	Coke produced (short tons).	Total value of coke at ovens.	Value of coke at ovens per ton.
		Built.	Building.					
1880	4	316	100	106,283	57.0	60,781	$183,063	$3.01
1890	20	4,805	371	1,809,964	59.0	1,072,942	2,589,447	2.41
1900	30	6,529	690	3,582,547	58.9	2,110,837	5,629,423	2.67
1909	43	10,061	0	5,080,764	60.7	3,085,824	8,068,267	2.61
1910	43	10,132	340	5,272,322	61.6	3,249,027	9,165,821	2.82
1911	44	10,121	280	4,411,298	62.6	2,761,521	7,593,594	2.75
1912	46	10,208	100	4,585,498	64.9	2,975,489	8,098,412	2.72
1913	46	[a]10,284	[b]20	5,218,323	63.6	3,323,664	9,627,170	2.90

[a] Includes 280 Semet-Solvay and 420 Koppers ovens.

[b] Semet-Solvay ovens.

More than 80 per cent of the coal used in the manufacture of coke in Alabama is washed before being charged into the ovens. In 1913, out of a total of 5,218,323 tons of coal made into coke, 4,349,664 tons were washed. Of the washed coal used, 3,665,441 tons were slack and 684,223 tons were mine run. The unwashed mine-run coal used was 868,659 tons. No unwashed slack was used in 1913.

The character of the coal used in the manufacture of coke in Alabama in 1890, 1900, and for the last five years, is shown in the following table:

Character of coal used in the manufacture of coke in Alabama, 1890–1913, in short tons.

Year.	Run of mine.		Slack.		Total.
	Unwashed.	Washed.	Unwashed.	Washed.	
1890	1,480,669	0	206,106	123,189	1,809,964
1900	1,729,882	152,077	165,418	1,535,170	3,582,547
1909	713,992	2,153,801	0	2,212,971	5,080,764
1910	771,931	1,308,085	0	3,192,306	5,272,322
1911	693,135	1,295,109	2,937	2,420,117	4,411,298
1912	747,305	896,421	18,793	2,922,979	4,585,498
1913	868,659	684,223	0	3,665,441	5,218,323

COLORADO.

The production of coke in Colorado decreased from 972,941 short tons, valued at $3,043,994, in 1912 to 879,461 tons, valued at $2,815,134, in 1913. The decrease, which amounted to 93,480 tons, or 9.6 per cent, in quantity and $228,860, or 7.5 per cent, in value, was due entirely to labor troubles among the miners and not to adverse trade conditions. In a struggle to secure recognition of the mine workers' union a strike was called in the latter part of September, 1913, and later developed into a sanguinary conflict which eventually resulted in the calling out of Federal troops to restore order. The principal disturbances were in Las Animas County, the leading coal-producing and coke-making county, and resulted in a decrease in production of coal of nearly a million tons and in the total decrease in the output of coke.

Prior to 1912 it was the custom to include the coke production of Utah with that of Colorado in the reports of this series, as there were only two establishments in the former State, both owned by one company. In the last two years, however, the statistics of Utah's production have been included with other States having less than three establishments, and the figures for Colorado alone are made comparable. There are 15 coke-making establishments in Colorado with a total of 3,588 ovens, all of the beehive type. Six of the establishments, with a total of 726 ovens, were idle throughout the year. In addition to the idle plants, there were 980 idle ovens at plants which made some coke in 1913, so that the total idle ovens numbered 1,706, or nearly one-half of the coking capacity in the State. There were no new ovens in construction at the end of the year.

According to the returns to the Survey, the average value per ton for Colorado coke advanced from $3.13 in 1912 to $3.20 in 1913. In 1911 the average was $3.30. These fluctuations are, however, more apparent than real. A large proportion of the coke produced in Colorado is made in ovens which are parts of plants including in their operations the mining of coal, the making of coke, and the manufacture of iron and steel or the smelting and refining of the precious and base metals. In such establishments the placing of a value on the coke is an arbitrary matter and does not represent market prices. Only about 30 per cent of the total output of Colorado in 1913 was commercial coke:

The statistics of the manufacture of coke in Colorado and Utah in 1880, 1890, 1900, and from 1909 to 1911, inclusive, are shown in the following table. The statistics for 1912 and 1913 are for Colorado alone.

Statistics of the manufacture of coke in Colorado, 1880–1913.

Year.	Establishments.	Ovens.		Coal used (short tons).	Yield of coal in coke (per cent).	Coke produced (short tons).	Total value of coke at ovens.	Value of coke at ovens per ton.
		Built.	Building.					
1880[a]	1	200	50	51,891	49.0	25,568	$145,226	$5.68
1890[a]	8	916	30	407,023	60.0	245,756	959,246	3.90
1900[a]	14	1,692	0	997,861	62.0	618,755	1,746,732	2.82
1909[a]	18	4,700	0	1,984,985	63.1	1,251,805	4,135,931	3.30
1910[a]	18	4,465	0	2,069,266	65.1	1,346,211	4,273,579	3.17
1911[a]	18	4,460	0	1,810,335	65.0	1,177,023	3,880,710	3.30
1912	15	3,588	0	1,473,112	66.0	972,941	3,043,994	3.13
1913	15	3,588	0	1,349,743	65.1	879,461	2,815,134	3.20

[a] Includes Utah.

The total quantity of coal consumed in the manufacture of coke in Colorado in 1913 was 1,349,743 tons, of which 1,028,366 tons were mine run and 321,377 tons were slack. All but 13,267 tons of the mine-run coal used and 85 per cent of the slack was washed before being charged into the ovens. The character of the coal used in making coke in Colorado in 1890, 1900, and from 1909 to 1913, inclusive, is shown in the following table:

Character of coal used in the manufacture of coke in Colorado, 1890–1913.

Year.	Run of mine.		Slack.		Total.
	Unwashed.	Washed.	Unwashed.	Washed.	
1890[a]	36,058	0	395,023	0	431,081
1900[a]	229,311	0	316,527	452,023	997,861
1909[a]	117,446	1,155,233	398,762	313,544	1,984,985
1910[a]	252,468	836,067	429,728	551,003	2,069,266
1911[a]	0	1,025,031	428,971	356,333	1,810,335
1912	680	1,061,917	43,310	367,205	1,473,112
1913	13,267	1,015,099	48,952	272,425	1,349,743

[a] Includes Utah.

GEORGIA.

Portions of two counties in the extreme northwest corner of the State, Dade and Walker, are underlain by the coal measures of the Appalachian province. Coal has been mined and coke has been made in both counties, but the Dade County mines and ovens have been idle the last few years and all the production at the present time is from Walker County. The sole operator in that county is the Durham Coal & Coke Co., of Chattanooga, Tenn. The statistics of its production of coke, as of coal, are published with the express permission of the company.

The production of coke at the one plant in Walker County in 1913 amounted to 42,747 short tons, valued at $186,304, compared with 43,158 short tons, valued at $161,842, in 1912. These figures indicate a slight decrease (411 tons) in quantity in 1913 but a gain in value of $24,462. Coke making, notwithstanding, or possibly because of, the smaller quantity produced, appeared to be more remunerative in 1913 than coal mining, for the average value per ton of the coal produced declined from $1.49 to $1.41, whereas the average value per ton of coke advanced from $3.75 in 1912 to $4.35 in 1913.

The two establishments in Georgia have a total coke-making equipment of 251 ovens, of which 100 were idle in 1913. All of the ovens are of the beehive type, the wasteful character of which is shown in the theoretical and practical yield of the Walker County coal in coke. The mine-run coal has a high content of fixed carbon (80 per cent), whereas the yield during the last few years has averaged less than 55 per cent, and in each of the last three years has been less than 52 per cent. The recovery is less than two-thirds of the possible yield.

The screened coal from Walker County makes a high-grade steam fuel and is in favor in the bunker trade. The screenings (or slack) only are used for coke making, and as most of the impurities in the coal pass through the screens with the slack, the latter is washed before being charged into the ovens.

The period of greatest activity in the coal mines and coke ovens of Georgia was during the first six or seven years of the present century, when the mines were operated by convicts leased by the State. The convict-lease system was abolished in 1908, and as the operators have been unable to supply this deficiency with free labor, the production of both coal and coke has been much reduced. The quantity of coal mined in the last six years has averaged less than 60 per cent of the production for an equal number of years just preceding.

The statistics of the manufacture of coke in Georgia in 1880, 1890, 1900, and from 1909 to 1913, inclusive, are shown in the following table:

Statistics of the manufacture of coke in Georgia, 1880–1913.

Year.	Establishments.	Ovens.		Coal used (short tons).	Yield of coal in coke (per cent).	Coke produced (short tons).	Total value of coke at ovens.	Value of coke at ovens per ton.
		Built.	Building.					
1880	1	140	40	63,402	60.0	38,041	$81,789	$2.15
1890	1	300	0	170,388	60.0	102,233	150,995	1.48
1900	2	480	0	140,988	52.4	73,928	210,646	2.85
1909	2	350	0	86,290	53.8	46,385	159,334	3.44
1910	2	350	0	80,019	54.8	43,814	173,049	3.95
1911	2	225	0	72,677	51.7	37,553	135,190	3.60
1912	2	251	0	87,300	50.0	43,158	161,842	3.75
1913	2	251	0	82,871	51.5	42,747	186,304	4.35

ILLINOIS.

All of the coke made in Illinois is the product of retort ovens, the Hemingway experimental ovens at Chicago and 24 beehive ovens at Gallatin having been permanently abandoned in 1913. They have not been in operation for several years. The retort-oven plants are at South Chicago, Joliet, and Waukegan, but they draw most of their coal from West Virginia or Pennsylvania mines. A common practice is to mix the West Virginia coal with Illinois coal in the proportion of 4 to 1. The mixture is ground fine and has been found to make an entirely satisfactory coke, with a yield of coal in coke of approximately 75 per cent. There are four establishments with a total of 568 ovens, all of which were in operation during the year. There were 58 new ovens in construction at the end of the year, 40 at South Chicago and 18 at Joliet, both installments being additions to plants already established.

The production of coke in Illinois increased from 1,764,944 short tons, valued at $8,069,903, in 1912 to 1,859,553 tons, valued at $8,593,581, in 1913, the gain in quantity amounting to 94,609 tons, or 5.4 per cent, and in value to $523,678, or 6.5 per cent. The increase in the value of the coke, however, was less than the increase in the value of the coal used in its manufacture. In 1912 the coal consumed in the coke ovens of Illinois amounted to 2,316,307 tons, valued at $6,568,003; in 1913 the coal used was 2,481,198 tons, and it was valued at $7,225,925, the difference being $657,922, or $134,244 more than the increase in the value of the coke made from it. But in Illinois, as elsewhere, a large part of the by-product coke is consumed by the producing or allied interests and the fixing of the values is an arbitrary matter and not indicative of market conditions.

The statistics of the manufacture of coke in Illinois during the last seven years is shown in the following table:

Statistics of the manufacture of coke in Illinois, 1907–1913.

Year.	Establishments.	Ovens.		Coal used (short tons).	Yield of coal in coke (per cent).	Coke produced (short tons).	Total value of coke at ovens.	Value of coke at ovens per ton.
		Built.	Building.					
1907	5	309	280	514,983	72.3	372,697	$1,737,464	$4.66
1908	6	430	140	503,359	72.0	362,182	1,538,952	4.25
1909	5	468	40	1,682,122	75.9	1,276,956	5,361,510	4.20
1910	5	508	0	1,972,955	76.8	1,514,504	6,712,550	4.43
1911	6	506	48	2,087,870	77.1	1,610,212	6,390,251	3.97
1912	6	594	40	2,316,307	76.2	1,764,944	8,069,903	4.57
1913	4	[a] 568	[b] 58	2,481,198	74.9	1,859,553	8,593,581	4.62

[a] Includes 253 Semet-Solvay and 315 Koppers ovens.
[b] Includes 40 Semet-Solvay and 18 Wilputte ovens.

INDIANA.

As in the neighboring State of Illinois, all the coke made in Indiana is the product of retort ovens and most of the coal used is brought from West Virginia. The State assumed importance in the manfuacture of coke in 1911, when a portion of the United States Steel Corporation plant at Gary was completed and put in blast. The entire plant was completed in 1912, and Indiana, from a relatively low place in the rank of coke-producing States in 1910 (seventeenth) advanced to third place in 1912 and 1913, outranking West Virginia, upon whose mines the ovens in Indiana depend for the greater part of their coal. The United States Steel Corporation's plant at Gary consists of 560 Koppers ovens, which in 1913 produced 90 per cent of the entire output of coke in the State. Prior to the completion of this plant, the Citizens Gas Co. at Indianapolis had built, in 1909, 50 United-Otto ovens, which plant was doubled in size by 50 additional ovens, completed in 1913. In 1912 the Central Indiana Gas Co. completed 22 Klönne ovens at Muncie; the Inland Steel Co. began the construction of 66 Koppers ovens (completed in 1913), and the construction of 41 Semet-Solvay ovens, which were still incomplete at the close of 1913, was begun at Indianapolis. One Roberts-Mass oven, an experimental installation, was built at Gary in 1913 by the American Coal & By-Products Coke Co. The total number of ovens in the State at the close of 1913 was 749, with 41 under construction. Ten beehive ovens at Black Creek were abandoned.

The production of retort coke in Indiana in 1913 was 2,727,025 short tons, valued at $13,182,136, against 2,616,339 tons in 1912, valued at $12,528,685. The increase in 1913 was 110,686 tons, or 4.2 per cent in quantity, and $653,451, or 5.2 per cent, in value. The average value per ton advanced from $4.79 to $4.83. The increase in the value of the coke was, however, only a little more than half of the increase in the value of the coal used, which in 1913 was $11,006,033, against $9,689,756 in 1912, the difference being $1,316,277. The 749 ovens had an average production in 1913 of 3,670 tons of coke, and an average yield of coal in coke of 77.1 per cent. In 1912 the average production per oven was 4,140 tons, and the average yield was 81.8 per cent. The lower averages in 1913 were probably due to a larger proportion of Illinois coal used in the oven charge.

The statistics of the manufacture of coke in Indiana in 1912 and 1913 are shown in the following table:

Statistics of the manufacture of coke in Indiana, 1912 and 1913.

Year.	Establishments.	Ovens.		Coal used (short tons).	Yield of coal in coke (per cent).	Coke produced (short tons).	Total value of coke at ovens.	Value of coke at ovens per ton.
		Built.	Building.					
1912	4	642	169	3,198,874	81.8	2,616,339	$12,528,685	$4.79
1913	5	*a* 749	*b* 41	3,535,136	77.1	2,727,025	13,182,136	4.83

a Includes 626 Koppers, 100 United-Otto, 22 Klönne, and 1 Roberts-Mass ovens.
b Semet-Solvay ovens.

KANSAS.

Kansas dropped out of the list of coke producers in 1913. The industry has never been of much importance in the State, and the largest production was 20,902 short tons in 1902. That product was made in ovens operated in connection with zinc works and was used in the zinc retorts. "Dead" coal mined in the State, and so called because of its absolutely noncoking quality, is used raw by the zinc smelters and takes the place of the coke. A small quantity of coke was made in 1910, 1911, and 1912 in underground ovens at Lansing, the coal being from the mines operated by the State penitentiary, but these were not used in 1913.

The statistics of the manufacture of coke in Kansas in 1880, 1890, 1900, and in 1909–1913 are shown in the following table:

Statistics of the manufacture of coke in Kansas, 1880–1913.

Year.	Establishments.	Ovens.		Coal used (short tons).	Yield of coal in coke (per cent).	Coke produced (short tons).	Total value of coke at ovens.	Value of coke at ovens per ton.
		Built.	Building.					
1880	2	6	0	4,800	64.0	3,070	$6,000	$1.95
1890	7	68	0	21,809	56.0	12,311	29,116	2.37
1900	9	91	0	10,303	57.7	5,948	14,985	2.52
1909	6	67	0	0	0	0	0	0
1910	6	71	0	(a)	(a)	(a)	(a)	(a)
1911	3	53	0	(a)	(a)	(a)	(a)	(a)
1912	2	3	0	(a)	(a)	(a)	(a)	(a)
1913	1	2	0	0	0	0	0	0

a Included with other States having less than 3 producers.

KENTUCKY.

Kentucky is the only one of the United States whose coal supplies are drawn from any two of the great fields. The eastern counties of the State are underlain by the coal measures of the Appalachian region, and the southern extremity of the eastern interior, or Illinois-Indiana field, is worked extensively in the western part of Kentucky. Coke has been made from coal mined in both the eastern and the western parts of the State, but although the coals of the eastern counties are in large part among the high-grade coking coals of the Appalachian field, most of the coke, until the last two years, has been made in the western district. The building of ovens has followed, however, upon recent extensive coal-mining developments in the Elkhorn district of Pike and Harlan counties; the principal coking activities have shifted to the eastern part of the State; and Kentucky is now assuming some importance as a coke-manufacturing State. The production has increased from less than 50,000 tons in 1909 to 191,555 tons in 1912 and to 317,084 tons in 1913. During the last year a plant of 54 Semet-Solvay ovens was completed for the Kentucky-Solvay Co., at Ashland, and added materially to the increased production. Fifty new beehive ovens were also added, and, by a coincidence, 104 ovens were abandoned, so that the total number in existence at the close of 1913 was the same (1,049) as at the close of 1912. The Wisconsin Steel Co., which completed 300 beehive ovens at Benham, in Harlan County, in 1912, had 100 additional ovens in course of construction at the end of 1913.

The 1,049 ovens are distributed among 9 establishments, 2 of which, with a total of 220 ovens, were idle in 1913.

The quantity of coal used in the manufacture of coke in 1913 was 512,245 short tons, of which 440,480 tons were unwashed run of mine and 71,765 tons were washed slack. All the latter was used in the western district.

The following table gives the statistics of production in Kentucky in 1880, 1890, 1900, and for the last five years:

Statistics of the manufacture of coke in Kentucky, 1880–1913.

Year.	Establishments.	Ovens.		Coal used (short tons).	Yield of coal in coke (per cent).	Coke produced (short tons).	Total value of coke at ovens.	Value of coke at ovens per ton.
		Built.	Building.					
1880	5	45	0	7,206	59.0	4,250	$12,250	$2.88
1890	9	175	103	24,372	51.0	12,343	22,191	1.80
1900	5	458	3	190,268	50.2	95,532	235,505	2.47
1909	6	495	0	89,083	52.0	46,371	101,257	2.18
1910	6	495	0	104,103	51.7	53,857	120,554	2.24
1911	8	577	300	118,255	55.9	66,099	134,862	2.04
1912	9	1,049	291	307,162	62.4	191,555	513,734	2.68
1913	9	[a] 1,049	100	512,245	61.9	317,084	753,897	2.38

[a] Includes 54 Semet-Solvay and 150 rectangular ovens.

MONTANA.

Some of the coals found in Montana possess coking quality, but so far the attempts to use them for that purpose have not been entirely successful. Four plants, with a total of 451 ovens, have been built, but none of them have been in active operation for the last three years, and one establishment of 100 ovens was abandoned in 1913. All of the ovens are of the beehive type.

In the following table are given the statistics of production of coke in Montana in 1884, when the first production was reported, and in 1890, 1900, and since 1909:

Statistics of the manufacture of coke in Montana, 1884–1913.

Year.	Establishments.	Ovens.		Coal used (short tons).	Yield of coal in coke (per cent).	Coke produced (short tons).	Total value of coke at ovens.	Value of coke at ovens per ton.
		Built.	Building.					
1884	3	5	12	165	46.0	75	$900	$12.00
1890	2	140	0	32,148	45.0	14,427	125,655	8.71
1900	3	342	111	108,710	50.3	54,731	337,079	6.16
1909	5	551	3	82,993	44.7	37,069	([a])	([a])
1910	4	451	0	([a])	([a])	([a])	([a])	([a])
1911	4	451	0	0	0	0	0	0
1912	4	451	0	0	0	0	0	0
1913	3	351	0	0	0	0	0	0

[a] Included with other States having less than 3 producers.

NEW MEXICO.

All of the coke made in New Mexico is from coal mined from the Raton field in Colfax County. This field is the southern part of the Raton Mountains coal region, which consists of the Raton field in northeastern New Mexico and the Trinidad field in Colorado. The coal measures are continuous, but the producing areas are separated by a high divide near the Colorado-New Mexico line. A bank of 50 ovens at Waldo, in Santa Fe County, has not been in operation for several years. Slack coal is used in the manufacture of coke, and as over 25 per cent of the total output of the mines yielding coking coal goes into slack, an ample supply of fuel for the coke ovens is available.

There are 4 coking establishments in the State, including the one of 50 ovens at Waldo, which has been idle during the last four years.

The total number of ovens in the State has not changed since 1909, there being altogether 1,030. Deducting the 50 idle ovens there were 980 that made coke in 1912 and 1913. There has been no new construction work started during the last five years. All of the ovens in the State are of the beehive type. At Dawson, however, 446 out of a total of 570 ovens, although of beehive type in construction, are provided with underflues through which the gases are conveyed to a large flue back of the ovens and thence to the power house. The heat obtained from the oven gases renders the use of other fuel in the power plant unnecessary. The power plant, in addition to furnishing power for the operation of the mines, for ventilation, electric haulage, the coal crusher, washery, etc., furnishes also steam heat to the offices, commissary, hotel, hospital, and theater, and electric light for the city of Dawson.

The quantity of coke made in New Mexico in 1913 was 467,945 short tons, valued at $1,548,536, the maximum record both in quantity and in value. Compared with 1912 the output in 1913 showed an increase of 54,039 tons, or 13 per cent, in quantity and of $191,590, or 14.4 per cent, in value. All of the coal used is washed slack from the mines at Dawson, Koehler, and Gardiner. The quantity used in 1913 was 788,172 tons. The yield of coal in coke was 59.4 per cent.

The statistics of production in 1882, 1890, 1900, and from 1909 to 1913 are shown in the following table:

Statistics of the manufacture of coke in New Mexico, 1882–1913.

Year.	Establishments.	Ovens.		Coal used (short tons).	Yield of coal in coke (per cent).	Coke produced (short tons).	Total value of coke at ovens.	Value of coke at ovens per ton.
		Built.	Building.					
1882	2	0	12	1,500	66.0	1,000	$6,000	$6.00
1890	2	70	0	3,980	51.5	2,050	10,025	4.89
1900	2	126	0	74,261	60.3	44,774	130,251	2.91
1909	4	1,030	0	694,390	53.9	373,967	1,099,694	2.94
1910	4	1,030	0	651,494	61.6	401,646	1,306,136	3.25
1911	4	1,030	0	620,639	61.5	381,927	1,240,963	3.25
1912	4	1,030	0	679,209	60.9	413,906	1,356,946	3.28
1913	4	1,030	0	788,172	59.4	467,945	1,548,536	3.31

NEW YORK.

All of the coke made in New York is from coal mined in Pennsylvania, and it is all made in retort ovens. There are 4 establishments in the State with a total of 555 ovens, 188 of which are Otto-Hoffmann (or United-Otto, as they are now called), 281 Rothberg, and 86 Semet-Solvay. The United-Otto and Rothberg ovens are operated by the Lackawanna Steel Co., at Buffalo; 40 of the Semet-Solvay ovens are located at Solvay, near Syracuse, and 46 at the Empire Coke Works at Empire. Although New York lies entirely outside the coal-producing area, it has the distinction of being the first State in which by-product ovens were built, the first 12 Semet-Solvay ovens constructed in the United States having been erected in 1893 at Solvay. This plant was increased to 25 ovens in 1896 and to 40 ovens in 1903.

All of the 4 establishments were in operation in 1913, but the production decreased from 794,618 tons in 1912 to 758,486 tons in 1913. The value, however, increased from $3,203,133 in 1912 to $3,301,400 in

1913. The decrease in quantity was 36,132 tons, or 4.5 per cent, and the increase in value was $98,267, or 3.1 per cent. The quantity of coal used in 1913 was 1,067,207 short tons, valued at $2,640,679, or an average of $2.47 per ton. The yield of coal in coke was 71.1 per cent. Nearly all of the coal used for coke making in New York is mine-run. In 1913, 1,057,964 tons of the coal used was mine-run, of which 835,600 tons were unwashed and 222,364 tons were washed. The slack coal used consisted of 6,259 tons of unwashed and 2,984 tons of washed coal.

The statistics of the manufacture of coke in New York since 1910 are shown in the following table:

Statistics of the manufacture of coke in New York, 1910–1913.

Year.	Establishments.	Ovens.		Coal used (short tons).	Yield of coal in coke (per cent).	Coke produced (short tons).	Total value of coke at ovens.	Value of coke at ovens per ton.
		Built.	Building.					
1910	4	555	0	910,293	71.7	652,459	$2,635,873	$4.04
1911	4	555	0	955,067	71.8	686,172	2,883,990	4.20
1912	4	555	0	1,095,198	72.6	794,618	3,203,133	4.03
1913	4	a 555	0	1,067,207	71.1	758,486	3,301,400	4.35

a Includes 188 United-Otto, 281 Rothberg, and 86 Semet-Solvay ovens.

OHIO.

The coals of Ohio belong to the Appalachian province, and most of the beds are correlated with those of Pennsylvania and West Virginia to the east and southeast. But although the bituminous and semi-bituminous coals of Pennsylvania and West Virginia include the highest grade coking coals in the United States, and although those two States are first and second in rank as coal producers, the coals seem to lose their coking qualities as the beds extend westward, and a large part of the coke made in Ohio is from coal brought from West Virginia to by-product retort ovens at Kokotto, near Cincinnati, and at Cleveland. The principal beehive operations are those of the United Iron & Steel Co. at Cherry Valley, in Columbiana County, and the coal for these ovens is brought from Pennsylvania mines. On the other hand, some of the coal mined in Ohio makes a satisfactory blast-furnace fuel in the raw state, but when so used, at the present time, it is usually mixed with coke. At one time raw bituminous coal was an important factor in the iron industry of Ohio.

Ohio ranks fourth among the States as a producer of coal, but stands somewhat far down in the list of coke producers, being fourteenth in this respect in 1913. It is believed, however, that coke making is bound to become a much more important industry in the State. Ohio is second among the States in the manufacture of pig iron, and blast furnaces have been supplied largely by Connellsville coke; but, as in Illinois and Indiana, the future blast-furnace fuel in Ohio will be the product of retort ovens located at or near the points of consumption. The first installation of this kind was a bank of 50 Otto-Hoffmann ovens near Hamilton built in 1901 by the Hamilton-Otto Coke Co. A second installation of the same number of ovens was completed in 1909, and, in 1910, 49 Semet-Solvay ovens were completed at Cleveland. This plant is now being increased to 100 ovens, construction of the additional 51 ovens having been begun in 1912. In 1913 construction work also was begun on 68 Koppers ovens at Youngstown for the Republic Iron & Steel Co.

The production of coke in Ohio in 1913 was 351,846 short tons, valued at $1,231,554, against 388,669 tons, valued at $1,365,905 in 1912, a decrease in 1913 of 36,823 short tons, or 9.5 per cent in quantity and of $134,351, or 9.8 per cent in value. The decreased production in 1913 is attributed to the floods in the early part of the year and the prolonged drought in the summer and early fall.

The plant under construction at Youngstown included, there were 8 establishments in the State in 1913, with 471 ovens completed and 119 buildings at the end of the year. Of the 471 completed ovens, 29 were idle throughout the year. The active ovens consisted of 149 retort ovens and 293 beehive. The retort coke in 1913 amounted to 236,032 tons, or an average of 1,584 tons per oven, and the beehive coke to 115,814, or an average of 439 tons per oven.

The statistics of the production of coke in Ohio in 1880, 1890, 1900, and for the last five years are shown in the following table:

Statistics of the manufacture of coke in Ohio, 1880–1913.

Year.	Establishments.	Ovens.		Coal used (short tons).	Yield of coal in coke (per cent).	Coke produced (short tons).	Total value of coke at ovens.	Value of coke at ovens per ton.
		Built.	Building.					
1880	15	616	25	172,453	58.0	100,596	$255,905	$2.54
1890	13	443	1	126,921	59.0	74,633	218,090	2.92
1900	8	369	50	115,269	62.5	72,116	194,042	2.69
1909	7	447	49	340,735	65.4	222,711	683,155	3.07
1910	8	496	0	413,059	68.3	282,315	911,987	3.23
1911	8	496	0	456,222	68.2	311,382	961,904	3.09
1912	7	471	119	561,426	69.2	388,669	1,365,905	3.51
1913	7	[a] 471	[b] 119	507,417	69.3	351,846	1,231,554	3.50

[a] Includes 100 United-Otto and 49 Semet-Solvay ovens.
[b] Includes 51 Semet-Solvay and 68 Koppers ovens.

Most of the coal used for coke making in Ohio is unwashed run of mine. In 1913 the total quantity of coal carbonized was 507,417 short tons, of which 479,286 tons were unwashed mine-run, 7,726 tons were washed mine-run, and 7,414 tons were unwashed slack, and 12,988 tons were washed slack.

The character of the coal used in the manufacture of coke in Ohio in 1890, 1900, and from 1909 to 1913 is shown in the following table:

Character of coal used in the manufacture of coke in Ohio since 1890, in short tons.

Year.	Run of mine.		Slack.		Total.
	Unwashed.	Washed.	Unwashed.	Washed.	
1890	34,729	0	54,473	37,719	126,921
1900	68,175	0	17,094	30,000	115,269
1909	293,554	0	12,312	34,869	340,735
1910	333,397	0	12,212	67,450	413,059
1911	417,101	16,574	5,504	17,043	456,222
1912	506,883	23,541	15,598	15,404	561,426
1913	479,286	7,726	7,417	12,988	507,417

OKLAHOMA.

No coke has been made in Oklahoma since 1910, and of 536 ovens in existence in 1909 more than half (276) have been abandoned.

The following table gives the statistics of the manufacture of coke in Oklahoma (Indian Territory) in 1880, 1890, 1900, and from 1909 to 1913:

Statistics of the manufacture of coke in Oklahoma (Indian Territory), 1880–1913.

Year.	Establishments.	Ovens.		Coal used (short tons).	Yield of coal in coke (per cent).	Coke produced (short tons).	Total value of coke at ovens.	Value of coke at ovens per ton.
		Built.	Building.					
1880	1	20	0	2,494	62.0	1,546	$4,638	$3.00
1890	1	80	0	13,278	50.0	6,639	21,577	3.25
1900	3	230	0	79,534	48.0	38,141	152,204	3.99
1909	5	536	0	0	0	0	0	0
1910	4	408	0	(a)	(a)	(a)	(a)	(a)
1911	4	410	0	0	0	0	0	0
1912	2	260	0	0	0	0	0	0
1913	2	260	0	0	0	0	0	0

a Included with other States having less than 3 producers.

PENNSYLVANIA.

The quantity of coke produced in Pennsylvania in 1913 amounted to 28,753,444 short tons, valued at $67,929,864, against 27,438,693 tons, valued at $56,336,255, in 1912. The production in 1913, both in quantity and in value, was the maximum record for the State, and represented an increase over 1912 of 1,314,751 short tons, or 4.8 per cent, in quantity and of $11,593,609, or 20.6 per cent, in value. The features of interest in 1913 were the marked increase in value as compared with the increase in production, the decreased output in both the Connellsville and the Lower Connellsville districts, and the relative gain on the Connellsville district made by its younger neighbor the Lower Connellsville. The latter district opened in 1900 and entered its "teens" in 1913. For a number of years it has been the second coke-producing district not only in Pemmsylvania but in the United States, and is now within 25 per cent of equaling the Connellsville district as a coke producer. In 1913 the Lower Connellsville district produced 78 per cent as much coke as the Connellsville, and 31 per cent of the total output of the State.

Prices in 1913 ruled considerably higher than in 1912, quotations for Connellsville coke at the first of the year being more than double what they were at the beginning of 1912; but conditions in the two years were reversed. In 1912 there was a steady advance with the demand gradually overtaking and finally exceeding the supply, and finally almost a famine, particularly in foundry coke. In 1913, on the other hand, with a strong opening in January there was a somewhat irregular falling off in business, with a gain in supply over demand, culminating in a slump in the iron trade in October, and prices declined until in December they were down to the low level of the beginning of 1912. A study of the table of prices on page 512 would give the impression that the average for 1913 was about the same as in 1912, but it must be remembered that the larger part of the product is delivered on contracts made several months before, and most of the coke delivered in 1912 was on the low-contract basis of the early part of that year. In 1913, on account of the higher prices at the opening, contract buyers were less anxious to close and less contract coke was sold during the year; but sufficient quantities were contracted for to make the total returns for 1913 much more satisfactory to the producers than had been the case for many years. The average value per ton for Connellsville coke in 1913 was $2.23 as compared with $1.90 in 1912, whereas the averages of the higher contract monthly prices were $2.40 in 1912 and $2.42½ in 1913.

For the first time in three years there was in 1913 an increase in the number of coke ovens in operation, as compared with the preceding year, although there was a net decrease of 1 in the number of establishments. Seven establishments were abandoned during 1913, and 6 new ones were completed. The net increase in the number of ovens in 1913 as compared with 1912 was 1,302. There were 740 ovens abandoned and 2,042 new ovens constructed. Most of the new construction was in the Pittsburgh district, where 825 ovens, all of them of the Mitchell or rectangular type, were built. The Lower Connellsville district showed an increase of 211 ovens, and 224 new ovens (150 of them Didier) were added to the miscellaneous plants included under "Other districts." The number of ovens in the Connellsville district has decreased in each of the last three years, and there were 30 fewer ovens in this district in 1913 than in 1912. As noted in the report for 1912 the period of expansion in the Connellsville coke trade proper is ended, and its supersession as the leading coke-producing district in the United States at no late date is to be expected. The area of the Connellsville Basin proper is limited, and the drains upon it during the last three decades of marvelous expansion in our iron and steel industries have exhausted the most of the supply of Connellsville coal. By some authorities it is estimated that in another generation the manufacture of coke in the Connellsville district will be largely a matter of history. This reason is assigned as the principal one for the continuance of beehive-oven practice in the district, the expense of substituting retort ovens for beehive not being warranted by the short life ahead of the Connellsville coal field. This, however, was hardly true 20 years ago and is not true of the Lower Connellsville district, where the beehive or its equally wasteful companion, the rectangular oven, continues to be built. It is indeed to be hoped that with the continued construction of by-product ovens at other points, the beehive type of ovens in the Connellsville districts will be abandoned more rapidly than the coal is exhausted and that Connellsville coal will become for a while at least an important fuel for the retort ovens.

The total number of ovens in Pennsylvania increased from 53,756 in 1912 to 55,058 in 1913. Of these ovens 9,432 were idle throughout the year, nearly half of them in the Connellsville district, where 1,895 were the entire equipment of 19 establishments. There were 257 establishments that made coke in 1913, a gain of 1 over 1912, when 21 plants were idle. The 257 active establishments had 45,626 ovens in operation during the year and produced 28,753,444 tons of coke, an average of 111,881 tons of coke to each establishment and of 630 tons per oven. The 45,626 active ovens in 1913 included

1,467 of the by-product type. The active by-product ovens constituted 3.2 per cent of the total active number, and produced 2,628,680 tons of coke, or 9.1 per cent of the total output. The average production for each active retort oven was 1,792 tons of coke, and the yield of coal in coke was 75.3 per cent. The 44,159 active beehive ovens produced an average of 592 tons of coke, and the yield of coal in coke was 65.8 per cent.

At the close of 1913 there were 582 ovens in course of construction, 512 of them rectangular and 70 beehive. Eighty per cent of the new ovens (all of them rectangular) were building in the Lower Connellsville district, where this type of oven has achieved considerable popularity. The chief advantage possessed by the rectangular oven over the beehive is that the coking chamber being long and narrow like the retort oven, the coke may be pushed from it and does not have to be drawn as is the case with the beehive oven. The process of carbonization is the same—that of partial combustion.

The statistics of the production of coke in Pennsylvania for the years 1880, 1890, 1900, and for the last five years are shown in the following table:

Statistics of the manufacture of coke in Pennsylvania, 1880–1913.

Year.	Establishments.	Ovens.		Coal used (short tons).	Yield of coal in coke (per cent).	Coke produced (short tons).	Total value of coke at ovens.	Value of coke at ovens per ton.
		Built.	Building.					
1880	124	9,501	836	4,347,558	65.0	2,821,384	$5,255,040	$1.86
1890	106	23,430	74	13,046,143	65.6	8,560,245	16,333,674	1.91
1900	177	32,548	2,310	20,239,966	66.0	13,357,295	29,692,258	2.22
1909	283	54,506	2,072	36,983,568	67.3	24,905,525	50,377,035	2.02
1910	288	55,656	1,334	39,455,785	66.7	26,315,607	55,254,599	2.10
1911	279	54,904	1,271	32,875,655	66.7	21,923,935	43,053,367	1.96
1912	277	53,756	1,887	41,268,532	66.5	27,438,693	56,336,255	2.05
1913	276	[a]55,058	[b] 582	43,195,801	66.6	28,753,444	67,929,864	2.36

[a] Includes 932 United-Otto, 360 Semet-Solvay, 150 Didier, and 5,059 rectangular ovens.
[b] Includes 512 rectangular ovens.

By far the larger part of the coal used in coke making in Pennsylvania is unwashed run of mine. The coal mined in the Connellsville districts is an ideal coking coal, and requires no preparation for the coke oven, though some of it is crushed before being charged. Of the 43,195,801 short tons of coal used in 1913 for coke making in Pennsylvania, 36,621,183 tons were unwashed run of mine and 1,199,859 tons were unwashed slack. The washed coal used consisted of 2,191,944 short tons of mine run and 3,182,815 tons of slack.

The character of the coal used in the manufacture of coke in Pennsylvania in 1890, 1895, 1900, 1905, and from 1909 to 1913, has been as follows:

Character of coal used in the manufacture of coke in Pennsylvania since 1890, in short tons.

Year.	Run of mine.		Slack.		Total.
	Unwashed.	Washed.	Unwashed.	Washed.	
1890	11,788,625	303,591	630,195	323,732	13,046,143
1895	13,618,376	34,728	440,869	117,594	14,211,567
1900	17,692,623	647,045	1,300,796	599,502	20,239,966
1905	26,148,696	1,335,631	2,436,621	1,109,397	31,030,345
1909	31,712,482	2,278,927	1,016,576	1,975,583	36,983,568
1910	32,688,029	2,372,115	1,275,348	3,120,293	39,455,785
1911	27,601,050	1,958,360	1,029,149	2,287,096	32,875,655
1912	35,344,633	2,493,661	1,098,392	2,331,846	41,268,532
1913	36,621,183	2,191,944	1,199,859	3,182,815	43,195,801

Pennslyvania stands preeminent among the States in the production of coal and in the manufacture of coke. As a producer of coke Pennsylvania is relatively of greater importance than as a producer of coal, for, whereas, including the production of anthracite, Pennsylvania contributes less than half the entire output of coal in the United States, nearly two-thirds the total production of coke is made within that State. In 1913 the two principal coking districts of Pennsylvania—the Connellsville and the Lower Connellsville districts—both included in the two counties of Fayette and Westmoreland, produced 45 per cent of the coke product of the United States. Ever since coke became the principal fuel in the manufacture of iron (it superseded anthracite for this purpose in 1875) the Connellsville district has been the chief source of supply. What is known as the Lower Connellsville district came into existence in 1900, and in its 13 years of life has exhibited a rapidity in development that has outrivaled any coke-making district in the world. The Connellsville Basin proper is included in both Westmoreland and Fayette counties; the Lower Connellsville Basin is entirely in Fayette County, lies southwest of the southern end of the Connellsville Basin, and is separated from it by the Greensburg anticline. The Lower Connellsville district is now the second coke-producing district in the United States and will probably in a few years rival its older neighbor for first place. In both the Connellsville and the Lower Connellsville districts all but a very small quantity of the coke is made in beehive ovens or in rectangular ovens, in which the process is one of partial combustion, as in the beehive ovens, and without recovery of by-products or utilization of the heat generated in the coking process. With the exception of 110 Semet-Solvay ovens in the Connellsville district, all the by-product recovery ovens in Pennsylvania are outside of the coking-coal mining districts.

PRODUCTION BY DISTRICTS.

In previous chapters of this series of reports it has been customary to consider the production of coke in Pennsylvania according to certain well-defined districts. These divisions are based to some extent upon geographic boundaries, but also upon the quality of the coal mined and the coke produced. Each district has been more fully described in some of the preceding volumes, but the following brief statement regarding the territory included in the different coking districts is repeated here for the sake of convenience.

The Allegheny Mountain district includes the ovens along the line of the Pennsylvania Railroad from Gallitzin eastward over the crest of the Alleghenies to a point beyond Altoona. The Allegheny Valley district formerly included the coke works of Armstrong and Butler counties and one of those in Clarion County, the other ovens in the latter county being included in the Reynoldsville-Walston district. All but two of the Allegheny Valley plants have been abandoned, and the production is combined with that of the Allegheny Mountain district. What was previously known as the Beaver district included the ovens in Beaver and Mercer counties, but all the ovens in Beaver County have been abandoned, those formerly operated by the Semet-Solvay Co. in Mercer County have been abandoned, and the operations of the one establishment of United-Otto ovens at South Sharon are now included in the Pittsburgh district. The Blossburg and the Broadtop districts embrace the Blossburg and the Broadtop coal fields. The ovens of the Clearfield-Center district are chiefly in the two counties from which it derives its name. The Connellsville district is the well-known region of western Pennsylvania in Westmoreland and Fayette counties, extending from just south of Latrobe to Fairchance. The Lower Connellsville region is entirely in Fayette County and southwest of the Connellsville Basin proper, from which it is separated by the Greensburg anticline. It embraces the important developments in the vicinity of Uniontown and is now the second producing district of the State. The Greensburg, Irwin, Pittsburgh, and Reynoldsville-Walston districts include the ovens near the towns which have given the names to these districts. The Upper Connellsville district, sometimes called the Latrobe district, is near the town of Latrobe. The Semet-Solvay ovens at Chester, Steelton, and Lebanon, the 300 Didier ovens at South Bethlehem, and the United-Otto ovens at Lebanon are in what has been designated as the Lebanon-Schuylkill district.

Coke production in Pennsylvania in 1912 and 1913, by districts.

1912.

District.	Establishments.	Ovens.		Coal used (short tons).	Yield of coal in coke (per cent).	Coke produced (short tons).	Total value of coke at ovens.	Value of coke per ton.
		Built.	Building.					
Allegheny Mountain	25	2,483	0	1,252,141	69.6	870,951	$2,384,725	$2.74
Allegheny Valley	2	52	0	0	0	0	0	0
Connellsville	109	22,219	148	17,772,202	66.5	11,814,588	22,463,602	1.90
Lower Connellsville	74	15,525	422	13,456,074	67.1	9,023,371	17,166,837	1.90
Greensburg	7	2,040	0	1,358,845	65.8	894,271	1,883,068	2.11
Irwin	2	289	0	0	0	0	0	0
Pittsburgh	11	3,724	796	3,560,298	64.6	2,301,362	5,813,575	2.53
Reynoldsville - Walston	10	2,881	200	1,211,655	57.9	701,667	1,586,844	2.26
Upper Connellsville	22	2,749	143	1,120,295	68.1	762,700	1,564,457	2.05
Lebanon and Schuylkill Valley	5	628	150	1,215,146	70.9	861,072	2,917,244	3.39
Broadtop; Clearfield-Center	10	1,166	28	321,876	64.8	208,711	555,903	2.66
Total	277	53,756	1,887	41,268,532	66.5	27,438,693	56,336,255	2.05

1913.

District.	Establishments.	Built.	Building.	Coal used (short tons).	Yield of coal in coke (per cent).	Coke produced (short tons).	Total value of coke at ovens.	Value of coke per ton.
Allegheny Mountain and Allegheny Valley	27	*a* 2,505	0	1,300,110	69.0	897,913	$2,618,932	$2.91
Connellsville	106	*b* 22,189	60	17,379,314	66.6	11,566,778	25,830,382	2.23
Lower Connellsville	75	*c* 15,736	*d* 440	13,498,088	66.5	8,976,781	19,868,322	2.21
Pittsburgh	14	*e* 4,554	0	4,258,903	64.7	2,756,954	7,438,745	2.70
Upper Connellsville	21	*f* 2,828	*g* 82	1,244,230	65.9	820,192	1,811,353	2.21
All other districts	33	*h* 7,246	0	5,515,156	68.1	3,734,826	10,362,130	2.77
Total	276	55,058	582	43,195,801	66.6	28,753,444	67,929,864	2.36

a Includes 372 United-Otto ovens.
b Includes 110 Semet-Solvay and 1,132 rectangular ovens.
c Includes 2,271 rectangular ovens.
d Rectangular ovens.
e Includes 332 United-Otto and 1,135 rectangular ovens.
f Includes 210 rectangular ovens.
g Includes 72 rectangular ovens.
h Includes 250 Semet-Solvay, 228 United-Otto, 300 Didier, and 311 rectangular ovens.

Connellsville district.—The Connellsville district of Pennsylvania continues to be the most important coke-producing district of the world, though in the last few years it has been gradually losing its relatively exalted position in the coke production of the United States. This relative retrogression may be expected to continue as this wonderful portion of the great Pittsburgh bed approaches exhaustion, an eventuality which, according to conservative estimates, is only three or four decades distant. The beginning of the decline may have already begun, for in 1913, when for the greater part of the year prices were exceptionally high and when production for the State as a whole showed a gain of practically 5 per cent, the output in the Connellsville district decreased nearly 250,000 tons.

There were fewer ovens in the Connellsville region in 1913 than in any year since 1905, and the number has been decreasing steadily for the last three years from the maximum of 24,481 ovens in 1910. In 1913 there were 22,189 ovens in the Connellsville region, 30 fewer than in 1912. There were only 148 ovens building at the close of 1912, and only 60 ovens at the close of 1913. The number of establishments has decreased with the number of ovens, there being 106 coke-making plants in the Connellsville district in 1913 against 109 in

1912. Of the 106 plants, with 22,189 ovens, in existence at the close of 1913, 1 plant, with 42 ovens, was idle throughout the year, in addition to which there were 4,264 idle ovens at plants portions of which were in operation. Altogether there were 17,883 ovens in the Connellsville district making coke in 1913. They produced a total of 11,566,778 tons of coke, or an average of 647 tons per oven. In 1912 there were 18,151 active ovens, producing 11,814,588 tons of coke, or an average of 651 tons per oven. The average value per ton for coke made in Pennsylvania was $2.05 in 1912 and $2.36 in 1913. The average value of Connellsville coke was $2.23 in 1913, against $1.90 in 1912. The apparent lower value for Connellsville coke is due to including in the total production the output from a number of by-product plants located at distances from the mines, where the expense of transportation of the coal is added to the cost thereof, and is naturally reflected in the higher prices for the coke at the ovens. The total quantity of retort-oven coke in Pennsylvania was 2,628,680 short tons, valued at $8,238,924, or an average of $3.13 per ton, which had the effect of increasing the average value per ton of all the coke produced in the State. Of the 22,189 ovens in the Connellsville district, only 110 are of the by-product recovery type. These are Semet-Solvay ovens operated by the Semet-Solvay Co. at Dunbar. A few rectangular, or Mitchell, ovens have been constructed in the district but in them, as in the beehive ovens, the process is one of partial combustion and not of distillation.

In the following table are presented the statistics of the manufacture of coke in the Connellsville district in 1880, 1890, 1900, and from 1909 to 1913:

Statistics of the manufacture of coke in the Connellsville region, Pennsylvania, 1880–1913.

Year.	Establishments.	Ovens.		Coal used (short tons).	Yield of coal in coke (per cent).	Coke produced (short tons).	Total value of coke at ovens.	Value of coke at ovens per ton.
		Built.	Building.					
1880	67	7,211	731	3,367,856	65.5	2,205,946	$3,948,643	$1.79
1890	28	15,865	30	9,748,449	66.3	6,464,156	11,537,370	1.94
1900	98	20,981	686	14,946,659	67.0	10,020,907	22,383,432	2.23
1909	117	24,422	370	17,581,899	66.9	11,769,758	23,379,149	1.99
1910	118	24,481	206	17,205,615	66.6	11,459,601	23,121,556	2.02
1911	112	23,879	227	14,420,328	66.3	9,565,013	18,471,506	1.93
1912	109	22,219	148	17,772,202	66.5	11,814,588	22,463,602	1.90
1913	106	[a]22,189	60	17,379,314	66.6	11,566,778	25,830,382	2.23

[a] Includes 110 Semet-Solvay by-product and 922 rectangular ovens.

The following table, compiled by the Courier, of Connellsville, Pa., shows the shipments of coke, by months, from the Connellsville and the Lower Connellsville districts. The figures are given in cars and tons, with the average number of cars shipped each working day of the month, and include shipments from the Lower Connellsville district as well as from the Connellsville district proper. This authority gives the shipments in 1913 at 20,078,679 short tons, whereas the combined production of the Connellsville and Lower Connellsville district as reported to the Geological Survey amounted to 20,543,559 tons. It will be noted that in the first seven months of 1913, with one exception—April—the shipments exceeded those of 1912. The falling off in the demand for coke following the slump in the iron trade in October is exhibited in these statistics for 1913 by a decrease of 90,000 tons in the shipments for October, 260,000 tons in the shipments for November, and of nearly 400,000 tons in the shipments for December. The heaviest shipments in 1913 were in the month of January, 1,867,336 tons; in 1912 the largest shipments were in October, 1,793,432 tons. The average of the daily records of shipments in 1913 was 1,950 cars; in 1912 the average daily shipments were 1,911 cars. The highest average daily shipments were in February, 2,114 cars, and the smallest daily car record was made in December, 1,365 cars. The largest shipment of cars in any month during the last three years occurred in January of 1913, 55,148 cars; the smallest number was in December of 1913, 35,506 cars.

The monthly shipments from this region from 1909 to 1913, inclusive, reported by the Courier, are given in the following table:

Monthly shipments of coke from the Connellsville and Lower Connellsville regions, 1909–1913, in short tons.

Month.	1909	1910	1911	1912	1913
January	1,205,650	1,952,406	1,194,047	1,575,198	1,867,336
February	1,143,487	1,787,164	1,302,098	1,583,567	1,716,525
March	1,185,814	1,922,575	1,621,301	1,750,944	1,777,977
April	1,144,751	1,754,654	1,419,369	1,710,417	1,707,727
May	1,235,044	1,527,515	1,343,879	1,778,860	1,823,674
June	1,429,289	1,544,964	1,299,295	1,621,004	1,687,486
July	1,605,937	1,446,294	1,257,820	1,565,126	1,717,683
August	1,641,287	1,464,060	1,355,774	1,690,681	1,690,636
September	1,704,919	1,390,140	1,394,752	1,553,246	1,622,630
October	1,821,444	1,450,717	1,424,232	1,793,432	1,703,438
November	1,835,745	1,252,797	1,385,627	1,736,938	1,473,484
December	1,832,465	1,196,436	1,335,974	1,672,862	1,289,983
Total	17,785,832	18,689,722	16,334,168	20,032,275	20,078,579

The total shipments in cars for the last 26 years, the total number of cars in 1912 and 1913, the daily car average, and the total number of tons shipped, as reported by the Courier, are shown in the following tables:

Total and daily average shipments in cars, 1888–1913.

Year.	Daily average.	Total cars.	Year.	Daily average.	Total cars.	Year.	Daily average.	Total cars.
1888	905	282,441	1897	1,181	367,383	1906	2,385	745,274
1889	1,046	326,220	1898	1,415	441,249	1907	2,210	691,757
1890	1,147	355,070	1899	1,676	523,203	1908	1,173	368,222
1891	884	274,000	1900	1,619	504,410	1909	1,920	600,979
1892	1,106	347,012	1901	1,857	581,051	1910	1,923	598,706
1893	874	270,930	1902	1,986	624,198	1911	1,570	488,672
1894	900	281,677	1903	1,782	558,738	1912	1,911	595,336
1895	1,410	441,243	1904	1,623	510,759	1913	1,950	582,071
1896	920	289,137	1905	1,886	688,328			

Shipments of coke from the Connellsville region, including the Lower Connellsville district, in 1912 and 1913, by months.

Month.	1912			1913		
	Cars.	Daily car average.	Short tons.	Cars.	Daily car average.	Short tons.
January	46,537	1,723	1,546,892	55,148	2,042	1,868,149
February	47,212	1,888	1,560,182	50,736	2,114	1,715,917
March	52,015	2,000	1,747,959	51,454	1,979	1,728,709
April	50,862	1,956	1,697,734	51,026	1,963	1,730,183
May	53,142	1,968	1,776,415	53,287	1,974	1,817,805
June	48,959	1,958	1,635,824	49,144	1,966	1,685,635
July	46,723	1,797	1,564,377	49,223	1,823	1,710,435
August	50,244	1,861	1,704,307	48,730	1,874	1,696,368
September	45,753	1,830	1,555,483	47,150	1,813	1,649,368
October	52,443	1,940	1,782,302	48,695	1,803	1,719,045
November	51,261	1,971	1,736,888	41,972	1,679	1,496,000
December	50,185	2,007	1,692,510	35,506	1,365	1,280,287
Total	595,336	1,911	20,000,873	582,071	1,950	20,097,901

As Connellsville coke is recognized as the standard for the United States and governs largely the prices for the product of other districts, the following table is given showing the prices for furnace and foundry coke, by months, during the years 1911 to 1913. These prices are quoted from The Iron Age and are for strict Connellsville coke. "Main Line" and "outside" cokes are usually quoted from 15 to 20 cents below the strict Connellsville.

During the last three years there seems to have been some disposition to get away from the buying of coke on six months' contract for delivery, and accordingly two sets of statistics for prices have developed—one for spot coke and one for contract, usually made for six months at a time. As a general thing the contract prices are higher than spot, the latter being frequently made on unsold coke which happens to be thrown upon the market, but not always so. During 1911 the prices for Connellsville coke were low. Spot coke ranged steadily below contracts. In the latter part of 1912, however, and in January of 1913 spot coke was in active demand and famine prices were realized, from $4.25 to $4.50 being obtained for spot coke, while a portion of the deliveries were on contracts made the previous summer, when prices were from $2.40 to $2.50 per ton. The steady advance in prices in 1912 and the almost equally steady decline in 1913 are clearly exhibited in this statement. The high average of the spot furnace coke in 1912 was $3.85 to $4 in November, and the high average for 1913 was in January, $3.50 to $4.15. The average value per ton for Connellsville coke was $1.90 in 1912 and $2.23 in 1913, from which it appears that the price quotations do not exactly harmonize with the actual receipts by the producers.

Prices of Connellsville furnace and foundry coke per short ton at ovens, 1911–1913, by months.

Month.	Furnace.					
	1911		1912		1913	
	Spot.	Contract.	Spot.	Contract.	Spot.	Contract.
January	$1.40 to $1.55	$1.70 to $2.00	$1.75 to $1.85	$1.65 to $1.70	$3.50 to $4.15	$3.15 to $3.25
February	1.45 to 1.55	1.70 to 1.75	1.75 to 1.80	1.75 to 1.80	2.25 to 3.00	2.50 to 3.00
March	1.50 to 1.65	1.70 to 2.00	1.85 to 2.25	1.75 to 1.80	2.30 to 2.40	2.50
April	1.60 to 1.65	1.80 to 2.00	2.10 to 2.60	2.15 to 2.25	2.00 to 2.25	2.25
May	1.50 to 1.65	1.75 to 1.85	2.10 to 2.50	2.25 to 2.35	2.00 to 2.20	2.25
June	1.40 to 1.50	1.55 to 1.85	1.90 to 2.10	2.25 to 2.35	2.10 to 2.15	2.25
July	1.45 to 1.55	1.55 to 1.75	2.15 to 2.25	2.25	2.25 to 2.50	2.25 to 2.50
August	1.45 to 1.55	1.60 to 1.65	2.15 to 2.25	2.25	2.50	2.50
September	1.50 to 1.55	1.60 to 1.70	2.15 to 2.50	2.25 to 2.50	2.15 to 2.50	2.25 to 2.50
October	1.50 to 1.55	1.55 to 1.70	2.65 to 4.00	2.50 to 3.00	2.00 to 2.15	2.10 to 2.25
November	1.50 to 1.55	1.50 to 1.75	3.85 to 4.00	3.00 to 3.25	1.75 to 1.90	1.90 to 2.00
December	1.50 to 1.80	1.60 to 1.75	4.00	3.25	1.75	1.80 to 1.85

Month.	Foundry.					
	1911		1912		1913	
	Spot.	Contract.	Spot.	Contract.	Spot.	Contract.
January	$1.90 to $2.50	$2.25 to $2.50	$1.90 to $2.00	$2.10 to $2.15	$4.25 to $4.50	$3.60 to $4.00
February	2.10 to 2.50	2.25 to 2.50	2.00 to 2.25	2.10 to 2.25	3.00 to 3.50	3.00 to 3.50
March	2.00 to 2.50	2.25 to 2.40	2.25 to 2.75	2.25 to 2.50	3.00	3.00
April	2.00 to 2.00	2.25 to 2.40	2.50 to 2.75	2.50 to 2.75	3.00	3.00
May	1.75 to 2.00	2.10 to 2.40	2.50 to 2.75	2.40 to 2.65	2.75 to 3.00	2.90 to 3.00
June	1.75 to 2.00	2.00 to 2.40	2.40	2.40 to 2.60	2.75 to 2.85	3.00
July	1.85 to 2.00	2.10 to 2.40	2.40	2.40 to 2.60	2.75	3.00
August	1.95 to 2.00	2.00 to 2.50	2.40	2.50	2.90	3.00
September	1.85 to 2.00	2.10 to 2.40	2.40 to 2.75	2.50 to 2.75	2.90	3.00
October	1.85 to 2.00	2.10 to 2.40	3.00 to 4.25	3.00 to 3.75	2.75 to 2.90	3.00
November	1.85 to 2.00	2.10 to 2.40	4.25	3.75	2.50 to 2.65	2.75
December	1.90 to 2.00	2.10 to 2.25	4.25 to 4.50	3.75 to 4.00	2.50	2.60 to 2.75

Lower Connellsville district.—This district is now the second in importance among the coke-making districts of the United States. It bids fair to rival the Connellsville district within a few years. The first ovens were built in 1900, so that at the close of 1913 the district was only a little more than 13 years old. The production in 1912 was 9,023,371 short tons and in 1913 it was 8,976,781, indicating a slight decrease. The value, however, increased from $17,166,837 in 1912 to $19,868,322, the average price per ton rising from $1.90 in 1912 to $2.21 in 1913.

There was a gain of 211 in the total number of ovens in existence at the close of the year, as against a decrease of 30 ovens in the Connellsville district, and there were 440 ovens building at the close of the year in contrast with only 60 building in the Connellsville district. The number of establishments in the Lower Connellsville district increased from 74 to 75. There were 2 idle establishments with a total of 86 ovens, and 1,377 additional ovens idle belonging to plants operated for a portion of the year. The rectangular or Mitchell ovens have found their greatest favor in the Lower Connellsville district, there being 2,271 of this type in existence at the close of the year and 430 building. There are no by-product recovery ovens in the district.

The record of coke production in the Lower Connellsville district in 1900, 1905, and from 1909 to 1913 is as follows:

Statistics of the manufacture of coke in the Lower Connellsville district, Pennsylvania, 1900, 1905, and 1909–1913.

Year.	Establishments.	Ovens.		Coal used (short tons).	Yield of coal in coke (per cent).	Coke produced (short tons).	Total value of coke at ovens.	Value of coke at ovens per ton.
		Built.	Building.					
1900	12	2,033	1,112	579,928	66.5	385,909	$792,886	$2.05
1905	45	7,484	1,145	5,666,812	68.3	3,871,310	7,532,382	1.95
1909	70	14,215	1,036	9,781,803	69.1	6,761,335	12,490,518	1.85
1910	73	14,805	668	12,130,425	67.8	8,219,492	16,048,675	1.95
1911	71	14,857	654	10,771,495	68.3	7,354,736	12,998,192	1.77
1912	74	15,525	422	13,456,074	67.1	9,023,371	17,166,837	1.90
1913	75	[a]15,736	[b]440	13,498,088	66.5	8,976,781	19,868,322	2.21

[a] Includes 2,271 rectangular ovens. [b] Rectangular ovens.

The combined production of the Connellsville, Upper Connellsville, and Lower Connellsville districts in 1913 amounted to 21,363,751 tons, as compared with 21,600,659 tons in 1912. All the other coke-producing districts in Pennsylvania, including the by-product ovens at Lebanon, Steelton, South Bethlehem, and Chester, amounted to 7,389,693 short tons, valued at $20,419,807. The three Connellsville districts produced 74 per cent of the total for Pennsylvania.

TENNESSEE.

The eastern part of Tennessee is crossed, in a northeast-southwest direction, by the coal measures of the Appalachian province. Coal is mined in 17 counties and coke is made in 8. The counties in which coke is made are Campbell, Grundy, Hamilton, Marion, Morgan, Rhea, Roane, and Sequatchie. The larger part of the workable coal in the State occurs in three basins, the Wartburg, the Walden, and the Sewanee. (See report on production of coal, 1910.) Each of these basins contains a number of workable coal beds, as many as seven having been noted in the Walden Basin. Nearly all of the Tennessee coals possess coking qualities, but not all to the same degree, as is attested by the number of idle ovens during the last six years. There are 15 establishments in the State with a total of 2,427 ovens (157 less than in 1912), of which 6 with a total of 768 ovens were idle. In addition to the idle plants there were 370 idle ovens at establishments which operated some of their ovens during the year. The 1,289 active ovens, all of which are of the beehive type, produced 364,578 tons of coke in 1913, a decrease of 5,498 tons as compared with 1912, when 370,076 tons were produced by 1,466 active ovens. The value decreased from $951,853 to $925,430. There were no new ovens in course of construction in either 1912 or 1913.

The statistics of the manufacture of coke in Tennessee in 1880, 1890, 1900, and from 1909 to 1913, are shown in the following table:

Statistics of the manufacture of coke in Tennessee, 1880–1913.

Year.	Establishments.	Ovens.		Coal used (short tons).	Yield of coal in coke (per cent).	Coke produced (short tons).	Total value of coke at ovens.	Value of coke at ovens per ton.
		Built.	Building.					
1880	6	656	68	217,656	60.0	130,609	$316,607	$2.42
1890	11	1,664	292	600,387	58.0	348,728	684,116	1.96
1900	14	2,107	340	854,789	55.6	475,432	1,269,555	2.67
1909	16	2,792	0	493,283	53.1	261,808	667,723	2.55
1910	16	2,792	0	597,658	54.0	322,756	959,104	2.97
1911	15	2,547	30	628,118	52.6	330,418	797,758	2.41
1912	15	2,584	0	685,861	54.0	370,076	951,853	2.57
1913	15	2,427	0	694,085	52.5	364,578	925,430	2.50

Nearly all of the coal used for coke making in Tennessee is washed before being charged into the ovens. In 1913 the total quantity of coal used was 694,085 tons, of which 669,758 tons (202,014 tons of mine-run and 467,744 tons of slack) were washed. The unwashed coal was 24,327 tons of slack.

Character of coal used in the manufacture of coke in Tennessee, 1890, 1900, and 1909–1913, in short tons.

Year.	Run of mine.		Slack.		Total.
	Unwashed.	Washed.	Unwashed.	Washed.	
1890	255,359	0	273,028	72,000	600,387
1900	150,697	349,448	24,122	330,522	854,789
1909	30,361	285,591	0	177,331	493,283
1910	41,650	346,769	0	209,239	597,658
1911	0	283,203	0	344,915	628,118
1912	0	189,887	86,678	409,296	685,861
1913	0	202,014	24,327	467,744	694,085

VIRGINIA.

All the coking coals of Virginia are contained in a few counties lying in the extreme southwestern portion of the State and within the coal fields of the Appalachian province. The development of this region began in 1883 with the completion of the New River division of the Norfolk & Western Railway, and for 10 years the manufacture of coke, as well as the production of coal, in Virginia was almost entirely from Tazewell County. Ten years from the opening of the district, or in 1893, the Norfolk & Western Railway completed a branch up the Clinch Valley and opened in Wise County what is now the most important coking-coal district in the State. During 1906 and 1907 extensive developments in what is known as the Black Mountain field in Lee County followed the construction into that district of the Black Mountain Railway, now operated jointly by the Southern Railway and the Louisville & Nashville Railroad.

The principal coke-making activities are in Wise County, which now produces nearly 90 per cent of the total coke output of the State and considerably more than that proportion of the coal used in its manufacture. The coal for the ovens in Tazewell County is drawn from mines whose workings extend across the State boundary line into West Virginia, and a part of the coal, probably the greater part, comes from the West Virginia side of the line. The ovens at Low Moor and Covington draw their supplies of coal from the New River district of West Virginia.

There are 18 establishments in the State, with a total of 5,695 ovens. Coke was made at all 18 plants in 1913, but 2,406 ovens, more than 40 per cent of the total number, were idle. The production, however, increased from 967,947 short tons, valued at $1,815,975, in 1912 to 1,303,603 tons, valued at $2,840,275, in 1913. The gain amounted to 335,656 tons, or 34.7 per cent, in quantity and to $1,024,300, or 56.4 per cent, in value. In two earlier years, 1909 and 1910, the output exceeded that of 1913, but in the value of the product 1913 exceeded all previous records. The output in 1910 was larger than that of 1913 by 190,000 tons, but fell below the value of the later year by more than $100,000.

The statistics of the manufacture of coke in Virginia in 1883, when the first operations were begun, and in 1890, 1900, and from 1909 to 1913, are shown in the following table:

Statistics of the manufacture of coke in Virginia, 1883–1913.

Year.	Establishments.	Ovens.		Coal used (short tons).	Yield of coal in coke (per cent).	Coke produced (short tons).	Total value of coke at ovens.	Value of coke at ovens per ton.
		Built.	Building.					
1883	1	200	0	39,000	65.0	25,340	$44,345	$1.75
1890	2	550	250	251,683	66.0	165,847	278,724	1.68
1900	7	2,331	300	1,083,827	63.2	685,156	1,464,556	2.14
1909	19	5,469	100	2,060,518	65.1	1,347,478	2,415,769	1.79
1910	18	5,389	100	2,310,742	64.6	1,493,655	2,731,348	1.83
1911	18	5,496	100	1,425,303	63.9	910,411	1,615,609	1.77
1912	18	5,408	0	1,555,969	62.2	967,947	1,815,975	1.88
1913	18	5,695	100	2,015,259	64.7	1,303,603	2,840,275	2.18

All the coal used in the manufacture of coke in Virginia is of exceptionally high grade, and none of it requires preparation other than crushing before being charged into the ovens. The character of the coal used is nearly evenly divided between run of mine and slack. The total quantity of coal consumed in the manufacture of coke in 1913 was 2,015,259 short tons, of which 916,808 tons were mine run and 1,098,451 tons were unwashed slack.

The following table shows the character of the coal used in coke making in Virginia in 1890, 1900, and from 1909 to 1913:

Character of coal used in the manufacture of coke in Virginia, 1890–1913, in short tons.

Year.	Run of mine.		Slack.		Total.
	Unwashed.	Washed.	Unwashed.	Washed.	
1890	98,215	0	153,468	0	251,683
1900	620,207	0	463,620	0	1,083,827
1909	1,405,111	0	655,407	0	2,060,518
1910	1,554,784	0	755,958	0	2,310,742
1911	675,497	0	749,806	0	1,425,303
1912	793,019	0	762,950	0	1,555,969
1913	916,808	0	1,098,451	0	2,015,259

WASHINGTON.

Washington is the only Pacific coast State possessing coal of coking quality, but the coking industry is restricted to a limited area in Pierce County. The coal mined in the northern part of the Roslyn field in Kittitas County (the only coal field in Washington east of the Cascades) is of coking grade, but no attempt at producing coke from it commercially has been made. There are 6 establishments in the State, with a total of 331 ovens; but 3 of the plants, 1 of 50 ovens and 2 of 25 ovens each, have been idle for several years, the entire production being from 3 establishments in the Wilkeson-Carbonado field of Pierce County. The production in 1913 was the largest in the history of the State, amounting to 76,221 short tons, valued at $432,770, and exceeding that of 1912 by 26,961 tons, or 54.7 per cent, in quantity and $153,665, or 55 per cent, in value. Most of the coke is consumed by the smelter at Tacoma. All of the coal used for making coke in 1913 was washed run of mine.

The first ovens were built in Washington in 1885, but 400 tons of coke were made in pits the preceding year.

The statistics of production in 1884, 1890, 1900, and from 1909 to 1913 are as follows:

Statistics of the manufacture of coke in Washington, 1884–1913.

Year.	Establishments.	Ovens.		Coal used (short tons).	Yield of coal in coke (per cent).	Coke produced (short tons).	Total value of coke at ovens.	Value of coke at ovens per ton.
		Built.	Building.					
1884	1	0	0	700	57.0	400	$1,900	$4.75
1890	2	30	80	9,120	64.0	5,837	46,696	8.00
1900	2	90	0	54,310	61.5	33,387	160,165	4.80
1909	6	285	0	69,708	61.7	42,981	240,604	5.60
1910	6	285	0	94,223	63.0	59,337	347,540	5.86
1911	5	235	0	60,201	66.6	40,180	216,262	5.38
1912	6	313	0	78,693	62.6	49,260	279,105	5.67
1913	6	331	0	118,786	64.2	76,221	432,770	5.68

WEST VIRGINIA.

The manufacture of coke in West Virginia is far from keeping pace with the progress shown by that State in the mining of coal, in spite of the fact that, next to Pennsylvania, West Virginia possesses more wealth in supplies of high-grade coking coals than any other State in the Union. The production of coal in West Virginia in 1913 exhibited an increase over 1912 of 4,523,295 short tons, and reached a total of 71,308,982 tons, whereas the output of coke showed an insignificant gain of 6,766 tons, or only a little more than one-fourth of 1 per cent. The coke production in 1913 in this State was but 5 per cent larger than in 1900 and was less than the output of either 1909 or 1910 by more than one-third. The reasons assignable for this actually stationary and relatively retrogressive condition are found in the almost entire absence of an iron industry in the State and the now somewhat rapid shifting of the coke-making activities from the coal-mining regions to the consuming centers, as the beehive ovens are being replaced by the more economical by-product retorts. But while no advance is being made by West Virginia in the manufacture of coke, larger quantities of West Virginia coal are being used for coke making in other States, most of the retort ovens in Ohio, Indiana, and Illinois drawing their coal supplies from West Virginia mines. The quantity of coal made into coke in West Virginia in 1913 was 4,034,251 short tons, whereas inquiries as to the source of the coal made into coke in retort ovens outside of the coking-coal regions developed the information that 7,546,674 tons, or nearly twice as much as that consumed in West Virginia, were from the mines of that State.

In coke making, as in coal mining, West Virginia is handicapped by having relatively little home consumption for her products. As a coal producer this State ranks second only to Pennsylvania and has in a number of years held the same rank in the manufacture of coke, but has now fallen behind both Alabama and Indiana. Only a small proportion of either product is consumed within the State, fully 80 per cent of the coal mined and nearly all of the coke produced being shipped to consumers in other States, usually at prices to the producers much below those obtained for lower grades from other districts.

The quantity of coke made in West Virginia in 1913 was 2,472,752 short tons, valued at $5,504,416, against 2,465, 986 tons, valued at $4,692,393, in 1912. The increase in quantity was only 6,766 tons, but the increase in value amounted to $812,023, or 17.3 per cent, and was due to the general advance in the prices of coke which prevailed during the early part of the year.

With the exception of 120 Semet-Solvay ovens at Benwood, near Wheeling, all the ovens in West Virginia are of the beehive type. It is to be noted that the average yield of coal in coke in West Virginia is only about 61 per cent, notwithstanding the fact that a large part of the coal used for making coke in the State contains only from 15 to 20 per cent of moisture and volatile matter. The coal should yield about 80 per cent in coke. The difference in actual results is due to the necessity of burning off at least one-fourth of the fixed carbon in the beehive oven in order to secure the heat necessary to produce a high-grade cellular coke. When it is considered that in the retort ovens to which West Virginia coal is shipped the theoretical yield is practically obtained, the shifting of coking activity from the mining districts of West Virginia to the industrial centers of the Middle West is not difficult to understand.

The number of coke-making establishments decreased from 129 in 1912 to 124 in 1913. Six plants with a total of 964 ovens were abandoned, and 1 new plant was added to the Upper Monongahela district, notwithstanding more than half the plants and ovens in the district were idle. The total number of ovens abandoned in 1913 was 1,342 and the net decrease in the number of ovens in the State was 1,238, reducing the total from 19,064 in 1912 to 17,826 in 1913. Of the 1,342 ovens abandoned in 1913, 381 were in the Pocahontas district, 149 were in the New River district, and 807 were in the upper Potomac district. Of the 17,826 ovens in existence in 1913, considerably more than half, or 9,129, were idle. The greatest percentage of idleness was in the Tug River district, where out of a total of 2,151 ovens 1,493 were idle. Nearly half of the ovens in the Pocahontas district and a little over half each in the Kanawha, the New River, and the Upper Potomac districts were idle.

In the following table will be found the statistics of the manufacture of coke in West Virginia in 1880, 1890, 1900, and for the last five years:

Statistics of the manufacture of coke in West Virginia, 1880–1913.

Year.	Establishments.	Ovens.		Coal used (short tons).	Yield of coal in coke (per cent).	Coke produced (short tons).	Total value of coke at ovens.	Value of coke at ovens per ton.
		Built.	Building.					
1880	18	631	40	230,758	60.0	138,755	$318,797	$2.30
1890	55	4,060	334	1,395,266	60.0	833,377	1,524,746	1.83
1900	106	10,249	1,306	3,868,840	60.9	2,358,499	4,746,633	2.01
1909	138	20,283	126	6,361,759	62.0	3,943,948	7,525,922	1.91
1910	135	19,912	230	6,226,234	61.1	3,803,850	7,354,039	1.93
1911	138	19,876	130	3,754,561	60.4	2,291,049	4,236,845	1.85
1912	129	19,064	0	4,061,702	60.7	2,465,986	4,692,393	1.90
1913	124	[a]17,826	35	4,034,251	61.3	2,472,752	5,504,416	2.23

[a] Includes 120 Semet-Solvay ovens at Benwood.

The larger part of the coal used in coke making in West Virginia (nearly 70 per cent) is slack. In 1913, out of a total of 4,034,251 short tons of coal consumed in coke-making operations, 2,879,048 tons were slack. Of that quantity 2,525,919 tons were unwashed and 353,129 tons were washed. The total quantity of mine-run coal used was 1,155,203 tons, of which 916,068 tons were unwashed and 239,135 tons were washed coal. The total quantity of coal washed, including mine-run and slack, was 592,264 short tons, or 14 per cent of the total quantity of coal consumed in the manufacture of coke in the State.

The character of the coal used in the manufacture of coke in West Virginia in 1890, 1900, and from 1909 to 1913 is shown in the following table:

Character of coal used in the manufacture of coke in West Virginia, 1890–1913, in short tons.

Year.	Run of mine.		Slack.		Total.
	Unwashed.	Washed.	Unwashed.	Washed.	
1890	324,847	0	930,989	139,430	1,395,266
1900	509,960	8,000	3,140,064	210,816	3,868,840
1909	2,282,403	32,285	3,644,271	402,800	6,361,759
1910	2,088,553	234,484	3,462,927	440,270	6,226,234
1911	925,460	158,308	2,408,299	262,494	3,754,561
1912	1,146,620	143,309	2,433,229	338,544	4,061,702
1913	916,068	239,135	2,525,919	353,129	4,034,251

PRODUCTION BY DISTRICTS.

It has been customary in the preceding reports of this series to consider the coke production by the districts into which the State has been divided. These districts are known, respectively, as the Upper Monongahela, the Upper Potomac, the Kanawha, the New River, and the Flat Top. The first two are in the northern part of the State and are named from the rivers, the Monongahela and the Potomac, by whose headwaters they are drained. The other three districts are in the southern part of the State. The New River district includes the ovens along the line of the Chesapeake & Ohio Railway and its branches from Quinnimont to Hawks Nest, near which point the coals of the New River region go below water level. The Kanawha district embraces all of the ovens along Kanawha River and its tributaries from Mount Carbon to the western limit of the coal fields. The ovens of the Gauley Mountain Coal Co. at Ansted are included in the New River district, although the Ansted coal belongs in realty to the coal series of the Kanawha district and lies about 1,000 feet above the New River coals. The Flat Top region is drained by the upper portions of New, Guyandotte, and Big Sandy Rivers, and includes the ovens in West Virginia, which belong to the Pocahontas coal field. The Flat Top district is by far the most important and bears the same relation to the production of West Virginia that the Connellsville district bears to that of Pennsylvania. Since 1900 the statistics of production of the Flat Top district have included the new operations along Tug River lying west of and continuous with the Flat Top district. The output from the Flat Top-Tug River district averages somewhat more than 50 per cent of the total coke production of the State.

The statistics of the production of coke in West Virginia, by districts, in 1912 and 1913 are shown in the following table:

Production of coke in West Virginia in 1912 and 1913, by districts.

1912.

District.	Establishments.	Ovens.		Coal used (short tons).	Yield of coal in coke (per cent).	Coke produced (short tons).	Total value of coke at ovens.	Value of coke at ovens per ton.
		Built.	Building.					
Flat Top [a]	53	11,280	0	2,094,283	56.6	1,185,978	$2,057,456	$1.73
Kanawha	10	1,628	0	499,085	62.2	310,350	515,508	1.66
New River	20	1,709	0	290,805	62.0	180,190	426,475	2.37
Upper Monongahela	33	2,873	0	887,612	66.6	591,243	1,326,661	2.24
Upper Potomac and Tygarts Valley	13	1,574	0	289,917	68.4	198,225	366,293	1.85
Total	129	19,064	0	4,061,702	60.7	2,465,986	4,692,393	1.90

1913.

District.	Establishments.	Ovens.		Coal used (short tons).	Yield of coal in coke (per cent).	Coke produced (short tons).	Total value of coke at ovens.	Value of coke at ovens per ton.
		Built.	Building.					
Flat Top [a]	52	10,952	0	2,047,926	58.8	1,203,690	2,543,953	2.11
Kanawha	10	1,628	0	533,035	61.8	329,618	700,559	2.12
New River	19	1,561	0	322,070	60.1	193,418	489,071	2.53
Upper Monongahela	34	[b] 2,918	0	793,508	64.9	515,189	1,279,614	2.48
Upper Potomac and Tygarts Valley	9	767	35	337,712	68.4	230,837	491,219	2.12
Total	124	17,826	35	4,034,251	61.3	2,472,752	5,504,416	2.23

[a] Includes Tug River district.

[b] Includes 120 Semet-Solvay ovens.

OTHER STATES.

In the following table are presented statistics of the production of coke in those States in which there are three or less establishments, and for which permission to give separate publication has not been granted. Permission has been given to give separate publication for the operations of the Camden Coke Co.'s plant, and New Jersey, therefore, is not included in "Other States" in the present report. Kansas, which was also included in "Other States" in 1912, is dropped this year because all the ovens have been idle, and, in fact, have been practically abandoned. Six States are therefore included in the report for 1913 against 8 in 1912. The 6 States included are Maryland, Massachusetts, Michigan, Minnesota, Utah, and Wisconsin. These 6 States have 9 establishments with a total of 2,005 ovens, all but those of Utah being of the by-product recovery type. The total production for the 6 States included in this table in 1913 was 2,345,329 short tons, valued at $9,354,765, or an average of $3.99 per ton. Of the 6 States, Maryland, Michigan, Minnesota, and Wisconsin obtain their coal from mines in other States, Massachusetts obtains its supply from Nova Scotia and West Virginia; the Utah ovens are supplied from mines within the State.

Statistics of coke production from 1900 to 1905 and from 1909 to 1913 in States having only one or two establishments.

Year.	Establishments.	Ovens.		Coal used (short tons).	Yield of coal in coke (per cent).	Coke produced (short tons).	Total value of coke at ovens.	Value of coke at ovens per ton.
		Built.	Building.					
1900	10	832	594	708,295	71.5	506,730	$1,454,029	$2.87
1905	12	1,666	145	2,222,723	74.7	1,660,857	5,500,337	3.31
1909	20	2,553	563	3,427,732	73.3	2,509,306	9,129,282	3.64
1910	29	2,878	563	4,903,129	75.1	3,684,276	14,509,072	3.94
1911	23	2,850	95	4,002,047	75.6	3,023,607	10,989,538	3.63
1912	11	2,006	174	3,623,019	69.8	2,530,018	9,386,978	3.71
1913	9	[a] 2,005	[b] 210	3,299,345	71.1	2,345,329	9,354,765	3.99

[a] Includes 495 Semet-Solvay and 752 United-Otto ovens.
[b] All Koppers ovens.

BORAX.

By Charles G. Yale and Hoyt S. Gale.

PRODUCTION AND VALUE OF CRUDE BORATE MATERIALS IN 1913.

In 1913 the production of crude borate materials in the United States was 58,051 short tons, valued at $1,491,530, as compared with 42,315 tons in 1912, valued at $1,127,813. This is an increase of 37.19 per cent in the total quantity produced. All of this material consists in various degrees of purity of the mineral colemanite (calcium borate), which is derived from several mines in southern and southeastern California. The value of the product as here given is fixed on a basis of $1 per unit per cent of anhydrous boric acid (boron trioxide, B_2O_3) in the raw material as shipped, which is approximately the present price at the mine or point of shipment.

The statistics of production of borate ores in California from 1895 to 1913, inclusive, are given in the following table:

Production of borate of lime, or colemanite, in California, 1895–1913.

Year.	Quantity.	Value.	Year.	Quantity.	Value.
	Short tons.			Short tons.	
1895	[a] 5,959	$595,900	1905	[b] 46,334	$1,019,154
1896	[a] 6,754	675,400	1906	[b] 58,173	1,182,410
1897	[a] 8,000	1,108,000	1907	[b] 52,850	1,121,520
1898	[a] 8,000	1,120,000	1908	[b] 25,000	975,000
1899	[a] 20,357	1,139,882	1909	[b] 41,434	1,534,365
1900	[a] 25,837	1,013,251	1910	[b] 42,357	1,201,842
1901	[a] 23,231	1,012,118	1911	[b] 53,330	1,569,151
1902	[a] 20,004	2,538,614	1912	[b] 42,315	1,127,813
1903	[b] 34,430	661,400	1913	[b] 58,051	1,491,530
1904	[b] 45,647	698,810			

[a] Refined product. [b] Crude product.

REVIEW OF CONDITIONS OF INDUSTRY.

Source of domestic material.—All the borax in the United States continues to be produced from ores derived from California (see Pl. II), mainly from a few mines in Inyo and Los Angeles counties, though small quantities were produced in 1913 in Ventura County. During 1913 the Russell Borate Co., in Ventura County, ceased operations and the mine was sold to a San Francisco firm, operations as conducted having been unprofitable. In the same county the National Borax Co. also closed its mine and plant, and the property reverted to the United States Borate Co. through failure to meet payments.

This is the old Columbus or Calm Bros. mine, and the National Borax Co. was organized as a holding company to finance the United States Borate Co. Since the close of 1913 the extensive holdings of F. M. Smith in the Pacific Coast Borax Co. have been sold to the Borax Consolidated (Ltd.), of London, England, the transaction involving payment of about $4,000,000. The sale includes the famous Lila C. borax mine in the Death Valley region of Inyo County.

Thus far there has been no output of borax from the potash properties in the Searles Lake region, San Bernardino County, where the promoters expect to obtain borax as a by-product of the potash mining operations.

An unconfirmed report of new deposits near Kramer, Kern County, Cal. (sec. 22, T. 11 N., R. 8 W. San Bernardino meridian), appeared in the San Francisco newspapers in October, 1913. The reported deposits have not been examined by any member of the Survey, nor has any direct information concerning them been obtained.

Price.—According to price quotations in the trade journals the prices of borax and boric acid have not fluctuated or changed noticeably from those obtaining in recent years. They are as follows:[1] Borax, crystals, in bags, 3¾ to 4½ cents a pound; borax, crystals, in barrels, 4 to 4½ cents a pound. Boric acid, crystals, 7 to 7½ cents a pound; boric acid, powdered, 7 to 7½ cents a pound.

Tariff.—The tariff act, as passed and approved October 3, 1913, reads as follows:

DUTIABLE LIST.

Schedule A.—Chemicals, oils and paints:
Boric acid, ¾ cent per pound.
Soda, borate of, or borax refined, ½ cent per pound.

FREE LIST.

Borax, crude and unmanufactured, and borate of lime, soda, and other borate material, crude and unmanufactured, not otherwise provided for in this section.

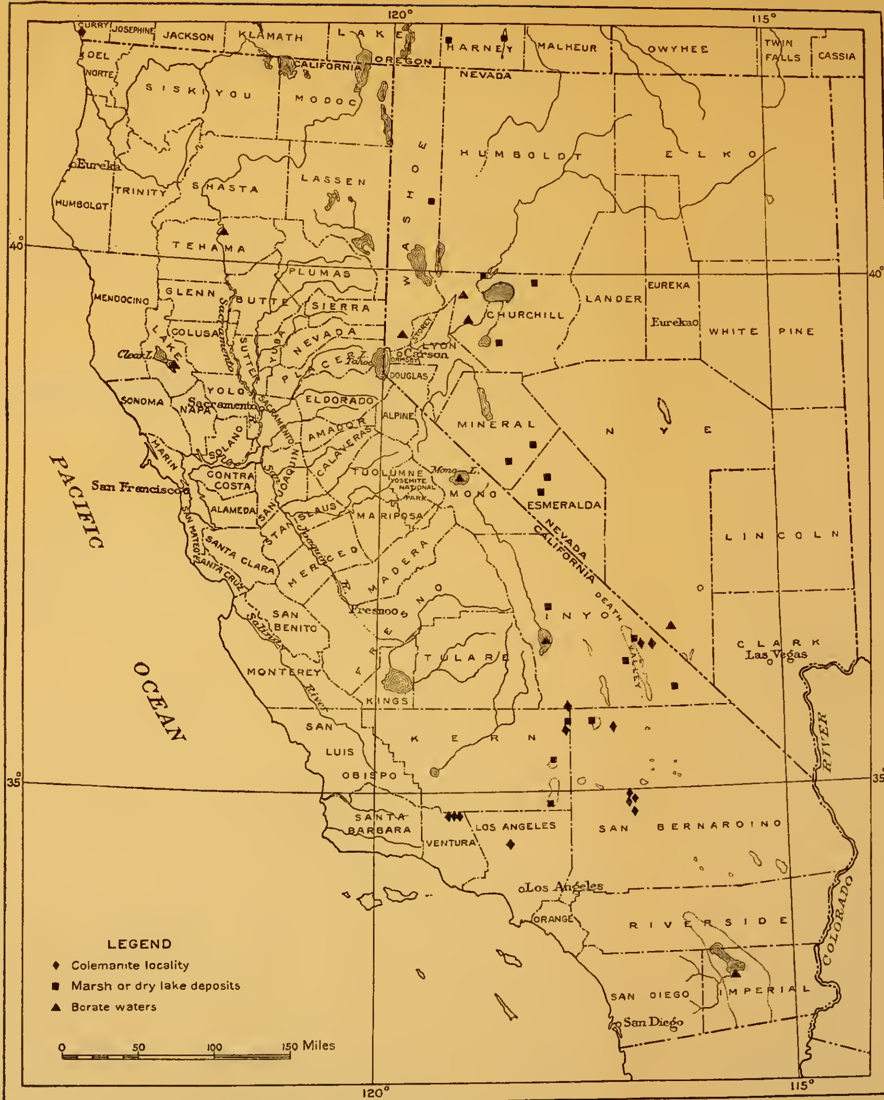
IMPORTS.

The following table shows the imports of borax and borates into the United States from 1902 to 1913, inclusive:

Imports for consumption of borax and borates into the United States, 1902–1913, in pounds.

Year.	Borax.		Borates, calcium and sodium (crude) and refined sodium borate.		Boric acid.	
	Quantity.	Value.	Quantity.	Value.	Quantity.	Value.
1902	684,537	$20,795	186,807	$12,002	822,907	$30,439
1903	68,978	5,727	146,654	13,280	693,619	28,011
1904	153,952	10,569	89,447	6,630	708,815	27,658
1905	166,960	8,802	20,395	1,626	676,105	22,372
1906	791,425	27,343	57,711	2,436	986,021	33,200
1907	2,268,065	77,258	2,959	175	534,524	23,547
1908	641,632	22,058	40	4	385,064	14,702
1909	7,124	1,023	20,284	1,956	265,985	8,708
1910	6,860	1,170	563	66	336,466	11,164
1911	9,582	732	28,815	5,230	458,900	17,666
1912	9,280	636	16,091	1,861	232,545	8,752
1913	4,215	477	7,900	1,025	423,215	16,932

[1] Oil, Paint, and Drug Reporter, New York, market quotations, wholesale.



MAP SHOWING BORAX DEPOSITS IN THE UNITED STATES.

HISTORY OF THE BORAX INDUSTRY.

The history of the borax industry has been repeatedly reviewed and summarized, and accounts of the occurrence of borate minerals in various parts of the world have appeared from time to time. In the following bibliography is to be found about as complete an account of this history and of the occurrence of these materials as can at present be given in summary. For further study of the subject reference may be had to the originals cited.

BIBLIOGRAPHY.

By Hoyt S. Gale.

The following bibliography of publications relating to borax and borates is arranged in order of publication.

1844.

Hayes, A. A., Hydrous borate of lime; Am. Jour. Sci., 1st ser., vol. 47, p. 215, 1844.
Quotes an early analysis of borate of lime from Iquique, Chile, where it was associated with gypsum, magnesia alum, sodium iodate, and glauberite.

1857.

Veatch, J. A. (under date of June 28, 1857), quoted in report on the Mineral Resources of the States and Territories west of the Rocky Mountains, Washington, pp. 178–185, 1867.
An interesting narrative account of the first recognition of borax and boric acid in natural waters on the Pacific coast and the steps then taken for the further investigation and development of these resources. Borax crystals were first observed by Dr. Veatch forming in the residue from the evaporation of waters from Lick Springs in Tehama County, Cal., on January 8, 1856. They were recognized as borax by the crystal form, the determination being later confirmed by chemical test. Dr. Veatch describes his visit to and examination of Clear Lake, Borax Lake, and Sulphur Bank, and the later finding of the crystals of borax in the mud on the bottom of Borax Lake.

1859.

Veatch, J. A., Occurrence of boracic acid in the sea water of the Pacific (paper read before the society Jan. 17, 1859); California Acad. Sci. Proc., vol. 2, pp. 7–8, 1863.
Dr. Veatch mentions that he had in the month of January, 1856, discovered borate of soda in solution in the water of a mineral spring in Tehama County, Cal., and that prosecuting the research he had found traces of boric acid in the form of borates in nearly all the mineral springs with which the State of California abounds. He relates how he found boric acid also in salt derived from solar evaporation of the sea water along the Pacific coast, and following this, showed the presence of appreciable quantities of boric acid in the sea water off the coast—a maximum near San Diego and in diminishing quantity northward, until barely perceptible in specimens of water brought from beyond Oregon. This peculiarity seems to extend to no great distance seaward; no trace found 30 or 40 miles out.

1861.

Forbes, David, On the geology of Bolivia and southern Peru: Geol. Soc. London Quart. Jour., vol. 17, p. 7, 1861. (Read Nov. 21, 1860.)
Describes salines near Iquique and also occurrences scattered over the whole arid portion of the west coast. These are defined as post-Tertiary. A list of saline minerals found is given, which are ascribed to a marine origin supposed to be the desiccated products of lagoons of sea water elevated by crustal movement. The origin of nitrates and borates is particularly referred to. (It may be added by way of comment on this paper that the list of saline minerals given is probably capable of other interpretation, as the minerals, common salt, thenardite, glauberite, gypsum, and probably most of the others mentioned, characterize continental as well as marine salines.

How, H., Natro-boro-calcite and another borate occurring in the gypsum of Nova Scotia: Am. Jour. Sci., 2d ser., vol. 32, p. 9, 1861. (See also Philos. Mag., 4th ser., vol. 35, p. 31, 1868; vol. 41, p. 270, 1871.)

In the gypsum beds of Windsor, Nova Scotia, ulexite, howlite, and cryptomorphite are found, associated with anhydrite, selenite, mirabilite, salt, aragonite, and calcite.

Veatch, J. A., Boracic acid in the sea water of the Pacific on the coast of California: Chem. News, July 13, p. 16, 1861.

Notes boric acid in sea water of Pacific coast in July, 1857. In January of 1856 discovered borate of soda and other borates in solution in the water of a mineral spring in Tehama County. (This may be a quotation from the California Acad. Sci. Proc.)

1863.

Forbes, David, On the chemical composition of some Chilian minerals: Philos. Mag. and Jour. Sci., 4th ser., vol. 25, London, pp. 113–114, 1863.

Finding a calcium borate (hayesine), either ulexite or bechilite, actually in process of deposition at the hot springs of Banos del Toro, in the Cordilleras of Coquimbo, Chile, the author believes volcanic origin of borate minerals to be confirmed.

1865.

Whitney, J. D., Geological survey of California, vol. 1, p. 96, 1865.

Describes Clear Lake, about 65 miles northwest of Suisun Bay, and 36 miles from the Pacific, the volcanic evidences, the hot springs, and the relations to them of Borax Lake, which occupies a depression on the east side of the narrow arm of Clear Lake. An analysis of water from Borax Lake collected in September, 1863, is quoted, showing 2,401.56 grains of solid matter per gallon, of which about one-half is NaCl, one-fourth Na_2CO_3, and 281.48 grains of anhydrous biborate of soda (=535.08 crystallized borax). Contains notes as to the occurrence of distinct borax crystals imbedded in the muds at the bottom of Borax Lake. Also describes the "Sulphur Banks" near by.

1866.

Whitney, J. D., On borax in California: Am. Jour. Sci., 2d ser., vol. 41, pp. 255–258, 1866.

Quotation from Geological survey of California, vol. 1, p. 96, with additional note from the San Francisco papers quoting production from the Borax Lake locality.

1867.

Browne, J. R., Mineral resources of the States and Territories west of the Rocky Mountains, pp. 178–187, 1867.

Consists chiefly of the quotation from J. A. Veatch already referred to (1857), but includes notes as to foreign sources of borax at that time, the production in California, and the process of working at Borax Lake in Lake County. The mud was taken from the lake bottom through cofferdams which could be moved from place to place and then bailed out. The fine crystals were formed in the upper layer of soft mud to a depth of about 6 feet, which were separated by solution in hot water and redeposited by cooling. Below the top stratum was a stiff blue mud containing the largest crystals which were picked out by hand, the mud being too stiff to be treated by washing. It was, of course, recognized that a great deal of borax was also present in solution in the waters of the lake

1873.

Chase, A. W., On the Oregon borate of lime: Am. Jour. Sci., 3d ser., vol. 5, p. 287, 1873.

Describes mineral afterward named priceite, in what appears to be a unique deposit at Chetco, Curry County, Oreg. When found it lay as an outcrop of a white substance like chalk in the banks of a little stream 500 yards from the sea and about 20 feet above it. Upon mining it was shown to be in the form of distinct bowlders or rounded masses imbedded in a tough blue clay.

Silliman, B., Mineralogical notes on Utah, California, and Nevada, with a description of priceite, a new borate of lime: Am. Jour. Sci., 3d ser., vol. 6, pp. 128–133, 1873.

Adds further notes and analyses of the mineral priceite, on the occurrence of ulexite in the Western States and of borax from "the eastern slope of the Sierra Nevada, not far from Walker's Pass" [probably China Lake or Searles Lake.]

1877.

DIEULAFAIT, L., Annales chim. et phys., 5th ser., vol. 12, p. 318, 1877.

Boric acid exists in the waters of all the oceans and contrary to chemical expectation it is concentrated in the last mother liquor.

KING, CLARENCE, U. S. Geol. Expl. 40th Par., vol. 2, pp. 594, 744, 1877.

In the Humboldt River valley above Osino Canyon, saline incrustations yielded on analysis 52 per cent soluble alkaline salts, chiefly carbonate of soda, 4½ per cent of the water-soluble part being borax.

Near Brown's station, opposite Humboldt Lake, a quantity of saline incrustation found covering the ground was collected, mixed with the fine impalpable soil of the valley. Analysis showed the salts to be about one-half sodium chloride, a considerable proportion of sulphate and carbonate of soda, and 11.3 per cent borax.

PHILLIPS, J. A., The alkaline and boracic lakes of California: Pop. Sci. Rev., vol. 16 (2d ser., vol. 1), pp. 153–164, London, 1877; Kansas City Rev., vol. 1, pp. 225–235, 1878.

A very interesting account (for this date) of Owens and Mono lakes, with the earliest recorded analysis of the water of the former. Contains descriptions as a result of a visit made in 1866 to the two borax lakes near Clear Lake, Lake County, Cal., of the occurrence of the borax crystals in the mud on the lake bottom and the method of recovering same by means of cofferdams. Notes the manipulation at Little Borax Lake of ulexite brought from Wadsworth, Nev., to be treated here on account of the presence of carbonate of sodium and the cheapness of fuel. Notes an occurrence of borax in the bed of an ancient lake near Walker's Pass, mentions "similar deposits in Panamint and Death valleys in lower Nevada; but these desolate tracts have not as yet received so careful an examination as they deserve." Ulexite in the Cane Spring district, and at the Hot Springs in northwestern Nevada are also referred to. Finally notes as to the purification of crude borax (tincal) are added, with the remark that recent discovery of large quantities of borates in Nevada "will, no doubt, eventually to some extent affect the Tuscan producers of boric acid."

1878.

SCHLAGINTWEIT, H. VON, München Acad. Sitzungsb., vol. 8, p. 518, 1878.

Describes the great borax deposits of the Puga Valley, in Ladak, in northern British India, where the mineral covers the ground over a large area to an average depth of 3 feet. The borate is a deposit from hot springs, which issue more than 15,000 feet above sea level, at a temperature ranging from 54° to 58° C. The saline mass contains free boric acid and sulphur, with lesser quantities of salt, ammonium chloride, magnesium sulphate and alum, and there is much gypsum in the vicinity. No ulexite was found.

1880.

KYLE, J., J. J., La boronatrocalcita de la Provincia de Salta (Argentina): Soc. cient. argentina Anales, vol. 10, p. 169, 1880.

Describes ulexite associated with glauberite from the Province of Salta and refers to its existence in Catamarca.

LOCK, C. G. W., Pandermite, a new boracic mineral: Soc. Arts Jour., vol. 28, pp. 767–768, Aug. 6, 1880.

Pandermite, named from its port of shipment, Panderma, was found on the Tchinar-son, a small stream feeding Rhyndacus River, whose outlet is in the Sea of Marmora, about 40 miles (English) from Panderma, on the Asiatic shore. The field is situated in a region of Tertiary rocks, including granite, trachyte, and columnar basalt, also characterized by hot and mineral springs. The pandermite occurs as a stratum at the bottom of an enormous bed of gypsum, 60 to 150 feet in thickness, the borate mineral occurring in the form of closely packed nodules of irregular size and shape and weighing as much as a ton. The mineral resembles a snow-white fine-grained marble. The material has for some time been shipped to Europe as a source of borax and boric acid.

1882.

AYERS, W. O., Borax in America: Pop. Sci. Monthly, vol. 21, pp. 350–361, July, 1882.
A good description from personal observation of the workings for borax at Borax Lake and Hachinhama in the vicinity of Clear Lake, Cal., and also of the occurrence of borax and ulexite at Columbus Marsh, Nev. This account records the discontinuance of the crystal borax washings at Borax Lake (1864–1868), "when it ceased, not from failure of the supply, but simply from mismanagement of the work." The other locality, Hachinhama, on the southern side of Clear Lake, about 4 miles west of Borax Lake, was then operated. Here no borax had already crystallized, and only the solution in the lake water was available. This was concentrated by boiling and the borax crystallized by cooling. Later, as this small, shallow lake became more nearly or quite dry, the surface efflorescence of salts was scraped and was purified by resolution and crystallization as before. This process was continued until the spring of 1872, when the ulexite from the Nevada marsh deposits began to be brought in, and was used to increase the yield from the Hachinhama waters. This continued until 1874, when the large supply of borax from Nevada fields made the work in these California lakes unprofitable. Then follows a description and discussion of the deposits at Columbus Marsh, Nev.

DARTON, N. H., On a new locality for hayesine and its novel occurrence: Am. Jour. Sci., 3d ser., vol. 23, pp. 458–459, 1882.
Describes a mineral from Bergen Hill, N. J., identified as hayesine, with the formula $CaB_2O_7+3H_2O$ calculated from an analysis. It occurs with datolite and calcite in cavities in trap rock, as an asbestos-like, soft, fibrous mass.

1883.

HANKS, H. G., Report on the borax deposits of California and Nevada: California State Min. Bur. Third Ann. Rept., pt. 2, pp. 1–102, 1883.
An extended review of the subject of borax, including its ancient history, its early production and refining, the history of its discovery in the United States, many quotations concerning these subjects and reports of occurrences, together with a map of localities in California and Nevada. Besides the description of the discovery and workings near Clear Lake in California, accounts are given of Searles Lake (p. 26), the Death Valley fields, the discovery of colemanite in the Calico district, and the Desert or Cane Springs deposits. Descriptions of Nevada localities are given as follows: Columbus Marsh, Sand Springs, Teels Marsh, Rhodes Marsh, Fish Lake Valley, and Pyramid Lake. The use of a hand spectroscope in a test for boric acid is described, as also other chemical methods for its detection and determination. A review of the methods of recovery from the Tuscan fumaroles is also given by quotation. Statistical data are followed by descriptions of borate minerals and salts.

ANON., Borax: U. S. Geol. Survey Mineral Resources, 1882, pp. 566–577, 1883.
A short and general review of the whole field, including the history of the development of the industry in this country, presumably by abstract from previous publications; a short description of Fish Lake Marsh, Columbus Marsh, Rhodes Marsh, Teels Marsh; and references to borax workings at Sand Springs, at Hot Springs on the Central Pacific Railroad, at Soda Lake near Ragtown in Nevada, and to developments at Slate Range Marsh (Searles Lake), at Furnace Creek in Death Valley, and at Resting Springs in California. Mention is made of reported discovery of borax in Soda Lake, the sink of Mohave River. Statistics of production from 1873–1882 are quoted. Price of borax in New York is quoted as 13½ cents a pound for refined and 10½ to 11 cents for crude. The tariff is quoted as 5 cents a pound on refined borax and boric acid, ranging to 4 cents and 3 cents on other materials carrying boric acid.

1884.

HANKS, H. G., California minerals: California State Min. Bur. Fourth Ann. Rept., pp. 80–93, 311–314, and 391–394, 1884.
Mineralogical descriptions of borax, priceite, pandermite, colemanite, ulexite, contained in a list of California minerals, including description of tests, etc.; reference to history of production, largely by abstract from the report of the preceding year, but with some additional data.

JACKSON, A. W., On colemanite, a new borate of lime: Am. Jour. Sci., 3d ser., vol. 28, p. 447, 1884.

A new borate of lime recently determined by J. T. Evans, of the California Acad. Sciences, as $2CaO.3B_2O_3.5$ aq., and differing from pandermite in containing 5 instead of 3 molecules of water; gives crystallographic determination on specimens. Short note. No locality references.

1885.

DIEULAFAIT, L., Nouvelle contribution à la question de l'origine de l'acide borique; eaux de Montecatini (Italie): Compt. Rend., vol. 100, pp. 1240–1243, 1885.

Boric acid with lithium and strontium occur in the waters of Montecatini, and as these rare minerals signalize the sea-water solution particularly, the belief is expressed that these salines of Montecatini are derived from formations which have been derived from ancient lakes or lagoons, the unusual association being naturally concentrated in the last mother liquors of sea waters.

EVANS, J. T., The chemical properties and relations of colemanite: California Acad. Sci. Bull. 2, January, 1885.

Deduces the formula $2CaO.3B_2O_3.5H_2O$ and compares formulas of pandermite, $2CaO.3B_2O_3+3H_2O$, and priceite, $3CaO.4B_2O_3+6H_2O$.

JACKSON, A. W., On the morphology of colemanite: California Acad. Sci. Bull. 2, p. 3, 1885.

A crystallographic description of colemanite. Statement is made that colemanite was discovered by R. Neuschwander in October, 1882, in southern California, and named after W. T. Coleman, of San Francisco.

ANON., Borax: U. S. Geol. Survey Mineral Resources, 1883–84, pp. 859–863, 1885.

Contains an announcement of the discovery of new deposits of borates in Death Valley, Inyo County, at Desert Springs, Kern County, and in the eastern part of the Calico district, San Bernardino County, Cal. A decline in the price of borax until it reached 8½ cents in New York and 8 cents in San Francisco is recorded, including mention of a new tariff bill which had temporarily raised the price. Statistics of production are quoted. A description of the methods of working in Fish Lake Valley, Nevada, taken from a Candelaria newspaper, reviews the apparatus and operations in some detail.

1886.

ANON., Borax: U. S. Geol. Survey Mineral Resources, 1885, pp. 491–493, 1886.

Continued decline in the price of borax is noted, the San Francisco selling price being 6 to 8 cents per pound. Statistics of production are given, and also statement of imports. The condition of the industry is summarized in the statement: "Only the practice of the strictest economy has enabled existing companies to continue operations till the present time."

1887.

GOOCH, F. A., A method for the separation and estimation of boric acid, with an account of a convenient form of apparatus for quantitative distillations: U. S. Geol. Survey Bull. 42, pp. 64–72, 1887.

ANON., Borax: U. S. Geol. Survey Mineral Resources. 1886, pp. 678–680, 1887.

Statistics of production and imports. Price in San Francisco May, 1887, was 5 to 6 cents for concentrated or refined borax.

1888.

ANON., Senate Rept. No. 2332, pt. 2, 50th Cong., 1st sess., pp. 205–218 [June 18, 1888].

BECKER, G. F., Geology of the quicksilver deposits of the Pacific coast: U. S. Geol. Survey Mon. 13, pp. 265, 347–349, 440, 1888.

Incidental to the main subject of the monograph, Borax Lake, Lake County, Cal., is described and a very complete analysis of its waters given (p. 265), which shows 5 grams per liter of borax in solution (about 6¼ per cent of the total salts, the dissolved constituents amounting to about 8 per cent of the original solution). The relation of this district to former volcanic activity is pointed out.

A very complete analysis of the water from Steamboat Springs, Nev., is given (p. 347), showing water that contains borax to the amount of about 11 per cent of the total dissolved salts, the water, however, being dilute, carrying only about 0.28 per cent dissolved salts.

Reference is made (p. 440) to the probable ultimate source of borax in these natural waters, ascribing as a rational explanation a source in volcanic emanations from some deep-seated positions.

Biddle, H. J., Notes on the surface geology of southern Oregon: Am. Jour. Sci., 3d ser., vol. 35, p. 476, 1888.
Incidentally mentions occurrence of ulexite in Warner Valley, Oreg., observed in summer of 1887.

Anon., Borax: U. S. Geol. Survey Mineral Resources, 1887, pp. 4–9, 1888.
Statistics of production.

Witting, F., Die Boraxfabrication aus Boronatrocalcite: Zeitschr. angew. Chemie, vol. 17, pp. 483–487. (The manufacture of borax from boronatrocalcite.)
Discusses the manufacture of borax in Germany from the crude boronatrocalcite obtained in the north of Chile, at Maricunga, Pedernal, and at Ascotan. Process consists of the following steps: Boiling of the borate of lime with soda; working up the residual mud; fine crystallization; and working up the lyes. The process is reviewed in some detail.

Witting, F., On the manufacture of borax from boronatrocalcite: Soc. Chem. Ind. Jour., vol. 7, p. 748, 1888.
Review in English of paper in Zeitschr. angew. Chemie, pp. 483–487. 1888.

1889.

Hake, C. N., An account of a borax lake in California: Soc. Chem. Ind. Jour., pp. 854–857, 1889.
The borax works at Borax [Searles] Lake, San Bernardino County, Cal., are described as a result of a visit of a month or six weeks, while work on these deposits was in progress. A sketch of the Searles Basin and salt deposits with small map of the salt and borax deposits is included. The data given are mostly observations of a general nature, but include some analyses, descriptions of methods of working for borax, etc.

Hanks, H. C., On the occurrence of hanksite in California: Am. Jour. Sci., 3d ser., vol. 37, p. 63, 1889.
Some general notes as to Searles Lake [Borax Lake] in San Bernardino County, Cal., with special reference to the occurrence there of the mineral hanksite.

Whitfield, J. E., Analyses of natural borates and borosilicates: U. S. Geol. Survey Bull. 55, pp. 56–59, 1889.
Analyses and descriptions of minerals: Colemanite from Death Valley, Cal.; priceite from Curry County, Oreg.; pandermite from the island of Panderma, in the Black Sea; and ulexite from Rhodes Marsh, Nev.

1890.

Chatard, T. M., Natural soda; its occurrence and utilization: U. S. Geol. Survey Bull. 60, 1890.
Incidental to the discussion of the general topics of the paper, notes borate content of waters of Owens and Mono lakes, which show B_4O_7 0.32 per cent of the dissolved salts, the latter being 5.1 per cent of the weight of the original water sample.

Crossman, J. H., Borax: California State Min. Bur. Ninth Ann. Rept., p. 225, 1890.
A single paragraph concerning developed fields in California.

De Groot, H., The Searles borax marsh, California: California State Min. Bur. Tenth Ann. Rept., pp. 534–539, 1890.
The plant, property, and operations of the San Bernardino Borax Co. at Searles Lake, Cal., with a review of the history and the general features of the desert basin; a quotation of the old Searles deep well log to a depth of 230 feet; an account of the origin of the salts and the minerals found there; description of the methods of manufacture of borax.

Mather, J. W., and others, Borax and its products; tariff hearings before the Committee on Way and Means; 51st Cong., 1st sess., Misc. Doc. 176, p. 361, 1890.
Statements as to the importance of the borax industry in the United States and argument for more stringent regulations for the imposition of duty on foreign borate products. The law of 1883 is said to have made duty on refined borax and boric acid 5 cents a pound, on commercial boric acid 4 cents, and 3 cents on crude orax, borate of soda, and borate of lime, but that boracic acid had been on free list until then.

Anon., Borax: U. S. Geol. Survey Mineral Resources, 1888, p. 5, 1890.
Contains only a brief statement of production and price—6 cents a pound.

1891.

Soc. Chem. Ind. Jour., p. 367, 1891.

An English patent (No. 2526, Feb. 17, 1890) "deals with the manufacture of borax from pandermite. It has not been accomplished by heating this mineral with soda, probably because the lime and boric acid therein are not in the right proportions for conversion into borax."

Witting, F., Borax from boronatrocalcite: Zeitschr. angew. Chemie, p. 367 1891.

1892.

Anon., The history of borax in the United States: Eng. and Min. Jour., vol. 54, pp. 247–248, 1892.

Review of the history of the industry, including the discovery and working of the colemanite deposits in the Calico district, California.

Kemp, J. F., Borax: Eng. and Min. Jour., vol. 53, p. 8, 1892.

A short review of the boron minerals; localities of occurrence; manufacture and uses.

Scheuer, ——, Überblick über die Industrie der Borsäure und des Borax [Review of the boric acid and borax industry]: Zeitschr. angew. Chemie, pp. 241–248, 1892.

In 1870 Germany took up the borax and boric acid industry, and now produces enough to cover home consumption. Review of uses of borax and boric acid, also of the sources of these materials.

Stassfurt boracite (stassfurtite) occurs in the salt mines as roundish white nodules, from the size of a barleycorn to that of a bead, imbedded in the salt. Its composition is approximately expressed $2Mg_3B_8O_{15}+MgCl_2$. Stassfurtite is decomposed by sulphuric acid, yielding boric acid and magnesium sulphate which are recovered by crystallization.

The conditions governing the conversion of boric acid into borax are summarized. (See review, Soc. Chem. Ind. Jour., vol. 2, pp. 683–685, 1892.

Spears, J. R., Illustrated sketches of Death Valley and other borax deserts of the Pacific coast, pp. 13–226, Rand, McNally & Co., 1892.

A popularized account of the historical record of Death Valley and vicinity; the discovery of borax minerals; the location of Searles Lake for borax; the early history of the Nevada borax marshes, etc.

Yale, C. G., Borax: U. S. Geol. Survey Mineral Resources, 1889 and 1890, pp. 494–506, 1892.

This chapter again reviews the history of the discovery and development of the industry in California and Nevada, giving notes on most of the localities of production or attempted production. Reference is made to the attempted workings at Soda Lake near Ragtown, at Sand Springs, and at Hot Springs, Nev. De Groot's article (1890) on Searles Lake, Cal., is quoted. The Calico colemanite deposits discovered in 1883 are noted as being actively worked, and Rhodes Marsh, Columbus Marsh, Nev., the Chetco deposits in Oregon, and in Saline Valley in California are described and production noted. The price for these years is reported as 6½ to 7 cents a pound.

1893.

Storms, W. H., Mineral resources of San Bernardino County, Cal.: California State Mining Bur., Eleventh Ann. Rept., pp. 345–348, 1893.

Describes deposits of colemanite at Borate in the Calico mining district near Daggett, Cal., and offers an explanation as to their origin. This statement is probably the first advocating a lacustrine origin for the colemanite in the tuffs, sandstones, and clays.

Anon., Borax: U. S. Geol. Survey Mineral Resources, 1891, pp. 587, 588, 1893.

A brief review of conditions of the borax industry, with statistics of production. The price of borax is stated as 6½ to 7½ cents a pound.

U. S. Geol. Survey Mineral Resources, 1892, p. 5, 1893.

Contains merely a statement of production of borax for the year.

1894.

Anon., Borax: U. S. Geol. Survey Mineral Resources, 1893, pp. 734–736, 1894.

Contains a statement of production and imports of borax.

1895.

U. S. Geol. Survey Sixteenth Ann. Rept., pt. 4, Mineral Resources, 1894, p. 13, 1895.
Statement of production of borax for the year 1894.

1896.

U. S. Geol. Survey Seventeenth Ann. Rept., pt. 3, continued, Mineral Resources. 1895, p. 11, 1896.
Statement of production of borax for the year 1895.

1897.

U. S. Geol. Survey Eighteenth Ann. Rept., pt. 5, continued, Mineral Resources, 1896, pp. 14–15, 1897.
Statement of production of borax for the year 1896.

1898.

U. S. Geol. Survey Nineteenth Ann. Rept., pt. 6, continued, Mineral Resources, 1897, p. 9, 1898.
Statement of production of borax for the year 1897.

1899.

U. S. Geol. Survey Twentieth Ann. Rept., pt. 6, continued, Mineral Resources, 1898, pp. 16–17, 1899.
Statement of production of borax for the year 1898.

1901.

Buttgenbach, H., Gisements de borate des Salinas Grandes de la République Argentine; propriétés optiques de l'ulexite; Soc. géol. Belgique Annales, vol. 28, M, p. 99, 1901.
Ulexite formed at Salinas Grandes, Province of Jujuy, Argentina, is described in some detail. Analyses of ulexite given. The boric acid of the ulexite is regarded as of volcanic origin. Microscopic study of ulexite; distinction of ulexite from hayesine; general observations concerning the mode of origin of the deposits.

U. S. Geol. Survey Twenty-first Ann. Rept., pt. 6, continued, Mineral Resources, 1899, pp. 18–19, 1901.
Statement of production of borax for the year 1899.

U. S. Geol. Survey Mineral Resources, 1900, p. 21, 1901.
Statement of production of borax for the year 1900.

Newton, William, A new system for the manufacture of borax and nitrates: Soc. Chem. Ind. Jour., vol. 20, pp. 324–325, 1901. London.
Refers to difficulties encountered in usual methods of heating for evaporation of solutions of crude borates and nitrates, evidently from the Chilean deposits. Suggests a method of evaporation and stirring by direct application of all the hot combustion gases from the furnace by passing them through the liquid under pressure.

1902.

Bailey, G. E., The saline deposits of California: California State Min. Bur. Bull. 24, pp. 33–90, 1902.
Contains general review of history of the borax industry; fluctuations in market price; statistics of production in California and of imports until 1902. Review of the California localities by counties; short descriptions of localities at Bennetts Wells, Confidence, Furnace Creek, Mount Blanco, Owens Lake, Resting Springs, Saline Valley, Salt Wells Valley, Tecopa, and Amargosa Canyon in Inyo County; Buckhorn Springs, China Lake, Indian Springs, Cane Springs, and El Paso Wells in Kern County; Borax Lake and Lake Hachinhama, and other borate springs in Lake County; Colorado Desert in Riverside and San Diego counties; Calico district, Cave Springs, China Lake, Coyote Holes or Willow Springs Lake, Lone Star, Lone Willow, Soda Lake, the sink of Mohave River, Owl Springs, Palma Lake, Saratoga Springs, Searles Lake, and other playas and springs in San Bernardino County; the Lick or Tuscan Springs in Tehama County, and the colemanite deposits of Ventura County. A list of springs reported or possibly containing borates and a short review of processes of manufacture of refined borax are given.

CAMPBELL, M. R., Reconnaissance of the borax deposits of Death Valley and Mohave Desert: U. S. Geol. Survey Bull. 200, 23 pp., 1902.

Presents in the form of an itinerary a summary of observations on the occurrence of lake beds and of borate minerals and other geologic data along a route traversed by the author in the year 1900. The trip constituted a large circuit crossing the Mohave Desert and passing through Death Valley and Panamint and Owens valleys. The colemanite deposits were at that time generally regarded as products of the dessication of ancient extinct lakes, and it was assumed that general study of the lake beds might lead to the discovery of borate deposits elsewhere than were then known. The observations recorded along the route form an interesting commentary for further study of the geology and physiography of the region.

CAMPBELL, M. R., Reconnaissance of the borax deposits of Death Valley and the Mohave Desert: Eng. and Min. Jour., vol. 74, pp. 517–519, 1902.

An account covering much the same ground as U. S. Geol. Survey Bull. 200.

DENNIS, W. B., A borax mine in southern Oregon: Eng. and Min. Jour., vol. 73, pp. 581–582, 1902.

Describes marsh borax deposits in Harney County, Oreg., said to cover 10,000 acres of lowland immediately south of Lake Alvord. The crude salt incrustation said to show 5 to 20 per cent boric acid, which was then (April 25, 1902) being worked with an annual production of 400 tons, shipped by mules 130 miles to Winnemucca, Nev.

EAKLE, A. S., Colemanite from southern California; a description of the crystals and of the method of measurement with two-cycle goniometer: California Univ. Dept. Geology Bull., vol. 3, No. 2, pp. 31–50, 1902.

Detailed crystallographic description of colemanite from various localities including crystal measurements and drawings.

STRUTHERS, JOSEPH, Borax: U. S. Geol. Survey Mineral Resources, 1901, pp. 869–872, 1902.

A short review of the borax industry by Joseph Struthers, containing statements of production and imports, and notes concerning operations in this country and abroad. Announcement is made of the installation of the refining plants at Daggett, Cal., during 1901, to work the low-grade colemanite-bearing shales ("mud" deposits), of continued production from the colemanite deposits at Borate north of Daggett, and of the development and production from the colemanite mines in Ventura County, Cal. Notes concerning the marsh deposits in Harney County, Oreg., then producing. The foreign borate fields in Argentina, Chile, Russia, Turkey, are briefly mentioned. The price of borax during 1901 was reported as 7 to 7¾ cents a pound.

VERNADSKY, W. S., and POPOFF, S. P.: Zeitschr. prakt. Geologie, p. 79, 1902.

On the peninsula of Kertch, near the sea of Azov, Crimea, south Russia, borax occurs among the erupted substances of the so-called mud volcanoes. It effloresces on the surface of the dried mud, and is more or less mixed with salt and soda.

1903.

CAMPBELL, M. R., Borax deposits of eastern California: U. S. Geol. Survey Bull. 213, pp. 401–405, 1903.

An abstract of material presented in Bulletin 200 relating particularly to the noted occurrences and developments of borate minerals.

GILES, W. B., Bakerite (a new borosilicate of calcium) and howlite from California: Mineralog. Mag., vol. 13, pp. 353–355, 1903.

The discovery and naming of a new mineral, bakerite, a borosilicate of calcium ($8CaO.5B_2O_3.6SiO_2.6H_2O$), is announced, and the occurrence noted of this and of howlite, another borosilicate of calcium ($4CaO.5B_2O_3.2SiO_2.5H_2O$) previously recorded only from Nova Scotia, at the California borax mines near Daggett, where the latter is said to occur in immense quantities. Analyses of specimens from this locality are given.

HART, EDWARD, Death Valley, Cal., and its borax industry: Am. Ceramic Soc. Trans., vol. 5, pp. 64–73, 1903.

An interesting narrative, with map and pictures, of a trip from Daggett to Saratoga Springs and Morrisons, made during the time when borax operations were at their maximum at Daggett.

MAGUIRE, D., American borax mines: Mines and Minerals, pp. 298–300, February, 1903.

A popular account of the history of borate discoveries and developments (cf. California State Mining Bur. Third Ann. Rept., 1883).

Spurr, J. E., Descriptive geology of Nevada south of the fortieth parallel and adjacent portions of California: U. S. Geol. Survey Bull. 208, pp. 189-190, 1903.

Reference to the colemanite deposits on Furnace Creek as interbedded in the Tertiary sedimentary series, deposited by the evaporation of waters of an inclosed lake which is supposed to have been of great dimensions. Discussion of geologic relations of the Tertiary and other terranes.

1904.

Stafford, O. F., Mineral resources and mineral industry of Oregon for 1903: Oregon Univ. Bull., new ser., vol. 1, No. 4, p. 6, 1904.

Brief quotations from Mineral Industry concerning the borate deposits south of Lake Alvord, Harney County, and the priceite deposit near Chetco in Curry County.

Bailey, G. E., The desert dry lakes of California: Min. and Sci. Press, vol. 89, pp. 138, 161, 174, 192-193, 205-206, 222-223, 241-242, 255, 1904.

Popularized magazine accounts, made up chiefly from former publications, much by direct quotation.

Cortese, Emilio, A quicksilver deposit: Eng. and Min. Jour., vol. 78, pp. 741-742, Nov. 10, 1904.

Describes three centers of solfataric emanation similar to the soffioni of Tuscany, the waters of which contain saline compounds, together with boric acid, ammonium, chloride, etc., in the Chaguarama Valley, Venezuela, noting also the occurrence of cinnabar in sandstone.

Herrick, C. L., Lake Otero, an ancient salt lake basin in southeastern New Mexico: Am. Geologist, vol. 34, pp. 174-192, 1904.

A general description and map of the Otero basin. Refers to the occurrence of borax in the salines in the playas.

Struthers, Joseph, Borax: U. S. Geol. Survey Mineral Resources, 1902, pp. 891-896, 1904.

Short review containing brief references to general abandonment of operations on the marsh deposits and production from the "bedded" deposits of colemanite. Statistics of production and of imports from 1864 and 1868 to 1902 are quoted. The review of the industry for 1902 contains reference to deep-mining operations about Daggett, developments in Ventura County, and smaller production from marshes in California, Nevada, and Oregon. The prices quoted range from 6¾ to 7¼ cents a pound for refined borax. A table of world's production is accompanied by notes on foreign producing localities: Argentina, Bolivia, Chile, Italy, Peru, and Turkey.

Yale, C. G., Borax: U. S. Geol. Survey Mineral Resources, 1903, pp. 1017-1028, 1904.

Summary review of history of borax, quoting statistics of production, imports, and world's production, with a statement of the industry for the year in the various fields—Ventura County, San Bernardino County, Inyo County, Cal.; and review of the uses of borax and of technology of its manufacture.

Morgan, W. C., and Tallmon, M. C., A peculiar occurrence of bitumen and evidences as to its origin: Am. Jour. Sci., 4th ser., vol 18, pp. 363-377, 1904.

A peculiar occurrence of the mineral colemanite within a fossil egg, which was found inclosed within a larger pebble embedded in placer gravels on Gila River in Arizona, and which is described and figured in detail.

Wiley, H. W., Results of borax experiment: U. S. Dept. Agr. Bur. Chemistry Circ. No. 15, pp. 1-27, 1904.

Report of the results and conclusions derived from experimental investigation of the effects of borax on foods and on the general state of health of individuals to whom various doses are regularly administered. The conclusion is reached that small doses given for a long period or large quantities for a short period create disturbances of appetite, of digestion, and of health.

1905.

Yale, C. G., Borax: U. S. Geol. Survey Mineral Resources, 1904, pp. 1017-1028, 1905.

A review similar in form to that of preceding year, with notes as to developments for the year and a more detailed review of the Blumenberg process for treatment of the shale deposits near Daggett.

1906.

Reichert, F., Chem. Zeitung, vol. 30, p. 150, 1906.

Describes eight of the Argentine "borateras" and gives analyses of their products. His complete report, Los yacimientos de boratos, is in Anales del Ministerio de Agricultura, Buenos Aires, 1907. For an abstract, see Zeitschr. Kryst. Min., vol. 47, p. 205, 1909.

——— The mineral production of Chile in 1903; Borax: Min. Jour., London, vol. 80, pp. 411-412, Mar. 31, 1906.

An abstract and translation from Estadística minera de Chile en 1903, p. 321, Santiago de Chile, 1905, with a mining map of the country and a geologic map of Atacama.

The yield of borates in 1903 is given as 18,605½ short tons, about 92 per cent of which was controlled by the Borax Consolidated Co.

The principal borax deposits of Chile are found as in Peru, Bolivia, and Argentina, on the high plateaus of the Andes, in Chile, at altitudes ranging from 11,500 to over 13,000 feet, and at distances of 125 to 150 miles from the coast. The borates appear to have been derived from the evaporation of ancient lakes as they lie in more or less marshy depressions where they are mixed with other saline substances. They resemble the saline marshes of California and Nevada. The only borax mineral reported is ulexite, which has a tendency to be localized near the margins of the saline deposits. Since the year 1852 borates have been obtained from these fields, in Tarapaca, Antofagasta, etc. Quotations from a British consular report published in 1896 are given describing the Maricunga, Chilcaya, and Ascotan deposits. The main shipping port is Antofagasta.

Bailey, G. E., The borax deposits of California: Mining World, vol. 24, pp. 4-5, 1906.

Generalized statements as to borax of California desert deposits illustrated by several views of the borate beds and workings at Daggett, saline crusts in the Mohave Desert, etc.

Yale, C. G., Borax: U. S. Geol. Survey Mineral Resources, 1905, pp. 1091-1096, 1906.

A short statement of conditions in the borax industry for the year 1905. Contains notes of late developments, record of fall in market price to 6½ to 6¾ cents a pound for refined borax.

Spurr, J. E., Ore deposits of the Silver Peak quadrangle, Nevada: U. S. Geol. Survey Prof. Paper 55, pp. 21, 158-165, 1906.

Chapter headed "Borates and salt." Playas or alkali flats of Fish Lake Valley, Clayton Valley, and Big Smoky Valley described by quotation from H. W. Turner, with several analyses of playa deposits showing borate content. Section on the genesis of the deposits, including reference to colemanite in the Tertiary sediments, the borate minerals said to be chemically precipitated deposits a result of evaporation of Tertiary alkaline lakes. The borates in the playas are believed to have originated in part at least from the concentration of the saline constituents of hot-spring waters, and the localization of the borate deposits is in part explained by the variation in the constituents of the different hot-spring waters, which in turn have presumably derived their borate salts in some way from volcanic exhalations.

Taft, H. H., Notes on Inyo County, Cal.: Eng. and Min. Jour., vol. 81, pp. 704-705, Apr. 14, 1906.

Some rather general notes relating to borax deposits, Death Valley, Owens Lake Valley, etc.

Taft, H. H., Notes on southern Nevada and Inyo County, Cal.: Am. Inst. Min. Eng. Trans., vol. 37, pp. 178-197, 1906.

In a general account of the country incidental mention is made of a little borax in the spring waters at Ash Meadows, Nevada (p. 184), and two paragraphs are devoted to borax deposits in general (pp. 191-192).

Willey, D. A., Borax mining in California: Eng. and Min. Jour., vol. 82, pp. 633-634, 1906.

Description and views of the mine at Borate, in the Calico district north of Daggett, Cal.

1907.

Ball, S. H., A geologic reconnaissance in southwestern Nevada and eastern California: U. S. Geol. Survey Bull. 308, pp. 41, 198, 1907.

In discussing geologic history of the desert region reference is made to the deposition of limestone, gypsum, and boron minerals by the desiccation of the hypothetical "Pahute" Lake; and later (p. 198) in description of the Death Valley

region reference is made to colemanite and other chemical precipitates interbedded with the other deposits (which) were laid down during periods of unusual evaporation—evidently based on the acceptance of a desiccated alkaline lake hypothesis for the origin of these minerals.

JOCHAMOWITZ, A., Yacimiento de borax de la Laguna de Salinas: Cuerpo Ing. Minas Perú Bol. 49, Lima, 24 pp., 1907. Abstract in Min. Jour., London, vol. 82, p. 247, Aug. 24, 1907. Quoted in Eng. and Min. Jour., vol. 84, p. 780, 1907.

A dry lake basin, carrying borates and other saline salts, is known as Lake Salinas, 12 leagues east of Arequipa City on the line separating the Departments of Areguipa and Moquegua. It lies at an altitude of 14,200 feet. The crust consists of chloride and sulphate of soda and fine sand, 10–14 centimeters, gravel 6 centimeters, sand with layers of borate 20–50 centimeters, fine sand, thin bed, borate of variable thickness, usually 40 centimeters to maximum of 1 meter. The borate is the mineral ulexite. Ulexite of Laguna de Salinas is regarded as of volcanic origin. The original text contains topographic maps of the salinas and of the general region showing by contours the topography of adjacent mountains, also good views of the deposit.

YALE, C. G., Borax: U. S. Geol. Survey Mineral Resources, 1906, pp. 1059–1062, 1907.

Review containing usual statistics and notes of developments in various fields.

1908.

YALE, C. G., Borax: U. S. Geol. Survey Mineral Resources, 1907, pt. 2, pp. 631–635, 1908.

Notes sudden drop in market price during 1907, which resulted in closing all but the largest producing operators in the field. Price of borax fell to 4½ to 5½ cents a pound. Quotes usual statistics of production and imports. Notes opening of the Lila C. mine in Inyo County, Cal., and abandonment of the mines at Borate, near Daggett, San Bernardino County, Cal.; also the discovery of important colemanite deposits near Lang in Los Angeles County, Cal., in November, 1907.

MUNROE, C. E., Borax industry in the United States: Census Bur. Bull. 92, pp. 36–37, 1908.

Borax industry discussed chiefly by quotation from California State Mining Bur. Bull. 24.

1909.

ANON. The borate field of Chile: Chem. Trade Jour., vol. 45, pp. 380–382, 1909.

The mineral found principally in the borate fields in Chile bordering on Bolivia is an impure borate of lime containing in the crude state about 36 per cent boric acid, 35 per cent water, some sodium borate, silicates, etc. The silicates and calcium sulphate are difficult impurities to separate. By calcining, part of the water is driven off, and the product shipped from the mines contains about 45 per cent boric acid.

KEYES, C. R., Borax deposits of the United States: Am. Inst. Min. Eng. Bull. 34, pp. 867–903, 1909.

A dissertation dealing with surface features, geologic formations, and borate occurrences in Death Valley, Mohave Desert, and elsewhere in southern California, with considerable theorizing based on the assumption that the borate minerals are interbedded deposits, formed under conditions of an arid climate in a great shallow arm of the Pacific Ocean that had been cut off by the upheaval of the mountains along the coast.

KEYES, C. R., American borax deposits: Eng. and Min. Jour., vol. 88, pp. 826–827, Oct. 23, 1909.

An account of the development of the colemanite ores in southern California, a statement as to the character of the Tertiary rocks with which they are associated, and of the ores and methods of mining.

YALE, C. G., Borax: U. S. Geol. Survey Mineral Resources, 1908, pt. 2, pp. 603–605, 1909.

A brief statement for the year, with the usual statistics.

WAINWRIGHT, W. B., Borate deposits of California: Inst. Min. Eng. [London] Trans., vol. 37, pt. 1, pp. 156–162, 1909; Manchester Geol. and Min. Soc. Trans., vol. 31, pt. 4, pp. 60–66, 1909.

A compilation of notes concerning the occurrence of mining and manufacture of borates in California.

WILSON, E. B., Boron: Mines and Minerals, vol. 30, pp. 168–170, October, 1909.
A list of minerals in which boron occurs, a review in some detail of the methods of test for and analysis of boron minerals, and a few notes on the borax localities in the United States.

1910.

ANON., India Geol. Survey Records, vol. 41, p. 168, 1910.
Brief statistical review as follows: "Although borax is not produced in India, but in Tibet, most of the output probably comes to this country for export and distribution. The amount exported during 1910 rose to 6,272 hundredweight."

BOEKE, H. E., The borates of the potash deposits: Leipzig, Centralbl. Mineralogie, pp. 531–539, 1910.
A brief description of heintzite, pinnoite, ascharite, boracite, the identity of which with stassfurtite is reaffirmed, and sulfoborite.

DUPONT, F. M., The borax industry: Jour. Ind. and Eng. Chem., vol. 2, pp. 500–503, 1910.

REICHERT, F. [The deposits of borate and other useful minerals in the region of the Andes (Puna de Atacama)]: Chem. Zentralbl., vol. 81, pt. 1, pp. 197–198, 1910.
Review of paper published in Argentina Minist. Agr. Anales, 1907.

STRONG, A. M., Borax deposits of the United States: Am. Inst. Min. Eng. Bull. 38, pp. 167–171, February, 1910.
Discussion of C. R. Keyes's paper, objecting to suggestion by Keyes of marine origin of borates and borate-bearing beds, calling attention to evidence of fresh-water deposition within this series, as of the occurrence of fresh-water mollusks, fish, and plants, as well as coal beds. Reports colemanite within Saline Valley drainage.

SURR, G., The origin and commercial value of borates: Min. World, vol. 33, pp. 1137–1138, Dec. 17, 1910.
Speculations of a general character concerning the origin of borates and boric acid in natural occurrences.

WHITFIELD, J. E., Analyses of borates: U. S. Geol. Survey Bull. 419, p. 300, 1910.
Analyses of colemanites from Death Valley, Cal.; priceite from Curry County, Oreg.; and pandermite from Island of Panderma, Black Sea. The pandermite from the original described locality agrees very closely in composition with the priceite from its original locality. An analysis of ulexite from Rhodes Marsh, Nevada, is also given.

1911.

BAKER, C. L., Notes on the later Cenozoic history of the Mohave Desert in southwestern California: California Univ. Dept. Geology Bull., vol. 6, No. 15, pp. 333–383, 1911.
Describes the "Rosamond series," including various occurrences of the "borate member" in southern California, and discusses the genesis of borate deposits (p. 358).

CLARKE, F. W., The data of geochemistry, 2d ed.: U. S. Geol. Survey Bull. 491, pp. 231–240; also pp. 14, 110, 150, 165, 1911.
The general distribution of boron (p. 14); its occurrence in sea water (p. 110); its occurrence in Mono and Owens lakes, California; Harney Lake, Oregon; Big Lake, Track Lake, Red Lake, otherwise known as Laramie or Union Pacific lakes of Wyoming (pp. 150–152); and a general discussion of borates (pp. 231–240), their relation to volcanism, referring especially to the relation between boric acid and ammonium in hot-spring waters of evident volcanic relations. The literature relating to borates in various parts of the world is reviewed, an abstract of these references being incorporated in this bibliography.

EAKLE, A. S., Neocolemanite, a variety of colemanite, and howlite from Lang, Los Angeles County, Cal.: California Univ. Dept. Geology Bull., vol. 6, No. 9, pp. 179–189, 1911.
A careful study of the supposed colemanite from the deposits north of Lang, Los Angeles County, Cal., has revealed a mineral of somewhat distinct optical and crystallographic properties, although identical with colemanite in chemical composition and general physical properties. To the new mineral the name neocolemanite is given. Crystallographic measurements are given, and a few paragraphs describing the manner or occurrence, and also an associated borate mineral, howlite.

YALE, C. G., Borax: U. S. Geol. Survey Mineral Resources, 1909, pt. 2, pp. 631-632, 1911.
Brief statement containing the usual statistics.
——— U. S. Geol. Survey Mineral Resources, 1910, pt. 2, pp. 701-702, 1911.
Brief statement containing usual statistics. Virtually entire product of borax in the United States then derived from two mines, one in Inyo County and one in Los Angeles County, both in California.
WEINTRAUB, E., On the properties and preparation of the element boron: Jour. Ind. and Eng. Chem., vol. 3, pp. 299-300, 1911.
Artificial production of the element boron, its properties, especially the influence of temperature on its electrical resistance, on which some of its principal industrial applications are likely to be based.

1912.

CHAMBERLIN, R. T., The physical setting of the Chilean borate deposits: Jour. Geology, vol. 20, pp. 763-768, November-December, 1912.
A description of the salinas, or dry saline lake beds, characteristic of Chile, Bolivia, and Peru, with views of Ascotan, Borax Lake, and a similar borax lake near Cellobar. The relations of these areas of interior drainage to volcanoes are pointed out—suggesting a direct volcanic source of the boron salts they contain. The boron occurs almost entirely as a single compound, the mineral ulexite. The material is so free from other salts that it is only necessary to dry it before shipping it to Europe, where it is later manufactured into the commercial salts.
YALE, C. G., and GALE, H. S., Borax: U. S. Geol. Survey Mineral Resources, 1911, pt. 2, pp. 857-866, 1912.
Review of the borax industry, containing usual statistics. Market price of refined borax remains low, 3½ to 4 cents a pound. Contains historical review and map of known borax localities. An account and map of the Lila C. borax mine at Ryan, Cal., and a bibliography of publications relating to borax, by Hoyt S. Gale.

1913.

BAXERES DE ALZUGARAY, Borates and consumption of boron compounds: Min. and Eng. World, Jan. 8, 1913, p. 99.
New uses for boron compounds, such as in extension and improvement in the making of enamels for the lining of iron, steel, and other metallic vessels; the use of alkali perborates as bleaching agents highly recommended, and also as powerful oxidizers in disinfecting, where the perborates have the advantage that they may be stored without deteriorating. In metallurgy of iron and steel, boron alloys resistant to acids may become of value. The use of boric acid and borates in tanning and bleaching of leather and as general mordants in dyeing of fabrics, in soap making and treating of fatty acids, as an antiseptic and as a wood preserver, and in paper making, etc., is referred to.
GALE, H. S., Borate deposits in Ventura County, Cal.: U. S. Geol. Survey Bull. 540 (chapter A, published separately, 1913), pp. 434-456, 1914.
Describes geology of the colemanite deposits in Ventura County, a district which has yielded crude colemanite valued at approximately a million dollars.
——— Salt, borax, and potash in Saline Valley, Inyo County, Cal.: U. S. Geol. Survey Bull. 540 (chapter N, published separately, 1913), pp. 416-421, 1914.
Brief summary of production of borax in the "marsh" form of deposits from this valley in the early days of the industry in the country.
——— The origin of colemanite deposits: U. S. Geol. Survey Prof. Paper 85 (chapter A, published separately, 1913), pp. 3-9, 1914.
Reviews former hypotheses as to the origin of colemanite as a product of desiccation of Tertiary alkaline waters; notes the evidence and argument to show that colemanite is not a desiccation deposit at all, but is a vein deposit, in part at least, of the replacement type.
YALE, C. G., and GALE, H. S., Borax: U. S. Geol. Survey Mineral Resources, 1912, pt. 2, pp. 839-846, 1913.
Review of statistics and conditions, similar to that of preceding year, with a republication of the bibliography relating to borax, somewhat enlarged.

ASPHALT.

By David T. Day.

INTRODUCTION.

The use of asphalt is increasing. Oil asphalt obtained as a residue from the distillation of asphaltic oils is becoming more and more available from Mexican, Gulf, and California oils, and even from those of the Middle West. There is correspondingly less interest in the development of new sources of natural asphalt. No new sources of supply have entered into the trade.

PRODUCTION.

NATURAL ASPHALT.

The production of natural asphalt, including all the varieties of natural asphalt, asphaltic sandstone, and limestone, amounted in 1913 to 92,604 short tons, valued at $750,713. This was a decline from 95,166 short tons, valued at $865,225, in 1912. This decline in natural products was undoubtedly due to the fact not only that oil asphalt dominates the industry but that its relative importance is increasing at the expense of the natural varieties. Thus 354,344 short tons of manufactured or oil asphalt was produced in 1912, and in 1913 the production was 436,586 short tons, with corresponding increase in value from $3,755,506 to $4,531,657. Of the total of 529,190 short tons of asphalt products of the United States in 1913 only 17.5 per cent was natural asphalt, including asphaltic limestone and sandstone. This large supply of oil asphalt is only for such purposes as street paving, road binders, and roofing, and has no bearing on the demand of asphalt for varnish and many other high-grade uses, for which such natural asphalt as gilsonite and other hard asphalts are needed.

Production of natural asphalt and bituminous rock, 1882–1913, in short tons.

Year.	Quantity.	Value.	Year.	Quantity.	Value.
1882	3,000	$10,500	1898	76,337	$675,649
1883	3,000	10,500	1899	75,085	553,904
1884	3,000	10,500	1900	54,389	415,958
1885	3,000	10,500	1901	63,134	555,335
1886	3,500	14,000	1902	84,632	461,799
1887	4,000	16,000	1903	55,068	483,282
1888	50,450	187,500	1904	64,167	420,701
1889	51,735	171,537	1905	62,898	305,242
1890	40,841	190,416	1906	73,052	674,934
1891	45,054	242,264	1907	85,913	938,381
1892	87,680	445,375	1908	78,565	517,485
1893	47,779	372,232	1909	99,061	572,846
1894	60,570	353,400	1910	98,893	854,234
1895	68,163	348,281	1911	87,074	817,250
1896	80,503	577,563	1912	95,166	865,225
1897	75,945	664,632	1913	92,604	750,713

MANUFACTURED OR OIL ASPHALT.

The following table shows the production of manufactured or oil asphalt since 1902, inclusive:

Production of manufactured or oil asphalt, 1902–1913, in short tons.

Year.	Quantity.	Value.	Year.	Quantity.	Value.
1902	20,826	$303,249	1908	119,817	$1,540,396
1903	46,187	522,164	1909	129,594	1,565,427
1904	44,405	459,135	1910	161,187	2,225,833
1905	52,369	452,911	1911	277,192	3,173,859
1906	64,997	615,406	1912	354,344	3,755,506
1907	137,948	1,898,108	1913	436,586	4,531,657

TOTAL PRODUCTION BY CLASSES AND BY STATES.

The changes in production in the different classes of asphalt are detailed for five years in the table which follows:

Production of asphalt, 1909–1913, by varieties, in short tons.

Variety.	1909		1910		1911	
	Quantity.	Value.	Quantity.	Value.	Quantity.	Value.
Bituminous rock	55,376	$205,756	64,554	$400,557	[a] 42,654	[a] $159,670
Maltha	652	8,047	1,252	12,742	8,574	125,966
Wurtzilite (elaterite)	220	1,400			610	30,500
Gilsonite	[b] 38,889	[b] 323,406	[b] 33,087	[b] 440,935	30,236	486,114
Grahamite	3,894	32,737			5,000	15,000
Ozokerite and tabbyite	30	1,500				
Total	99,061	572,846	98,893	854,234	87,074	817,250
Manufactured or oil asphalt [c]	129,594	1,565,427	161,187	2,225,833	277,192	3,173,859
Total	228,655	2,138,273	260,080	3,080,067	364,266	3,991,109

Variety.	1912		1913	
	Quantity.	Value.	Quantity.	Value.
Bituminous rock	[a] 54,762	[a] $173,018	57,549	$173,764
Maltha	474	3,518		
Wurtzilite (elaterite)	[d] 8,452	[d] 115,620	35,055	576,949
Gilsonite	31,478	573,069		
Grahamite	([e])	([e])		
Total	95,166	865,225	92,604	750,713
Manufactured or oil asphalt [c]	354,344	3,755,506	436,586	4,531,657
Total	449,510	4,620,731	529,190	5,282,370

[a] Includes small output of mastic.
[b] Includes gum.
[c] This item includes material previously referred to as refined bitumen.
[d] Includes grahamite.
[e] Included in wurtzilite.

The following table shows the production of natural asphalt, by States in 1909–1913:

Production of natural asphalt, by States, 1909–1913, in short tons.

State.	1909		1910		1911	
	Quantity.	Value.	Quantity.	Value.	Quantity.	Value.
California	43,825	$218,625	41,299	$165,954	36,481	$220,580
Kentucky	15,898	85,005	9,938	53,703	(a)	(a)
Oklahoma	b 10,419	b 48,130	11,959	65,244	c 19,747	c 80,056
Utah	28,919	221,086	35,697	569,333	30,846	516,614
West Virginia	(d)	(d)	....	....	....	....
Total	99,061	572,846	98,893	854,234	87,074	817,250

State.	1912		1913	
	Quantity.	Value.	Quantity.	Value.
California	36,741	$100,481	27,870	$69,825
Kentucky	e 10,145	e 46,032	e 17,465	e 60,131
Oklahoma	15,766	85,643	16,459	91,416
Texas	(f)	(f)	(f)	(f)
Utah	32,514	633,069	30,810	529,341
Total	95,166	865,225	92,604	750,713

a Included in Oklahoma.
b Includes West Virginia.
c Includes Kentucky.
d Included in Oklahoma.
e Includes Texas.
f Included in Kentucky.

CONDITIONS AND PRODUCTION IN THE CHIEF PRODUCING STATES.

California.—An interesting development of the year 1913 in the production of oil asphalt in California was the acquisition by the larger companies of a number of the smaller asphalt refineries and the vigorous efforts of the larger companies to control the market, with the result that as many as 11 of the smaller companies disappeared from the market and others showed greatly reduced activity and production while the larger companies showed proportionate increase.

The only natural asphaltic material produced in California in 1913 was the bituminous sandstone from the well-developed deposits near Santa Cruz in Santa Cruz County and from San Luis Obispo County. The low cost of production for local use allows this industry to persist in spite of the encroachments of oil asphalt, which reduced the output from 36,741 short tons in 1912 to 27,870 short tons in 1913. The average price declined from $2.73 at the quarries in 1912 to $2.51 in 1913.

Kentucky.—Kentucky produces only bituminous rock. The production showed an increase for 1913, due partly to an increase in the Texas product, which is included with Kentucky to avoid disclosing individual returns.

Oklahoma.—The product of Oklahoma includes grahamite, bituminous sandstone, and bituminous limestone. The total output and its value was greater in 1913 than in any previous year, the apparently larger production in 1911 being due to combining the production of Kentucky with that of Oklahoma.

L. C. Snyder, of the Geological Survey of Oklahoma, has published a comprehensive account of the occurrence of asphalt in Oklahoma, in Circular 52 of that survey, together with a detailed description of the deposits in the Wichita Mountains, in Stephens and Jefferson counties, in the Ardmore district, in the Arbuckle Mountains, in the Ouachita Mountains, and in the Red River district. He has also given a valuable review of the uses to which the asphalt is put for paving, etc., with prices.

Utah.—The production of hard asphalts, gilsonite, and elaterite from Utah fills a demand which is fairly steady; nevertheless the output in 1913 was slightly less than in 1912 and the average price per short ton received at the mines declined from $19.47 in 1912 to $17.01 in 1913.

Philippines.—Consul General George E. Anderson, at Hongkong, reports, in the Daily Consular and Trade Report of June 9, 1914, the discovery of a vein of asphalt of high quality and of large extent in the Philippine Islands. He thinks the material is likely to have a marked influence on street paving in cities in the Far East. It lies in the province of Leyte, barrio of Campopoc, on the northwestern peninsula of the island of Leyte, about 10 miles from the shore.

The vein is about 4 feet thick and can be readily followed for 160 yards along the side of the hill. Analysis made in Europe shows that it is of a quality suitable for the highest uses. The material is also being used for roofing and similar purposes. The Far East is just commencing to use asphalt for paving and roofing, the supply coming at present largely from the west coast of the United States.

PRODUCTION IN PRINCIPAL COUNTRIES.

The following table shows the production of asphalt in the principal producing countries from 1904 to 1913, inclusive:

Production of asphalt and bituminous rock in the principal producing countries, 1904–1913, in short tons.

Year.	United States.		Trinidad.[a]		Germany.	
	Quantity.	Value.	Quantity.	Value.	Quantity.	Value.
1904	64,167	$420,701	152,392	$727,552	101,121	$212,058
1905	62,898	305,242	114,845	626,293	113,513	235,620
1906	73,052	674,934	150,373	832,964	129,388	268,631
1907	85,913	938,381	171,271	832,274	139,567	264,494
1908	78,565	517,485	143,552	403,023	98,088	188,334
1909	99,061	572,846	159,416	459,446	85,446	176,897
1910	98,893	854,234	157,120	421,419	89,491	152,565
1911	87,074	817,250	[b] 179,718	[c] 494,000	90,256	154,938
1912	95,166	865,225	[b] 189,496	[c] 521,000	....	....
1913	92,604	750,713	[b] 230,031	[c] 633,000	....	....

[a] Includes small quantity of manjak, produced in Barbados. [b] Exports. [c] Estimated.

Production of asphalt and bituminous rock in the principal producing countries, 1904–1913, in short tons—Continued.

Year.	France.		Italy.[a]		Spain.	
	Quantity.	Value.	Quantity.	Value.	Quantity.	Value.
1904	250,222	$289,415	123,347	$307,985	4,146	$7,259
1905	211,043	325,340	117,929	298,097	7,135	14,794
1906	216,405	345,599	144,802	349,926	8,587	17,130
1907	195,136	330,065	178,127	442,014	9,057	16,001
1908	188,616	264,188	148,433	368,306	13,635	24,084
1909	186,298	269,161	123,361	305,159	5,822	10,282
1910	187,085	277,210	179,261	452,911	7,072	18,308
1911	....	....	207,926	591,550	[b] 3,394	8,754
1912	....	....	181,946	581,383	....	....
1913	....	....	....	....	....	....

Year.	Austria-Hungary.		Russia.		Venezuela.	
	Quantity.	Value.	Quantity.	Value.	Quantity.	Value.
1904	4,029	$59,386	[c] 95	$230,541	[d] 14,910	$262,809
1905	8,257	854,197	23,659	201,965	[d] 33,803	258,526
1906	10,633	778,781	12,517	110,294	[d] 22,128	98,250
1907	11,335	727,892	14,116	101,705	[d] 37,637	167,938
1908	12,239	768,162	24,961	([e])	[d] 31,539	141,912
1909	11,179	663,246	([e])	([e])	[d] 37,292	180,061
1910	9,070	702,022	([e])	([e])	[d] 31,890	[f] 151,000
1911	....	....	....	....	[d] 50,163	[f] 238,000
1912	....	....	....	....	[d] 65,875	[f] 312,000
1913	....	....	....	....	[d] 83,825	[f] 400,000

[a] Only about 7 per cent of the quantity given represents asphalt, the remainder being bituminous sandstone and limestone.
[b] In addition 6,306 tons of bituminous rock were produced, no value being reported.
[c] Ozokerite only; quantity of asphalt not available.
[d] Exports.
[e] Not available.
[f] Estimated.

IMPORTS.

The following table shows the imports, for consumption, of asphalt, by calendar years, from 1908 to 1913, inclusive:

Asphalt imported for consumption into the United States, 1908–1913, in short tons.

Year.	Crude.		Dried or advanced.		Bituminous limestone.		Total.	
	Quantity.	Value.	Quantity.	Value.	Quantity.	Value.	Quantity.	Value.
1908	137,808	$532,297	7,642	$67,364	6,224	$20,758	151,674	[a] $624,979
1909	128,109	511,631	10,087	94,146	6,409	18,440	144,605	[a] 633,205
1910	162,435	588,206	20,180	178,704	3,696	9,301	186,311	[a] 785,963
1911	167,681	572,198	20,461	184,954	8,180	23,468	196,322	789,236
1912	193,645	726,345	20,707	177,992	3,976	15,808	218,328	921,145
1913	[b] 207,033	738,452	[c] 14,750	133,336	6,395	38,823	228,178	910,611

[a] Imports for 1908 include $4,560 of manufactures; 1909, $8,988; 1910, $9,752.
[b] Includes dried or advanced asphalt for last three months of 1913.
[c] Last three months of 1913 included in crude asphalt.

The ozokerite imported amounted to 4,472,708 pounds, valued at $388,461, in 1911. This increased to 6,352,003 pounds in 1912, valued at $488,894. The import price declined from 8.7 cents a pound in 1911 to 7.7 cents a pound in 1912. In 1913 the quantity imported rose to 7,141,514 pounds, valued at $549,992.

The following table shows the imports, by countries, of asphalt into the United States for the fiscal years 1909 to 1913:

Asphalt imported into the United States during the fiscal years ending June 30, 1909 to 1913, by countries, in long tons.

Imported from—	1909		1910		1911		1912		1913	
	Quantity.	Value.	Quantity.	Value.	Quantity.	Value.	Quantity.	Value.	Quantity.	Value.
Europe:										
Belgium			12	$369	364	$5,498	420	$2,914	89	$538
France	84	$1,120	1,648	7,917	119	1,598	248	2,390		
Germany	1,210	1,054	2,294	18,587	2,091	17,576	2,586	22,111	1,898	16,444
Italy	4,222	15,441	3,050	8,092	6,099	17,636	5,515	22,873	4,619	18,874
Netherlands	59	666				41			100	598
Switzerland	817	6,937	1,280	9,184	750	5,783	1,453	9,863	1,235	8,272
United Kingdom	304	4,002	274	6,808	297	6,876	434	5,278	7,721	18,736
North America:										
Canada	2	90			36	600	94	2,351	1	28
Mexico	76	1,390	145	2,652	32	457	581	11,089	64	482
West Indies—										
British	83,529	312,944	89,994	407,325	94,594	405,735	115,884	475,299	108,216	438,362
Cuba	7,174	36,618	13,873	73,455	14,027	73,233	12,405	68,879	9,696	57,804
Danish			200	800						
South America:										
Colombia	34	1,356	1	9	45	1,639	11	1,216		
Venezuela	30,528	214,049	33,503	173,363	34,104	170,683	53,922	260,074	78,221	390,907
Asia:										
Turkey			8	554					3	639
Oceania	11	429	89	3,436	10	391	25	967	10	396
Total	128,050	606,096	146,371	712,551	152,568	707,746	193,578	885,304	211,873	952,080

Tariff.—Under the law which became effective October 4, 1913, all asphalt, except manufactured products, is imported free of duty. The duty provided by the former law, that of June 1, 1912, was $1.50 a ton on crude asphalt, $3 a ton on that dried or advanced, and $0.50 a ton on limestone-rock asphalt.

EXPORTS.

Exports of domestic asphalt in fiscal years 1907 to 1913 are shown in the following table:

Value of asphalt exported from the United States during the fiscal years 1907–1913, in short tons.

Year.	Unmanufactured.	Manufactures of.	Total.
1907	(a)	(a)	$374,476
1908	(a)	(a)	451,968
1909	(a)	(a)	425,429
1910	$488,703	$213,817	702,520
1911	565,581	302,971	868,552
1912	707,997	462,885	1,170,882
1913	1,164,486	475,541	1,640,027

a Figures given as "Asphaltum and manufactures of," until 1910.

EXPORTS FROM TRINIDAD.

The exports of asphalt from Trinidad from 1907 to 1913, inclusive, have been fairly steady, with a gradual increase as is shown in the following table:

Total exports of asphalt from Trinidad, 1907–1913, in short tons.

Year.[a]	To United States.			To Europe.			To other countries.			Grand total.
	Lake.	Land.	Total.	Lake.	Land.	Total.	Lake.	Land.	Total.	
1907	97,243	4,642	101,885	59,987	224	60,211	....	230	230	162,096
1908	92,212	5,886	98,098	51,183	1,276	52,459	....	....	....	150,557
1909	97,629	13,787	111,416	49,345	224	49,569	....	....	....	160,985
1910	109,198	9,274	118,472	65,778	150	65,928	....	....	....	184,400
1911	103,590	8,040	111,630	67,105	....	67,105	983	....	983	179,718
1912	95,111	8,600	103,711	85,299	....	85,299	486	....	486	189,496
1913	123,873	1,400	125,273	104,153	....	104,153	605	....	605	230,031

[a] Ending Jan. 31 of year succeeding.

UNITED STATES GEOLOGICAL SURVEY PUBLICATIONS ON ASPHALT.

The following list comprises the more important papers relative to asphalt published by the United States Geological Survey or by members of its staff. The Government publications, except those to which a price is affixed, can be obtained free by applying to the Director, United States Geological Survey, Washington, D. C. The folios may be purchased from the Geological Survey; the other priced publications from the Superintendent of Documents, Government Printing Office, Washington, D. C.

Anderson, Robert, An occurrence of asphaltite in northeastern Nevada: Bull. 380, pp. 283–285, 1909. 40 cents.

Boutwell, J. M., Oil and asphalt prospects in Salt Lake basin, Utah: Bull. 260, pp. 468–479. 1905. Exhausted.

Branner, J. C., Newsome, J. F., and Arnold, Ralph, Geological Atlas, Santa Cruz folio (No. 163), 1909. Exhausted.

Clarke, F. W., The data of geochemistry, 2d ed.: Bull. 491, pp. 686–689, 1911. 70 cents.

Day, D. T., Asphalt, related bitumens, and bituminous rock: Mineral Resources, 1909, pt. 2, pp. 731–733 (75 cents), 1910; idem, 1910, pt. 2, pp. 833–839, 1911 ($1.25); idem, 1911, pt. 2, pp. 1003–1021, 1912 (exhausted); idem, 1912, pt. 2, pp. 997–1000, 1913; idem, 1913, pt. 2, pp. 537–544, 1914.

Day, W. C., The coal and pitch coal of the Newport mine, Oregon: Nineteenth Ann. Rept., pt. 3, pp. 370–376, 1899. Exhausted.

Eldridge, G. H., The uintaite (gilsonite) deposits of Utah: Seventeenth Ann. Rept., pt. 1, pp. 909–949, 1896. $2.

——— The asphalt and bituminous rock deposits of the United States: Twenty-second Ann. Rept., pt. 1, pp. 209–452, 1901. $1.60.

——— Origin and distribution of asphalt and bituminous rock deposits in the United States: Bull. 213, pp. 296–305, 1903. 25 cents.

Fairbanks, H. W., Geological Atlas, San Luis folio (No. 101), 1904. 5 cents.

Fuller, M. L., Asphalt, oil, and gas in southwestern Indiana: Bull. 213, pp. 333–335, 1903. 25 cents.

Hayes, C. W., Asphalt deposits of Pike County, Ark.: Bull. 213, pp. 353–355, 1903. 25 cents.

HILGARD, E. W., The asphaltum deposits of California: Mineral Resources, 1883–84, pp. 938–948, 1885. 60 cents.
HOVEY, E. O., Asphaltum and bituminous rock: Mineral resources, 1903, pp. 745–754 (70 cents), 1904; idem, 1904, pp. 789–799 (70 cents), 1905.
RICHARDSON, C., Asphaltum: Mineral Resources, 1893, pp. 626–669, 1894. 50 cents.
SMITH, C. D. (See Taff, J. A., and Smith, C. D.)
TAFF, J. A., Albertite-like asphalt in the Choctaw Nation, Indian Territory: Am. Jour. Sci., 4th ser., vol. 8, pp. 219–224, 1899.
——— Description of the unleased segregated asphalt lands in the Chickasaw Nation, Indian Territory: Circ. No. 6, U. S. Dept. Interior, 14 pp. 1904.
——— Grahamite deposits of southeastern Oklahoma: Bull. 380, pp. 286–297, 1909. 40 cents.
——— Asphalt and bituminous rock: Mineral Resources, 1906, pp. 1131–1137 (50 cents); 1907; idem, 1907, pt. 2, pp. 723–730 ($1), 1908.
TAFF, J. A., and SMITH, C. D., Ozokerite deposits in Utah: Bull. 285, pp. 369, 372, 1906. Exhausted.
VAUGHAN, T. W., The asphalt deposits of western Texas: Eighteenth Ann. Rept., pt. 5 (cont.), pp. 930–935, 1897. $1.
——— Geol. Atlas, Uvalde folio (No. 64), 1899. 5 cents.

CLAY-WORKING INDUSTRIES.

By Jefferson Middleton.

INTRODUCTION.

The present report deals with the products of the clay-working industries, with the exception of the section on clay mining; hence the tables are made up to show the products of clay manufactured and not the production of clay.

The year 1913 in the clay-working industries was on the whole one of progress. The total value of all clay products marketed in the year—the principal criterion in judging the status of the industry—was $181,289,132, compared with $172,811,275 in 1912, an increase of $8,477,857, or 4.91 per cent. Compared with 1908, the year of general business depression, the increase was $48,091,370, or 36.11 per cent, and compared with 1903, it was $50,226,711, or 38.32 per cent.

Of the two great divisions of the industry (1) brick and tile and (2) pottery, the former showed the larger increase, both actual and proportionate. The increase in the brick and tile industry was $6,989,646, or 5.13 per cent; the increase in the pottery industry was $1,488,211, or 4.08 per cent.

The most prominent features in the industries in 1913 were the large decrease in the production and value of common brick in the region supplying the New York market and in the value of architectural terra cotta, and the large increase in the value of vitrified brick, sewer pipe, fireproofing, and fire brick. The engineering and refractory products, vitrified brick, draintile, sewer pipe, fire brick, and stove lining, showed an increase of $7,257,428, and the structural materials showed a net decrease of $521,315 in 1913. The growing use of hollow tile not only in fireproof construction in the larger buildings, but also in dwelling houses and other small structures, is shown in the large and continued increase in the value of this material, the making of which seems destined to be an important branch of the industry. The vitrified paving brick industry had probably the most satisfactory year it has yet experienced, there being a large increase in its production, value, and average price per 1,000. The effect of the educational work of the several associations devoted to the increased use of vitrified brick as a paving material, not only for city streets but as the most satisfactory, enduring, and economical material for country roads, is being felt, and this industry no doubt has a bright future.

In the brick and tile industry decrease was shown in the quantity and value of common brick, and in the value of fancy or ornamental brick and of architectural terra cotta. The decrease in the quantity of commom brick was 466,448,000, or 5.45 per cent, but owing to the higher prices prevailing in 1913 the proportionate decrease in value was less—3.21 per cent. Increase was recorded in the quantity and value of vitrified paving brick, of front brick, and of fire brick; in the value of enameled brick, sewer pipe, drain tile, stove lining, fireproofing, and tile, not drain. Vitrified brick, enameled brick, fire brick, sewer pipe, fireproofing, and tile, not drain, reached their maximum value in 1913, as also did the total value for brick and tile products.

The largest increase in value recorded was fire brick—$2,749,493, or 15.38 per cent, and the largest decrease was in common brick—$1,661,509, or 3.21 per cent.

In the pottery industry every variety of ware as classified in this report except one showed an increase, and the year was one of notable progress in every way. The new tariff law which will have a much greater influence on the pottery industry than on the brick and tile industry, both in raw material and on the finished product, went into effect so late in the year that it had little or no apparent result. For the information of those interested the old and the new tariff acts, so far as they relate to pottery, are given on another page of this report. The value of pottery imports, which were principally of high-grade ware, showed a considerable increase in 1913 over 1912—$621,921, or 6.51 per cent—but with the exception of 1912 was the lowest recorded in 11 years. The exports of high-grade domestic pottery, though small, increased, but the exports of low-grade pottery decreased over 60 per cent, and the value of all exports decreased.

In statements to the Geological Survey quantities are reported for common brick, front brick, vitrified paving brick, fire and silica brick, but not for fancy or ornamental brick or enameled brick. The average price per 1,000 increased in 1913 in every case, except front brick, which was the same in both years—$11.62. The increase in the price of common brick was 15 cents, of vitrified paving brick 68 cents, of clay fire brick 72 cents, and of silica brick 34 cents.

A notable feature of the clay-working industries in the last few years has been the concentration of the industry into fewer and larger units, principally by the elimination of the smaller temporary plants, though considerable consolidation has also been going on. This concentration is shown by the fact that the average value of output per operator has increased from $21,451 in 1904 to $44,598 in 1913.

There were no strikes of great importance in the clay-working industries in 1913, though there were some local labor disturbances that had no serious effect. The pottery industry was threatened with labor troubles for a time, but serious consequences were avoided. In Chicago there were strikes, not in the clay-working industries, but in the building trades, which affected the use of clay products; but these appear to have been settled in a manner to insure more permanent peace than has been enjoyed there for some years. The scarcity of labor and the legislative restrictions concerning the employment of women and children in some States have affected the industries. On the whole, however, the year was an important one in development of the industries, and constant efforts are being made to introduce economies in manufacture and improvement in the wares.

ACKNOWLEDGMENTS.

The writer again desires to thank the clay workers of the country on behalf of the Geological Survey for their cooperation, without which this report would be impossible.

The State geological surveys of Alabama, Florida, Georgia, Illinois, Iowa, Kansas, Maryland, Michigan, Missouri, New Jersey, New Mexico, North Carolina, Oklahoma, Oregon, Pennsylvania, Virginia, Washington, and Wisconsin have cooperated in the collection of the statistics in these States, the completeness of the returns and the earlier publication of the results being due largely to their efforts.

Thanks are also extended to the clay-working press for its support and appreciation and to the officials who have supplied information concerning the building operations of the various cities of the country.

PRODUCTION.

PRODUCTION BY STATES.

In the following table will be found a statement of the value of the clay products in the United States in 1912 and 1913, by States:

Value of the products of clay in the United States in 1912 and 1913, by States and Territories.

State or Territory.	1912			1913		
	Brick and tile.	Pottery.	Total.	Brick and tile.	Pottery.	Total.
Alabama	$1,912,966	$22,213	$1,935,179	$2,071,423	$20,158	$2,091,581
Arizona	178,564	....	178,564	218,542	....	218,542
Arkansas	433,648	28,957	462,605	509,867	19,757	529,624
California	5,692,797	219,653	5,912,450	5,054,703	290,255	5,344,958
Colorado	1,396,147	41,247	1,437,394	1,247,010	46,501	1,293,511
Connecticut and Rhode Island	1,465,000	(a)	1,465,000	1,372,234	(a)	1,372,234
Delaware	162,216	....	162,216	187,280	....	187,280
District of Columbia	217,486	(a)	217,486	149,014	11,000	160,014
Florida	272,766	....	272,766	253,344	....	253,344
Georgia	2,787,484	19,057	2,806,541	2,664,091	28,528	2,692,619
Idaho and Nevada	176,108	....	176,108	150,701	....	150,701
Illinois	14,279,039	931,951	15,210,990	14,280,611	915,263	15,195,874
Indiana	6,858,149	1,077,102	7,935,251	7,311,940	1,186,706	8,498,646
Iowa	4,492,185	30,141	4,522,326	5,552,983	20,698	5,573,681
Kansas	2,036,500	(a)	2,036,500	1,919,910	(a)	1,919,910
Kentucky	2,329,536	114,204	2,443,740	2,812,158	102,118	2,914,276
Louisiana	523,643	(a)	523,643	638,491	(a)	638,491
Maine	534,101	(a)	534,101	661,573	(a)	661,573
Maryland	1,681,042	184,711	1,865,753	1,762,466	155,034	1,917,500
Massachusetts	1,515,067	252,099	1,767,166	1,583,530	231,345	1,814,875
Michigan	2,350,606	194,892	2,545,498	2,451,242	222,883	2,674,125
Minnesota	1,611,040	(a)	1,611,040	1,781,017	(a)	1,781,017
Mississippi	589,093	12,706	601,799	623,820	17,451	641,271
Missouri	6,409,346	3,515	6,412,861	6,598,664	3,412	6,602,076
Montana	314,017	(a)	314,017	456,897	(a)	456,897
Nebraska	805,398	....	805,398	886,166	(a)	886,166
New Hampshire	492,096	(a)	492,096	462,534	(a)	462,534
New Jersey	10,902,633	8,935,920	19,838,553	10,866,833	8,838,545	19,705,378
New Mexico	185,575	....	185,575	176,528	....	176,528
New York	9,653,326	2,405,532	12,058,858	8,627,818	2,841,658	11,469,476
North Carolina	1,456,703	8,950	1,465,653	1,600,723	13,683	1,614,406
North Dakota	231,245	....	231,245	262,580	....	262,580
Ohio	19,302,773	15,508,735	34,811,508	21,868,407	16,519,889	38,388,296
Oklahoma	535,318	....	535,318	573,371	....	573,371
Oregon	734,226	(a)	734,226	771,795	(a)	771,795
Pennsylvania	19,408,681	2,128,540	21,537,221	22,185,383	2,046,099	24,231,482
Porto Rico	14,294	(a)	14,294	6,359	(a)	6,359
South Carolina	697,802	6,761	704,563	573,459	9,782	583,241
South Dakota	41,496	....	41,496	46,685	....	46,685
Tennessee	1,327,850	173,166	1,501,016	1,347,985	145,100	1,493,085
Texas	2,739,464	146,604	2,886,068	2,968,975	80,374	3,049,349
Utah	724,978	(a)	724,978	708,906	(a)	708,906
Vermont	79,266	....	79,266	94,773	....	94,773
Virginia	1,874,174	(a)	1,874,174	1,705,651	(a)	1,705,651
Washington	2,388,870	(a)	2,388,870	2,390,226	(a)	2,390,226
West Virginia	1,410,708	3,365,166	4,775,874	1,783,383	3,424,887	5,208,270
Wisconsin	1,036,586	7,900	1,044,486	1,013,028	7,700	1,020,728
Wyoming	45,103	....	45,103	61,678	....	61,678
Other States	....	684,442	684,442	....	793,549	793,549
Total	136,307,111	36,504,164	172,811,275	143,296,757	37,992,375	181,289,132
Percentage of total	78.88	21.12	100.00	79.04	20.96	100.00

[a] Included in "Other States."

This table shows that the brick and tile products as classified in this report continue to constitute approximately four-fifths and the pottery products one-fifth of the total value.. These approximate proportions have been maintained for many years. Every State is a producer of burned clay. Of the Territories, Alaska and Hawaii reported none for 1913. A small production was reported from the District of Columbia and from Porto Rico. In Nevada and Rhode Island there was not a sufficient number of producers reporting to permit the publication of State totals without disclosing individual returns, so that statistics for these States have been combined with those of contiguous States.

Value of the clay products of the United States, by States and Territories, in 1912 and 1913, showing increase or decrease, with percentage of increase or decrease.

State or Territory.	1912	1913	Increase (+) or decrease (—) in 1913.	Percentage of increase(+) or decrease(—) in 1913.
Alabama	$1,935,179	$2,091,581	+ $156,402	+ 8.08
Arizona	178,564	218,542	+ 39,978	+22.39
Arkansas	462,605	529,624	+ 67,019	+14.49
California	5,912,450	5,344,958	— 567,492	— 9.60
Colorado	1,437,394	1,293,511	— 143,883	—10.01
Connecticut and Rhode Island	1,465,000	1,372,234	— 92,766	— 6.33
Delaware	162,216	187,280	+ 25,064	+15.45
District of Columbia	217,486	160,014	— 57,472	—26.43
Florida	272,766	253,344	— 19,422	— 7.12
Georgia	2,806,541	2,692,619	— 113,922	— 4.06
Idaho and Nevada	176,108	150,701	— 25,407	—14.43
Illinois	15,210,990	15,195,874	— 15,116	— .10
Indiana	7,935,251	8,498,646	+ 563,395	+ 7.10
Iowa	4,522,326	5,573,681	+1,051,355	+23.25
Kansas	2,036,500	1,919,910	— 116,590	— 5.73
Kentucky	2,443,740	2,914,276	+ 470,536	+19.25
Louisiana	523,643	638,491	+ 114,848	+21.93
Maine	534,101	661,573	+ 127,472	+23.87
Maryland	1,865,753	1,917,500	+ 51,747	+ 2.77
Massachusetts	1,767,166	1,814,875	+ 47,709	+ 2.70
Michigan	2,545,498	2,674,125	+ 128,627	+ 5.05
Minnesota	1,611,040	1,781,017	+ 169,977	+10.55
Mississippi	601,799	641,271	+ 39,472	+ 6.56
Missouri	6,412,861	6,602,076	+ 189,215	+ 2.95
Montana	314,017	456,897	+ 142,880	+45.50
Nebraska	805,398	886,166	+ 80,768	+10.03
New Hampshire	492,096	462,534	— 29,562	— 6.01
New Jersey	19,838,553	19,705,378	— 133,175	— .67
New Mexico	185,575	176,528	— 9,047	— 4.88
New York	12,058,858	11,469,476	— 589,382	— 4.89
North Carolina	1,465,653	1,614,406	+ 148,753	+10.15
North Dakota	231,245	262,580	+ 31,335	+13.55
Ohio	34,811,508	38,388,296	+3,576,788	+10.27
Oklahoma	535,318	573,371	+ 38,053	+ 7.11
Oregon	734,226	771,795	+ 37,569	+ 5.12
Pennsylvania	21,537,221	24,231,482	+2,694,261	+12.51
Porto Rico	14,294	6,359	— 7,935	—55.51
South Carolina	704,563	583,241	— 121,322	—17.22
South Dakota	41,496	46,685	+ 5,189	+12.50
Tennessee	1,501,016	1,493,085	— 7,931	— .53
Texas	2,886,068	3,049,349	+ 163,281	+ 5.66
Utah	724,978	708,906	— 16,072	— 2.22
Vermont	79,266	94,773	+ 15,507	+19.56
Virginia	1,874,174	1,705,651	— 168,523	— 8.99
Washington	2,388,870	2,390,226	+ 1,356	+ .06
West Virginia	4,775,874	5,208,270	+ 432,396	+ 9.05
Wisconsin	1,044,486	1,020,728	— 23,758	— 2.27
Wyoming	45,103	61,678	+ 16,575	+36.75
Other States	[a] 684,442	[a] 793,549	+ 109,107	+15.94
Total	172,811,275	181,289,132	+8,477,857	+ 4.91

[a] Includes pottery products which could not be separately classified without disclosing individual figures.

Of the States and Territories represented in this table, 29 showed increase as compared with 1912 and 19 showed decrease, the same numbers as for 1912. Ohio showed the largest increase, $3,576,788, or 10.27 per cent. This State also showed the largest increase in 1912 over 1911—$2,147,613, or 6.57 per cent. The largest proportionate increase was in Montana, 45.5 per cent. The largest decrease was in New York, $589,382, or 4.89 per cent. The largest proportionate decrease was in Porto Rico, 55.51 per cent. The State increases or decreases were not confined to any one section of the country. Of the 19 States that showed decrease 2 were in New England—Connecticut and Rhode Island (taken together) and New Hampshire; 3 in the middle Atlantic region—District of Columbia, New Jersey, and New York; 5 in the Southern States—Florida, Georgia, South Carolina, Tennessee, and Virginia; 2 in the Central States—Illinois and Wisconsin; 1 in the Western States—Kansas; 4 in the Rocky Mountain region—Colorado, Idaho and Nevada (taken together), New Mexico, and Utah; 1 on the Pacific coast—California; and Porto Rico. Six of the States that showed decrease in 1913 also showed decrease in 1912, namely: Colorado, District of Columbia, Idaho and Nevada (taken together); Kansas, Porto Rico, and Wisconsin. Four of the first 10 States in value of production—New Jersey, Illinois, New York, and California—showed decrease in 1913.

Value of the products of clay in the United States in 1912 and 1913, with increase or decrease.

Product.	1912	1913	Increase (+) or decrease (—) in 1913.	Percentage of increase(+) or decrease(—) in 1913.
Common brick	$51,796,266	$50,134,757	—$1,661,509	— 3.21
Vitrified paving brick or block	10,921,575	12,138,221	+ 1,216,646	+11.14
Front brick	9,455,297	9,614,138	+ 158,841	+ 1.68
Fancy or ornamental brick	225,367	109,703	— 115,664	—51.32
Enameled brick	1,027,314	1,225,708	+ 198,394	+19.31
Draintile	8,010,250	8,558,320	+ 548,070	+ 6.84
Sewer pipe	12,147,677	14,872,103	+ 2,724,426	+22.43
Architectural terra cotta	8,580,436	7,733,306	— 847,130	— 9.87
Fireproofing	7,174,148	8,620,216	+ 1,446,068	+20.16
Tile (not drain)	5,809,495	6,109,180	+ 299,685	+ 5.16
Stove lining	516,874	535,667	+ 18,793	+ 3.64
Fire brick	17,877,629	20,627,122	+ 2,749,493	+15.38
Miscellaneous	2,764,783	3,018,316	+ 253,533	+ 9.17
Total brick and tile	136,307,111	143,296,757	+ 6,989,646	+ 5.13
Total pottery	36,504,164	37,992,375	+ 1,488,211	+ 4.08
Grand total	172,811,275	181,289,132	+ 8,477,857	+ 4.91

This table shows that 10 of the brick and tile items showed increase and only 3 showed decrease in 1913. The decrease was entirely in the structural materials, the engineering and refractory products showing large increases. In 1912, 8 of these items showed increase and 5 decrease. The increases were large in that year and the decreases small, so that the net gain in 1912 was larger than that of 1913.

The greatest of all clay products in point of value and geographic distribution, common brick, which showed decrease in 1910 and 1911, and increase in 1912, fell back and showed a large decrease in 1913—$1,661,509, or 3.21 per cent. This was considerable more than one-half of the total decrease.

Vitrified paving brick, which suffered a decrease of $194,167, or 1.75 per cent, in 1912, rallied in 1913 and showed a large increase—$1,216,646, or 11.14 per cent.

Sewer pipe, which has increased steadily in value since 1909, showed the second largest increase, $2,724,426, in 1913 and the largest proportionate increase, 22.43 per cent. This increase was due, in part, at least, to the floods in the Ohio valley during 1913.

Draintile, which showed the largest decrease in 1912, $816,064, or 9.25 per cent, showed a considerable gain in 1913—$548,070, or 6.84 per cent—in spite of the unusually dry season in the Middle West.

Front brick only slightly more than held its own, showing an increase of $158,841, or 1.68 per cent, over 1912. In 1912 it increased $806,420, or 9.32 per cent, over 1911.

Fireproofing, which showed a gain of $1,513,976, or 26.75 per cent, in 1912, showed another large gain in 1913, namely, $1,446,068, or 20.16 per cent.

The manufacture of tiles other than drain tiles is a growing industry in the United States. The value of these tiles increased $299,685, or 5.16 per cent, in 1913. These tiles, which have been used chiefly in the construction of the better class of buildings, are now being used extensively as a sanitary material even in the smallest modern residences. In 1912 this class showed an increase over 1911 of $453,311, or 8.46 per cent.

Architectural terra cotta, which showed the largest gain in 1912 over 1911—$2,562,635, or 42.58 per cent—was one of the three brick and tile products to decrease in value in 1913. This decrease was $847,130, or 9.87 per cent, and was principally in Illinois.

Fire brick, which in 1912 made a large increase—$1,802,943, or 11.22 per cent—continued to gain in value of production, and in 1913 increased $2,749,493, or 15.38 per cent, over 1912. For 1913 silica brick was reported to the value of $3,815,806, which should be deducted from the figures here given to arrive at the value of the clay fire brick.

The total increase in the brick and tile products in 1913 was $9,613,949; the total decrease was $2,624,303—a net increase of $6,989,646, or 5.13 per cent. The pottery production showed an increase of $1,488,211, or 4.08 per cent, the total net increase for both industries being $8,477,857, or 4.91 per cent. In 1912 the brick and tile production increased in value $8,589,490, or 6.73 per cent, and pottery production increased $1,985,604, or 5.75 per cent, the net increase in that year being $10,575,094, or 6.52 per cent.

The following table shows the value of the production of clay in the United States from 1903 to 1913, inclusive, by varieties of products, together with the total for each year, and the number of active firms reporting:

Products of clay in the United States, 1903–1913, by varieties.

Year.	Number of active firms reporting.	Common brick.			Vitrified paving brick.		
		Quantity (thousands).	Value.	Average price per thousand.	Quantity (thousands).	Value.	Average price per thousand.
1903	6,034	8,463,683	$50,532,075	$5.97	654,499	$6,453,849	$9.86
1904	6,108	8,665,171	51,768,558	5.97	735,489	7,557,425	10.28
1905	5,925	9,817,355	61,394,383	6.25	665,879	6,703,710	10.07
1906	5,857	10,027,039	61,300,696	6.11	751,974	7,857,768	10.45
1907	5,536	9,795,698	58,785,461	6.00	876,245	9,654,282	11.02
1908	5,328	7,811,046	44,765,614	5.73	978,122	10,657,475	10.90
1909	5,068	9,791,870	57,251,115	5.85	1,023,654	11,269,586	11.01
1910	4,915	9,221,517	55,219,551	5.99	968,000	11,004,666	11.37
1911	4,628	8,475,277	49,885,262	5.89	948,758	11,115,742	11.72
1912	4,284	8,555,238	51,796,266	6.05	911,869	10,921,575	11.98
1913	4,065	8,088,790	50,134,757	6.20	958,680	12,138,221	12.66

Year.	Front brick.			Fancy or ornamental brick (value).	Enameled brick (value).	Fire brick (value).	Stove lining (value).	Draintile (value).
	Quantity (thousands).	Value.	Average price per thousand.					
1903	433,016	$5,402,861	$12.48	$328,387	$569,689	a $14,062,369	(a)	$4,639,214
1904	434,351	5,560,131	12.80	300,233	545,397	11,167,972	(a)	5,348,555
1905	541,590	7,108,092	13.12	293,907	636,279	12,735,404	$645,432	5,850,210
1906	617,469	7,895,323	12.79	207,119	773,104	14,206,868	743,414	6,543,289
1907	585,943	7,329,360	12.51	361,243	918,173	14,946,045	627,647	6,864,162
1908	584,482	6,935,600	11.87	259,556	660,862	10,696,216	529,976	8,661,476
1909	816,164	9,712,219	11.90	174,073	993,902	16,620,695	423,583	9,799,158
1910	697,857	8,590,057	12.31	179,505	832,225	18,111,474	593,806	10,389,822
1911	724,911	8,648,877	11.93	177,015	1,038,865	16,074,686	614,116	8,826,314
1912	814,007	9,455,297	11.62	225,367	1,027,314	17,877,629	516,874	8,010,250
1913	827,665	9,614,138	11.62	109,703	1,225,708	20,627,122	535,667	8,558,320

Year.	Sewer pipe (value).	Architectural terra cotta (value).	Fireproofing (value).	Tile, not drain (value).	Miscellaneous (value).	Total brick and tile (value).	Pottery (value).	Total value.
1903	$8,525,369	$4,672,028	$3,861,343	$3,505,329	$3,073,856	$105,626,369	$25,436,052	$131,062,421
1904	9,187,423	4,107,473	3,629,101	3,023,428	3,669,282	105,864,978	25,158,270	131,023,248
1905	10,097,089	5,003,158	4,098,793	3,647,726	3,564,111	121,778,294	27,918,894	149,697,188
1906	11,114,967	5,739,460	4,586,538	4,634,898	3,988,394	129,591,838	31,440,884	161,032,722
1907	11,482,845	6,026,977	4,250,618	4,551,881	3,000,201	128,798,895	30,143,474	158,942,369
1908	11,003,731	4,577,367	3,168,037	3,877,780	2,268,517	108,062,207	25,135,555	133,197,762
1909	10,322,324	6,251,625	4,466,708	5,291,963	2,694,821	135,271,772	31,049,441	166,321,213
1910	11,428,696	6,976,771	5,110,597	5,240,644	2,743,482	136,331,296	33,784,678	170,115,974
1911	11,454,616	6,017,801	5,660,172	5,356,184	2,847,971	127,717,621	34,518,560	162,236,181
1912	12,147,677	8,580,436	7,174,148	5,809,495	2,764,783	136,307,111	36,504,164	172,811,275
1913	14,872,103	7,733,306	8,620,216	6,109,180	3,018,316	143,296,757	37,992,375	181,289,132

a Stove lining is included in fire brick in 1903; in miscellaneous in 1904.

This table shows the growth of the clay-working industries during 11 years. Considering a 10-year period for comparative purposes, the total value of these products ranged from $131,023,248 in 1904 to $181,289,132 in 1913. The increase of 1913 over 1904 was $50,265,884, or 38.36 per cent. In three years, within the 10-year period, 1907, 1908, and 1911, there were decreases. The greatest decrease was in 1908—$25,744,607, or 16.2 per cent, and the greatest increase was in 1909—$33,123,451, or 24.87 per cent. The maximum value was reached in 1913 in six brick and tile products, vitrified paving brick, enameled brick, fire brick, sewer pipe, fireproofing, and tile, not drain. The total value of brick and tile products was also the greatest yet attained. Pottery also reached its maximum value in 1913.

The maximum quantity of common brick was reached in 1906 and the maximum value in 1905. The production in 1913 was less than the maximum output by 1,938,249,000 brick, or 19.33 per cent, and less than the maximum value by $11,259,626, or 18.34 per cent. The average price per 1,000 ranged from $5.73 in 1908 to $6.25 in 1905. The average price in 1913 was 15 cents higher than that of 1912, and within 5 cents of the maximum.

Vitrified paving brick reached its maximum quantity in 1909 and its maximum value in 1913. The output of 1913 was 64,974,000 brick, or 6.35 per cent, less than that of 1909, but its value in 1913 was $868,635, or 7.71 per cent, greater than that of 1909. The output in 1913 was 46,811,000 brick, or 5.13 per cent, greater than that of 1912, and the value in 1913 was $1,216,646, or 11.14 per cent, greater. The average price per 1,000 ranged in the 10-year period from $10.07 in 1905 to $12.66 in 1913.

Front brick reached its maximum quantity in 1913 and its maximum value in 1909. The output of 1913 was 13,658,000 brick, or 1.68 per cent, greater than that of 1912, and the value of the 1913 output was $98,081, or 1.01 per cent, less than that of 1909. The average price per 1,000 was the same, $11.62, in both 1912 and 1913, and was the lowest in 10 years. The highest average price was in 1905—$13.12.

Enameled brick reached its maximum value in 1913—$1,225,708. This was an increase of $186,843, or 17.99 per cent, over 1911, the year of maximum value prior to 1913. The production of 1913 was valued at more than twice as much as that of 1904.

Fire brick showed a very large increase and attained its maximum value in 1913. This was $2,515,648, or 13.89 per cent, greater than that of 1910, the next highest value, and was nearly twice as large as that for 1908, the year of minimum value in the 10-year period.

Draintile, after a steady increase for 10 years, showed a large decrease in 1911 and 1912, but in 1913 rallied and showed a considerable increase, so that the value of 1913 was but $1,831,502, or 17.63 per cent, less than that of 1910, the year of maximum value.

Sewer pipe made large increase in 1913, and attained its maximum. The value of sewer pipe in 1913 was $5,684,680, or 61.87 per cent, greater than that of 1904, the year of minimum value in the 10-year period.

Architectural terra cotta was the only product that showed a decrease in 1913, after reaching its maximum value in 1912. This decrease in 1913 is probably due to the falling off of building operations in some of the larger cities, which are the largest consumers of architectural terra cotta. With the exception of 1912, however, the value of architectural terra cotta in 1913 was the highest reported. Its value in 1913 was $3,625,833, or 88.27 per cent, greater than that of 1904.

Fireproofing, including hollow building tile or block, again showed a large increase and in 1913 attained its maximum value. This product has increased steadily in value since 1908, the year of minimum value in the 10-year period and in 1913 its value was $5,452,179, or 172.1 per cent, greater than that of 1908.

Tile, not drain, which embraces all kinds of tile except drain tile, has varied considerably. It showed a large increase in 1909, a small decrease in 1910, and increases in 1911, 1912, and 1913, reaching its maximum value in 1913. Its value in 1913 was $3,085,752, or 102.06 per cent, greater than that of 1904.

The number of active firms reporting continues to decrease—from 4,284 in 1912 to 4,065 in 1913. There has been a steady decrease in the number of active operators reporting since 1904, the net decrease in this period being 2,043, or 33.45 per cent. This condition is partly due to the consolidation of companies, but the principal cause is undoubtedly the elimination of the smaller plants. It should be borne in mind, however, that no attempt is made to show the number of yards or plants, or even the number of operators, but merely the number of operators reporting sales of products during the year. The number of plants is considerably larger than the number of firms reporting business during the year, as many operators have more than one plant and some as many as 20 or more, and many were idle or reported no sales.

RANK OF STATES.

The following table shows the rank of States in the value of clay products, the number of operating firms reporting, and the percentage of the total value produced in each State in 1912 and 1913:

Rank of States, value of output, and percentage of total value of clay products in 1912 and 1913.

State or Territory.	1912				1913			
	Rank.	Number of active firms reporting.	Value.	Percentage of total products.	Rank.	Number of active firms reporting.	Value.	Percentage of total products.
Ohio	1	596	$34,811,508	20.14	1	563	$38,388,296	21.18
Pennsylvania	2	393	21,537,221	12.46	2	377	24,231,482	13.37
New Jersey	3	155	19,838,553	11.48	3	149	19,705,378	10.87
Illinois	4	301	15,210,990	8.80	4	281	15,195,874	8.38
New York	5	219	12,058,858	6.98	5	215	11,469,476	6.33
Indiana	6	278	7,935,251	4.59	6	257	8,498,646	4.69
Missouri	7	110	6,412,861	3.71	7	105	6,602,076	3.64
Iowa	10	200	4,522,326	2.62	8	186	5,573,681	3.07
California	8	91	5,912,450	3.42	9	91	5,344,958	2.95
West Virginia	9	54	4,775,874	2.76	10	58	5,208,270	2.87
Texas	11	104	2,886,068	1.67	11	102	3,049,349	1.68
Kentucky	14	90	2,443,740	1.41	12	83	2,914,276	1.61
Georgia	12	96	2,806,541	1.62	13	92	2,692,619	1.49
Michigan	13	101	2,545,498	1.47	14	98	2,674,125	1.48
Washington	15	50	2,388,870	1.38	15	45	2,390,226	1.32
Alabama	17	74	1,935,179	1.12	16	68	2,091,581	1.15
Kansas	16	46	2,036,500	1.18	17	43	1,919,910	1.06
Maryland	19	55	1,865,753	1.08	18	49	1,917,500	1.06
Massachusetts	20	63	1,767,166	1.02	19	60	1,814,875	1.00
Minnesota	21	79	1,611,040	.93	20	69	1,781,017	.98
Virginia	18	75	1,874,174	1.09	21	69	1,705,651	.94
North Carolina	23	162	1,465,653	.85	22	157	1,614,406	.89
Tennessee	22	80	1,501,016	.87	23	79	1,493,085	.82
Connecticut and Rhode Island	24	41	1,465,000	.85	24	42	1,372,234	.76
Colorado	25	71	1,437,394	.83	25	68	1,293,511	.71
Wisconsin	26	92	1,044,486	.61	26	85	1,020,728	.56
Nebraska	27	59	805,398	.47	27	56	886,166	.49
Oregon	28	65	734,226	.42	28	59	771,795	.43
Utah	29	32	724,978	.42	29	30	708,906	.39
Maine	33	47	534,101	.31	30	38	661,573	.37
Mississippi	31	55	601,799	.35	31	57	641,271	.35
Louisiana	34	40	523,643	.30	32	38	638,491	.35
South Carolina	30	42	704,563	.41	33	41	583,241	.32
Oklahoma	32	29	535,318	.31	34	31	573,371	.32
Arkansas	36	43	462,605	.27	35	39	529,624	.29
New Hampshire	35	26	492,096	.29	36	26	462,534	.26
Montana	37	23	314,017	.18	37	22	456,897	.25
North Dakota	39	12	231,245	.13	38	11	262,580	.14
Florida	38	18	272,766	.16	39	15	253,344	.14
Arizona	42	17	178,564	.10	40	17	218,542	.12
Delaware	44	17	162,216	.09	41	15	187,280	.10
New Mexico	41	12	185,575	.11	42	13	176,528	.10
District of Columbia	40	9	217,486	.13	43	8	160,014	.09
Idaho and Nevada	43	26	176,108	.10	44	25	150,701	.08
Vermont	45	5	79,266	.05	45	5	94,773	.05
Wyoming	46	10	45,103	.03	46	8	61,678	.03
South Dakota	47	7	41,496	.02	47	7	46,685	.03
Porto Rico	48	14	14,294	.01	48	13	6,359	.00
Other States	......	....	a 684,442	.40	......	....	a 793,549	.44
Total	......	4,284	172,811,275	100.00	......	4,065	181,289,132	100.00

a Undistributed pottery products.

The value of clay products ranged by States in 1913 from $6,359 in Porto Rico to $38,388,296, or 21.18 per cent of the total, in Ohio. For 1912 Ohio reported 20.14 per cent of the total. Ohio has been the leading State in the value of clay products since figures were first compiled by the Geological Survey in 1894. It is likely to maintain this position for many years, as its output in 1913 was valued at $14,156,814, or 58.42 per cent more than that of Pennsylvania, the second State whose output was valued at $24,231,482, or 13.37 per cent of the total. For 1912 Pennsylvania reported 12.46 per cent of the total. New Jersey was the third State in both years. There was no change in the relative rank of the first seven States. Iowa, which was tenth in 1912, was eighth in 1913, and California, which was eighth in 1912, was ninth in 1913, and West Virginia, which was ninth in 1912, was tenth in 1913. There were but slight changes in the relative ranks of the other States. Kentucky rose from fourteenth in 1912 to twelfth in 1913; Virginia fell from eighteenth in 1912 to twenty-first in 1913; Maine rose from thirty-third in 1912 to thirtieth in 1913, exchanging places with South Carolina; and the District of Columbia fell from fortieth in 1912 to forty-third in 1913. The first 10 States reported for 1913 wares valued at $140,218,137, or 77.35 per cent of the total; for 1912 the same States reported wares valued at $133,015,892, or 76.97 per cent of the total. The first 5 States reported wares in 1913 valued at $108,990,506, or 60.13 per cent of the total, as compared with $103,457,130, or 59.87 per cent of the total in 1912.

BRICK AND TILE.

PRODUCTION.

PRODUCTION BY STATES.

The following tables show the output and value of the building brick and other structural products of clay, and of the fire brick, paving brick, and other clay products used in engineering work, the rank of the State in these products, and the percentage of the total value of each State in 1912 and 1913:

Brick and tile products in the United States in 1912.

Rank.	State or Territory.	Common brick.			Vitrified brick or block.		
		Quantity (thousands).	Value.	Average price per thousand.	Quantity (thousands).	Value.	Average price per thousand.
16	Alabama	136,989	$759,409	$5.54	26,480	$353,303	$13.34
42	Arizona	13,166	114,309	8.68			
36	Arkansas	52,986	345,154	6.51	(a)	(a)	8.69
8	California	349,797	2,198,303	6.28	5,443	72,495	13.32
24	Colorado	66,833	407,428	6.10	(a)	(a)	12.04
21	Connecticut and Rhode Island	214,700	1,377,456	6.42	(a)	(a)	17.71
44	Delaware	18,574	147,716	7.95			
40	District of Columbia	22,841	182,230	7.98			
38	Florida	44,710	262,766	5.88			
10	Georgia	315,476	1,634,670	5.18	(a)	(a)	12.00
43	Idaho and Nevada	19,306	155,486	8.05			
3	Illinois	1,210,499	6,437,331	5.32	136,708	1,839,721	13.46
6	Indiana	202,056	1,204,494	5.96	55,237	654,341	11.85
9	Iowa	148,472	1,017,097	6.85	15,033	197,035	13.11
15	Kansas	145,986	584,273	4.00	80,906	806,427	9.97
14	Kentucky	99,119	656,373	6.62	(a)	(a)	8.36
34	Louisiana	74,617	473,702	6.35			
33	Maine	41,451	297,987	7.19	(a)	(a)	25.00
18	Maryland	154,560	1,053,335	6.82	(a)	(a)	17.93
20	Massachusetts	157,527	1,095,584	6.95			
13	Michigan	271,189	1,592,283	5.87	(a)	(a)	13.94
19	Minnesota	129,604	760,983	5.87	(a)	(a)	16.34
31	Mississippi	87,431	522,901	5.98			
7	Missouri	188,496	1,243,070	6.59	30,551	342,930	11.22
37	Montana	18,811	185,793	9.88	(a)	(a)	17.33
27	Nebraska	98,895	637,983	6.45	(a)	(a)	15.00
35	New Hampshire	62,135	492,096	7.92			
4	New Jersey	429,309	2,592,091	6.04			
41	New Mexico	12,120	110,342	9.10	(a)	(a)	10.99
5	New York	1,273,641	7,311,675	5.74	18,634	287,089	15.41
22	North Carolina	193,058	1,236,443	6.40			
39	North Dakota	15,031	117,301	7.80			
2	Ohio	395,836	2,414,482	6.10	268,271	2,830,309	10.55
32	Oklahoma	67,712	341,589	5.04	18,805	175,905	9.35
28	Oregon	47,174	363,374	7.70			
1	Pennsylvania	697,023	4,590,784	6.59	112,372	1,411,096	12.56
48	Porto Rico	1,840	14,294	7.77			
30	South Carolina	112,175	663,550	5.92			
47	South Dakota	4,239	33,356	7.87			
25	Tennessee	154,211	903,032	5.86	(a)	(a)	11.11
11	Texas	242,748	1,590,960	6.55	(a)	(a)	14.56
29	Utah	44,044	294,105	6.68			
45	Vermont	8,126	49,167	6.05			
17	Virginia	244,541	1,513,338	6.19			
12	Washington	78,000	547,061	7.01	(a)	(a)	16.88
23	West Virginia	60,819	393,864	6.48	52,200	633,709	12.14
26	Wisconsin	122,910	830,773	6.76			
46	Wyoming	4,455	44,473	9.98			
	Other States b				91,229	1,317,215	14.44
	Total	8,555,238	51,796,266	6.05	911,869	10,921,575	11.98
	Percentage of brick and tile products		38.00			8.01	
	Percentage of total of clay products		29.97			6.32	

a Included in "Other States."
b Includes all products made by less than 3 producers in 1 State.

Brick and tile products in the United States in 1912—Continued.

Rank.	State or Territory.	Front brick.			Fancy or ornamental brick.	Drain-tile.	Sewer pipe.	Architectural terra cotta.	Fireproofing.
		Quantity (thousands).	Value.	Average price per thousand.	Value.	Value.	Value.	Value.	Value.
16	Alabama	10,629	$132,033	$12.42	(a)	$5,465	(a)	....	(a)
42	Arizona	(a)	(a)	20.00	....	....	(a)	....	(a)
36	Arkansas	2,643	28,068	10.62	....	5,220	....	....	(a)
8	California	18,714	492,617	26.32	(a)	37,377	$1,136,429	$650,637	$250,931
24	Colorado	20,087	233,175	11.61	$3,785	20,250	(a)	(a)	22,213
21	Connecticut and Rhode Island	(a)	(a)	13.25	(a)	....	....	....	....
44	Delaware	(a)	(a)	20.00	....	(a)	....	....	....
40	District of Columbia	....	....	....	....	(a)	(a)	....	(a)
38	Florida	....	....	....	....	10,000	....	....	....
10	Georgia	11,527	114,000	9.89	(a)	(a)	622,627	(a)	(a)
43	Idaho and Nevada	898	16,822	18.73	....	....	....	....	....
3	Illinois	21,894	268,433	12.26	8,785	1,189,910	500,844	2,485,012	507,222
6	Indiana	60,544	659,492	10.89	(a)	1,657,368	544,491	(a)	623,123
9	Iowa	11,912	142,637	11.97	(a)	2,293,084	291,672	....	535,254
14	Kansas	27,972	215,873	7.72	(a)	50,948	(a)	(a)	48,173
15	Kentucky	5,025	46,300	9.21	(a)	71,826	(a)	....	29,530
34	Louisiana	(a)	(a)	10.71	....	(a)	....	....	....
33	Maine	2,160	20,000	9.26	....	(a)	(a)	....	....
18	Maryland	1,968	39,664	20.15	(a)	3,043	....	(a)	(a)
20	Massachusetts	(a)	(a)	20.00	....	....	....	....	(a)
13	Michigan	3,934	41,476	10.54	....	387,945	(a)	....	1,461
19	Minnesota	11,555	144,125	12.47	....	126,690	(a)	....	160,804
31	Mississippi	1,060	15,746	14.85	....	48,221	....	....	....
7	Missouri	19,963	264,375	13.24	19,838	141,297	1,178,482	654,163	75,551
37	Montana	1,076	17,753	16.50	....	(a)	(a)	....	(a)
27	Nebraska	5,229	80,650	15.42	....	5,260	....	....	60,016
35	New Hampshire	....	....	....	....	....	....	....	....
4	New Jersey	48,852	558,372	11.43	(a)	50,984	(a)	2,330,065	2,031,350
41	New Mexico	2,872	41,338	14.41	....	....	....	....	(a)
5	New York	9,499	123,378	12.99	(a)	51,005	(a)	1,139,291	217,411
22	North Carolina	(a)	(a)	8.92	....	10,745	(a)	....	....
39	North Dakota	5,392	104,396	19.36	(a)	....	....	....	....
2	Ohio	184,405	1,836,989	9.96	16,692	1,546,723	4,022,078	....	1,750,715
32	Oklahoma	1,803	16,924	9.39	....	(a)	....	....	....
28	Oregon	(a)	(a)	24.95	....	74,737	(a)	(a)	40,367
1	Pennsylvania	217,328	2,321,479	10.68	43,186	12,421	829,917	569,943	350,219
48	Porto Rico	....	....	....	....	....	....	....	....
30	South Carolina	(a)	(a)	13.40	....	(a)	....	....	....
47	South Dakota	(a)	(a)	18.33	....	(a)	....	....	(a)
25	Tennessee	11,118	101,575	9.14	(a)	39,459	(a)	....	(a)
11	Texas	24,510	394,524	16.10	....	10,694	(a)	....	57,433
29	Utah	13,473	167,770	12.45	....	34,946	(a)	....	(a)
45	Vermont	....	....	....	....	(a)	....	....	....
17	Virginia	21,755	313,551	14.41	(a)	4,025	(a)	....	....
12	Washington	6,881	146,265	21.26	....	24,676	496,500	365,109	163,077
23	West Virginia	(a)	(a)	12.00	....	(a)	(a)	....	(a)
26	Wisconsin	14,096	135,520	9.61	....	67,993	....	....	....
46	Wyoming	(a)	(a)	14.00	....	....	....	....	....
	Other States [b]	13,233	219,927	16.62	133,081	27,938	2,524,637	386,216	249,298
	Total	814,007	9,455,297	11.62	[c]1,252,681	8,010,250	12,147,677	8,580,436	7,174,148
	Percentage of brick and tile products	....	6.94	....	.92	5.88	8.91	6.29	5.26
	Percentage of total of clay products	....	5.47	....	.72	4.64	7.03	4.97	4.15

[a] Included in "Other States."
[b] Includes all products made by less than 3 producers in 1 State.
[c] Includes enameled brick valued at $1,027,314, made in the following States: California, Colorado, Illinois, Maryland, Missouri, New Jersey, Ohio, and Pennsylvania.

Brick and tile products in the United States in 1912—Continued.

Rank.	State or Territory.	Tile, not drain. Value.	Stove lining. Value.	Fire brick. Quantity (thousands).	Fire brick. Value.	Fire brick. Average price per thousand.	Miscellaneous.[a] Value.	Total value.	Percentage of total value.
16	Alabama			9,930	$240,434	$24.21	(b)	$1,912,966	1.40
42	Arizona			(b)	(b)	50.78		178,564	.13
36	Arkansas			(b)	(b)	13.50		433,648	.32
8	California	$76,358	(b)	19,033	513,583	26.98	$113,277	5,692,797	4.18
24	Colorado	2,200		15,519	301,680	19.44	68,197	1,396,147	1.02
21	Connecticut and Rhode Island	(b)	(b)	(b)	(b)	22.00		1,465,000	1.08
44	Delaware							162,216	.12
40	District of Columbia							217,486	.16
38	Florida							272,766	.20
10	Georgia	(b)		4,250	61,231	14.41		2,787,484	2.05
43	Idaho and Nevada							176,108	.13
3	Illinois	(b)		19,088	319,619	16.74	43,915	14,279,039	10.48
6	Indiana	(b)	(b)	6,769	114,419	16.90	518,090	6,858,149	5.03
9	Iowa			(b)	(b)	12.96	13,774	4,492,185	3.30
15	Kansas	(b)		(b)	(b)	25.03	3,685	2,036,500	1.49
14	Kentucky	310,945		53,162	1,000,056	18.81	2,500	2,329,536	1.71
34	Louisiana			(b)	(b)	29.73	29,353	523,643	.38
33	Maine			(b)	(b)	15.00		534,101	.39
18	Maryland		$26,673	13,986	262,817	18.79		1,681,042	1.23
20	Massachusetts	(b)	173,256	2,302	83,454	36.25		1,515,067	1.11
13	Michigan	(b)	(b)	(b)	(b)	17.78	(b)	2,350,606	1.73
19	Minnesota			(b)	(b)	15.00	(b)	1,611,040	1.18
31	Mississippi			(b)	(b)	35.00	1,875	589,093	.43
7	Missouri	(b)	(b)	97,751	1,941,347	19.86	191,319	6,409,346	4.70
37	Montana			714	27,555	38.59		314,017	.23
27	Nebraska	(b)					12,089	805,398	.59
35	New Hampshire							492,096	.36
4	New Jersey	1,255,246	(b)	60,782	1,460,988	24.04	212,287	10,902,633	8.00
41	New Mexico			604	10,980	18.18		185,575	.14
5	New York	45,865	75,751	8,962	328,644	36.67	19,772	9,653,326	7.08
22	North Carolina			324	4,430	13.67	(b)	1,456,703	1.07
39	North Dakota			(b)	(b)	25.89		231,245	.17
2	Ohio	2,421,783	37,544	94,955	1,629,638	17.16	755,034	19,302,773	14.16
32	Oklahoma			(b)	(b)	23.08		535,318	.39
28	Oregon	(b)		85	2,000	23.53	(b)	734,226	.54
1	Pennsylvania	385,952	138,630	335,054	6,178,870	18.44	616,916	19,408,681	14.24
48	Porto Rico							14,294	.01
30	South Carolina			2,018	29,242	14.49		697,802	.51
47	South Dakota	(b)						41,496	.03
25	Tennessee			871	10,981	12.61	375	1,327,850	.97
11	Texas			6,627	112,983	17.05	55,126	2,739.464	2.01
29	Utah	(b)	(b)	(b)	(b)	31.16	6,818	724,978	.53
45	Vermont		(b)					79,266	.06
17	Virginia			(b)	(b)	14.37	1,374	1,874,174	1.38
12	Washington	(b)	(b)	1,170	34,293	29.31	(b)	2,388,870	1.75
23	West Virginia	200,390		14,421	105,719	7.33	7,112	1,410,708	1.04
26	Wisconsin						(b)	1,036,586	.76
46	Wyoming							45,103	.03
	Other States [c]	1,110,756	65,020	9,726	179,492	18.45	91,895	(d)	
	Total	5,809,495	516,874	[e]913,681	[e]17,877,629	19.57	2,764,783	136,307,111	100.00
	Percentage of brick and tile products.	4.26	0.38		13.12		2.03	100.00	
	Percentage of total of clay products..	3.36	0.30		10.35		1.60	78.88	

[a] Including adobes, aquarium ornaments, assay furnaces, burnt-clay ballast, charcoal furnaces, chemical brick, chimney pipe and tops, conduits, crucibles, flue pipe and lining, furnaces for heating irons, gas logs, glasshouse supplies, glazed brick, grave and lot markers, muffles, radial chimney brick and block, retorts, saggers, scorifiers, segments, silo blocks, stone pumps, sundials, vases and ornaments, and wall coping.

[b] Included in "Other States."

[c] Includes all products made by less than 3 producers in 1 State.

[d] The total of "Other States" is distributed among the States to which it belongs, in order that they may be fully represented in the totals.

[e] In the total quantity and total value of fire brick are included, respectively, 135,578,000 silica brick, valued at $2,923,174, of which 101,596,000, valued at $1,950,708, was produced by Pennsylvania and the remainder, 33,982,000, valued at $972,466, by Alabama, Colorado, Idaho, Illinois, Indiana, Missouri, Montana, Ohio, and Utah.

Brick and tile products in the United States in 1913.

Rank.	State or Territory.	Common brick. Quantity (thousands).	Common brick. Value.	Common brick. Average price per thousand.	Vitrified brick or block. Quantity (thousands).	Vitrified brick or block. Value.	Vitrified brick or block. Average price per thousand.
15	Alabama	130,923	$730,148	$5.58	24,183	$361,722	$14.96
40	Arizona	20,478	181,042	8.84			
35	Arkansas	64,680	433,242	6.70	(a)	(a)	8.09
9	California	295,729	1,699,426	5.75	1,923	44,725	23.26
25	Colorado	45,590	291,113	6.39	3,807	46,220	12.14
23	Connecticut and Rhode Island	185,737	1,252,126	6.74	(a)	(a)	15.30
41	Delaware	23,253	173,051	7.44			
44	District of Columbia	14,614	110,064	7.53			
39	Florida	42,450	240,126	5.66			
12	Georgia	278,504	1,464,322	5.26	(a)	(a)	12.81
43	Idaho and Nevada	16,555	136,455	8.24			
3	Illinois	1,155,480	6,445,821	5.58	133,938	1,883,199	14.06
6	Indiana	208,500	1,268,710	6.08	54,579	690,164	12.65
8	Iowa	143,263	1,052,036	7.34	16,398	222,105	13.54
16	Kansas	122,465	541,741	4.42	53,382	543,929	10.19
11	Kentucky	98,364	681,727	6.93	(a)	(a)	10.13
31	Louisiana	95,736	600,234	6.27			
30	Maine	43,201	312,182	7.23	(a)	(a)	15.02
19	Maryland	153,053	1,004,146	6.56	(a)	(a)	17.91
22	Massachusetts	153,818	1,106,437	7.19			
13	Michigan	273,571	1,626,287	5.94	8,571	126,062	14.71
18	Minnesota	129,261	800,441	6.19	(a)	(a)	15.85
32	Mississippi	90,801	523,526	5.77			
7	Missouri	185,872	1,270,581	6.84	19,383	275,164	14.20
37	Montana	27,094	283,075	10.45	926	15,888	17.16
27	Nebraska	89,727	586,192	6.53	(a)	(a)	13.26
36	New Hampshire	56,904	462,534	8.13			
4	New Jersey	401,702	2,391,287	5.95			
42	New Mexico	10,009	89,538	8.95	(a)	(a)	10.90
5	New York	1,068,516	6,029,103	5.64	33,901	514,677	15.18
21	North Carolina	204,097	1,354,062	6.63			
38	North Dakota	22,087	135,734	6.15			
2	Ohio	407,685	2,523,014	6.19	304,391	3,308,975	10.87
34	Oklahoma	73,176	369,344	5.05	14,912	149,844	10.05
28	Oregon	36,885	302,584	8.20	(a)	(a)	25.00
1	Pennsylvania	704,493	4,772,229	6.77	140,407	1,814,833	12.93
48	Porto Rico	916	6,334	6.91			
33	South Carolina	87,938	536,434	6.10			
47	South Dakota	5,016	39,065	7.79			
24	Tennessee	151,072	902,832	5.98	(a)	(a)	15.32
10	Texas	248,271	1,826,793	7.36	(a)	(a)	12.85
29	Utah	36,405	283,013	7.77			
45	Vermont	9,498	62,431	6.57			
20	Virginia	217,408	1,409,798	6.48	(a)	(a)	12.88
14	Washington	67,435	475,874	7.06	42,717	701,550	16.42
17	West Virginia	68,745	476,248	6.93	58,728	795,555	13.55
26	Wisconsin	116,534	815,461	7.00			
46	Wyoming	5,279	56,794	10.76			
	Other States [b]				46,534	643,609	13.83
	Total	8,088,790	50,134,757	6.20	958,680	12,138,221	12.66
	Percentage of brick and tile products		34.99			8.47	
	Percentage of total of clay products		27.65			6.70	

[a] Included in "Other States." [b] Includes all products made by less than 3 producers in 1 State.

Brick and tile products in the United States in 1913—Continued.

Rank.	State or Territory.	Front brick. Quantity (thousands).	Front brick. Value.	Front brick. Average price per thousand.	Fancy or ornamental brick. Value.	Drain-tile. Value.	Sewer pipe. Value.	Architectural terra cotta. Value.	Fireproofing. Value.
15	Alabama	(a)	(a)	$15.29		$10,802	(a)		(a)
40	Arizona	(a)	(a)	24.00			(a)		(a)
35	Arkansas	2,819	$35,638	12.64		2,190			
9	California	16,605	368,149	22.17	(a)	34,413	$1,032,094	$629,103	$322,200
25	Colorado	10,851	129,590	11.94	(a)	47,871	(a)	(a)	25,220
23	Connecticut and Rhode Island	(a)	(a)	12.73	(a)				
41	Delaware	(a)	(a)	15.90		(a)			
44	District of Columbia					(a)	(a)		(a)
39	Florida					(a)			
12	Georgia	9,749	96,568	9.91		9,100	634,478	(a)	33,900
43	Idaho and Nevada	844	11,196	13.27	(a)				
3	Illinois	29,566	363,010	12.28	$2,295	1,225,190	787,896	1,908,399	592,337
6	Indiana	67,202	708,745	10.55		1,595,290	661,783	(a)	703,189
8	Iowa	14,078	181,911	12.92		2,798,816	503,360		762,563
16	Kansas	39,451	335,940	8.52	(a)	36,565	(a)	(a)	80,220
11	Kentucky	4,098	42,637	10.40		78,023	162,370		39,341
31	Louisiana	(a)	(a)	10.37		(a)			(a)
30	Maine	(a)	(a)	9.00		(a)	(a)		
19	Maryland	(a)	(a)	23.00	(a)	3,744		(a)	55,162
22	Massachusetts	869	17,380	20.00					(a)
13	Michigan	505	5,940	11.76		415,543	(a)		(a)
18	Minnesota	13,392	163,380	12.20		110,543	(a)		170,214
32	Mississippi	(a)	(a)	10.11		79,454			
7	Missouri	27,191	414,778	15.25	18,734	130,661	1,213,889	480,372	104,073
37	Montana	970	17,368	17.91		(a)	(a)		(a)
27	Nebraska	9,368	178,781	19.08	(a)	5,615			95,578
36	New Hampshire								
4	Mew Jersey	45,841	474,501	10.35	(a)	44,020	(a)	2,388,298	2,092,370
42	Nex Mexico	2,452	36,593	14.93		(a)			(a)
5	New York	7,636	83,823	10.98	(a)	83,695	(a)	1,110,726	208,625
21	North Carolina	(a)	(a)	8,89		13,584	(a)		(a)
38	North Dakota	(a)	(a)	20.04	(a)				(a)
2	Ohio	185,810	1,950,433	10.50	20,950	1,508,564	5,159,548		2,115,861
34	Oklahoma	3,119	31,103	9.97					
28	Oregon	3,757	96,043	25.56		73,873	(a)		55,308
1	Pennsylvania	214,734	2,325,201	10.83	35,446	11,730	1,326,971	506,100	480,675
48	Porto Rico								
33	South Carolina	(a)	(a)	13.49		(a)			(a)
47	South Dakota	(a)	(a)	15.12		(a)			(a)
24	Tennessee	16,085	154,681	9.62		42,294	(a)		(a)
10	Texas	21,766	293,077	13.46		8,840	(a)		129,763
29	Utah	14,760	173,589	11.76		29,698	(a)		(a)
45	Vermont								
20	Virginia	18,040	247,142	13.70	(a)	6,400	(a)		
14	Washington	6,122	128,989	21.07		28,172	501,102	316,628	157,069
17	West Virginia	2,732	33,484	12.26		3,191	(a)		(a)
26	Wisconsin	11,178	121,739	10.89		73,328			
46	Wyoming	(a)	(a)	15.07					
	Other States [b]	26,075	392,729	15.06	32,278	47,111	2,888,612	393,685	396,548
	Total	827,665	9,614,138	11.62	[c]1,335,411	8,558,320	14,872,103	7,733,306	8,620,216
	Percentage of brick and tile products		6.71		.93	5.97	10.38	5.40	6.02
	Percentage of total clay products		5.30		.74	4.72	8.20	4.27	4.75

[a] Included in "Other States."
[b] Includes all products made by less than 3 producers in 1 State.
[c] Includes enameled brick valued at $1,225,708 made in the following States: California, Colorado, Illinois, Maryland, Missouri, New Jersey, and Ohio.

Brick and tile products in the United States in 1913—Continued.

Rank.	State or Territory.	Tile, not drain.	Stove lining.	Fire brick.			Miscellaneous.[a]	Total value.	Percentage of total value.
		Value.	Value.	Quantity (thousands).	Value.	Average price per thousand.	Value.		
15	Alabama	(b)		(b)	(b)	$17.74	$26,086	$2,071,423	1.45
40	Arizona			(b)	(b)	30.00		218,542	.15
35	Arkansas			(b)	(b)	13.17		509,867	.36
9	California	$151,252	(b)	19,305	$523,692	27.13	75,434	5,054,703	3.53
25	Colorado	(b)		14,261	306,843	21.52	58,965	1,247,010	.87
23	Connecticut and Rhode Island	(b)	(b)	(b)	(b)	22.00		1,372,234	.96
41	Delaware							187,280	.13
44	District of Columbia							149,014	.10
39	Florida							253,344	.18
12	Georgia	(b)		4,405	64,167	14.57		2,664,091	1.86
43	Idaho and Nevada							150,701	.11
3	Illinois	82,168		20,376	351,324	17.24	78,101	14,280,611	9.97
6	Indiana	(b)	(b)	6,016	105,286	17.50	573,184	7,311,940	5.10
8	Iowa	(b)		264	3,250	12.31	25,742	5,552,983	3.88
16	Kansas	(b)					31,464	1,919,910	1.34
11	Kentucky	301,094	(b)	79,342	1,428,938	18.01	2,780	2,812,158	1.96
31	Louisiana						16,105	638,491	.45
30	Maine			(b)	(b)	15.00		661,573	.46
19	Maryland		$23,006	14,444	295,707	20.47		1,762,466	1.23
22	Massachusetts	(b)	179,980	2,361	84,298	35.70	1,500	1,583,530	1.11
13	Michigan	(b)		(b)	(b)	16.41	35,000	2,451,242	1.71
18	Minnesota			(b)	(b)	16.67	17,348	1,781,017	1.24
32	Mississippi			(b)	(b)	25.00	8,000	623,820	.44
7	Missouri	(b)	(b)	104,728	2,138,368	20.42	138,720	6,598,664	4.60
37	Montana	(b)		1,244	49,542	39.82		456,897	.32
27	Nebraska						13,296	886,136	.62
36	New Hampshire							462,534	.32
4	New Jersey	1,308,787	(b)	43,181	1,246,294	28.86	353,378	10,866,833	7.58
42	New Mexico			1,223	24,920	20.38		176,528	.12
5	New York	67,700	67,327	8,215	341,524	41.57	39,900	8,627,818	6.02
21	North Carolina							1,600,723	1.12
38	North Dakota			(b)	(b)	27.51		262,580	.18
2	Ohio	2,492,380	(b)	109,884	1,961,020	17.85	728,399	21,868,407	15.26
34	Oklahoma						23,080	573,371	.40
28	Oregon			37	1,050	28.38		771,795	.54
1	Pennsylvania	385,322	142,303	361,548	7,094,794	19.62	680,839	22,185,383	15.48
48	Porto Rico						25	6,359	.00
33	South Carolina			1,426	21,832	15.31		573,459	.40
47	South Dakota							46,685	.03
24	Tennessee			697	13,205	18.95	152	1,347,985	.94
10	Texas		(b)	6,525	104,338	15.99	54,480	2,968,975	2.07
29	Utah		(b)	(b)	(b)	30.83	5,069	708,906	.49
45	Vermont		(b)					94,773	.07
20	Virginia			(b)	(b)	15.28	4,714	1,705,651	1.19
14	Washington		(b)	2,191	66,178	30.20	10,835	2,390,226	1.67
17	West Virginia	259,109		17,601	155,423	8.83	13,220	1,783,383	1.24
26	Wisconsin						2,500	1,013,028	.71
46	Wyoming							61,678	.04
	Other States[c]	1,061,368	123,051	23,779	429,323	18.05		(d)	
	Total	[e]6,109,180	535,667	[f]1,017,299	[f]20,627,122	20.28	3,018,316	143,296,757	100.00
	Percentage of brick and tile products	4.26	.37		14.39		2.11	100.00	
	Percentage of total of clay products.	3.37	.30		11.38		1.66	79.04	

[a] Including adobes, bake-oven tile, burnt-clay ballast, charcoal furnaces, chemical brick and tile, chimney pipe and tops, condensers, conduits, crucibles, flue pipe and lining, furnaces for heating irons, gas logs, glasshouse supplies, grave and lot markers, muffles, radial chimney brick and block, retorts, saggers, scorifiers, silo blocks, sundials, vases, and wall coping.

[b] Included in "Other States."

[c] Includes all products made by less than 3 producers in 1 State.

[d] The total of "Other States" is distributed among the States to which it belongs, in order that they may be fully represented in the totals.

[e] Including the following values: Floor tile, $2,483,082; wall tile, $1,763,992; roofing tile, $1,130,286; and faience tile, $731,820.

[f] In the total quantity and total value of fire brick are included, respectively, 174,246,000 silica brick, valued at $3,815,806, of which 132,042,000, valued at $2,608,940 was produced by Pennsylvania, and the remainder, 42,204,000, valued at $1,206,866, by Alabama, California, Colorado, Idaho, Illinois, Indiana, Missouri, Montana, New Jersey, Ohio, and Utah.

Common brick, as its name implies, is the most widely distributed of the clay products, being reported from every State and Territory except Alaska and Hawaii. There were 8,088,790,000 common brick reported for 1913, valued at $50,134,757, or $6.20 per 1,000, a decrease of 466,448,000 brick, or 5.45 per cent, from 1912. In 1912 there was an increase over 1911 of 79,961,000 brick, or 0.94 per cent. The value showed a decrease in 1913 of $1,661,509, or 3.21 per cent. In 1912 the value increased $1,911,004, or 3.83 per cent. Nineteen States showed increase in both quantity and value in 1913; 23 States showed decrease in both quantity and value; and 6 States—Illinois, Iowa, Kentucky, Massachusetts, Minnesota, and Missouri—showed decrease in quantity and increase in value.

In 1913 Illinois was the largest producer of common brick, displacing New York, which has been first for several years, and reporting 1,155,480,000 brick, valued at $6,445,821, or $5.58 per 1,000. This was a decrease of 55,019,000 brick, or 4.55 per cent, in quantity but an increase of $8,490, or 0.13 per cent, in value compared with 1912. New York was the second State in 1913, reporting 1,068,516,000 brick, valued at $6,029,103, or $5.64 per 1,000, a decrease in quantity of 205,125,000 brick, or 16.11 per cent, and in value of $1,282,572, or 17.54 per cent. The cause of the decrease in production of common brick in New York was the lessened activity in the building operations in New York City, the principal market in that State. The third State in rank in the production of common brick in 1913 was Pennsylvania, which reported 704,493,000 brick, valued at $4,772,229, or $6.77 per 1,000, an increase of 7,470,000 brick, or 1.07 per cent, in quantity and of $181,445, or 3.95 per cent, in value. Ohio was fourth in the production of common brick in 1913, displacing New Jersey, and reporting 407,685,000 brick, valued at $2,523,014, or $6.19 per 1,000, an increase of 11,849,000 brick in quantity, or 2.99 per cent, and of $108,532, or 4.50 per cent, in value. New Jersey was fifth in 1913, reporting 401,702,000 brick, valued at $2,391,287, or $5.95 per 1,000, a decrease of 27,607,000 brick, or 6.43 per cent, in quantity and of $200,804, or 7.75 per cent, in value. Of the Illinois production 717,682,000 brick, or 62.11 per cent, was from Cook County, and of the output of New York, 779,773,000, or 72.98 per cent, was from the Hudson River region. The average price per 1,000 in 1913 for common brick ranged from $4.42 in Kansas to $10.76 in Wyoming, the average for the entire country being $6.20, an advance of 15 cents over the average for 1912. These same States reported for 1912 the extremes in average price of $4 and $9.98. In Illinois there was an advance of 26 cents per 1,000; in New York there was a decline of 10 cents per 1,000, in Pennsylvania an advance of 18 cents, in Ohio an advance of 9 cents, and in New Jersey there was a decline of 9 cents.

Vitrified paving brick was reported from 29 States for 1913, an increase of 2—Oregon and Virginia, which reported none for 1912. Ohio, as for several years, was the leading State, reporting 304,391,000 brick, valued at $3,308,975, or $10.87 per 1,000. This was an increase of 36,120,000 brick, or 13.46 per cent, in quantity and of $478,666, or 16.91 per cent, in value over 1912. Ohio reported 31.75 per cent of the total production and 27.26 per cent of the total value in 1913. Pennsylvania was second in quantity but third in value, and Illinois was second in value and third in quantity in 1913. Pennsylvania reported 140,407,000 brick, valued at $1,814,833, or $12.93 per 1,000, an increase of 28,035,000 brick, or 24.95 per cent, in quantity and of $403,737, or 28.61 per cent, in value over 1912. Illinois reported 133,938,000 brick, valued at $1,883,199, or $14.06 per 1,000. This was a decrease of 2,770,000 brick, or 2.03 per cent, in quantity and an increase of $43,478, or 2.36 per cent, in value as compared with 1912. West Virginia was fourth in production and value; Washington was seventh in quantity and fifth in value, and Indiana fifth in quantity and sixth in value. The average price per 1,000 ranged in 1913 in the important producing States from $10.19 in Kansas to $16.42 in Washington, with a general average of $12.66.

Next to the common-brick industry, that of the front or face brick branch is most widely spread, production being reported from 43 States in 1913, the same as for 1912. In 1913 Pennsylvania, as for many years, was the leading front-brick producing State, reporting 214,734,000 brick, valued at $2,325,201, or $10.83 per 1,000. This was a decrease in quantity of 2,594,000 brick, or 1.19 per cent, but an increase in value of $3,722, or 0.16 per cent, compared with 1912. Pennsylvania's output in 1913 was 25.94 per cent of the total quantity and 24.19 per cent of the total value. Ohio was second in rank, Indiana third, and New Jersey fourth. The average price per 1,000 for front brick in 1913 ranged from $8.52 in Kansas to $25.56 in Oregon, with a general average of $11.62.

Draintile was reported from 38 States, or 1 less than for 1912, Oklahoma and Vermont reporting none for 1913, and New Mexico reentering the list of producers. Iowa, Indiana, Ohio, Illinois, and Michigan were the leading States in production in the order named in 1913, as for several years. These 5 States together reported draintile valued at $7,543,403, or 88.14 per cent of the total, in 1913; for 1912 these States reported draintile valued at $7,075,030, or 88.32 per cent of the total. Of these leading States Indiana and Ohio showed a decrease in 1913; Iowa showed an increase of $505,732, or 22.05 per cent; Illinois, $35,280, or 2.96 per cent; and Michigan, $27,598, or 7.11 per cent.

Sewer pipe was reported from 28 States in 1913, the same as for 1912. Ohio was the leading State in 1913, as for many years, and reported production valued at $5,159,548, an increase of $1,137,470, or 28.28 per cent, over that of 1912. Ohio's production constituted 34.69 per cent of the total for the country. Pennsylvania was second, displacing Missouri, which was third in 1913, and California, which was third in 1912, was fourth in 1913. These 4 States reported 58.71 per cent of the total for 1913. Sewer pipe constituted in 1912, 10.38 per cent of the value of all brick and tile products and 8.20 per cent of all clay products.

Architectural terra cotta was reported from 12 States for 1913, a decrease of 1, Oregon reporting none. In only 7 States were there a sufficient number of producers to permit the publication of figures without disclosing individual returns. Every one of these States, except New Jersey, showed a decrease in the value of production. New Jersey was the leading State in 1913, displacing Illinois, its output being valued at $2,388,293; this was an increase of $58,228, or 2.5

per cent. Illinois was second with an output valued at $1,908,399, a decrease of $576,613, or 23.2 per cent. New York was third, as in 1912, reporting production valued at $1,110,726, a decrease of $28,565, or 2.51 per cent. These 3 States reported 69.92 per cent of the total.

Fireproofing, including hollow building tile or block, was reported from 34 States in 1913, an increase of 3. Louisiana, North Carolina, North Dakota, and South Carolina, which reported no fireproofing for 1912, entered the list of producing States in 1913, and Arkansas dropped out. Ohio was the leading State in 1913, displacing New Jersey by a small margin—$23,491. The output of Ohio was valued at $2,115,861, an increase over 1912 of $365,146, or 20.86 per cent. New Jersey's output increased in value $61,020, or 3 per cent. These 2 States produced 48.82 per cent of the total. Iowa was third, Indiana fourth, and Illinois fifth in value of output in 1913. Fireproofing composed 6.02 per cent of the value of brick and tile products in 1913 and 4.75 per cent of all clay products, compared with 5.26 per cent and 4.15 per cent, respectively, in 1912.

"Tile, not drain," includes roofing, floor, wall, and art tile. These were reported from 19 States for 1913, a decrease of 2 States. Alabama, Iowa, and Montana, which reported no product for 1912, entered the list of producers in 1913, and Nebraska, Oregon, South Dakota, Utah, and Washington dropped out for 1913. Ohio, as for many years, was the leading State, reporting wares valued at $2,492,380, or 40.8 per cent of the total. This was an increase of $70,597, or 2.92 per cent, over 1912. New Jersey was second, as in 1912, reporting production valued at $1,308,787, or 21.42 per cent of the total, an increase of $53,541, or 4.27 per cent, over 1912. These 2 States, therefore, reported nearly two-thirds of the total production.

Fire brick in 1913, as for many years, was second only to common brick in value. It was reported from 33 States, a decrease of 4 States, as Kansas, Louisiana, North Carolina, and Oklahoma, which reported fire brick for 1912, reported none for 1913. The quantity reported, including silica brick, increased from 913,681,000 9-inch equivalent brick in 1912 to 1,017,299,000 brick in 1913, an increase of 103,618,000 brick, or 11.34 per cent. The total value was $20,627,122 in 1913, as compared with $17,877,629 in 1912, an increase of $2,749,493, or 15.38 per cent. The average price per 1,000 in 1913 for all fire brick was $20.28, compared with $19.57 in 1912. The total number of clay 9-inch equivalent fire brick reported for 1913 was 843,053,000, valued at $16,811,316, or $19.94 per 1,000. This was an increase of 64,950,000 brick, or 8.35 per cent, in quantity and $1,856,861, or 12.42 per cent, over 1912. Pennsylvania continues to be the leading producer of both clay and silica fire brick, reporting 42.89 per cent of the total quantity of clay fire brick reported for 1913 and 42.2 per cent of its value, and 75.78 per cent of the silica fire brick and 68.37 per cent of its value. If clay fire brick and silica fire brick be considered together, Pennsylvania produced 48.52 per cent of the quantity of fire brick and 47.04 per cent of its value. Ohio was second in quantity of fire brick in 1913 and third in value; Missouri was third in quantity and second in value; Kentucky was fourth in quantity and value; and New Jersey was fifth in both. All of the first 5 States, except New Jersey, showed increases in quantity and value over 1912. These 5 States reported 82.88 per cent of the production and 82.5 per cent of the value of all clay fire brick in 1913. The average price per 1,000 ranged in the important States for clay fire brick from $8.83 in West Virginia to $41.57 in New York.

The production of silica fire brick in 1913 was 174,246,000 9-inch equivalent brick, valued at $3,815,806, or $21.90 per 1,000, compared with 135,578,000 brick, valued at $2,923,174, or $21.56 per 1,000, in 1912. This was an increase of 38,668,000 brick, or 28.52 per cent, in quantity and of $892,632, or 30.54 per cent, in value over 1912.

Fire brick composed 14.39 per cent of the value of all brick and tile products in 1913 and 11.38 per cent of all clay products.

Pennsylvania was in 1913, as for many years, the leading State in the value of brick and tile products, reporting wares valued at $22,185,383, or 15.48 per cent of the total, an increase of $2,776,702, or 14.31 per cent, over 1912. Ohio, as in 1912, was second with products valued at $21,868,407, or 15.26 per cent of the total, an increase of $2,565,634, or 13.29 per cent. Illinois continued to be third, reporting wares valued at $14,280,611, or 9.97 per cent of the total, an increase of $1,572, or 0.01 per cent. New Jersey was fourth, reporting 7.58 per cent of the total; New York was fifth with 6.02 per cent of the total; Indiana was sixth and Missouri seventh; Iowa was eighth, displacing California, which was ninth, and Texas was tenth.

TILE, NOT DRAIN.

For the first time an effort was made to obtain figures for the various varieties of tile embraced under the head "Tile, not drain." The result of this effort is shown in the following table. There are a number of subdivisions and trade names under these varieties, but owing to the small number of producers of some of these subdivisions it has been thought best to classify them simply as floor, wall, roofing, and faïence tile, the latter class embracing art tile.

Value of the tile, not drain, production in the United States, in 1913, by varieties.

Variety.	Value.	Number of firms reporting each variety.
Floor	$2,483,082	39
Wall	1,763,992	15
Roofing	1,130,286	24
Faïence	731,820	23
Total	6,109,180	....

This table shows that floor tile is the variety of greatest value, $2,483,082, or more than 40 per cent of the total. This variety of tile was reported by 39 operators in California, Illinois, Indiana, Kentucky, Massachusetts, Montana, New Jersey, New York, Ohio, Pennsylvania, Rhode Island, and West Virginia. Ohio was the leading producer, reporting this ware to the value of $1,017,240, or more than 40 per cent of the total. New Jersey was second, with a value of $719,651.

Wall tile was reported by 15 operators to the value of $1,763,992, or nearly 29 per cent of the total of all tile, not drain. Ohio was the leading producer of wall tile, reporting $838,860, made entirely in Muskingum County, and New Jersey was second, with a value of $293,704. It was also made in California, Indiana, Kentucky, Massachusetts, Missouri, and Pennsylvania.

Roofing tile was third in value, $1,130,286 being reported by 24 operators in Alabama, California, Colorado, Georgia, Illinois, Iowa, Kansas, Kentucky, Michigan, Missouri, Ohio, Pennsylvania, and West Virginia. Here again Ohio was the leading State, with a production valued at $470,905, or more than 41 per cent of the total. Kansas was second and California was third.

Faïence, including art tile, was the variety of smallest value, being reported by 23 operators to the value of $731,820. New Jersey was the leading State, reporting this tile to the value of $295,432, or more than 40 per cent of the total.

HUDSON RIVER REGION.

New York City is the leading common brick market in the United States, many millions of brick being used there annually. The principal source of this supply is the Hudson River region, extending from New York to Cohoes on both sides of the river. Bergen County, N. J., has also contributed largely to this market, and within the last two years the Raritan River region, located in Middlesex County, N. J., has sent the larger portion of its output of common brick to the New York market. For this reason it is included in the table showing the output of the Hudson River region. Connecticut also is at times a factor in the New York brick market.

The water transportation enjoyed by the Hudson River yards and those located in the Hackensack and Raritan districts, however, gives them a great advantage, and it is only when prices are high—above $7 per 1,000—that Connecticut brick can profitably enter the New York City market. As prices were unusually low in 1913, few, if any, Connecticut brick were shipped to New York during that year.

The year 1913 was notable in this region principally for the large decrease in production—16.86 per cent—and the still greater decrease in value—20.99 per cent. The principal use of the brick made in this region is, and probably always will be, in the building industry of New York. Notwithstanding that the cost of the building operations in New York City decreased about 35 per cent in 1913 from 1912, the marketed brick decreased less than one-half as much, thus showing that the use of brick in building is expanding and that they are also being used more extensively than ever before for sewers, subways, and possibly for other purposes. Probably both of these conditions prevail. The back-to-brick campaign is apparently having its effect, not only in the common-brick industry, but in the higher grades of building brick and other clay products, such as hollow building tile and terra cotta, and it is confidently believed that the prospects for the structural branches of the clay-working industries, especially in the East, are bright, and that the consumption of clay products in the building industries in the future will be larger than during the last few years.

The following table shows the production and value of common brick along the Hudson River and in portions of New Jersey from 1901 to 1913, with the number of operating firms reporting and the average price received per thousand:

Production of common brick in the Hudson River district from 1901 to 1913, inclusive.

Year.	Number of active firms reporting.	Quantity.	Value.	Average price per thousand.
		Thousands.		
1901	127	830,154	$3,880,215	$4.67
1902	127	833,065	3,683,379	4.42
1903	115	844,500	3,973,316	4.70
1904	119	987,644	5,810,114	5.88
1905	129	1,297,389	9,063,753	6.99
1906	135	1,274,372	7,672,639	6.02
1907	132	1,064,892	5,515,585	5.18
1908	123	875,979	4,107,382	4.69
1909	127	1,313,760	6,438,642	4.90
1910	135	1,142,284	5,544,600	4.85
1911	125	926,072	4,717,633	5.09
1912 [a]	136	1,233,187	7,133,177	5.78
1913 [a]	132	1,025,308	5,636,061	5.50

[a] Includes Raritan district, New Jersey.

This table shows that the number of brick marketed in this region in 1913 was 1,025,308,000, valued at $5,636,061, as compared with 1,233,187,000, valued at $7,133,177, in 1912. This was a decrease of 207,879,000 brick, or 16.86 per cent, in quantity, and of $1,497,116, or 20.99 per cent, in value.

In the New York and Bergen County portions of the region, the production, 830,617,000 brick, in 1913, was the smallest since 1902, when it was 833,065,000 brick, and the value, $4,515,508, was the smallest since 1908, when it was $4,107,382. The average value per thousand, $5.44, was 30 cents lower than in 1912, but considerably higher than in any year from 1907 to 1911. Compared with the year of maximum production, 1909, there was a decrease of 483,143,000 brick, or 36.78 per cent, in 1913; and compared with the maximum value in 1905, there was a decrease of $4,548,245, or 50.18 per cent.

The average price per thousand for the region was $5.50, as compared with $5.78 in 1912. The maximum average price was $6.99 in 1905, and the minimum average price was $4.42 in 1902. The number of active firms reporting has varied in the New York and Bergen County portion of the region from 115 in 1903 to 135 in 1906 and 1910. In 1913 in this portion of the region there were 121 active firms reporting, a decrease of 5 from 1912. The number of active firms reporting for the whole region decreased from 136 in 1912 to 132 in 1913. As in other branches of the clay-working industry, the number of active firms reporting is not equivalent to the number of yards, as some of the operators have more than one yard.

The following table shows the production of common brick in the Hudson River district in 1912 and 1913 by counties:

Production of common brick in the Hudson River district (from Cohoes to New York City) and in Raritan district, New Jersey, in 1912 and 1913, by counties.

County.	1912				1913			
	Number of active firms reporting.	Common brick.		Average price per thousand.	Number of active firms reporting.	Common brick.		Average price per thousand.
		Quantity.	Value.			Quantity.	Value.	
		Thousands.				*Thousands.*		
Albany	12	71,600	$436,626	$6.10	12	61,792	$363,964	$5.89
Columbia	7	70,866	354,589	5.00	6	58,593	300,624	5.13
Dutchess	18	129,860	765,788	5.90	18	113,120	610,457	5.40
Greene	6	34,708	196,888	5.67	5	24,214	118,845	4.91
Orange	9	116,304	660,089	5.68	9	98,493	525,887	5.34
Rensselaer	5	15,760	85,797	5.44	5	14,076	87,063	6.19
Rockland	27	207,796	1,221,428	5.88	25	163,612	890,188	5.44
Ulster	24	259,480	1,458,554	5.62	24	194,125	1,026,870	5.29
Westchester	8	62,390	363,098	5.82	7	51,748	297,504	5.75
Total for New York portion of district	116	968,764	5,542,857	5.72	111	779,773	4,221,402	5.41
Bergen County, N. J.	10	50,495	307,913	6.10	10	50,844	294,106	5.78
Raritan district (Middlesex County), N. J.	10	213,928	1,282,407	5.99	11	194,691	1,120,553	5.76
Grand total	136	1,233,187	7,133,177	5.78	132	1,025,308	5,636,061	5.50

New York's portion was 76.05 per cent of the quantity of brick and 74.9 per cent of the value of the region. This portion, consisting of 779,773,000 brick in 1913, showed a decrease of 188,991,000 brick, or 19.51 per cent, from 1912. The value of New York's portion of the region was $4,221,402, a decrease of $1,321,455, or 23.84 per cent.

Of the counties included in the New York portion of this region in 1913, Ulster, as for many years, was first in output and value, reporting 194,125,000 brick, valued at $1,026,870, a decrease in quantity of 65,355,000 brick, or 25.19 per cent, and in value of $431,684, or 29.6 per cent. Rockland was second with 163,612,000 brick, valued at $890,188, a decrease of 44,184,000 brick, or 21.26 per cent, and of $331,240, or 27.12 per cent. Dutchess County was third, with 113,120,000 brick, valued at $610,457, a decrease of 16,740,000 brick, or 12.89 per cent, and of $155,331, or 20.28 per cent. Every county showed a decrease in production, and every county except Rensselaer—the smallest producing county in the region—showed a decrease in value. The increase in value in Rensselaer County was slight, $1,266, or less than 1½ per cent. The highest average price per thousand in 1913 was in Rensselaer County—$6.19, an increase of 75 cents over 1912. In 1912 the highest average price was attained in Albany County—$6.10. The lowest average price in 1913, $4.91, was in Greene County, a decrease of 76 cents. In 1912 the lowest average price, $5, was in Columbia County. The average for New York's portion of the region was $5.41 for 1913, compared with $5.72 in 1912 and with $5.06 in 1911.

New Jersey's portion of the production of this region is comparatively small, being 245,535,000 brick in 1913, or 23.95 per cent of the output of the region, and $1,414,659, or 25.1 per cent of the value. Bergen County showed a small increase in production in 1913 over 1912, 349,000 brick, or less than 1 per cent. The average price per thousand decreased in this county 32 cents from 1912, and the total value decreased $13,807, or 4.48 per cent. The Raritan district showed a decrease in both production and value in 1913 from 1912, the former 19,237,000 brick, or 8.99 per cent, and the latter $161,854, or 12.62 per cent.

The average price per thousand in New Jersey's portion of the region was $5.76, or 35 cents higher than that for New York's portion and 26 cents higher than that for the whole region.

Middlesex County, N. J., showed the largest production and value in the region in 1913, 194,691,000 brick, valued at $1,120,553. The production of this county in 1913 exceeded in quantity by 566,000 brick, or 0.29 per cent, and in value by $93,683, or 9.12 per cent, the production of Ulster County, the leading county of New York's portion of the region.

The number of active firms reporting decreased 5 in the New York portion ot the region and increased 1 in the New Jersey portion.

POTTERY.

INTRODUCTION.

The following tables show the status of the pottery industry in 1912 and 1913 and the production, imports, and exports of pottery from 1901 to 1913, inclusive. The figures indicate that the industry was in a prosperous condition in 1913. The year opened with bright prospects and sufficient business to keep the potteries busy, and throughout the spring and summer and well into the fall business was generally reported as unusually good. There resulted the largest production in the history of the industry. The underlying cause of this prosperity is no doubt the improved character of the American product in texture, finish, color, decoration, and prevention of crazing, some of the higher grades of American pottery equaling if not surpassing some of the best imported ware.

Although the pottery industry has been singularly free from labor troubles, the year 1913 was more or less disturbed by strikes, none of which were general and none of which were of a very grave character. The scarcity of labor, however, which was severely felt in 1913, and the legal restrictions concerning the employment of children and women in some States have affected the expansion of the industry. The year 1914 will have the largest kiln capacity ever known in the industry, about 47 new kilns having been added during 1913 or early in 1914.[1]

The value of all domestic pottery marketed in 1913 was $37,992,375, an increase of $1,488,211, or 4.08 per cent. The imports, which comprise almost exclusively the higher grades of ware, increased $621,921, or 6.51 per cent. In 1912 the imports of pottery decreased $1,083,086, or 10.18 per cent. The proportion of domestic production to consumption in 1913 was 79.86 per cent, a slightly less proportion than for 1912, when it was 81.45 per cent.

Every product as classified in this report, except stoneware and yellow and Rockingham ware, participated in the increase of 1913. The most important variety in value, white earthenware (valued at $15,066,811 in 1913), showed an increase of 1.6 per cent, and reached its maximum value. Other important products showing a large increase were sanitary ware and porcelain electrical supplies.

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[1] Report of committee on statistics, United States Potters Association, December, 1913.

Tariff.—The imports of pottery have always been more or less interesting. For many years the value of imported pottery exceeded the value of that made at home, but about the close of the nineteenth century domestic production caught up with imports and since that time has greatly exceeded them, the production of 1913 being nearly four times as great in value as the imports. The imports for 1913 are especially interesting in view of the tariff act of that year, which lowered the duties on all varieties of pottery products. The new law went into effect so late in the year that but little can be judged as to its effect on the industry. The law is at least very definite in its classification of pottery, and has created a separate class—earthenware and crockery composed of a nonvitrified absorbent body. This ware was imported to the value of $605,781 from October 4, when the law went into effect, to December 31, 1913. The classification of pottery and the rates of duty under the old and the new tariffs are as follows:

Act o fAugust 5, 1909.

92. Common yellow, brown, or gray earthenware, plain, embossed, or salt-glazed common stoneware, and earthenware or stoneware crucibles, all the foregoing not decorated in any manner, 25 per centum ad valorem; yellow earthenware, plain or embossed, coated with white or transparent vitreous glaze but not otherwise ornamented or decorated, and Rockingham earthenware, 40 per centum ad valorem.

93. China, porcelain, parian, bisque, earthen, stone, and crockery ware, including clock cases with or without movements, pill tiles, plaques, ornaments, toys, charms, vases, statues, statuettes, mugs, cups, steins, and lamps, all the foregoing wholly or in chief value of such ware; painted, colored, tinted, stained, enameled, gilded, printed, or ornamented or decorated in any manner; and manufactures in chief value of such ware not specially provided for in this section, 60 per centum ad valorem.

94. China, porcelain, parian, bisque, earthen, stone, and crockery ware, plain white, plain brown, including clock cases with or without movements, pill tiles, plaques, ornaments, toys, charms, vases, statues, statuettes, mugs, cups, steins, and lamps, all the foregoing wholly or in chief value of such ware, not painted, colored, tinted, stained, enameled, gilded, printed, or ornamented or decorated in any manner; and manufactures in chief value of such ware not specially provided for in this section, 55 per centum ad valorem.

Act of October 3, 1913.

78. Common yellow, brown, or gray earthenware made of natural unwashed and unmixed clay; plain or embossed, common salt-glazed stoneware; stoneware and earthenware crucibles; all the foregoing, not ornamented, incised, or decorated in any manner, 15 per centum ad valorem; if ornamented, incised, or decorated in any manner and manufactures wholly or in chief value of such ware, not specially provided for in this section, 20 per centum ad valorem; Rockingham earthenware, 30 per centum ad valorem.

79. Earthenware and crockery ware composed of a nonvitrified absorbent body, including white granite and semiporcelain earthenware, and cream-colored ware, and stoneware, including clock cases with or without movements, pill tiles, plaques, ornaments, toys, charms, vases, statues, statuettes, mugs, cups, steins, lamps, and all other articles composed wholly or in chief value of such ware; if plain white, plain yellow, plain brown, plain red, or plain black, not painted, colored, tinted, stained, enameled, gilded, printed, ornamented, or decorated in any manner, and manufactures in chief value of such ware not specially provided for in this section, 35 per centum ad valorem; if painted, colored, tinted, stained, enameled, gilded, printed, or ornamented or decorated in any manner, and manufactures in chief value of such ware not specially provided for in this section, 40 per centum ad valorem.

80. China and porcelain wares composed of a vitrified nonabsorbent body which when broken shows a vitrified or vitreous, or semivitrified or semivitreous fracture, and all bisque and parian wares, including clock cases with or without movements, plaques, ornaments, toys, charms, vases, statues, statuettes, mugs,

cups, steins, lamps, and all other articles composed wholly or in chief value of such ware, if plain white, or plain brown, not painted, colored, tinted, stained, enameled, gilded, printed, or ornamented or decorated in any manner; and manufactures in chief value of such ware not specially provided for in this section, 50 per centum ad valorem; if painted, colored, tinted, stained, enameled, gilded, printed, or ornamented or decorated in any manner, and manufactures in chief value of such ware not specially provided for in this section, 55 per centum ad valorem.

PRODUCTION.

The following table shows the statistics of the production of pottery in the United States from 1901 to 1913:

Value of pottery products in the United States, 1901–1913, by varieties.

Year.	Number of active firms reporting.	Red earthenware.	Stoneware and yellow and Rockingham ware.	White ware, including C. C. ware, etc.	China, bone china, delft, and belleek ware.	Sanitary ware.	Porcelain electrical supplies.	Miscellaneous.	Total.
1901	535	$703,698	$2,855,638	$11,608,898	$1,392,864	$2,877,650	$1,141,362	$1,883,750	$22,463,860
1902	518	735,386	3,383,678	12,371,111	1,219,293	3,555,662	1,350,255	1,512,068	24,127,453
1903	546	698,175	3,658,836	12,493,012	1,757,502	3,362,263	1,464,980	2,001,284	25,436,052
1904	556	756,625	3,701,844	11,924,404	1,512,115	3,585,375	1,431,452	2,246,455	25,158,270
1905	533	780,637	3,969,016	12,809,414	1,558,730	4,580,145	2,253,061	1,967,891	27,918,894
1906	540	909,262	4,193,884	14,152,503	1,787,776	5,098,310	2,838,284	2,460,865	31,440,884
1907	509	845,465	4,280,601	13,913,680	1,930,669	4,863,222	2,613,771	1,696,066	30,143,474
1908	497	757,900	3,518,841	11,474,147	1,581,020	4,373,590	2,009,005	1,421,052	25,135,555
1909	466	805,906	3,993,859	13,728,316	[a]1,766,766	5,989,295	3,047,499	[a]1,717,800	31,049,441
1910	463	854,196	3,796,688	14,780,980	1,962,126	6,758,996	3,794,153	1,837,539	33,784,678
1911	449	893,678	4,120,608	14,366,251	2,057,985	7,031,458	4,232,101	1,816,479	34,518,560
1912	434	958,270	3,919,778	14,829,431	2,177,305	7,902,255	4,927,316	1,789,809	36,504,164
1913	426	1,000,529	3,683,567	15,066,811	2,424,060	8,214,838	5,737,741	1,864,829	37,992,375

[a] China, bone china, delft, and belleek ware for Ohio is included in miscellaneous.

This table shows that the value of the pottery products of the United States in 1913 was $37,992,375, the largest yet reported, exceeding that of 1912 by $1,488,211, or 4.08 per cent, and that of 1911 by $3,473,815, or 10.06 per cent. In 1913, as in 1912, only one variety decreased in value—stoneware—which declined $236,211, or 6.03 per cent. With the exception of stoneware, every product reached its maximum value in 1913, the variety showing the largest gain, both proportionate and actual, being porcelain electrical supplies, which increased $810,425, or 16.45 per cent.

The value of white ware, including china, but excluding sanitary ware and porcelain electrical supplies, was $17,490,871 in 1913, as compared with $17,006,736 in 1912, an increase of $484,135, or 2.85 per cent. These articles constituted 46.04 per cent of all pottery products in 1913 and 46.59 per cent in 1912. If the value of sanitary ware and porcelain electrical supplies be added, the total for 1913 would be $31,443,450, or 82.76 per cent of all pottery products, an increase of $1,607,143, or 5.39 per cent, over the corresponding value for 1912.

Chinaware production showed an increase in value of $246,755, or 11.33 per cent. This product has increased in value almost steadily since 1902, the value in 1913, the highest recorded, being nearly twice as great as it was in 1902.

Red earthenware showed an increase of $42,259 over 1912, or 4.41 per cent; white ware, $237,380, or 1.6 per cent; and sanitary ware, $312,583, or 3.96 per cent.

The total value of the pottery products of the United States in 1913 was $6,551,491, or 20.84 per cent, greater than in 1906, $7,848,901, or 26.04 per cent, greater than in 1907, and $12,856,820, or 51.15 per cent, greater than in 1908. The value of these products has increased steadily during each year of the period covered by the table with the exception of 1904, 1907, and 1908.

In the following tables will be found the statistics of the production of pottery in the United States in 1912 and 1913 by States and varieties, the former year being given for comparison.

Value of pottery products in 1912, by varieties of products, by States.

Rank of State.	State.	Number of active firms reporting.	Red earthenware.	Stoneware and yellow or Rockingham ware.	White ware, including C. C. ware, white granite, semiporcelain ware, and semivitreous porcelain ware.	China, bone china, delft, and belleek ware.
18	Alabama	15	$10,990	$11,223		
17	Arkansas	5	(a)	12,123		
9	California	12	36,091	54,087	(a)	
15	Colorado	5	(a)	(a)		
	Connecticut		(a)	(a)		
	District of Columbia		(a)			
19	Georgia	18	11,472	7,510		
7	Illinois	24	35,827	675,244	(a)	
6	Indiana	10	(a)	46,100	(a)	
16	Iowa	4	(a)	(a)		
	Kansas			(a)		
14	Kentucky	8	22,523	91,681		
	Louisiana		(a)			
	Maine			(a)		
11	Maryland	8	8,451	(a)	(a)	
8	Massachusetts	12	163,010	26,300	(a)	
10	Michigan	6	99,555		(a)	
	Minnesota			(a)		
20	Mississippi	6	1,561	11,145		
24	Missouri	4	(a)	2,015		
	Montana		(a)			
	New Hampshire					
2	New Jersey	52	36,655	48,297	$1,090,683	$1,155,766
4	New York	24	31,497	(a)	(a)	691,065
21	North Carolina	21	778	8,172		
1	Ohio	106	263,085	1,832,266	9,969,491	
	Oregon		(a)	(a)		
5	Pennsylvania	29	162,137	281,526	902,585	280,472
	Porto Rico					
23	South Carolina	4	4,567	(a)		
12	Tennessee	9	1,205	44,089		
13	Texas	12	9,351	137,253		
	Utah		(a)	(a)		
	Virginia					
	Washington		(a)	(a)		
3	West Virginia	14		(a)	2,051,987	50,002
22	Wisconsin	3	7,900			
	Other States[b]		51,615	630,747	814,685	
	Total	[c]434	958,270	3,919,778	14,829,431	2,177,305
	Percentage of pottery products		2.63	10.74	40.62	5.96
	Percentage of total clay products		.55	2.27	8.58	1.26
	Number of firms reporting each variety		145	163	63	16

[a] Included in "Other States."
[b] Includes all products made by less than 3 producers in 1 State.
[c] Includes 23 firms not distributed.

Value of pottery products in 1912, by varieties of products, by States—Continued.

Rank of State.	State.	Sanitary ware.	Porcelain electrical supplies.	Miscellaneous.[a]	Total.	Percentage of total.
18	Alabama				$22,213	0.06
17	Arkansas			(b)	28,957	.08
9	California	(b)	(b)	$6,126	219,653	.60
15	Colorado			4,247	41,247	.11
	Connecticut		(b)	(b)	(c)	
	District of Columbia				(c)	
19	Georgia			(b)	19,057	.05
7	Illinois	(b)	(b)	23,812	931,951	2.55
6	Indiana	$633,578	(b)		1,077,102	2.95
16	Iowa			(b)	30,141	.08
	Kansas				(c)	
14	Kentucky				114,204	.31
	Louisiana			(b)	(c)	
	Maine				(c)	
11	Maryland			2,500	184,711	.51
8	Massachusetts		(b)	12,789	252,099	.69
10	Michigan		(b)	(b)	194,892	.53
	Minnesota				(c)	
20	Mississippi				12,706	.04
24	Missouri				3,515	.01
	Montana				(c)	
	New Hampshire			(b)	(c)	
2	New Jersey	5,199,278	$1,146,467	258,774	8,935,920	24.48
4	New York	(b)	1,269,108	51,988	2,405,532	6.59
21	North Carolina				8,950	.03
1	Ohio	451,971	1,827,290	1,164,632	15,508,735	42.49
	Oregon				(c)	
5	Pennsylvania	185,000	307,636	9,184	2,128,540	5.83
	Porto Rico			(b)	(c)	
23	South Carolina				6,761	.02
12	Tennessee			(b)	173,166	.47
13	Texas				146,604	.40
	Utah				(c)	
	Virginia			(b)	(c)	
	Washington				(c)	
3	West Virginia	1,156,478	(b)	36,444	3,365,166	9.22
22	Wisconsin				7,900	.02
	Other States [d]	275,950	376,815	219,313	[e] 684,442	1.88
	Total	7,902,255	4,927,316	1,789,809	36,504,164	100.00
	Percentage of pottery products	21.65	13.50	4.90	100.00	
	Percentage of total clay products	4.57	2.85	1.04	21.12	
	Number of firms reporting each variety	40	34	70		

[a] Including aquarium ornaments, art and chemical pottery, art tile, craquelle porcelain, faïence, Guernsey earthenware, Hampshire pottery, jardinières, lamps, pins, stilts, and spurs for potters' use, porcelain door knobs, filter stones, shuttle eyes and thread guides, porcelain hardware trimmings, porcelain lighting appliances, razor hones, tobacco pipes, toy marbles, turpentine cups, umbrella stands, and vases.
[b] Included in "Other States."
[c] Included in [e] ($684,442).
[d] Includes all products made by less than 3 producers in 1 State.
[e] Made up of State totals of Connecticut, District of Columbia, Kansas, Louisiana, Maine, Minnesota, Montana, New Hampshire, Oregon, Porto Rico, Utah, Virginia, and Washington.

Value of pottery products in 1913, by varieties of products, by States.

Rank of State.	State.	Number of active firms reporting.	Red earthenware.	Stoneware and yellow or Rockingham ware.	White ware, including C. C. ware, white granite, semiporcelain ware, and semivitreous porcelain ware.	China, bone china, delft, and belleek ware.
18	Alabama	9	$11,164	$8,994	....	....
19	Arkansas	4	(a)	12,905	....	....
8	California	11	33,481	49,720	....	....
15	Colorado	5	(a)	(a)	....	....
	Connecticut	....	(a)	(a)	....	....
22	District of Columbia	3	11,000	....	....	....
16	Georgia	19	17,238	11,290	....	....
7	Illinois	23	46,175	624,194	(a)	....
6	Indiana	11	(a)	61,550	(a)	....
17	Iowa	4	2,414	(a)	....	....
	Kansas	....	....	(a)	....	....
13	Kentucky	7	25,818	75,800	(a)	....
	Louisiana	....	....	....	....	....
	Maine	....	....	(a)	....	....
11	Maryland	6	7,534	(a)	(a)	....
9	Massachusetts	11	(a)	27,400	(a)	....
10	Michigan	6	106,527	....	....	....
	Minnesota	....	....	(a)	....	....
20	Mississippi	8	(a)	16,951	....	....
25	Missouri	5	2,537	(a)	....	....
	Montana	....	(a)	....	....	....
	Nebraska	....	(a)	....	....	....
	New Hampshire	....	....	....	....	....
2	New Jersey	51	35,360	66,993	$834,716	$1,239,453
4	New York	23	38,290	(a)	(a)	763,322
21	North Carolina	23	2,318	10,365	....	....
1	Ohio	105	236,883	1,649,186	10,548,628	....
	Oregon	....	(a)	(a)	....	....
5	Pennsylvania	27	187,625	268,407	839,838	(a)
	Porto Rico	....	(a)	....	....	....
23	South Carolina	5	7,821	1,961	....	....
12	Tennessee	8	2,153	36,153	....	....
14	Texas	14	7,894	72,480	....	....
	Utah	....	(a)	....	....	....
	Virginia	....	....	....	....	....
	Washington	....	(a)	(a)	....	....
3	West Virginia	14	....	(a)	2,024,104	(a)
24	Wisconsin	3	7,700	....	....	....
	Other States [b]	....	210,597	689,218	819,525	421,285
	Total	[c] 426	1,000,529	3,683,567	15,066,811	2,424,060
	Percentage of pottery products	....	2.63	9.70	39.66	6.38
	Percentage of totol clay products	....	.55	2.03	8.31	1.34
	Number of firms reporting each variety	....	147	154	55	14

[a] Included in "Other States."
[b] Includes all products made by less than 3 producers in 1 State.
[c] Includes 21 firms not distributed.

Value of pottery products in 1913, by varieties of products, by States—Continued.

Rank of State.	State.	Sanitary ware.	Porcelain electrical supplies.	Miscellaneous.[a]	Total.	Percentage of total.
18	Alabama				$20,158	0.05
19	Arkansas			(b)	19,757	.05
8	California	(b)		$12,514	290,255	.76
15	Colorado			6,501	46,501	.12
	Connecticut		(b)		(c)	
22	District of Columbia				11,000	.03
16	Georgia				28,528	.08
7	Illinois	(b)	(b)	11,710	915,263	2.41
6	Indiana	$719,103	(b)		1,186,706	3.12
17	Iowa			(b)	20,698	.05
	Kansas				(c)	
13	Kentucky				102,118	.27
	Louisiana			(b)	(d)	
	Maine				(d)	
11	Maryland			2,500	155,034	.41
9	Massachusetts		(b)	12,429	231,345	.61
10	Michigan		(b)	(b)	222,883	.59
	Minnesota				(d)	
20	Mississippi				17,451	.05
25	Missouri				3,412	.01
	Montana				(d)	
	Nebraska				(d)	
	New Hampshire			(b)	(d)	
2	New Jersey	5,238,013	$1,190,448	233,562	8,838,545	23.26
4	New York	(b)	1,560,870	91,715	2,841,658	7.48
21	North Carolina			(b)	13,683	.04
1	Ohio	590,193	2,184,201	1,310,798	16,519,889	43.48
	Oregon				(d)	
5	Pennsylvania	153,000	295,908	(b)	2,046,099	5.39
	Porto Rico			(b)	(d)	
23	South Carolina				9,782	.03
12	Tennessee			(b)	145,100	.38
14	Texas				80,374	.21
	Utah				(d)	
	Virginia			(b)	(d)	
	Washington				(d)	
3	West Virginia	1,146,205	(b)	20,578	3,424,887	9.01
24	Wisconsin				7,700	.02
	Other States	368,324	506,314	162,522	[e] 793,549	2.09
	Total	8,214,838	5,737,741	1,864,829	37,992,375	100.00
	Percentage of pottery products	21.62	15.10	4.91	100.00	
	Percentage of total clay products		4.53	3.17	1.03	20.96
	Number of firms reporting each variety	44	36	66		

[a] Including aquarium ornaments, art and chemical pottery, craquelle porcelain, Guernsey earthen ware, Hampshire, Niloak, Pewabic, Rookwood, Teco and Walley pottery, jardinieres, pins, stilts and spurs for potters' use, porcelain door knobs, filter stones and tubes, shuttle eyes and thread guides, porcelain hardware trimmings, porcelain lighting appliances, tobacco pipes, toy marbles, turpentine cups, umbrella stands, and vases.
[b] Included in "Other States."
[c] Included in [d] ($793,549).
[d] Included in [e] ($793,549).
[e] Made up of State totals of Connecticut, Kansas, Louisiana, Maine, Minnesota, Montana, Nebraska, New Hampshire, Oregon, Porto Rico, Utah, Virginia, and Washington.

The number of States reporting for 1913 ware classed as pottery in this report was 38, an increase of 1, Nebraska being added to the list of pottery-producing States. The important producing States, especially those reporting production of the higher grades of ware are few. White ware was reported from 10 States, a decrease of 1; china was reported from 4 States, the same number as for 1912; sanitary ware from 8 States, the same number as for 1912; and porcelain electrical supplies from 10 States, a decrease of 1, California reporting none.

Red earthenware, the commonest of pottery products, was reported from 31 States in 1913, an increase of 1, Nebraska and Porto Rico entering the list of producers of red earthenware, and Louisiana reporting none. Ohio was the leading State in 1913, as for several years, reporting red earthenware valued at $236,883, a decrease of $26,202, or 9.96 per cent. Pennsylvania was second, displacing Massachusetts, which became third. In 1913 the value of the output of Pennsylvania increased $25,488, or 15.72 per cent. Massachusetts, Ohio, and Pennsylvania together reported about 60 per cent of the total value of this product in 1913, 61.38 per cent in 1912, and 60.71 per cent in 1911. Red earthenware was reported by 147 producers in 1913, by 145 in 1912, and by 160 in 1911. It constituted 2.63 per cent of the total value of pottery in 1913 and 1912.

Stoneware, including yellow and Rockingham ware, was reported from 28 States in 1913, a decrease of 1, Utah reporting none. Ohio, in 1913, as for many years, was the leading State, reporting an output valued at $1,649,186, or 44.77 per cent of the total. This was a decrease of $183,080, or 9.99 per cent. Illinois, as for some years, was second, showing a decrease of $51,050, or 7.56 per cent, in 1913. These 2 States reported 61.72 per cent of the total value of this variety of ware in 1913. The number of producers reporting stoneware continues to decrease, 154 reporting for 1913, as compared with 163 for 1912 and with 175 for 1911. Stoneware constituted 9.70 per cent of the value of pottery in 1913, 10.74 per cent in 1912, and 11.94 per cent in 1911.

These tables show that the pottery products of greatest value are embraced under the heading white ware, which represents the general household wares. These wares were reported from but 10 States in 1913, a decrease of 1, California and Michigan reporting none for 1913, and Kentucky entering the list of producers. Ohio has been the leading producer of these wares for many years, and reported for 1913 white ware valued at $10,548,628, an increase of $579,137, or 5.81 per cent. Ohio's production in 1913 was 70.01 per cent of the value of the entire output, as compared with 67.23 per cent in 1912 and with 66.91 per cent in 1911. West Virginia was second, as for several years, and reported wares valued at $2,024,104, a decrease of $27,883, or 1.36 per cent. Pennsylvania was third in 1913, displacing New Jersey, which has been third for several years, by a narrow margin—$5,122. The value of these wares in 1913 in Pennsylvania showed a decrease of $62,747, or 6.95 per cent. New Jersey's production decreased $255,967, or 23.47 per cent. White ware constituted 39.66 per cent of all pottery products in 1913, 40.62 per cent in 1912, and 41.62 per cent in 1911. The number of producers reporting white ware in 1913 was 55, as compared with 63 in 1912 and with 61 in 1911.

China production was reported from 4 States in 1913, as in 1912. New Jersey was the leading State, as for many years, and reported china valued at $1,239,453, an increase of $83,687, or 7.24 per cent. The production of New Jersey constituted 51.13 per cent of the entire production. New York was second. The production of china is still comparatively unimportant, though it has been steadily increasing, showing a considerable gain in 1913 over 1912, and will no doubt in time constitute an important branch of the industry in this country. The value of the china output reported for 1913 was only 6.38 per cent of the total pottery production for the country, as compared with 5.96 per cent in 1912 and 1911. The number of operators reporting china in 1913 was 14, a decrease of 2 from 1912.

Production of sanitary ware was reported from 8 States in 1913, the same as for 1912. New Jersey was the leading State, reporting ware for 1913 valued at $5,238,013, an increase of $38,735, or 0.75 per cent. New Jersey's output was 63.76 per cent of the total for 1913. West Virginia was second, as in 1912, reporting sanitary ware valued at $1,146,205, a decrease of $10,273, or 0.89 per cent. Indiana was third, as for 1912, reporting ware valued at $719,103, which was an increase of $85,525, or 13.5 per cent. The number of producers reporting sanitary ware in 1913 was 44, as compared with 40 in 1912 and with 36 in 1911. Sanitary ware composed 21.62 per cent of the value of pottery products in 1913, 21.65 per cent in 1912, and 20.37 per cent in 1911.

Porcelain electrical supplies were reported from 10 States in 1913, 1 less than in 1912, California reporting no production for 1913. Ohio is the largest producer of porcelain electrical supplies, reporting for 1913 an output valued at $2,184,201, or 38.07 per cent of the total. This was an increase of $356,911, or 19.53 per cent. New York was second and New Jersey third, as in 1912. New York's output increased in value $291,762, or 22.99 per cent over that of 1912, and New Jersey's increased $43,981, or 3.84 per cent. The other seven States were comparatively unimportant producers, their combined output constituting but 13.98 per cent of the total value. The number of producers reporting porcelain electrical supplies for 1913 was 36, an increase of 2 over 1912. This variety constituted 15.1 per cent of the value of all pottery in 1913, 13.5 per cent in 1912, and 12.26 per cent in 1911.

Ohio is the leading pottery-producing State of the Union, reporting for 1913 wares valued at $16,519,889, or 43.48 per cent of the total, an increase of $1,011,154, or 6.52 per cent, over 1912. Ohio's principal pottery product is white ware, which constituted 63.85 per cent of the value of Ohio's entire pottery output in 1913. The second in importance is porcelain electrical supplies. Ohio produced every variety of pottery as classified in this report but one—china. New Jersey is the second largest pottery-producing State. For 1913 New Jersey reported wares valued at $8,838,545, or 23.26 per cent of the total, a decrease of $97,375, or 1.09 per cent. The principal pottery product of New Jersey is sanitary ware, which constituted 59.26 per cent of the State total for 1913. West Virginia is third in rank among the pottery-producing States, reporting for 1913 ware valued at $3,424,887, or 9.01 per cent of the total, an increase of $59,721, or 1.77 per cent. New York was fourth, as for several years, and Pennsylvania fifth, the former reporting 7.48 per cent of the total value and the latter 5.39 per cent. Indiana and Illinois maintained their relative ranks of sixth and seventh, reporting 3.12 per cent and 2.41 per cent, respectively. The first five States—Ohio, New Jersey, West Virginia, New York, and Pennsylvania—reported 88.63 per cent of the total production in 1913; in 1912 these States reported 88.61 per cent of the total, and in 1911, 88.04 per cent.

In considering the rank of States it should be borne in mind that the small number of producers in many of them in 1913, which prevents the publication of State totals without disclosing individual returns, makes the rank of all but the first few the relative and not the actual rank.

CONSUMPTION.

The pottery imported into the United States in 1913 was valued at $10,177,451 and the production at $37,992,375, a total of $48,-169,826. After deducting exports—domestic, $559,163, and foreign, $34,816—the net apparent consumption was valued at $47,575,847, of which the domestic production was 79.86 per cent. In 1912 this percentage was 81.45; in 1911 it was 78.93; in 1910 it was 77.08; and the next highest was in 1902, when it was 72.91.

POTTERY INDUSTRY BY STATES.

Alabama.—The pottery industry of Alabama is of comparatively little importance. Production was reported for 1913 by 9 operators, a decrease of 6. The output was valued at $20,158, a decrease of $2,055. The product consists of red earthenware and stoneware. There were 5 idle potteries in Alabama in 1913.

Arkansas.—In Arkansas there were 4 active potters in 1913, who reported wares valued at $19,757, a decrease of $9,200 from 1912. The product consists of stoneware, art pottery, and red earthenware. There was 1 idle pottery in Arkansas in 1913.

California.—Pottery products of California were reported by 11 operators for 1913, a decrease of 1 from 1912. The value of the products in 1913 was $290,255, an increase of $70,602, or 32.14 per cent, over 1912. The product of greatest value was sanitary ware, made in Contra Costa County. There were 4 idle works, and 1 new plant that had not begun operations at the close of the year.

Colorado.—Colorado's pottery production for 1913 was reported by 5 operators, the same number as in 1912, and was valued at $46,501, an increase of $5,254. Colorado's leading pottery product is stoneware made in Denver County. Red earthenware, art pottery, and "fireproof china" cooking utensils are also reported from this State. All of Colorado's potteries were active in 1913.

Connecticut.—The principal pottery product of Connecticut is porcelain electrical supplies made at Hartford. Red earthenware and stoneware are also made in Connecticut in small quantities.

District of Columbia.—There were 3 operators in the District of Columbia in 1913, all of whom reported red earthenware only.

Georgia.—Georgia's pottery products in 1913 were valued at $28,528, an increase of $9,471 over 1912. These consist entirely of red earthenware and stoneware. There were 6 idle works in the State in 1913.

Illinois.—Twenty-three operators reported production in Illinois for 1913, a decrease of 1, with products valued at $915,263, a decrease of $16,688. This loss was principally in stoneware, which decreased $51,050, or 7.56 per cent, every other variety of pottery showing an increase. The miscellaneous items showed a decrease also. Stoneware is the pottery product of chief value in Illinois, comprising 68.2 per cent of the total output, and is made in Brown, Green, La Salle, McDonough, Tazewell, and Warren counties. White ware in small, though increasing quantities, is also made in this State, as are filter stones, clay pipes, and art pottery. One new plant started operations in Illinois in 1913, and 2 were idle.

Indiana.—Indiana is the sixth State in rank in value of pottery products, reporting wares for 1913 valued at $1,186,706, an increase of $109,604, or 10.18 per cent. Indiana's principal pottery product is sanitary ware, which increased in value $85,525, or 13.5 per cent over 1912. This ware (60.6 per cent of the total value for the State in 1913) was reported from Howard and Vanderberg counties. There were 11 active operators in the State in 1913, an increase of 1, and 3 were idle.

Iowa.—The pottery industry of Iowa is of comparatively little importance. The total value of pottery in 1913 was $20,698, a decrease of $9,443. The principal pottery product was stoneware. There were 4 active firms reporting and 1 idle works in 1913 in Iowa.

Kansas.—There were 2 pottery works in Kansas in 1913, 1 of which was idle. The only pottery product reported from Kansas in 1913 was stoneware. Business was reported poorer in 1913 than in 1912.

Kentucky.—Seven operators reported pottery products from Kentucky for 1913. The output was valued at $102,118, a decrease of $12,086. A new company at Dayton began the production of semi-porcelain ware in 1913. The other pottery products reported from Kentucky were red earthenware and stoneware.

Louisiana.—Louisiana is the home of the Newcomb pottery, located at New Orleans, where the famous Newcomb art ware is made. Owing to the fact that there were less than 3 operators in Louisiana reporting pottery products for 1913, separate figures of production can not be published.

Maine.—Stoneware is the only pottery product of Maine. There being only 1 producer, separate figures can not be published.

Maryland.—The value of Maryland's pottery products in 1913 was $155,034, a decrease of $29,677. The principal pottery product of Maryland is white ware. Red earthenware, stoneware, and clay smoking pipes were also made in the State in 1913. Six operators were active and 1 plant was idle in 1913.

Massachusetts.—The principal pottery product of Massachusetts is red earthenware, of which it was the third largest producer in 1913. Stoneware, white ware, porcelain electrical supplies, art pottery, porcelain shuttle eyes and thread guides are also made there. The value of the pottery products in Massachusetts in 1913 was $231,345, a decrease of $20,754 from 1912. There were 11 active operators in 1913, a decrease of 1, and 1 plant was idle.

Michigan.—Michigan's pottery products in 1913 were valued at $222,883, an increase of $27,991. The principal pottery product of the State is porcelain electrical supplies, with red earthenware second. Art pottery is also produced. There were 6 active operators in the State in 1913, the same number as in 1912, and no idle plants.

Minnesota.—The only pottery product of Minnesota is stoneware, made at Red Wing, Goodhue County. There being but one operator reporting for 1913 separate figures of production are not published. There are two other plants in the State, both of which were idle.

Mississippi.—Mississippi's pottery products, red earthenware and stoneware, were valued at $17,451 in 1913, an increase of $4,745 over 1912. There were 8 operators in 1913, an increase of 2, and 1 idle plant.

Missouri.—Missouri is the leading Southern State in the production of clay wares, but its pottery industry is of minor importance. The value of the pottery output in 1913 was only $3,412, a decrease of $103 from 1912. Five operators reported for 1913, an increase of 1, and 4 plants were idle.

Montana, Nebraska, and New Hampshire.—There was only 1 pottery plant in each of these States in 1913, so that statistics of production are not published separately.

New Jersey.—New Jersey is the second largest pottery-producing State, reporting wares valued at $8,838,545 for 1913, or 23.26 per cent of the total for the United States, a decrease of $97,375, or 1.09 per cent, from 1912. New Jersey's leading product is sanitary ware, valued at $5,238,013, or 59.26 per cent of the State total in 1913, though every variety of pottery, as classified by the Survey, and in addition, chemical ware, smoking pipes, door knobs, hardware trimmings, souvenirs, and art pottery were reported from this State for 1913. Mercer County, in which Trenton is located, reported 89.36 per cent of the value of the pottery of the entire State—$7,898,474, a decrease in this county from 1912 of $171,220, or 2.12 per cent. No red earthenware or stoneware was made in 1913 in Mercer County. Middlesex County was the second largest pottery-producing county in the State, reporting wares (principally sanitary ware) valued at $370,026, an increase of $16,741 over 1912. There were 51 active potters in New Jersey in 1913, a decrease of 1; 6 were idle.

New York.—New York was the fourth State in 1913 in value of pottery produced, 23 operators reporting wares valued at $2,841,658, or 7.48 per cent of the total. This was an increase of $436,126, or 18.13 per cent over 1912. New York's principal pottery product in 1913 was porcelain electrical supplies manufactured chiefly in Schenectady and Ontario counties, and also in Kings, Livingston, and Onondaga counties. These were valued at $1,560,870, or 54.93 per cent of the total value of pottery for the State. China production was second in importance, being valued at $763,322 and constituting 26.86 per cent of the total. The principal china-making center is in Onondaga County. In addition to these wares, the manufacture of every other variety of pottery as classified in this report, and of art pottery, smoking pipes, chemical stoneware, and hardware trimmings was reported for 1913. Three pottery plants were idle in 1913.

North Carolina.—North Carolina had a comparatively large number (23) of active operators reporting for 1913, but the industry is of little importance, though the value of the product is increasing. The value of the pottery products of the State in 1913 was $13,683, an increase of $4,733. Red earthenware and stoneware and art pottery were the only wares made in the State. There were three idle pottery plants in North Carolina in 1913.

Ohio.—Ohio is the leading State in the production of pottery. The value of the output in 1913 was $16,519,889, or 43.48 per cent of the value for the entire country. This was an increase of $1,011,154, or 6.52 per cent, over 1912. Every variety of pottery as classified in this report, except china, was reported for 1913, and in addition, pins, stilts and spurs, saggers, porcelain filter tubes, art pottery, gas-mantle supplies, gas burners, toy marbles, umbrella stands, and chemical stoneware. White ware was the variety of chief value ($10,548,628 in 1913), constituting 63.85 per cent of the total for the State. This was an increase of $579,137, or 5.81 per cent, over 1912. Columbiana is the leading county (reporting a value of $6,664,682, or 63.18 per cent of the State total for this variety). Mahoning County was second, reporting white ware valued at $2,126,857, or 20.16 per cent of the State total. Porcelain electrical supplies was the variety of second importance in 1913—being valued at $2,184,201, or 13.22 per cent of the total value of pottery for the State. Stoneware and yellow and Rockingham ware (taken together) were third in importance in 1913, being reported to the value of $1,649,186, or 9.98 per cent of the State total.

Columbiana is the leading pottery-producing county of the State, reporting wares valued at $8,248,654, or 49.93 per cent of the total for the State. Mahoning County is second in importance, reporting wares for 1913 valued at $2,243,487, or 13.58 per cent of the State total. Mahoning's principal pottery product is white ware. Muskingum was the third county in importance, reporting for 1913 wares valued at $1,365,432, or 8.27 per cent of the State total. East Liverpool, Columbiana County, is the principal pottery center of the State, its wares being valued in 1913 at $6,683,007. There were 105 active and 8 idle operators in Ohio in 1913.

Oklahoma.—No production of pottery from Oklahoma was reported for 1913. Plans to erect a stoneware pottery in Oklahoma in 1914 were under consideration.

Oregon.—In Oregon only 2 potters reported production in 1913, so that the figures can not be published separately without disclosing individual operations. Red earthenware and stoneware are the only pottery products made in this State.

Pennsylvania.—Pennsylvania was the fifth State in value of pottery products in 1913, its output being valued at $2,046,099, a decrease of $82,441, or 3.87 per cent. This decrease was chiefly in white ware, which declined $62,747, though stoneware, sanitary ware, and porcelain electrical supplies also showed decrease. Only 2 varieties, red earthenware and china, showed increase. White ware, valued at $839,838, was Pennsylvania's leading pottery product in 1913, this variety constituting 41.05 per cent of the total value of pottery for the State. Twenty-seven active operators reported for 1913, a decrease of 2 from 1912. Three plants were idle in Pennsylvania in 1913, and 1 only operated in an experimental way.

Porto Rico.—Two potters located in Ponce district reported from Porto Rico in 1913.

South Carolina.—The pottery industry of South Carolina is of minor importance. There were 5 operators reporting wares valued at $9,782, an increase of $3,021 over 1912. Red earthenware and stoneware are the only products made.

Tennessee.—Eight firms reported pottery production in Tennessee in 1913. The principal product is turpentine cups, made in Hamilton County. The output of Tennessee pottery was valued at $145,100 in 1913, a decrease of $28,066.

Texas.—Though the kaolin beds of Texas are conceded to be equal if not superior to any others in the country, its pottery products are confined to the lowest grades of ware—red earthenware and stoneware. The total value of Texas pottery in 1913 was $80,374, a decrease of $66,230. This decrease may be more apparent than real, as it seems probable from reports received for 1913 that for 1912 some of the operators unintentionally duplicated figures. The Survey at this date, however, is unable to determine the extent of duplication, if there were any. Fourteen active operators reported for 1913, an increase of 2 over 1912, and 4 plants were idle in 1913.

Utah.—There were only 2 potters in Utah who reported production for 1913, so that no figures can be published. Red earthenware is the only pottery ware made in the State.

Virginia.—In Virginia only 2 potters reported production for 1913. Tobacco pipes was the only product reported.

Washington.—Washington pottery products are confined to red earthenware and stoneware and are comparatively unimportant.

West Virginia.—West Virginia was third in the value of pottery produced in 1913. This State is rapidly increasing in importance as a pottery-producing State, notwithstanding the small increase in value of pottery products in 1913 over 1912—$59,721, or 1.77 per cent. The new works mentioned as in contemplation in the last report were erected in 1913, but were not put in operation in time to affect the production for that year. West Virginia's pottery product of chief value is white ware, of which it was the second largest producer in the country. The value of the white ware made in 1913 in West Virginia was $2,024,104, or 59.1 per cent of the value of the pottery output of the State, a decrease of $27,883, or 1.36 per cent. This product is made principally in Hancock County, opposite East Liverpool, Ohio. The pottery products of this county in 1913 were valued at $1,894,682, or 55.32 per cent of the total for the State. Sanitary ware was second in value in this State in 1913, being valued at $1,146,205, a decrease of $10,273, or 0.89 per cent. Fourteen operators reported production from this State, the same number as in 1912.

Wisconsin.—Wisconsin's pottery production in 1913—red earthenware only—was valued at $7,700, a decrease of $200 from 1912. Three potters reported for 1913, the same number as for 1912.

IMPORTS AND EXPORTS.

The following tables show the imports and exports of clay products from 1901 to 1913:

Value of earthenware, china, brick, and tile imported and entered for consumption in the United States, 1901–1913.

Year.	Pottery.						Brick, fire brick, tile, etc.	Grand total.
	Brown earthen and common stone ware.[a]	Earthenware and crockery composed of a nonvitrified absorbent body.		China and porcelain.		Total.		
		Not decorated.	Decorated.	Not decorated.	Decorated.			
1901....	$51,551	....	....	$1,094,078	$8,385,514	$9,531,143	$150,268	$9,681,411
1902....	58,926	....	....	1,016,010	8,495,598	9,570,534	235,737	9,806,271
1903....	95,890	....	....	1,234,223	9,897,588	11,227,701	228,589	11,456,290
1904....	81,951	....	....	1,329,146	9,859,144	11,270,241	218,170	11,488,411
1905....	100,618	....	....	1,157,573	10,717,871	11,976,062	172,079	12,148,141
1906....	96,400	....	....	1,312,326	11,822,376	13,231,102	175,797	13,406,899
1907....	113,477	....	....	1,315,591	12,156,544	13,585,612	225,320	13,810,932
1908....	70,629	....	....	1,142,444	9,309,718	10,522,791	162,341	10,685,132
1909....	98,716	....	....	1,245,479	9,263,017	10,607,212	189,536	10,796,748
1910....	154,614	....	....	1,293,986	9,682,558	11,131,158	222,183	11,353,341
1911....	164,871	....	....	1,221,756	9,251,989	10,638,616	208,966	10,847,582
1912....	152,166	....	....	1,094,152	8,309,212	9,555,530	215,379	9,770,909
1913....	230,780	[b] $81,978	[b] $523,803	[c] 1,067,209	[c] 8,273,681	10,177,451	276,677	10,454,128

[a] Including Rockingham ware.
[b] Figures cover period from Oct. 4 to Dec. 31.
[c] Including wares classified under the act of 1913 as china and porcelain wares composed of a vitrified nonabsorbent body: Not decorated, $244,933; decorated, $2,204,851.

The value of imports of all clay products in 1913 increased $683,219, or 6.99 per cent; in 1912 there was a decrease from 1911 of $1,076,673, or 9.93 per cent. The total value for 1913 was, however, $393,454, or 3.63 per cent, less than that for 1911 and $3,356,804, or 24.31 per cent, less than that of 1907, the year of maximum value. Of the imports for 1913, 97.35 per cent was pottery and 2.65 per cent brick and tile. The pottery imports in 1913 increased in value $621,921, or 6.51 per cent, over 1912, but were $3,408,161, or 25.09 per cent, less than in 1907 and $461,165, or 4.33 per cent, less than in 1911. The brick and tile imports in 1913 increased in value $61,298, or 28.46 per cent, over 1912. The imports of brick and tile are, however, of relatively little importance. Of the pottery imports, 97.73 per cent was of the high-grade wares and 2.27 per cent of the low-grade wares.

Value of exports of clay wares of domestic manufacture from the United States, 1905–1913.

Year.	Brick.					Pottery.			Grand total.
	Building.	Fire.	Tile (except drain).	All other.	Total.	Earthen and stone ware.	China.	Total.	
1905	....	$536,002	....	[a]$263,876	$799,878	$882,069	$101,485	$983,554	$1,783,432
1906	....	637,441	....	[a]247,625	885,066	1,003,969	114,481	1,118,450	2,003,516
1907	....	631,779	....	[a]185,192	816,971	1,022,730	108,911	1,131,641	1,948,612
1908	....	[b]550,243	....	113,243	663,486	906,266	77,494	983,760	1,647,246
1909	....	[b]1,002,270	....	147,622	1,149,892	776,842	86,853	863,695	2,013,587
1910	....	[c]634,775	....	968,138	1,602,913	928,475	113,214	1,041,689	2,644,602
1911	....	1,057,725	....	1,206,629	2,264,354	1,278,892	122,474	1,401,366	3,665,720
1912	[c]$448,939	1,117,161	[c]$539,116	1,717,895	3,823,111	1,037,637	140,147	1,177,784	5,000,895
1913	689,515	1,121,590	851,631	1,566,340	4,229,076	409,882	149,281	559,163	4,788,239

[a] Building brick only.
[b] Includes all brick, other than building brick.
[c] Figures cover period from July 1 to Dec. 31.

The exports of domestic clay products in 1913 decreased in value $212,656, or 4.25 per cent, from 1912. In 1912 there was an increase of $1,335,175, or 36.42 per cent, over 1911. Of these exports in 1913, 11.68 per cent was pottery and 88.32 per cent was brick and tile. In 1912, 23.55 per cent was pottery and 76.45 per cent was brick and tile. Brick and tile exports increased in 1913 over 1912, $405,965, or 10.61 per cent, and pottery exports decreased $618,621, or 52.52 per cent. The increase in the exports of brick and tile was general, every item, except the one covering miscellaneous products, showing increase. The decrease in the pottery exports was entirely in earthen and stone ware, these wares decreasing in value $627,755. China exports are small, but have shown a steady growth since 1908, increasing in 1913, $9,134. Of the pottery exports 73.3 per cent was earthen and stone ware and 26.7 per cent was china.

CLAY PRODUCTS BY STATES.

In the following pages the statistics of the clay-working industry from 1909 to 1913, inclusive, are given for some of the more important States. Owing to the changes in the classification of the products in some of the minor items, the figures do not always represent solely the value of the products named, though the classification as given in the tables is sufficiently correct for comparative analysis. The item "Miscellaneous" under each State includes all products not otherwise classified and those that could not be published separately without disclosing individual returns. For details concerning the production of pottery in the several States, the reader is referred to the section of this report on pottery.

ALABAMA.

Alabama is rich in clays, but its rank as a clay-working State is not high. In 1913 it was sixteenth among the States, with products valued at $2,091,581, or 1.15 per cent of the total for the country. This was an increase over 1912 of $156,402, or 8.08 per cent. In 1913 Alabama was ninth in the production and value of vitrified brick, and ninth in production and eleventh in value of fire brick. The principal product is common brick, valued in 1913 at $730,148, and representing 34.91 per cent of the value of all of Alabama's clay products in that year. Front brick, fireproofing, and tile, not drain, were reported to the value of $258,130, so that the structural materials represent nearly one-half of Alabama's clay products in 1913. The engineering products, vitrified paving brick, draintile, sewer pipe, and fire brick were reported to the value of $1,057,059, or more than 50 per cent of the total. Pottery clays are abundant in the State, but this branch of the industry has not been developed extensively, the value of pottery production in 1913 being only $20,158.

Jefferson County is the principal clay-working county, reporting a production valued at $1,313,432, or 62.8 per cent of the total value for 1913, an increase of $178,093 over 1912. No pottery was reported from this county. All of the fire brick produced in the State comes from Jefferson County, and fire brick is its principal product. Vitrified brick was reported only from Jefferson and St. Clair counties, the former being the leading county with 22,710,000 brick, valued at $339,615. The leading counties in the value of common brick in 1913 were, in the order of their importance, Montgomery, Talladega, and Jefferson.

Clay products of Alabama, 1909–1913.

Product.	1909	1910	1911	1912	1913
Brick:					
Common—					
Quantity	146,180,000	135,785,000	129,694,000	136,989,000	130,923,000
Value	$799,693	$746,961	$708,903	$759,409	$730,148
Average per M	$5.47	$5.50	$5.47	$5.54	$5.58
Vitrified—					
Quantity	20,444,000	19,772,000	21,444,000	26,480,000	24,183,000
Value	$262,376	$236,516	$246,707	$353,303	$361,722
Average per M	$12.83	$11.96	$11.50	$13.34	$14.96
Front—					
Quantity	(a)	(a)	9,169,000	10,629,000	(a)
Value	(a)	(a)	$128,403	$132,033	(a)
Average per M	$16.19	$15.96	$14.00	$12.42	$15.29
Fancy ... value	(a)	....	(a)	(a)	....
Fire ... do	$196,887	$163,672	$193,375	$240,434	(a)
Draintile ... do	(a)	$3,773	$3,777	$5,465	$10,802
Sewer pipe ... do	(a)	(a)	(a)	(a)	(a)
Fireproofing ... do	(a)	(a)	(a)	(a)	(a)
Tile, not drain ... do	....	....	....	....	(a)
Pottery:					
Red earthenware ... do	$11,886	$3,475	$11,243	$10,990	$11,164
Stoneware and yellow and Rockingham ware .. value	$24,453	$16,371	$14,753	$11,223	$8,994
Miscellaneous ... do	$404,832	$496,791	$639,941	$422,322	$968,751
Total value	$1,700,127	$1,667,559	$1,947,102	$1,935,179	$2,091,581
Number of active firms reporting	100	87	82	74	68
Rank of State	22	22	17	17	16

a Included in "Miscellaneous."

CALIFORNIA.

California is an important clay-working State, being ninth in value of production in 1913. It was fourth in the value of fancy and enameled brick, sewer pipe, and architectural terra cotta; sixth in the value of front brick and fire brick; and seventh in the value of common brick, fireproofing, and tile, not drain. There were 91 active operators reporting for 1913, the same number as for 1912.

The total value of all of California's clay products in 1913 was $5,344,958, a decrease of $567,492, or 9.6 per cent, from 1912. California's principal clay product—common brick, made chiefly in Los Angeles and Contra Costa counties—was valued in 1913 at $1,699,426, or 31.79 per cent of all clay products in the State, but a decrease of $498,877 from 1912. The average price per 1,000 in 1913 was $5.75, a decline of 53 cents from 1912. Sewer pipe, made principally in Los Angeles and Alameda counties, is second in importance among the clay products of California, being reported at $1,032,094 for 1913, a decrease of $104,335 from 1912. Architectural terra cotta, made principally in Placer County, was the product of third importance; this also decreased in 1913—$21,534. The only products to show increases in 1913 were enameled brick, fire brick, fireproofing, tile, not drain, stove lining, and pottery. Pottery production was valued at $290,255, an increase over 1912 of $70,602.

Los Angeles, the principal common brick producing county, reported 161,398,000 brick, valued at $836,372, or 54.58 per cent of the total quantity and 49.21 per cent of value for the State in 1913.

The principal product of Los Angeles County was common brick, with sewer pipe second, these two constituting more than half the value of the county's clay products in 1913. Fire brick, fireproofing, and front brick are also produced in this county in considerable quantities. Los Angeles was also the leading clay-working county, reporting wares valued at $2,387,658, or 44.67 per cent of the State's total. This was an increase over 1912 of $109,273.

Clay products of California, 1909–1913.

Product.	1909	1910	1911	1912	1913
Brick:					
Common—					
Quantity	276,396,000	280,265,000	282,199,000	349,797,000	295,729,000
Value	$1,749,209	$1,694,312	$1,716,442	$2,198,303	$1,699,426
Average per M	$6.33	$6.05	$6.08	$6.28	$5.75
Vitrified—					
Quantity	7,180,000	8,538,000	9,186,000	5,443,000	1,923,000
Value	$135,203	$140,130	$155,885	$72,495	$44,725
Average per M	$18.83	$16.41	$16.97	$13.32	$23.26
Front—					
Quantity	10,359,000	11,475,000	15,197,000	18,714,000	16,605,000
Value	$309,770	$285,468	$381,226	$492,617	$368,149
Average per M	$29.90	$24.88	$25.09	$26.32	$22.17
Fancy or ornamental. value	(a)	$48,572	(a)	(a)	(a)
Enameled do	$57,914	$100,531	$113,407	$134,646	$160,727
Fire do	$297,577	$371,017	$468,120	$513,583	$523,692
Stove lining do	(a)	(a)	(a)	(a)	(a)
Draintile do	$29,620	$55,386	$34,780	$37,377	$34,413
Sewer pipe do	$904,473	$1,031,061	$999,546	$1,136,429	$1,032,094
Architectural terra cotta do	$345,402	$678,249	$475,647	$650,637	$629,103
Fireproofing do	$128,447	$151,503	$200,923	$250,931	$322,200
Tile, not drain do	$130,941	$97,685	$90,632	$76,358	$151,252
Pottery:					
Red earthenware do	$42,464	$34,367	$32,146	$36,091	$33,481
Stoneware and yellow and Rockingham ware value	$59,907	$42,726	$48,190	$54,087	$49,720
White ware, including C. C. ware, white granite, semiporcelain ware, and semivitreous porcelain ware value				(a)	
Sanitary ware do	(a)	(a)	(a)	(a)	(a)
Porcelain electrical supplies, value				(a)	
Miscellaneous do	$246,238	$111,384	$198,922	$258,896	$295,976
Total value	$4,437,165	$4,842,391	$4,915,866	$5,912,450	$5,344,958
Number of active firms reporting	99	107	92	91	91
Rank of State	9	9	8	8	9

a Included in "Miscellaneous."

COLORADO.

The total value of Colorado's clay products in 1913 was $1,293,511, a decrease of $143,883, or 10.01 per cent, from 1912. In 1913 Colorado's clay product of chief value was fire brick, displacing common brick, which was second. Fire brick was reported to the value of $306,843 in 1913, an increase of $5,163; common brick decreased 21,423,000 brick in quantity and $116,315 in value.

Denver County is the chief producer of common brick, reporting 18,162,000 brick, valued at $106,862. This was a decrease of 18,887,000 brick in quantity and of $101,324 in value from 1912. Denver County is the principal clay-working county, reporting wares valued at $654,612, or more than half the State's product. It is the leading county in the production of all clay products except enameled brick, tile, not drain, and refractory wares. Pueblo County is the principal producer of refractory wares. The pottery production of the State was valued at $46,501 in 1913.

Clay products of Colorado, 1909–1913.

Product.	1909	1910	1911	1912	1913
Brick:					
Common—					
Quantity	121,908,000	128,711,000	89,950,000	66,833,000	45,590,000
Value	$601,833	$852,986	$559,519	$407,428	$291,113
Average per M	$6.58	$6.63	$6.22	$6.10	$6.39
Vitrified—					
Quantity	(a)	(a)	2,334,000	(a)	3,807,000
Value	(a)	(a)	$31,572	(a)	$46,220
Average per M	$14.12	$14.15	$13.53	$12.04	$12.14
Front—					
Quantity	38,782,000	30,334,000	26,189,000	20,087,000	10,851,000
Value	$473,039	$368,538	$294,783	$233,175	$129,590
Average per M	$12.20	$12.15	$11.26	$11.61	$11.94
Fancy ... value		(a)	$1,220	$3,785	(a)
Enameled ... do				(a)	(a)
Fire ... do	$265.089	$205,550	$182,766	$301,680	$306,843
Draintile ... do	$13,626	$18,066	$23,655	$20,250	$47,871
Sewer pipe ... do	(a)	(a)	$297,800	(a)	(a)
Architectural terra cotta ... do				(a)	(a)
Fireproofing ... do	(a)	$32,565	(a)	$22,213	$25,220
Tile, not drain ... do	(a)	(a)	(a)	$2,200	(a)
Pottery:					
Red earthenware ... do	(a)	(a)	(a)	(a)	(a)
Stoneware and yellow and Rockingham ware ... value	(a)	(a)	(a)	(a)	(a)
Miscellaneous ... do	$495,437	$556,009	$215,394	$446,663	$446,654
Total value	$2,049,024	$2,033,714	$1,606,709	$1,437,394	$1,293,511
Number of active firms reporting	73	77	80	71	68
Rank of State	16	17	22	25	25

a Included in "Miscellaneous."

CONNECTICUT AND RHODE ISLAND.

There being but two producers in Rhode Island it is impossible to publish figures for the State, and they are combined with those of Connecticut. The value of the clay products of these States in 1913 was $1,372,234, a decrease of $92,766, or 6.33 per cent, from 1912. Connecticut's products are common brick, stove lining, fire brick, and tile, not drain. Rhode Island makes common, vitrified, front, and fancy brick and tile, not drain. Common brick composed 91.25 per cent of the total value of the clay products of these two States in 1913, but decreased in value $125,330. Hartford is the leading county in Connecticut, reporting wares valued at $784,146, or more than half the value of the entire State. It reported more than one-half of the value of the common brick in 1913. New Haven and Middlesex counties are also large producers of common brick. Fire brick is made only in New Haven County.

Clay products of Connecticut and Rhode Island, 1909–1913.

Product.	1909	1910	1911	1912	1913
Brick:					
Common—					
Quantity	242,000,000	240,234,000	206,631,000	214,700,000	185,737,000
Value	$1,408,033	$1,454,471	$1,153,409	$1,377,456	$1,252,126
Average per M	$5.82	$6.05	$5.58	$6.42	$6.74
Vitrified—					
Quantity	(a)	(a)	(a)	(a)	(a)
Value	(a)	(a)	(a)	(a)	(a)
Average per M	$13.00	$14.62	$15.50	$17.71	$15.30
Front—					
Quantity	(a)	(a)	(a)	(a)	(a)
Value	(a)	(a)	(a)	(a)	(a)
Average per M	$14.00	$15.75	$12.49	$13.25	$12.73
Fancy or ornamental..value	(a)	(a)	(a)	(a)	(a)
Fire ..do	(c)	(a)	(a)	(a)	(a)
Stove lining..do	(a)	(a)	(a)	(a)	(a)
Tile, not drain..do	....	....	(a)	(a)	(a)
Pottery: [b]					
Red earthenware..do	(b)	(b)	(b)	(b)	(b)
Stoneware and yellow and Rockingham ware..value	(b)	(b)	(b)	(b)	(b)
Porcelain electrical supplies, value	(b)	(b)	(b)	(b)	(b)
Miscellaneous..do	$107,562	$114,015	$103,930	$87,544	$120,1
Total value	$1,515,595	$1,568,486	$1,257,339	$1,465,000	$1,372,234
Number of active firms reporting	42	42	42	41	42
Rank of Connecticut and Rhode Island	24	23	25	24	24

a Included in "Miscellaneous."
b The value of the pottery products, which were produced by Connecticut alone, could not be included in the State totals without disclosing the operations of individual establishments.

GEORGIA.

The total value of all clay products in Georgia in 1913 was $2,692,619, a decrease of $113,922, or 4.06 per cent, from 1912. In 1913 Georgia was seventh in the production and ninth in the value of common brick, and seventh in the value of sewer pipe. The principal product is common brick, which was valued at $1,464,322, a decrease of $170,348 from 1912; the quantity decreased 36,972,000 brick. The value of common brick was 54.38 per cent of the value of all clay products. Sewer pipe is second in importance, its production being valued at $634,478, an increase of $11,851 over 1912. Bibb County is the leading producer of common brick and of sewer pipe, and reported 90,481,000 brick, valued at $453,513, or nearly a third of the output and value of the State. Richmond and Fulton counties are also large producers of common brick. Architectural terra cotta was reported only from Fulton County, and tile, not drain, from Liberty County. Pottery production was valued at $28,528. Bibb County was the leading clay-working county of the State, reporting wares for 1913 valued at $776,076, an increase of $71,659 over 1912.

Clay products of Georgia, 1909–1913.

Product.	1909	1910	1911	1912	1913
Brick:					
Common—					
Quantity	275,809,000	305,025,000	325,948,000	315,476,000	278,504,000
Value	$1,469,839	$1,620,174	$1,692,610	$1,634,670	$1,464,322
Average per M	$5.33	$5.31	$5.19	$5.18	$5.26
Vitrified—					
Quantity	(a)	(a)	(a)	(a)	(a)
Value	(a)	(a)	(a)	(a)	(a)
Average per M	$12.00	$11.11	$12.22	$12.00	$12.81
Front—					
Quantity	7,188,000	13,649,000	12,788,000	11,527,000	9,749,000
Value	$61,131	$129,393	$112,675	$114,000	$96,568
Average per M	$8.50	$9.48	$8.81	$9.89	$9.91
Fancy or ornamental.value	(a)	(a)	....	(a)	....
Fire.....do	$62,452	$67,622	$86,000	$61,231	$64,167
Stove lining.....do	....	....	(a)	....	....
Draintile.....do	$4,820	$8,920	$5,000	(a)	$9,100
Sewer pipe.....do	$351,492	$373,387	$417,267	$622,627	$634,478
Architectural terra cotta.....do	(a)	(a)	(a)	(a)	(a)
Fireproofing.....do	(a)	$19,354	(a)	(a)	$33,900
Tile, not drain.....do	(a)	$51,800	(a)	(a)	(a)
Pottery:					
Red earthenware.....do	$12,945	$10,558	$17,530	$11,472	$17,238
Stoneware and yellow and Rockingham ware..value	$16,435	$10,740	$6,800	$7,510	$11,290
Miscellaneous.....do	$315,387	$240,090	$298,498	$355,031	$361,556
Total value	$2,294,501	$2,532,038	$2,636,380	$2,806,541	$2,692,619
Number of active firms reporting	105	109	109	96	92
Rank of State	15	15	13	12	13

a Included in "Miscellaneous."

ILLINOIS.

Illinois, which makes every variety of clay product as classified in this report except china and stove lining, was the leading State in 1913 in the production and value of common brick, third in the production and second in the value of vitrified paving brick, third in the value of enameled brick, sixth in the production and seventh in the value of front brick and fire brick, fourth in the value of draintile, fifth in the value of sewer pipe and fireproofing, and second in the value of architectural terra cotta.

The total value of the clay products of Illinois in 1913 was $15,195,874, a decrease from 1912 of $15,116, or 0.1 per cent. The principal product of the State is common brick, the production of which was 1,155,480,000 brick, valued at $6,445,821, compared with 1,210,499,000 brick, valued at $6,437,331, in 1912, a decrease of 55,019,000 brick in quantity, but an increase of $8,490 in value. Common brick constituted 42.42 per cent of the value of all clay products of the State in 1913. Of the common-brick production, Cook County reported 717,682,000 brick, valued at $3,569,134, which was 62.11 per cent of the quantity and 55.37 per cent of the value of common brick for the State, and a decrease from 1912 of 48,163,000 brick in quantity and of $122,985 in value. This is the largest brick-making county in the country, and is the second largest common-brick making region of the United States, being surpassed only by the Hudson River region of New York, which embraces nine counties. The average price per 1,000 for common brick in 1913 in Illinois was $5.58, or 26 cents higher than that of 1912. The average price in Cook County was $4.97, or 15 cents higher than in 1912. Second in importance is architectural terra cotta, which was valued in 1913 at $1,908,399, or 12.56 per cent of the total value. This was a decrease of $576,613, or 23.2 per cent. The third product in point of value was vitrified brick, of which 133,938,000 were reported for 1913, valued at $1,883,199. Knox was the leading county in the production of vitrified brick, with Livingston County second. Madison County led in the value of front brick. Enameled brick was reported only from Kankakee County. La Salle led in the production of draintile, fireproofing, and fire brick, and sewer pipe was produced chiefly in McDonough County. Cook County was the largest producer of architectural terra cotta as well as of common brick. Pottery to the value of $915,263, principally stoneware, was reported for 1913.

Cook County, owing to the large local market, was the leading clay-working county in 1913, reporting products valued at $5,529,785, or 36.39 per cent of the total for the State in 1913, a decrease of $651,866 from 1912. Knox County was second, with a production valued at $1,094,564, or 7.2 per cent of the State's total. The principal clay products of this county are vitrified paving brick and sanitary ware.

Illinois has been fourth among the States in the value of clay products for a number of years, and reported 8.38 per cent of the total value of the whole country for 1913.

Clay products of Illinois, 1909–1913.

Product.	1909	1910	1911	1912	1913
Brick:					
Common—					
Quantity	1,257,025,000	1,196,526,000	1,074,486,000	1,210,499,000	1,155,480,000
Value	$5,927,054	$6,896,836	$6,126,911	$6,437,331	$6,445,821
Average per M	$4.72	$5.76	$5.70	$5.32	$5.58
Vitrified—					
Quantity	140,105,000	115,903,000	124,623,000	136,708,000	133,938,000
Value	$1,562,373	$1,415,355	$1,627,683	$1,839,721	$1,883,199
Average per M	$11.15	$12.21	$13.06	$13.46	$14.06
Front—					
Quantity	32,416,000	22,138,000	19,786,000	21,894,000	29,566,000
Value	$385,170	$274,699	$240,135	$268,433	$363,010
Average per M	$11.88	$12.41	$12.14	$12.26	$12.28
Fancy or ornamental..value..	$12,223	$10,875	$10,281	$8,785	$2,295
Enameled.............do....	(a)	(a)	(a)	(a)	(a)
Fire.................do....	$682,793	$368,730	$286,039	$319,619	$351,324
Stove lining.........do....	....	....	....	....	....
Draintile............do....	$1,613,593	$1,613,698	$1,372,049	$1,189,910	$1,225,190
Sewer pipe...........do....	$394,461	$538,633	$507,694	$500,844	$787,896
Architectural terra cotta..do....	$1,898,865	$1,680,438	$1,879,275	$2,485,012	$1,908,399
Fireproofing.........do....	$439,796	$552,905	$552,994	$507,222	$592,337
Tile, not drain......do....	$335,020	(a)	(a)	(a)	$82,168
Pottery:					
Red earthenware......do....	$31,771	$25,658	$41,875	$35,827	$46,175
Stoneware and yellow and Rockingham ware..value..	$702,411	$708,958	$832,813	$675,244	$624,194
White ware, including C. C. ware, white granite, semi-porcelain ware, and semi-vitreous porcelain ware, value	(a)	....	(a)	(a)	(a)
Sanitary ware........value..	(a)	(a)	(a)	(a)	(a)
Porcelain electrical supplies, value	....	....	(a)	(a)	(a)
Miscellaneous........value..	$358,923	$1,089,376	$855,262	$943,042	$883,866
Total value	$14,344,453	$15,176,161	$14,333,011	$15,210,990	$15,195,874
Number of active firms reporting.	379	346	330	301	281
Rank of State	4	4	4	4	4

[a] Included in "Miscellaneous."

There were 281 active operators reporting for 1913, and 301 for 1912. Compared with 1909 there were 98 less active operators in 1913, but the value of production was nearly $1,000,000 greater, and the average output per active operator increased from $37,848 in 1909 to $54,078 in 1913.

INDIANA.

Indiana is one of the most important clay-working States, ranking sixth in value and reporting 4.69 per cent of the total. It reported for 1913 every variety of clay wares as classified in this report except fancy brick, enameled brick, and china. It was second in 1913 in the production of draintile, third in the production and value of front brick and in the production of tile, not drain, fourth in the production of fireproofing, and sixth in the production of sewer pipe and in the value of vitrified brick.

Clay products of Indiana, 1909-1913.

Product.	1909	1910	1911	1912	1913
Brick:					
Common—					
Quantity	251,227,000	234,297,000	192,057,000	202,056,000	208,500,000
Value	$1,579,185	$1,402,154	$1,132,555	$1,204,494	$1,268,710
Average per M	$6.29	$5.98	$5.90	$5.96	$6.08
Vitrified—					
Quantity	53,597,000	61,034,000	31,198,000	55,237,000	54,579,000
Value	$559,201	$682,888	$392,136	$654,341	$690,164
Average per M	$10.44	$11.19	$12.57	$11.85	$12.65
Front—					
Quantity	50,135,000	46,691,000	40,777,000	60,544,000	67,202,000
Value	$511,171	$478,627	$480,709	$659,492	$708,745
Average per M	$10.20	$10.25	$11.79	$10.89	$10.55
Fancy or ornamental..value	(a)	(a)	(a)	(a)	....
Fire..do	$280,921	$166,217	$76,116	$114,419	$105,286
Stove lining..do	....	(a)	(a)	(a)	(a)
Draintile..do	$2,018,401	$2,071,564	$2,006,803	$1,657,368	$1,595,290
Sewer pipe..do	$332,449	$406,543	$455,014	$544,491	$661,783
Architectural terra cotta..do	(a)	(a)	(a)	(a)	(a)
Fireproofing..do	$410,500	$466,877	$437,778	$623,123	$703,189
Tile not drain..do	(a)	$622,726	(a)	(a)	(a)
Pottery:					
Red earthenware..do	$10,090	$12,650	$5,700	(a)	(a)
Stoneware and yellow and Rockingham ware..value	$59,598	$89,423	$81,567	$46,100	$61,550
White ware, including C. C. ware, white granite, semi-porcelain ware, and semi-vitreous porcelain ware, value	(a)	(a)	(a)	(a)	(a)
Sanitary ware..value	(a)	$468,301	$549,470	$633,578	$719,103
Porcelain electrical supplies, value	(a)	(a)	(a)	(a)	(a)
Miscellaneous..value	$1,883,707	$1,232,040	$1,382,923	$1,797,845	$1,984,826
Total value	$7,645,223	$8,100,010	$7,000,771	$7,935,251	$8,498,646
Number of active firms reporting	348	249	302	278	257
Rank of State	6	6	6	6	6

a Included in "Miscellaneous."

The total value of Indiana's clay products in 1913 was $8,498,646, an increase of $563,395, or 7.1 per cent, over 1912. Draintile is Indiana's principal clay product, which was reported to the value of $1,595,290 in 1913, and constituted 18.77 per cent of the total for the State. Madison was the principal draintile producing county in 1913 with a value of $186,105, an increase of $12,360, over 1912.

Common brick is the clay product of second importance, 208,500,000 brick, valued at $1,268,710, being reported for 1913, or 14.93 per cent of the value of the State's clay products. This was an increase of 6,444,000 brick in quantity, and of $64,216 in value over 1912. Lake County is the principal one in the production of common brick and is the second county in the value of all clay products. Clay is the principal clay-working county, reporting for 1913 wares valued at $1,329,075, or 15.64 per cent of the State's total. The value of the pottery production of the State in 1913 was $1,186,706. Sanitary ware is the principal pottery product of Indiana, and was valued at $719,103 in 1913.

There were 257 active operators reporting for 1913, compared with 278 in 1912 and with 348 in 1909. The average value of production per operator reporting was $33,069 in 1913, compared with $28,544 in 1912 and with $21,969 in 1909.

IOWA.

Iowa ranked eighth in the value of clay products in 1913 and tenth in 1912. The total value of Iowa's clay products in 1913 was $5,573,681, an increase of $1,051,355, or 23.25 per cent, over 1912. Iowa is the leading State in the production of draintile, the principal clay product of the State. In 1913 Iowa was the third State in the production of fireproofing and ninth in the production of sewer pipe. Draintile was valued at $2,798,816 and constituted 50.21 per cent of the value of Iowa's clay products, an increase of $505,732 over 1912. Common brick is the clay product of second importance in Iowa, and was valued at $1,052,036 in 1913, or 18.88 per cent of the total, an increase of $34,909 over 1912. The quantity of common brick decreased 5,209,000 brick. Fireproofing is third in point of value among Iowa's clay products, being valued at $762,563, an increase of $227,309 over 1912.

Cerro Gordo County is the leading producer of draintile, reporting a value of $1,043,440, or more than one-third the production of the entire State, an increase of $422,216 over 1912. Webster County, the second county, reported draintile to the value of $631,726. Woodbury County is the leading producer of common brick.

Cerro Gordo, owing to its large production of draintile in 1913, was the leading county in the State in value of all clay products (displacing Webster County, which was second), and reported wares valued at $1,401,015, or 25.14 per cent of the State's total, an increase of $516,678 over 1912. Webster County, whose principal product also is draintile, was second, reporting wares valued at $1,077,059, or 19.32 per cent of the total value. The pottery production of Iowa in 1913 was valued at $20,698.

There were 186 active operators reporting for 1913, compared with 200 in 1912 and with 247 in 1909. The average value of production per active operator reporting was $29,966 in 1913 and $19,833 in 1909.

Clay products of Iowa, 1909–1913.

Product.	1909	1910	1911	1912	1913
Brick:					
Common—					
Quantity	153,065,000	149,914,000	154,434,000	148,472,000	143,263,000
Value	$1,072,340	$1,088,266	$1,025,011	$1,017,097	$1,052,036
Average per M	$7.01	$7.26	$6.64	$6.85	$7.34
Vitrified—					
Quantity	18,586,000	19,887,000	8,879,000	15,033,000	16,398,000
Value	$198,780	$239,283	$103,384	$197,035	$222,105
Average per M	$10.70	$12.03	$11.64	$13.11	$13.54
Front—					
Quantity	12,015,000	8,142,000	9,241,000	11,912,000	14,078,000
Value	$138,218	$103,276	$114,178	$142,637	$181,911
Average per M	$11.50	$12.68	$12.36	$11.97	$12.92
Fancy or ornamental.value	(a)		(a)	(a)	
Fire.....do	(a)	(a)		(a)	$3,250
Draintile.....do	$2,830,910	$3,337,851	$2,468,962	$2,293,084	$2,798,816
Sewer pipe.....do	$282,637	$313,430	$284,817	$291,672	$503,360
Fireproofing.....do	$304,398	$200,965	$374,628	$535,254	$762,563
Tile, not drain.....do					(a)
Pottery:					
Red earthenware.....do	$8,175	$6,290	$6,936	(a)	$2,414
Stoneware and yellow and Rockingham ware..value	(a)	(a)	(a)	(a)	(a)
Miscellaneous.....do	$63,238	$38,880	$54,958	$45,547	$47,226
Total value	$4,898,696	$5,328,241	$4,432,874	$4,522,326	$5,573,681
Number of active firms reporting.	247	232	214	200	186
Rank of State	8	8	9	10	8

[a] Included in "Miscellaneous."

KANSAS.

The total value of clay products in Kansas in 1913 was $1,919,910, a decrease of $116,590, or 5.73 per cent, from 1912. The low prices of brick in this State mentioned in the last report as the principal feature of the clay-working industry in the State, prevailed also in 1913, though there was an advance in the average price of each variety. Vitrified brick is the leading clay product of Kansas, closely followed by common brick, the difference between the value of these products in 1913 being only $2,188—$543,929 for vitrified brick, against $541,741 for common brick. Vitrified brick showed the large decrease of $262,498 in value in 1913, and common brick showed a decrease of $42,532. On the other hand, front brick, sewer pipe, fireproofing, and tile, not drain, increased in value. Vitrified brick constituted 28.33 per cent of the value of Kansas clay products in 1913 and common brick 28.22 per cent of its value.

The principal vitrified brick-producing counties in Kansas in 1913, given in the order of the value of production, were Montgomery, Wilson, and Crawford. These three counties reported vitrified brick valued at $484,166, or 89.01 per cent of the State's total. Wilson County was the largest producer of common brick in 1913, reporting 49,378,000 brick, valued at $179,068, with Allen County second, and Montgomery County third.

Montgomery County was the leading clay-working county in 1913, its products being valued at $564,413, or more than one-fourth of the State's total, but a decrease of $114,078 from 1912. Vitrified brick is the principal clay product of the county, though front brick, and tile, not drain, are also important products. Wilson County is second in importance, the principal products of this county in 1913 being front brick and common brick.

Clay products of Kansas, 1909-1913.

Product.	1909	1910	1911	1912	1913
Brick:					
Common—					
Quantity	254,890,000	218,353,000	183,809,000	145,986,000	122,465,000
Value	$1,160,877	$922,940	$694,586	$584,273	$541,741
Average per M	$4.55	$4.22	$3.78	$4.00	$4.42
Vitrified—					
Quantity	103,264,000	118,950,000	83,337,000	80,906,000	53,382,000
Value	$932,419	$1,089,978	$823,505	$806,427	$543,929
Average per M	$9.03	$9.16	$9.88	$9.97	$10.19
Front—					
Quantity	26,170,000	25,814,000	27,887,000	27,972,000	39,451,000
Value	$235,875	$223,875	$213,711	$215,873	$335,940
Average per M	$9.01	$8.67	$7.66	$7.72	$8.52
Fancy or ornamental. value	(a)	(a)	(a)	(a)	(a)
Fire do	(a)	....	(a)	(a)	....
Draintile do	$37,862	$50,726	$35,875	$50,948	$36,565
Sewer pipe do	(a)	(a)	(a)	(a)	(a)
Architectural terra cotta do	(a)	(a)	(a)	(a)	(a)
Fireproofing do	(a)	(a)	$15,257	$48,173	$80,220
Tile, not drain do	(a)	(a)	(a)	(a)	(a)
Pottery:					
Stoneware and yellow and Rockingham ware..value	(b)	(b)	(b)	(b)	(b)
Miscellaneous do	$342,789	$374,008	$577,328	$330,806	$381,515
Total value	$2,709,822	$2,661,527	$2,360,262	$2,036,500	$1,919,910
Number of active firms reporting	58	59	53	46	43
Rank of State	13	13	15	16	17

[a] Included in "Miscellaneous."
[b] The value of pottery products for Kansas could not be included in the State totals without disclosing the operation of individual establishments.

KENTUCKY.

The value of Kentucky's clay products in 1913 was $2,914,276, an increase of $470,536, or 19.25 per cent, over 1912. Kentucky was fourth in the production and value of fire brick in 1913 and fifth in the production of tile, not drain. Kentucky's leading clay product is fire brick, which was valued at $1,428,938 in 1913, an increase of $428,882. The quantity of 9-inch equivalent fire brick marketed in Kentucky in 1913 was 79,342,000, an increase of 26,180,000 brick over 1912. The value of fire brick constituted 49.03 per cent of the value of Kentucky's clay products in 1913. Common brick was second in importance, being valued at $681,727. The clay product of third importance in the State was tile, not drain, valued at $301,094. Kentucky's pottery production in 1913 was valued at $102,118.

Carter County is the chief producer of fire brick, reporting 41,802,000 nine-inch equivalent fire brick, valued at $818,378, or over half the output and value of the State. This was an increase of 13,893,000 brick in quantity and of $267,806 in value over 1912. Fire brick was the only clay product made in Carter County in 1913. Jefferson County is second in the manufacture of fire brick and the leading county in the production of common brick, reporting 21,173,000 common brick, valued at $152,598, for 1913.

Carter County was the leading county in the value of clay products in 1913, Jefferson County being second with wares valued at $694,042. These two counties reported more than one-half of the value of the clay products of the State for 1913. Kenton County was third with products valued at $268,816, principally tile, not drain.

Clay products of Kentucky, 1909–1913.

Product.	1909	1910	1911	1912	1913
Brick:					
Common—					
Quantity	119,183,000	115,890,000	107,771,000	99,119,000	98,364,000
Value	$741,115	$743,732	$692,378	$656,373	$681,727
Average per M	$6.22	$6.42	$6.42	$6.62	$6.93
Vitrified—					
Quantity	(a)	(a)	(a)	(a)	(a)
Value	(a)	(a)	(a)	(a)	(a)
Average per M	$12.69	$12.74	$12.37	$8.36	$10.13
Front—					
Quantity	11,626,000	10,238,000	8,972,000	5,025,000	4,098,000
Value	$104,022	$99,532	$90,330	$46,300	$42,637
Average per M	$8.95	$9.72	$10.07	$9.21	$10.40
Fancy value	(a)	(a)		(a)	
Fire do	$899,363	$955,557	$890,810	$1,000,056	$1,428,938
Stove lining do	(a)				(a)
Draintile do	$53,213	$66,217	$64,005	$71,826	$78,023
Sewer pipe do	(a)	(a)	(a)	(a)	$162,370
Architectural terra cotta do	(a)				
Fireproofing do	(a)	(a)	(a)	$29,530	$39,341
Tile, not drain do	$296,179	$318,966	$292,563	$310,945	$301,094
Pottery:					
Red earthenware do	$20,225	$10,004	$12,880	$22,523	$25,818
Stoneware and yellow and Rockingham ware value	$126,172	$139,417	$101,214	$91,681	$75,800
White ware, including C. C. ware, white granite, semi-porcelain ware, and semi-vitreous porcelain ware value					(a)
Miscellaneous do	$238,583	$234,112	$223,914	$214,506	$78,528
Total value	$2,478,872	$2,567,537	$2,368,094	$2,443,740	$2,914,276
Number of active firms reporting	99	95	96	90	83
Rank of State	14	14	14	14	12

a Included in "Miscellaneous."

MARYLAND.

Maryland's clay products were valued at $1,917,500 in 1913, an increase of $51,747, or 2.77 per cent over 1912. In 1913 Maryland was the tenth State in the production and value of fire brick, though its principal clay product is common brick, 153,053,000 of the latter valued at $1,004,146, being reported for 1913, a decrease in quantity of 1,507,000 common brick and in value of $49,189. The average value per 1,000 for common brick declined 26 cents in 1913. Common brick constituted 52.37 per cent of the value of Maryland's clay products in 1913. Fire brick is Maryland's second clay product in point of value, 14,444,000 9-inch equivalent brick being reported for 1913, valued at $295,707. This was an increase in quantity of 458,000 brick and in value of $32,890 over 1912. Maryland's pottery production, mostly of the higher-grade wares, was valued at $155,034 in 1913.

The chief center of production of common brick was in the city of Baltimore and in Baltimore County. These two localities reported 111,894,000 common brick, valued at $725,435, or 73.11 per cent of the quantity and 72.24 per cent of the value of the State, respectively. This was a decrease of 7,231,000 brick in quantity and of $21,402 in value from 1912. Frederick County was also a large producer of common brick, reporting 11,366,000 brick in 1913, valued at $77,133. Allegany County was the leading fire brick-producing county, reporting 13,059,000 9-inch equivalent brick, valued at $248,795, which was

90.41 per cent of the production and 84.14 per cent of the value of fire brick for the State, and an increase of 302,000 brick in quantity and $17,525 in value over 1912.

Baltimore City and Baltimore County, whose chief product is common brick, but which also report high-grade pottery, constituted the principal clay-working center of the State, reporting production valued at $1,207,574, or 62.98 per cent of the total for 1913, an increase of only $7,437 over 1912. Baltimore County was the leading county in 1913, reporting wares valued at $717,819, and Baltimore City was second, with wares valued at $489,755.

Clay products of Maryland, 1909–1913.

Product.	1909	1910	1911	1912	1913
Brick:					
Common—					
Quantity	148,673,000	164,795,000	160,229,000	154,560,000	153,053,000
Value	$914,420	$1,051,381	$999,791	$1,053,335	$1,004,146
Average per M	$6.15	$6.38	$6.24	$6.82	$6.56
Vitrified—					
Quantity	(a)	(a)	(a)	(a)	(a)
Value	(a)	(a)	(a)	(a)	(a)
Average per M	$13.10	$16.96	$16.98	$17.93	$17.91
Front—					
Quantity	1,350,000	260.000	757,000	1,968,000	(a)
Value	$20.582	$3.953	$10.574	$39.664	(a)
Average per M	$15.25	$15.20	$13.97	$20.15	$23.00
Fancy or ornamental . value	(a)	(a)	(a)	(a)	(a)
Enameled . do	(a)	(a)	(a)	(a)	(a)
Fire . do	$278,777	$296,541	$249.674	$262,817	$295,707
Stove lining . do	$25,925	$23,067	$28,469	$26,673	$23,006
Draintile . do	$5,695	$5,899	$8,048	$3,043	$3,744
Architectural terra cotta . do	(a)	(a)	(a)	(a)	(a)
Fireproofing . do	....	....	....	(a)	$55,162
Tile, not drain . do	....	....	(a)	....	....
Pottery:					
Red earthenware . do	$8,034	$9,171	$8,281	$8,451	$7,534
Stoneware and yellow and Rockingham ware . value	(a)	....	(a)	(a)	(a)
White ware, including C. C. ware, white granite ware, semiporcelain and semivitreous porcelain ware . value	(a)	(a)	(a)	(a)	(a)
Sanitary ware . do	(a)	(a)	(a)	....	....
Miscellaneous . do	$467,379	$458,261	$467,597	$471,770	$528,201
Total value	$1,720,812	$1,848,273	$1,772.434	$1,865.753	$1.917.500
Number of active firms reporting	59	55	56	55	49
Rank of State	21	19	18	19	18

[a] Included in "Miscellaneous."

MASSACHUSETTS.

The value of clay products in Massachusetts in 1913 was $1,814,875, an increase of $47,709, or 2.7 per cent over 1912. The chief clay product of Massachusetts is common brick. There were 153,818,000 brick reported for 1913, valued at $1,106,437, a decrease in quantity of 3,709,000 brick but an increase in value of $10,853, compared with 1912. The average price per 1,000 increased 24 cents to $7.19. The value of common brick constituted 60.96 per cent of the value of all clay products in Massachusetts in 1913. Stove lining was second in value, being reported at $179,980 in 1913, an increase of $6,724 over 1912. Massachusetts is the leading State in this variety of clay product, reporting 33.6 per cent of the total for the country. Pottery production to the value of $231,345 was reported for 1913.

Middlesex County was the leading county in the value of common brick in the State in 1913, with Hampden second and Plymouth third. These 3 counties reported more than half the production and value of common brick in the State. Bristol County reported practically all of the stove lining of the State. This county was also the leading fire-brick producing county.

Middlesex County is the leading clay-working county reporting a production valued at $439,356, or nearly one-fourth of the production for the State and an increase of $16,894 over 1912. Bristol County was second and Hampden third.

Clay products of Massachusetts, 1909–1913.

Product.	1909	1910	1911	1912	1913
Brick:					
Common—					
Quantity	183,584,000	165,315,000	166,834,000	157,527,000	153,818,000
Value	$1,177,281	$1,120,924	$1,079,778	$1,095,584	$1,106,437
Average per M	$6.41	$6.78	$6.47	$6.95	$7.19
Front—					
Quantity	1,790,000	(a)	(a)	(a)	869,000
Value	$45,050	(a)	(a)	(a)	$17,380
Average per M	$25.17	$15.44	$18.00	$20.00	$20.00
Fancy or ornamental. value	(a)	....	....	....	....
Fire.......do	$75,160	$71,780	$70,104	$83,454	$84,298
Stove lining.......do	$159,530	$166,018	$167,802	$173,256	$179,980
Architectural terra cotta ..do	(a)	....	....	....	....
Fireproofing.......do	(a)	(a)	(a)	(a)	(a)
Tile, not drain.......do	$69,837	(a)	(a)	(a)	(a)
Pottery:					
Red earthenware.......do	$154,887	$148,909	$150,038	$163,010	(a)
Stoneware and yellow and Rockingham ware..value	$14,380	$9,654	$13,541	$26,300	$27,400
White ware, including C. C. ware, white granite ware, semiporcelain and semivitreous porcelain ware, value	(a)	(a)	(a)	(a)	(a)
Porcelain electrical supplies, value	(a)	(a)	(a)	(a)	(a)
Miscellaneous.......value	$191,761	$190,128	$219,024	$225,562	$399,380
Total value	$1,887,886	$1,707,413	$1,700,287	$1,767,166	$1,814,875
Number of active firms reporting	72	71	68	63	60
Rank of State	19	21	20	20	19

a Included in "Miscellaneous."

MICHIGAN.

The value of Michigan's clay products in 1913 was $2,674,125, an increase of $128,627, or 5.05 per cent over 1912. In 1913 Michigan ranked fifth among the States in the value of drain tile and eighth in the production and value of common brick. Michigan's leading clay product is common brick, 273,571,000 brick valued at $1,626,287 being reported for 1913, an increase in quantity of 2,382,000 brick and in value of $34,004 over 1912. The value of common brick constituted 60.82 per cent of the value of all clay products in Michigan in 1913. Draintile is second in importance in Michigan, and was reported to the value of $415,543 for 1913, an increase of $27,598 over 1912. Michigan's pottery production in 1913 was valued at $222,883.

Wayne County, in which Detroit is located, was the leading common brick producing county, reporting 215,534,000 brick valued at $1,270,639, or 78.79 per cent of the quantity and 78.13 per cent of the value of common brick for the entire State in 1913. This was an increase of 9,748,000 brick in quantity and of $77,041 in value over 1912. This county was also the leading clay-working county, reporting for 1913 a total value of $1,553,119, or 58.08 per cent of the total value for the State and an increase of $114,329 over 1912. Eaton County, the second in value of all clay products, is the principal draintile producing county, and draintile is its chief product.

Clay products of Michigan, 1909–1913.

Product.	1909	1910	1911	1912	1913
Brick:					
Common—					
Quantity	219,820,000	232,551,000	252,465,000	271,189,000	273,571,000
Value	$1,250,787	$1,363,316	$1,301,998	$1,592,283	$1,626,287
Average per M	$5.69	$5.86	$5.16	$5.87	$5.94
Vitrified—					
Quantity	10,473,000	9,080,000	5,597,000	(a)	8,571,000
Value	$129,283	$116,446	$78,336	(a)	$126,062
Average per M	$12.34	$12.82	$14.00	$13.94	$14.71
Front—					
Quantity	2,379,000	2,209,000	2,498,000	3,934,000	505,000
Value	$18,654	$27,533	$31,572	$41,476	$5,940
Average per M	$7.84	$12.46	$12.64	$10.54	$11.76
Fire value	....	....	(a)	(a)	(a)
Stove lining do	....	(a)	(a)	(a)	....
Draintile do	$364,006	$348,205	$313,072	$387,945	$415,543
Sewer pipe do	(a)	(a)	(a)	(a)	(a)
Fireproofing do	(a)	....	(a)	$1,461	(a)
Tile, not drain do	(a)	(a)	(a)	(a)	(a)
Pottery:					
Red earthenware do	$60,939	$90,450	$80,580	$99,555	$106,527
White ware, including C. C. ware, white granite ware, semi porcelain ware, and semivitreous porcelain ware value	....	....	....	(a)	....
Porcelain electrical supplies, value	....	(a)	(a)	(a)	(a)
Miscellaneous value	$218,829	$250,272	$278,374	$422,778	$393,766
Total value	$2,042,498	$2,196,222	$2,083,932	$2,545,498	$2,674,125
Number of active firms reporting	122	118	111	101	98
Rank of State	17	16	16	13	14

a Included in "Miscellaneous."

MINNESOTA.

The value of clay products in Minnesota in 1913, exclusive of pottery, was $1,781,017, an increase of $169,977, or 10.55 per cent, over 1912. Minnesota was eighth among the States in the production of sewer pipe in 1913. The principal clay product is common brick, of which 129,261,000 brick, valued at $800,441, were reported, a decrease of 343,000 brick in quantity and an increase of $39,458 in value, compared with 1912. The average price per 1,000 increased 32 cents to $6.19 in 1913. The value of the common brick constituted 44.94 per cent of all of Minnesota's brick and tile products in 1913. Sewer pipe is second among Minnesota's clay products, but as it was made by less than three producers, figures of production are not published. Fireproofing is third, this product being valued at $170,214 in 1913, an increase of $9,410 over 1912.

Carver County was the largest producer of common brick in 1913, and reported 38,965,000 brick, valued at $239,500, or 30.14 per cent of the production and 29.92 per cent of the value of common brick in the State. This was a decrease of 2,035,000 brick in quantity, but an increase of $12,000 in value, compared with 1912.

Goodhue County was the leading clay-working county in the State; Hennepin was second, and Carver third.

Clay products of Minnesota, 1909–1913.

Product.	1909	1910	1911	1912	1913
Brick:					
Common—					
Quantity	161,585,000	182,895,000	153,015,000	129,604,000	129,261,000
Value	$969,729	$1,104,898	$868,037	$760,983	$800,441
Average per M	$6.00	$6.04	$5.67	$5.87	$6.19
Vitrified—					
Quantity	(a)	....	(a)	(a)	(a)
Value	(a)	....	(a)	(a)	(a)
Average per M	$9.00	....	$13.16	$16.34	$15.85
Front—					
Quantity	14,350,000	7,240,000	10,853,000	11,555,000	13,392,000
Value	$171,600	$88,000	$135,085	$144,125	$163,380
Average per M	$11.96	$12.15	$12.45	$12.47	$12.20
Fire ..... value	....	(a)	(a)	(a)	(a)
Draintile ..... do	$109,371	$160,706	$121,965	$126,690	$110,543
Sewer pipe ..... do	(a)	(a)	(a)	(a)	(a)
Fireproofing ..... do	$53,398	$93,731	$109,812	$160,804	$170,214
Tile, not drain ..... do	(a)	....	(a)	....	....
Pottery:					
Earthenware and stoneware, value	(b)	(b)	(b)	(b)	(b)
Miscellaneous ..... do	$451,340	$453,961	$458,579	$418,438	$536,439
Total value	$1,755,438	$1,901,296	$1,693,478	$1,611,040	$1,781,017
Number of active firms reporting	80	84	81	79	69
Rank of State	20	18	21	21	20

a Included in "Miscellaneous."
b The value of pottery products for Minnesota could not be included in the State totals without disclosing the operations of individual establishments.

MISSOURI.

Missouri is one of the most important clay-working States of the country and is the leading Southern State. It reported for 1913 every variety of brick and tile products as classified in this report and was the seventh State in the value of clay products. In 1913 it was the second State in the value of enameled brick and of fire brick, third in the output of fire brick, third in the value of fancy brick and of sewer pipe, fifth in the value and seventh in quantity of front brick, sixth in the value of architectural terra cotta, and tenth in the production and value of vitrified paving brick.

The total value of the clay products of Missouri in 1913 was $6,602, 076, an increase of $189,215, or 2.95 per cent, over 1912. Fire brick was the product of chief value. There were 104,728,000 9-inch equivalent clay fire brick reported from Missouri for 1913, valued at $2,138,368, or $20.42 per 1,000, an increase of 6,977,000 brick in quantity and of $197,021 in value The value of fire brick constituted 32.39 per cent of the value of clay products of the State in 1913. Common brick was second in value, closely followed by sewer pipe. There were 185,872,000 common brick, valued at $1,270,581, reported for 1913, a decrease of 2,624,000 brick but an increase of $27,511 in value. The average price per 1,000 increased 25 cents to $6.84 in 1913.

Sewer pipe was third in the value of products, $1,213,889 being reported as its value for 1913, an increase of $35,407 over 1912. Architectural terra cotta was fourth, the output for 1913 being valued at $480,372, a decrease of $173,791. Pottery production to the value of only $3,412 was reported for 1913.

The leading producer of fire brick in 1913 was St. Louis City, which reported 39,979,000 9-inch equivalent fire brick, valued at $967,676, an increase of 6,986,000 brick in quantity and of $167,534 in value over 1912. St. Louis County was second, with 37,185,000 9-inch equivalent brick, valued at $685,438, a decrease of 1,800,000 brick in quantity and of $45,847 in value compared with 1912. These two localities reported 73.68 per cent of the quantity and 77.31 per cent of the value of the fire brick for the State. They are also the leading localities in the production of common brick. St. Louis City reported 81,379,000 common brick, valued at $571,822, a decrease of 4,123,000 brick in quantity but an increase of $32,353 in value compared with 1912, the average price per 1,000 increasing 71 cents in 1913. St. Louis County reported 37,664,000 common brick, valued at $246,764, a decrease of 5,770,000 brick in quantity and of $52,350 in value from 1912. These two localities reported 64.05 per cent of the total quantity and 64.43 per cent of the total value of the common brick of the State, and constitute the fourth largest common brickmaking center of the country. St. Louis City is also the leading producer of every other variety of brick and tile products and is the only place in the State where fancy or ornamental brick, enameled brick, tile, not drain, and silica brick are made.

Clay products of Missouri, 1909–1913.

Product.	1909	1910	1911	1912	1913
Brick:					
Common—					
Quantity	276,403,000	201,281,000	217,466,000	188,496,000	185,872,000
Value	$1,961,805	$1,284,997	$1,309,164	$1,243,070	$1,270,581
Average per M	$7.10	$6.38	$6.02	$6.59	$6.84
Vitrified—					
Quantity	59,863,000	56,703,000	44,813,000	30,551,000	19,383,000
Value	$781,706	$647,441	$488,299	$342,930	$275,164
Average per M	$13.06	$11.42	$10.90	$11.22	$14.20
Front—					
Quantity	36,194,000	38,428,000	25,491,000	19,963,000	27,191,000
Value	$589,782	$516,505	$330,332	$264,375	$414,778
Average per M	$16.30	$13.44	$12.96	$13.24	$15.25
Fancy or ornamental. value	$29,683	$23,673	$24,269	$19,838	$18,734
Enameled ... do	(a)	(a)	(a)	(a)	(a)
Fire ... do	$1,598,302	$2,059,845	$1,763,548	$1,941,347	$2,138,368
Stove lining ... do	(a)	(a)	(a)	(a)	(a)
Draintile ... do	$127,166	$121,068	$164,393	$141,297	$130,661
Sewer pipe ... do	$1,162,730	$1,210,348	$1,156,626	$1,178,482	$1,213,889
Architectural terra cotta ... do	(a)	(a)	$402,969	$654,163	$480,372
Fireproofing ... do	$110,464	$146,931	$123,499	$75,551	$104,073
Tile, not drain ... do	(a)	(a)	(a)	(a)	(a)
Pottery:					
Red earthenware ... do	$4,792	$3,080	$2,755	(a)	$2,537
Stoneware and yellow and Rockingham ware.. value	$66,830	$25,981	$2,453	$2,015	(a)
Miscellaneous ... do	$1,006,923	$1,047,897	$506,046	$549,793	$552,919
Total value	$7,440,183	$7,087,766	$6,274,353	$6,412,861	$6,602,076
Number of active firms reporting	156	150	122	110	105
Rank of State	7	7	7	7	7

a Included in "Miscellaneous."

St. Louis City is the leading clay-working district in the State. It reported for 1913 clay products valued at $3,918,805, or 59.36 per cent of the value for the entire State, an increase of $192,199 over 1912. St. Louis County was next, reporting production valued at $934,739, a decrease of $100,289 from 1912. Jackson County was third, with wares valued at $464,571, Audrain fourth ($312,788), and Henry fifth. St. Louis County and St. Louis City reported together 73.52 per cent of the value of clay products of the State in 1913.

The number of active operators reporting in 1913 was 105, compared with 110 in 1912 and with 156 in 1909. The average output per active operator was $62,877 in 1913 and $47,693 in 1909.

NEW JERSEY.

New Jersey ranks third in the value of clay products. It reported every variety of product as classified in this report for 1913, except vitrified paving brick. It is second in the value of pottery products and fourth in the value of brick and tile products. In 1913 it was first in the value of china and sanitary ware, enameled brick, and architectural terra cotta; second in the value of fireproofing and of tile, not drain; third in the value of porcelain electrical supplies; fourth in the production and value of front brick and in the value of white ware; and fifth in the production and value of common and fire brick.

The value of New Jersey's clay products in 1913 was $19,705,378—brick and tile $10,866,833, and pottery $8,838,545, a decrease of $133,175, or 0.67 per cent, from 1912. This decrease was principally in pottery—$97,375. New Jersey's leading clay product is sanitary ware, which was reported to the value of $5,238,013, an increase of $38,735 over 1912, and which constituted 26.58 per cent of the value of all of New Jersey's clay products in 1913. Common brick was second, closely followed by architectural terra cotta. There were 401,702,000 common brick reported for 1913, valued at $2,391,287, a decrease of 27,607,000 brick in quantity and of $200,804 in value, compared with 1912. The value of common brick was 12.14 per cent of the value of all clay products of New Jersey in 1913. Architectural terra cotta ranks third in value among New Jersey's clay products. It was valued at $2,388,293 (or 12.12 per cent of the State's total) in 1913, an increase of $58,228 over 1912. New Jersey was the only one of the important States to show an increase in value of this product in 1913. Fireproofing was New Jersey's fourth clay product in 1913. It was valued at $2,092,370, which was an increase of $61,020 over 1912. The value of this product was 10.62 per cent of New Jersey's clay products in 1913. Tile, not drain, is also an important product in this State, being reported to the value of $1,308,787, an increase of $53,541 over 1912.

Mercer County, in which Trenton is located, is the most important clay-working county in the State, and its leading product is sanitary ware, of which the value reported was $4,620,330 in 1913, or 88.21 per cent of the State's total for this variety—a decrease of $42,438 from 1912. The value of all of the Mercer County clay products in 1913 was $8,618,496, or 43.74 per cent of the State's total, a decrease of $154,551 from 1912. Middlesex County, second in importance as a clay-working county, its production being valued at $8,451,232, or 42.89 per cent of the State's total in 1913, was the principal producer of common brick, reporting 194,641,000 brick, valued at $1,120,553. This county is the leading producer of every variety of brick and tile product, except fancy or ornamental brick, of which it produced none, and it was the only producer in 1913 of enameled brick, stove lining, and silica brick. Middlesex County reported for 1913 architectural terra cotta valued at $2,084,137, or 87.26 per cent of total value for the State; fireproofing to the value of $1,864,623, and tile, not drain, to the value of $718,210, or 89.12 per cent of the State total of the former and 54.88 per cent of the latter. Its production of clay fire brick was 35,934,000 9-inch equivalent brick, valued at $1,031,159. Bergen County was second in the manufacture of common brick, with 50,844,000 brick, valued at $294,106 in 1913. The principal market for Bergen County common brick (its only clay product) is Greater New York.

In value of brick and tile products Middlesex County was first with products valued at $8,081,206, and Mercer second, with products valued at $720,022. In value of pottery Mercer was first with products valued at $7,898,474, and Middlesex second with $370,026.

There were 149 active operators in New Jersey reporting for 1913 compared with 155 in 1912 and 165 in 1909. The average value of production per operator in 1913 was $132,251 and $104,173 in 1909.

Clay products of New Jersey, 1909–1913.

Product.	1909	1910	1911	1912	1913
Brick:					
Common—					
Quantity	460,966,000	401,103,000	429,367,000	429,309,000	401,702,000
Value	$2,609,605	$2,215,628	$2,401,962	$2,592,091	$2,391,287
Average per M	$5.66	$5.52	$5.59	$6.04	$5.95
Vitrified—					
Quantity	(a)	....	(a)	....	....
Value	(a)	....	(a)	....	....
Average per M	$11.41	....	$14.99	....	....
Front—					
Quantity	80,855,000	47,451,000	47,606,000	48,852,000	45,841,000
Value	$862,245	$609,845	$528,656	$558,372	$474,501
Average per M	$10.66	$12.85	$11.10	$11.43	$10.35
Fancy or ornamental . value	$8,578	(a)	(a)	(a)	(a)
Enameled ..... do	(a)	(a)	(a)	(a)	(a)
Fire ..... do	$907,276	$1,001,063	$1,344,884	$1,460,988	$1,246,294
Stove lining ..... do	....	(a)	(a)	(a)	(a)
Draintile ..... do	$37,211	$23,147	$26,502	$50,984	$44,020
Sewer pipe ..... do	(a)	(a)	$103,137	(a)	(a)
Architectural terra cotta ..... do	$1,637,705	$2,000,039	$1,669,973	$2,330,065	$2,388,293
Fireproofing ..... do	$1,299,540	$1,582,101	$1,728,811	$2,031,350	$2,092,370
Tile, not drain ..... do	$992,606	$1,199,113	$1,197,330	$1,255,246	$1,308,787
Pottery:					
Red earthenware ..... do	$36,573	$26,529	$38,910	$36,655	$35,360
Stoneware and yellow and Rockingham ware . value	$66,293	$55,734	$75,915	$48,297	$66,993
White ware, including C. C. ware, white granite semi-porcelain ware, and semi-vitreous porcelain ware, ... value	$1,242,361	$1,345,156	$1,148,904	$1,090,683	$834,716
China, bone china, delft, and belleek ware ..... value	$1,082,398	$1,131,412	$1,105,278	$1,155,766	$1,239,453
Sanitary ware ..... do	$4,341,040	$4,955,066	$4,898,588	$5,199,278	$5,238,013
Porcelain electrical supplies, ... value	$823,056	$874,013	$913,921	$1,146,467	$1,190,448
Miscellaneous ..... do	$1,225,607	$815,463	$995,457	$882,311	$1,154,843
Total value	$17,172,094	$17,834,309	$18,178,228	$19,838,553	$19,705,378
Number of active firms reporting	165	167	162	155	149
Rank of State	3	3	3	3	3

a Included in "Miscellaneous."

NEW YORK.

New York is the fifth State in the value of clay products and reported for 1913 every variety as classified in this report, except enameled brick and silica brick. It was the fifth State in the value of brick and tile products and fourth in pottery. Its most interesting feature is the remarkable production of common brick along Hudson River, the largest brick-producing region in the country and probably in the world. New York was the second State in 1913 in the production and value of common brick, Illinois being first, by reason of the large decrease in the Hudson River region. It was also second in the value of china and porcelain electrical supplies, third in the value of terra cotta and stove lining, fifth in the value of white ware, and eighth in the production and value of vitrified paving brick.

The value of clay products in New York in 1913 was $11,469,476—$8,627,818 brick and tile and $2,841,658 pottery, a decrease of $589,382, or 4.89 per cent, from 1912. Common brick is New York's principal clay product. For 1913 there were 1,068,516,000 brick reported, valued at $6,029,103, a decrease of 205,125,000 brick, or 16.11 per cent, in quantity, and of $1,282,572, or 17.54 per cent, in value. The decrease in production was principally in the Hudson River region—188,991,000 brick—and the decrease in value was entirely in the Hudson River region, the decrease there being $1,321,455. The average price per 1,000 in 1913 for the whole State was $5.64, a decrease of 10 cents. In the Hudson River region the average price declined 31 cents per 1,000. The value of common brick constituted 52.57 per cent of the value of all of New York's clay products in 1913. Next to common brick in value are porcelain electrical supplies, which were valued in 1913 at $1,560,870, an increase of $291,762 over 1912; third, terra cotta, valued at $1,110,726, a decrease of $28,565; and china fourth with a value of $763,322 in 1913, an increase of $72,257 over 1912.

Ulster County was the leading county in the production of common brick, reporting 194,125,000 brick in 1913, valued at $1,026,870. Rockland County was second with 163,612,000 brick, valued at $890,188. The only clay product made in these counties is common brick.

Onondaga was the leading county in the value of clay products in 1913. It reported wares valued at $1,074,727—pottery $934,575 and brick and tile $140,152. This was an increase over 1912 of $128,206—pottery $114,863 and brick and tile $13,343. For 1912 Onondaga County was third and Ulster first and Rockland second. For 1913 Ulster County was second and Erie County third with a production valued at $1,005,359. Schenectady and Ontario counties are the principal producers of porcelain electrical supplies, reporting together a production valued at $1,025,296, or nearly two-thirds of the State total for this variety, an increase of $166,451 over 1912.

There were 215 active operators reporting for 1913, 219 for 1912, and 243 for 1909. The average value of production per operator in 1913 was $53,346, compared with $50,030 in 1909.

Clay products of New York, 1909–1913.

Products.	1909	1910	1911	1912	1913
Brick:					
Common—					
Quantity	1,542,552,000	1,380,084,000	1,143,726,000	1,273,641,000	1,068,516,000
Value	$7,760,746	$6,897,438	$5,918,286	$7,311,675	$6,029,103
Average per M	$5.03	$5.00	$5.17	$5.74	$5.64
Vitrified—					
Quantity	16,063,000	21,662,000	17,035,000	18,634,000	33,901,000
Value	$238,697	$334,432	$290,728	$287,089	$514,677
Average per M	$14.86	$15.44	$17.07	$15.41	$15.18
Front—					
Quantity	9,815,000	9,229,000	9,942,000	9,499,000	7,636,000
Value	$148,126	$137,748	$133,563	$123,378	$83,823
Average per M	$15.09	$14.93	$13.43	$12.99	$10.98
Fancy or ornamental . value	....	(a)	(a)	(a)	(a)
Fire ..... do	$491,872	$514,990	$347,415	$328,644	$341,524
Stove lining ..... do	$79,653	$86,248	$82,803	$75,751	$67,327
Draintile ..... do	$125,640	$272,836	$112,609	$51,005	$83,695
Sewer pipe ..... do	$126,908	$136,576	$116,184	(a)	(a)
Architectural terra cotta .. do	$998,535	$1,108,371	$673,529	$1,139,291	$1,110,726
Fireproofing ..... do	$199,999	$210,954	$227,871	$217,411	$208,625
Tile, not drain ..... do	$62,795	$72,815	$86,602	$45,865	$67,700
Pottery:					
Earthenware ..... value	$30,200	$26,863	$34,295	$31,497	$38,290
Stoneware and yellow and Rockingham ware .. value	$46,905	$43,325	$40,946	(a)	(a)
White ware, including C. C. ware, white granite, semi-porcelain ware, and semi-vitreous porcelain ware, value	(a)	(a)	(a)	(a)	(a)
China, bone china, delft, and belleek ware ..... value	$592,611	$642,592	$730,983	$691,065	$763,322
Sanitary ware ..... do	(a)	(a)	(a)	(a)	(a)
Porcelain electrical supplies, value	$752,185	$957,101	$988,716	$1,269,108	$1,560,870
Miscellaneous ..... value	$502,564	$429,660	$399,846	$487,079	$599,794
Total value	$12,157,436	$11,871,949	$10,184,376	$12,058,858	$11,469,476
Number of active firms reporting	243	240	222	219	215
Rank of State	5	5	5	5	5

a Included in "Miscellaneous."

NORTH CAROLINA.

The value of clay products in North Carolina in 1913 was $1,614,406, an increase of $148,753, or 10.15 per cent, over 1912. The clay product of chief value is common brick, of which there were 204,097,000 reported, valued at $1,354,062, an increase of 11,039,000 brick in quantity and of $117,619 in value over 1912. The value of common brick constituted 83.87 per cent of all clay products in North Carolina in 1913. Front brick and draintile were made in small quantities. Sewer pipe was made in considerable quantity by one operator; hence the figures are not published. The production of pottery was valued at $13,683 in 1913.

Wayne County is the principal common-brick producing county, and reported 33,300,000 brick, valued at $230,000 for 1913, an increase of 9,700,000 brick in quantity and of $68,600 in value over 1912. Wake is the second county in quantity of common brick, but was third in value, and Craven County was second in value and third in quantity.

Guilford is the principal clay-working county in the State, reporting for 1913 products valued at $281,542, an increase of $13,080 over 1912. Common brick, draintile, sewer pipe, and fireproofing were reported from this county for 1913. Wayne County was second in the value of all clay products in 1913.

Clay products of North Carolina, 1909–1913.

Products.	1909	1910	1911	1912	1913
Brick:					
Common—					
Quantity	188,313,000	167,966,000	178,235,000	193,058,000	204,097,000
Value	$1,140,727	$1,039,319	$1,076,183	$1,236,443	$1,354,062
Average per M	$6.06	$6.19	$6.04	$6.40	$6.63
Front—					
Quantity	725,000	550,000	(a)	(a)	(a)
Value	$9,250	$5,800	(a)	(a)	(a)
Average per M	$12.76	$10.55	$9.81	$8.92	$8.89
Fire.....value	....	....	(a)	$4,430	....
Draintile.....do	$8,890	$9,555	$11,704	$10,745	$13,584
Sewer pipe.....do	(a)	(a)	(a)	(a)	(a)
Fireproofing.....do	....	(a)	(a)	....	(a)
Pottery:					
Red earthenware.....do	$1,780	$1,961	$1,333	$778	$2,318
Stoneware and yellow and Rockingham ware..value	$16,929	$13,029	$7,223	$8,172	$10,365
Miscellaneous.....do	$125,035	$154,000	$183,683	$205,085	$234,077
Total value	$1,302,611	$1,223,664	$1,280,126	$1,465,653	$1,614,406
Number of active firms reporting	187	184	163	162	157
Rank of State	25	25	24	23	22

a Included in "Miscellaneous."

OHIO.

Ohio is the leading State of the Union in the value of clay products. For 1913 it reported every variety of brick and tile products as classified in this report, except terra cotta, and all of the pottery products except china. It was the leading State in 1913 in the production of vitrified paving brick, sewer pipe, fireproofing, tile, not drain, red earthenware, stoneware, white ware, and porcelain electrical supplies. It was second in the production and value of front brick and in the value of fancy brick, and second in the production and third in the value of fire brick and of draintile; fourth in production and value of common brick, and in value of sanitary ware.

The value of its clay products in 1913 was $38,388,296, or 21.18 per cent of the total for the country. This was an increase of $3,576,788, or 10.27 per cent over 1912, and was the largest increase reported by any State for 1913. Ohio's brick and tile production in 1913 was valued at $21,868,407, and its pottery production at $16,519,889. Ohio's principal clay product is white ware, which was reported to the value of $10,548,628 in 1913, an increase of $579,137, or 5.81 per cent, over 1912. The value of white ware constituted 27.48 per cent of the value of all of Ohio's clay products in 1913. Sewer pipe was the second product, being reported to the value of $5,159,548, an increase of $1,137,470 over 1912. Vitrified brick, Ohio's third product, increased 36,120,000 in quantity and $478,666 in value in 1913. The fourth product in value in 1913 was common brick, of which 407,685,000 were reported, valued at $2,523,014, or $6.19 per 1,000. This was an increase of 11,849,000 brick in quantity and of $108,532 in value over 1912. Common brick was closely followed in value by tile, not drain, which was reported to the value of $2,492,380, an increase of $70,597 over 1912.

Columbiana County, the most important clay-working county in Ohio, is the principal producer of white ware. The clay products for the county in 1913 were valued at $8,920,853, or 23.24 per cent of the State's total, an increase of $640,026 over 1912. The value of the white ware produced in this county in 1913 was $6,664,682, or 63.18 per cent of this product for the State, an increase of $219,042 over 1912. Sewer pipe is produced most largely in Summit County, which reported it to the value of $1,707,911 for 1913; Jefferson County was second, reporting sewer pipe to the value of $1,603,802; and these two counties reported 64.19 per cent of the total of this product for the State. The leading county in the value of vitrified paving brick in 1913 was Stark; and Athens County was third in production and second in value and Cuyahoga County second in production, but third in value in 1913. Cuyahoga County was the leading common brick producing county in the State in 1913, reporting 107,796,000 brick, valued at $640,023, or 26.44 per cent of the quantity and 25.37 per cent of the value for the entire State, an increase of 1,650,000 brick in quantity and of $34,271 in value over 1912. The city of Cleveland furnishes the principal market for this output. Lucas County was second, reporting 36,690,000 brick valued at $215,012, a decrease of 10,036,000 brick in quantity and of $65,614 in value from 1912.

Clay products of Ohio, 1909–1913.

Product.	1909	1910	1911	1912	1913
Brick:					
Common—					
Quantity	420,999,000	409,773,000	389,515,000	395,836,000	407,685,000
Value	$2,429,879	$2,507,742	$2,299,194	$2,414,482	$2,523,014
Average per M	$5.77	$6.12	$5.90	$6.10	$6.19
Vitrified—					
Quantity	324,530,000	289,817,000	315,944,000	268,271,000	304,391,000
Value	$3,113,128	$2,876,157	$3,200,475	$2,830,309	$3,308,975
Average per M	$9.59	$9.92	$10.13	$10.55	$10.87
Front—					
Quantity	130,684,000	134,759,000	159,118,000	184,405,000	185,810,000
Value	$1,393,787	$1,489,094	$1,630,898	$1,836,989	$1,950,433
Average per M	$10.67	$11.05	$10.25	$9.96	$10.50
Fancy or ornamental . value	$24,367	$32,995	$25,340	$16,692	$20,950
Enameled ... do	...	...	...	(a)	(a)
Fire ... do	$1,730,401	$1,709,039	$1,539,450	$1,629,638	$1,961,020
Stove lining ... do	$23,803	(a)	$86,673	$37,544	(a)
Draintile ... do	$2,032,528	$1,869,823	$1,684,420	$1,546,723	$1,508,564
Sewer pipe ... do	$3,009,798	$3,289,537	$3,445,601	$4,022,078	$5,159,548
Architectural terra cotta ... do	(a)	...	...	...	...
Fireproofing ... do	$804,637	$934,960	$1,086,287	$1,750,715	$2,115,861
Tile, not drain ... do	$1,912,343	$1,896,572	$2,312,482	$2,421,783	$2,492,380
Pottery:					
Red earthenware ... do	$145,137	$161,799	$233,060	$263,085	$236,883
Stoneware and yellow and Rockingham ware . . value	$1,806,798	$1,664,572	$1,758,785	$1,832,266	$1,649,186
White ware, including C. C. ware, white granite, semi-porcelain ware, and semi-vitreous porcelain ware, value	$8,884,189	$9,730,408	$9,612,315	$9,969,491	$10,548,628
China, bone china, delft, and belleek ware ... value	(a)	...	...	...	...
Sanitary ware ... do	$310,254	$327,438	$378,779	$451,971	$590,193
Porcelain electrical supplies, value	$1,146,694	$1,277,144	$1,610,925	$1,827,290	$2,184,201
Miscellaneous ... value	$1,578,498	$1,758,668	$1,759,211	$1,960,452	$2,138,460
Total value	$30,346,241	$31,525,948	$32,663,895	$34,811,508	$38,388,296
Number of active firms reporting	685	683	633	596	563
Rank of State	1	1	1	1	1

a Included in "Miscellaneous."

Muskingum County, the second county in the State in the value of all clay products, reported wares valued at $3,615,605, or 9.42 per cent of the State's total. This was an increase of $131,443 over 1912 in spite of the loss in business caused by the flood of March, 1913. Of the value of Muskingum's clay products in 1913, $2,250,173 was brick and tile, principally tile, not drain, and $1,365,432 was pottery, principally stoneware. Summit County was third in importance, reporting clay products valued at $3,387,018, an increase of $364,640 over 1912. Of this total, $2,286,926 was brick and tile and $1,100,092 was pottery. Summit county's principal brick and tile product is sewer pipe ($1,707,911 in 1913), and its principal pottery product is porcelain electrical supplies ($549,324 in 1913). Jefferson County, fourth in the value of clay products, reported for 1913 wares valued at $2,930,707, of which $2,523,098 was brick and tile and $407,609 was pottery. Jefferson County's principal brick and tile product is sewer pipe ($1,603,802 in 1913), and its principal pottery product is white ware.

There were 563 active operators reporting for 1913, compared with 596 in 1912 and with 685 in 1909. The average value of production per active operator was $68,185 in 1913, and $44,301 in 1909.

PENNSYLVANIA.

Pennsylvania is the second State in the value of clay products, reporting for 1913 every variety of ware as classified in this report, except enameled brick. In 1913 it was first in the value of brick and tile products and fifth in the value of pottery; it was the leading producer of front, fancy, and fire brick, reporting over one-fourth of the front brick and nearly one-third of the fancy brick, and over two-fifths of the clay fire brick production; second in the production of vitrified paving brick (but third in its value), sewer pipe, stove lining, and red earthenware; third in the production and value of common brick and in the value of white ware and china; fourth in the value of tile, not drain, and porcelain electrical supplies; and fifth in the value of terra cotta.

Pennsylvania's clay products in 1913 were valued at $24,231,482, an increase of $2,694,261, or 12.51 per cent, over 1912. This total was 13.37 per cent of the value of all clay products of the country. Its brick and tile production was valued at $22,185,383 and its pottery production at $2,046,099. Its principal brick and tile product is fire brick, and its chief pottery product is white ware.

Pennsylvania's clay product of greatest value is fire brick. Including silica fire brick, Pennsylvania reported 493,590,000 9-inch equivalent brick for 1913, valued at $9,703,734, or $19.66 per 1,000, an increase of 56,940,000 brick in quantity and of $1,574,156 in value over 1912. Of the clay fire brick, Pennsylvania reported 361,548,000, valued at $7,094,794, or $19.62 per 1,000, an increase of 26,494,000 brick and of $915,924 over 1912. Pennsylvania reported 42.88 per cent of the quantity of clay fire brick of the entire country for 1913, and 42.2 per cent of its value. It reported 132,042,000 9-inch equivalent silica fire brick for 1913, valued at $2,608,940, or $19.76 per 1,000. This was an increase of 30,446,000 brick in quantity and of $658,232 in value over 1912. The value of all fire brick production in Pennsylvania in 1913 composed 40.05 per cent of the State's total for all clay products. Pennsylvania's second clay product in value is common brick. The quantity reported for 1913 was 704,493,000 brick, valued at $4,772,229, or $6.77 per 1,000. This was an increase of 7,470,000 brick in quantity and of $181,445 in value over 1912. Its third product is front brick, the quantity of which reported for 1913 decreased 2,594,000 brick from 1912, but the value increased slightly—$3,722. The average value per 1,000 increased 15 cents—to $10.83.

Philadelphia County, the third largest common brick producing center of the country, with the city of Philadelphia for a market, is the principal producer of common brick, reporting 186,131,000 brick for 1913, valued at $1,353,620, an increase of 8,987,000 brick in quantity and of $94,489 in value over 1912, and Allegheny County, the home of "Greater Pittsburgh," is second with 92,430,000 brick valued at $620,724 in 1913, an increase of 3,229,000 brick in quantity and of $59,811 in value over 1912. Vitrified paving brick was produced most largely in Lawrence County in 1913, with Beaver County second and McKean County third; in value of product, however, McKean was second and Beaver third. Front brick is made chiefly in Armstrong County, 70,494,000 brick, valued at $806,196, or about one-third of the production and value for the State being reported for 1913, a decrease of 5,911,000 brick in quantity and of $49,295 in value from 1912. Clearfield County is the largest producer of clay fire brick and reported 101,141,000 9-inch equivalent brick, valued at $2,209,062, or more than one-fourth of the production and value of all clay fire brick for the State, an increase of 3,582,000 brick in quantity and of $340,656 in value over 1912. Huntingdon County is the largest producer of silica fire brick and reported 70,287,000 9-inch equivalent brick, valued at $1,433,255, or over one-half of the production and value for the State, an increase of 12,137,000 brick in quantity and of $289,809 in value over 1912.

Clearfield County is the most important clay-working county in the State, reporting wares valued at $2,612,191 in 1913, an increase of $361,208 over 1912. Clearfield's principal product is fire brick, though considerable quantities of vitrified and front brick are made there also. Allegheny County was second in importance by a small margin, $6,497, in 1913, displacing Philadelphia County, which was third. Allegheny County's clay products were valued at $2,193,642 in 1913, an increase of $486,373 over 1912, the chief product being clay fire brick ($815,044). Philadelphia County's clay products in 1913 were valued at $2,187,145, an increase of $9,554 over 1912. The principal product of this county is common brick, though architectural terra cotta and fire brick are important products.

There were 377 active operators reporting for 1913, compared with 393 for 1912 and with 457 for 1909. The average value of production per active operator was $64,274 in 1913 and $46,360 in 1909.

Clay products of Pennsylvania, 1909-1913.

Product.	1909	1910	1911	1912	1913
Brick:					
Common—					
Quantity	872,658,000	828,703,000	774,122,000	697,023,000	704,493,000
Value	$5,607,490	$5,371,707	$4,963,232	$4,590,784	$4,772,229
Average per M	$6.43	$6.48	$6.41	$6.59	$6.77
Vitrified—					
Quantity	116,735,000	101,330,000	124,125,000	112,372,000	140,407,000
Value	$1,329,317	$1,204,724	$1,511,061	$1,411,096	$1,814,833
Average per M	$11.39	$11.89	$12.17	$12.56	$12.93
Front—					
Quantity	194,695,000	171,415,000	184,569,000	217,328,000	214,734,000
Value	$2,111,556	$2,001,967	$2,111,492	$2,321,479	$2,325,201
Average per M	$10.85	$11.68	$11.44	$10.68	$10.83
Fancy or ornamental. value	$27,963	$35,768	$44,883	$43,186	$35,446
Enameled ... do	(a)	(a)	(a)	(a)	....
Fire ... do	$8,107,807	$6,454,928	$5,555,529	$6,178,870	$7,094,794
Stove lining ... do	$97,270	$132,567	$164,848	$138,630	$142,303
Draintile ... do	$14,668	$11,480	$12,779	$12,421	$11,730
Sewer pipe ... do	$445,594	$583,418	$560,809	$829,917	$1,326,971
Architectural terra cotta ... do	$428,522	$472,150	$389,000	$569,943	$506,100
Fireproofing ... do	$324,860	$300,187	$300,687	$350,219	$480,675
Tile, not drain ... do	$441,243	$413,047	$358,913	$385,052	$385,322
Pottery:					
Red earthenware ... do	$159,796	$178,348	$159,420	$162,137	$187,625
Stoneware and yellow and Rockingham ware.. value	$297,029	$323,990	$304,998	$281,526	$268,407
White ware, including C. C. ware, white granite ware, semiporcelain ware, and semivitreous porcelain ware ... value	$812,338	(a)	(a)	$902,585	$839,838
China, bone china, delft, and belleek ware ... value	$91,757	$188,122	$216,724	$280,472	(a)
Sanitary ware ... do	$252,951	$254,747	$215,590	$185,000	$153,000
Porcelain electrical supplies ... value	(a)	(a)	(a)	$307,636	$295,908
Miscellaneous ... do	$636,552	$4,167,135	$3,400,068	$2,585,368	$3,591,100
Total value	$21,186,713	$22,094,285	$20,270,033	$21,537,221	$24,231,482
Number of active firms reporting	457	451	423	393	377
Rank of State	2	2	2	2	2

a Included in "Miscellaneous."

TENNESSEE.

The total value of all of Tennessee's clay products in 1913 was $1,493,085, a decrease of $7,931, or 0.53 per cent, from 1912. The principal product was common brick. There were 151,072,000 brick reported for 1913, valued at $902,832, or $5.98 per 1,000. This was practically the same output as for 1912, there being a decrease of only 3,139,000 brick in quantity and of $200 in value. The value of common brick constituted 60.47 per cent of the value of all clay products of the State in 1913. Front brick was second in importance in 1913, there being 16,085,000 brick reported, valued at $154,681, an increase of 4,967,000 brick in quantity and of $53,106 in value over 1912.

Davidson County was the largest producer of common brick in 1913, reporting 32,396,000 brick, valued at $187,131. Shelby County was second in the value of common brick ($143,450), although Hamilton County's production (28,471,000 brick) was larger than Shelby's output (19,354,000 brick) in 1913.

Hamilton County was the principal clay-working county of the State, its production being valued in 1913 at $440,981, or 29.53 per cent of the State's total. Davidson was second with production valued at $278,870. This was a decrease of $26,531 in Hamilton County and an increase of $5,049 in Davidson County, as compared with 1912. Hamilton County's chief clay products in 1913 were common brick, front brick, sewer pipe, and turpentine cups. Davidson's principal clay products in 1913 were common brick and front brick.

Clay products of Tennessee, 1909–1913.

Product.	1909	1910	1911	1912	1913
Brick:					
Common—					
Quantity	159,328,000	140,878,000	144,824,000	154,211,000	151,072,000
Value	$1,022,282	$826,533	$842,864	$903,032	$902,832
Average per M	$6.42	$5.87	$5.82	$5.86	$5.98
Vitrified—					
Quantity	(a)	(a)	(a)	(a)	(a)
Value	(a)	(a)	(a)	(a)	(a)
Average per M	$13.08	$10.80	$10.41	$11.11	$15.32
Front—					
Quantity	11,397,000	10,119,000	9,547,000	11,118,000	16,085,000
Value	$125,661	$98,450	$94,733	$101,575	$154,681
Average per M	$11.03	$9.73	$9.92	$9.14	$9.62
Fancy ... value	(a)	(a)	(a)	(a)	.....
Fire ... do	(a)	$14,907	$15,915	$10,981	$13,205
Draintile ... do	$67,472	$29,707	$51,721	$39,459	$42,294
Sewer pipe ... do	(a)	(a)	(a)	(a)	(a)
Fireproofing ... do	(a)	(a)	(a)	(a)	(a)
Pottery:					
Red earthenware ... do	(a)	$4,540	$3,938	$1,205	$2,153
Stoneware and yellow and Rockingham ware ... value	$35,100	$44,640	$38,759	$44,089	$36,153
Miscellaneous ... do	$398,357	$395,511	$337,170	$400,675	$341,767
Total value	$1,648,872	$1,414,288	$1,385,100	$1,501,016	$1,493,085
Number of active firms reporting	100	97	84	80	79
Rank of State	23	24	23	22	23

a Included in "Miscellaneous."

TEXAS.

The value of clay products in Texas in 1913 was $3,049,349, an increase of $163,281, or 5.66 per cent, over 1912. In 1913 Texas was the ninth State in the production of common brick, and sixth in its value; it was eighth in the production of front brick and ninth in value, and eleventh in the value of sewer pipe reported. The principal product is common brick. There were reported for 1913, 248,271,000 brick, valued at $1,826,793, an increase of 5,523,000 brick in quantity and of $235,833 in value over 1912. The value of common brick constituted 59.91 per cent of the value of all clay products of the State. Sewer pipe was the second product, front brick third, and fireproofing fourth. Pottery production was valued at $80,374 in 1913.

Ellis County was the largest producer of common brick for 1913, reporting 90,481,000 brick, valued at $612,391, an increase of 14,221,000 brick in quantity and of $170,532 in value. Sewer pipe was reported from Wilson and Bowie counties in considerable quantities, but there being less than three producers figures are not published. Fireproofing showed a large increase—$72,330. Ellis County is the leading clay-working county in the State. It reported nothing but common brick for 1913.

Clay products of Texas, 1909–1913.

Product.	1909	1910	1911	1912	1913
Brick:					
Common—					
Quantity	293,660,000	271,640,000	255,811,000	242,748,000	248,271,000
Value	$1,890,601	$1,779,062	$1,596,763	$1,590,960	$1,826,793
Average per M	$6.44	$6.55	$6.24	$6.55	$7.36
Vitrified—					
Quantity	(a)	(a)	(a)	(a)	(a)
Value	(a)	(a)	(a)	(a)	(a)
Average per M	$10.32	$13.67	$15.92	$14.56	$12.85
Front—					
Quantity	26,726,000	21,646,000	19,331,000	24,510,000	21,766,000
Value	$407,023	$325,074	$297,847	$394,524	$293,077
Average per M	$15.23	$15.02	$15.41	$16.10	$13.46
Fancy or ornamental.value	(a)				
Fire.....do	$123,393	$75,950	$78,230	$112,983	$104,338
Stove lining.....do					(a)
Draintile.....do	$28,414	$18,408	$12,817	$10,694	$8,840
Sewer pipe.....do	(a)	(a)	(a)	(a)	(a)
Fireproofing.....do	$20,170	(a)	$47,038	$57,433	$129,763
Pottery:					
Red earthenware.....do	$10,889	$6,481	$8,963	$9,351	$7,894
Stoneware and yellow and Rockingham ware.value	$111,539	$112,604	$123,454	$137,253	$72,480
Miscellaneous.....do	$556,434	$546,351	$494,807	$572,870	$606,164
Total value	$3,148,463	$2,863,930	$2,659,919	$2,886,068	$3,049,349
Number of active firms reporting	113	124	118	104	102
Rank of State	11	12	12	11	11

a Included in "Miscellaneous."

VIRGINIA.

The total value of Virginia's clay products in 1913 was $1,705,651, a decrease of $168,523, or 8.99 per cent from 1912. In 1913 Virginia was the tenth State in the production and value of common brick, and it was ninth in the production of and tenth in the value of front brick reported. Virginia's principal clay product is common brick from the Coastal Plain region. There were 217,408,000 brick reported, valued at $1,409,798 in 1913, a decrease of 27,133,000 brick in quantity and of $103,540 in value. This product constituted 82.65 per cent of the value of the State's clay products in 1913. Front brick is the only other clay product of importance in Virginia. In 1913 it was valued at $247,142, a decrease of $66,409 from 1912. The average price per 1,000 for common brick increased 29 cents to $6.48, and that for front brick decreased 71 cents from $14.41.

Henrico County was the leading common brick producing county in 1913, reporting 44,326,000 brick, valued at $284,531, or $6.42 per 1,000, a decrease of 8,906,000 brick in quantity and of $49,577 in value from 1912. Alexandria County, which was first in quantity and second in value in common brick in 1912 was second in both quantity and value in 1913, showing a decrease of 23,944,000 brick in quantity and of $114,728 in value from 1912. The average price per 1,000 for common brick in this county in 1913 was $6.05, an increase of 56 cents over 1912. These two counties are the principal sources of supply of common brick of Richmond, Va., and Washington, D. C., respectively, and the decline in building operations in these cities probably accounts for the decrease in production in these counties, though some of the clays of Alexandria County have been worked out. Front brick was made most largely in Alexandria County, and it is that county's principal clay product.

Alexandria County was the leading clay-working county in the State in 1913, with production valued at $423,563.

Clay products of Virginia, 1909–1913.

Product.	1909	1910	1911	1912	1913
Brick:					
Common—					
Quantity	249,794,000	229,982,000	219,035,000	244,541,000	217,408,000
Value	$1,540,648	$1,460,460	$1,374,439	$1,513,338	$1,409,798
Average per M	$6.17	$6.35	$6.27	$6.19	$6.48
Vitrified—					
Quantity					(a)
Value					(a)
Average per M					$12.88
Front—					
Quantity	24,717,000	20,813,000	21,032,000	21,755,000	18,040,000
Value	$333,057	$294,348	$314,201	$313,551	$247,142
Average per M	$13.47	$14.14	$14.94	$14.41	$13.70
Fancy or ornamental.value	(a)	(a)	(a)	(a)	(a)
Fire.....do	(a)	(a)	(a)	(a)	(a)
Draintile.....do	$6,298	$5,276	$10,875	$4,025	$6,400
Sewer pipe.....do	(a)	(a)	(a)	(a)	(a)
Pottery:					
Sanitary ware.....do			(a)		
Porcelain electrical supplies, value	(a)	(a)			
Miscellaneous.....value	$76,514	$79,603	$40,385	$43,260	$42,311
Total value	$1,956,517	$1,839,687	$1,739,900	[b] $1,874,174	[b] $1,705,651
Number of active firms reporting	89	84	77	75	69
Rank of State	18	20	19	18	21

[a] Included in "Miscellaneous."
[b] The value of pottery products for Virginia for 1912 and 1913 could not be included in the State total without disclosing individual figures. The entire product for both years was classified as miscellaneous pottery.

WASHINGTON.

The total value of the clay products of Washington in 1913 was $2,390,226, an increase of $1,356, or 0.06 per cent, over 1912. In 1912 there was a large decrease in this State—$451,502, or 15.9 per cent, principally in common brick, vitrified brick, and sewer pipe. In 1913 there was a further decrease in common brick, but vitrified brick and sewer pipe showed an increase. In 1913 Washington was the seventh State in the production and fifth in the value of vitrified paving brick; it was seventh in the value of architectural terra cotta and tenth in the value of sewer pipe. Washington's principal clay product is vitrified paving brick, which in 1913 constituted 29.35 per cent of the value of Washington's clay products. Sewer pipe is the product of second importance; it was valued at $501,102 in 1913, a slight increase—$4,602—over 1912, and constituted 20.96 per cent of the total State value. Common brick, the third product in value, showed a decrease of 10,565,000 brick in quantity, and of $71,187 in value from 1912. Architectural terra cotta, the next product in importance, showed a decrease of $48,481 from 1912.

King County, with Seattle and Tacoma for markets, is the principal producer of common brick, and reported 30,812,000 brick, or 45.69 per cent of the State's total, for 1913, valued at $207,955, or 43.7 per cent of the total. This was a decrease of 5,889,000 brick in quantity and $43,095 in value from 1912. This county is also the leading clay-working county, and reported wares valued at $1,517,307, or 63.48 per cent of the State's total, an increase of $195,329 over 1912. Spokane County, whose principal product in 1913 was sewer pipe, was second, with production valued at $254,474.

Clay products of Washington, 1909–1913.

Product.	1909	1910	1911	1912	1913
Brick:					
Common—					
Quantity	143,198,000	130,634,000	99,588,000	78,000,000	67,435,000
Value	$1,081,579	$956,510	$695,100	$547,061	$475,874
Average per M	$7.55	$7.32	$6.98	$7.01	$7.06
Vitrified—					
Quantity	(a)	(a)	40,291,000	(a)	42,717,000
Value	(a)	(a)	$743,352	(a)	$701,550
Average per M	$18.72	$18.87	$18.45	$16.88	$16.42
Front—					
Quantity	7,802,000	5,570,000	5,224,000	6,881,000	6,122,000
Value	$155,600	$124,952	$118,615	$146,265	$128,989
Average per M	$19.94	$22.43	$22.71	$21.26	$21.07
Fancy ..... value			(a)		
Fire ..... do	$103,531	$25,017	$63,654	$34,293	$66,178
Stove lining ..... do			(a)	(a)	(a)
Draintile ..... do	$18,495	$34,128	$29,314	$24,676	$28,172
Sewer pipe ..... do	$737,847	$817,086	$738,473	$496,500	$501,102
Architectural terra cotta ..... do	$206,324	$198,358	$283,608	$365,109	$316,628
Fireproofing ..... do	$71,067	$114,501	$153,180	$163,077	$157,069
Tile, not drain ..... do				(a)	
Pottery:					
Red earthenware ..... do	(a)	(b)	(b)	(b)	(b)
Stoneware and yellow and Rockingham ware ..... value	(a)	(b)	(b)	(b)	(b)
Miscellaneous ..... do	$686,043	$753,302	$758,428	$611,889	$14,664
Total value	$3,060,486	$3,023,854	$2,840,372	$2,388,870	$2,390,226
Number of active firms reporting	65	65	55	50	45
Rank of State	12	11	11	15	15

a Included in "Miscellaneous."
b The value of pottery products for Washington for 1910, 1911, 1912, and 1913 could not be included in the State totals without disclosing the operations of individual establishments.

WEST VIRGINIA.

West Virginia was the tenth State in the value of clay products in 1913, reporting products valued at $5,208,270—pottery, $3,424,-887, or 65.76 per cent of the total, and brick and tile $1,783,383, or 34.24 per cent of the total—an increase in 1913 of $432,396, or 9.05 per cent. This increase was principally in the brick and tile products—$372,675, pottery increasing only $59,721. In 1913 West Virginia was second in value of white ware and of sanitary ware, fourth in the production and value of vitrified paving brick, sixth in the value of tile, not drain, and eighth in the production and twelfth in the value of fire brick. West Virginia's principal clay product is white ware; for 1913 it was reported to the value of $2,024,104, or 38.86 per cent of the State's total. Next in importance is sanitary ware, which in 1913 was valued at $1,146,205, or 22.01 per cent of the State's total. The principal brick and tile product of West Virginia is vitrified brick, which in 1913 was valued at $795,555, an increase in value of $161,846 and in quantity of 6,528,000 brick over 1912. The average price per 1,000 increased $1.41, to $13.55. Common brick also increased 7,926,000 brick in quantity and $82,384 in value in 1913. The average price per thousand of common brick increased 45 cents in 1913, to $6.93.

Hancock County is the leading producer of vitrified brick, and reported for 1913, 50,050,000 brick, valued at $689,263, or 85.22 per cent of the quantity and 86.64 per cent of the value for the entire State. This was an increase of 6,111,000 brick in quantity and of $152,733 in value over 1912. Hancock County is the leading clay-working county of the State, its production in 1913 being valued at $2,839,864, or 54.53 per cent of the State's total, an increase of $208,994. Of this production $1,894,682 was pottery, principally white ware, and $945,182 was brick and tile, principally vitrified brick. West Virginia was the third State in production of pottery in 1913.

There were 58 active operators reporting for 1913, compared with 54 in 1912 and with 50 in 1909. The average value of production per active plant in 1913 was $89,798, and in 1909 it was $70,202.

Clay products of West Virginia, 1909–1913.

Product.	1909	1910	1911	1912	1913
Brick:					
Common—					
Quantity	53,983,000	77,916,000	59,961,000	60,819,000	68,745,000
Value	$327,141	$508,422	$400,916	$393,864	$476,248
Average per M	$6.06	$6.53	$6.69	$6.48	$6.93
Vitrified—					
Quantity	45,661,000	46,098,000	56,956,000	52,200,000	58,728,000
Value	$565,218	$564,578	$681,747	$633,709	$795,555
Average per M	$12.38	$12.25	$11.97	$12.14	$13.55
Front—					
Quantity	(a)	(a)	(a)	(a)	2,732,000
Value	(a)	(a)	(a)	(a)	$33,484
Average per M	$14.74	$10.00	$14.98	$12.00	$12.26
Fire ... value	$80,773	$32,003	$74,596	$105,719	$155,423
Draintile ... do	(a)	$2,330	$3,487	(a)	$3,191
Sewer pipe ... do	(a)	(a)	(a)	(a)	(a)
Fireproofing ... do	(a)	(a)	(a)	(a)	(a)
Tile, not drain ... do	$82,461	$104,633	$136,586	$200,390	$259,109
Pottery:					
Stoneware and yellow and Rockingham ware ... value	(a)	(a)	(a)	(a)	(a)
White ware, including C. C. ware, white granite ware, semiporcelain ware, and semivitreous porcelain ware ... value	$1,769,808	$1,894,429	$1,920,294	$2,051,987	$2,024,104
China, bone china, delft, and belleek ware ... value	...	...	(a)	$50,002	(a)
Sanitary ware ... do	$500,432	$618,868	$814,599	$1,156,478	$1,146,205
Porcelain electrical supplies, value	...	(a)	(a)	(a)	(a)
Miscellaneous ... value	$184,264	$272,782	$301,195	$183,725	$314,951
Total value	$3,510,097	$3,998,045	$4,333,420	$4,775,874	$5,208,270
Number of active firms reporting	50	56	55	54	58
Rank of State	10	10	10	9	10

[a] Included in "Miscellaneous."

WISCONSIN.

The total value of Wisconsin's clay products in 1913 was $1,020,728, a decrease of $23,758, or 2.27 per cent. Wisconsin's principal clay product is common brick, of which 116,534,000 were reported for 1913, valued at $815,461. This was a decrease of 6,376,000 brick in quantity and of $15,312 in value from 1912. The average price per 1,000 increased 24 cents in 1913, to $7. The value of common brick constituted 79.89 per cent of the total value of Wisconsin's clay products in 1913. Pottery production in Wisconsin in 1913, which was entirely red earthenware, was valued at $7,700.

Milwaukee was the leading clay-working county with products in 1913 valued at $278,243, nearly all of which was common brick. This county alone reported 38,133,000 common brick, valued at

$268,943, or 32.72 per cent of the quantity and 32.98 per cent of the value of this product for the State, an increase of 782,000 brick in quantity and of $11,976 in value over 1912. There was an increase of $11,976 in the value of Milwaukee County's clay product in 1913 over 1912. Dunn County, whose principal product is front brick, was second with a total value of $217,011 in 1913.

Clay products of Wisconsin, 1909–1913.

Product.	1909	1910	1911	1912	1913
Brick:					
Common—					
Quantity	147,741,000	161,083,000	151,331,000	122,910,000	116,534,000
Value	$956,232	$1,071,457	$985,824	$830,773	$815,461
Average per M	$6.47	$6.65	$6.51	$6.76	$7.00
Front—					
Quantity	7,788,000	2,400,000	9,920,000	14,096,000	11,178,000
Value	$74,120	$29,900	$100,140	$135,520	$121,739
Average per M	$9.52	$12.46	$10.09	$9.61	$10.89
Fancy or ornamental . value	(a)	(a)			
Fire . do	(a)				
Draintile . do	$95,899	$64,391	$58,547	$67,993	$73,328
Fireproofing . do	(a)		(a)		
Pottery:					
Red earthenware . do	$9,109	$8,965	$8,600	$7,900	$7,700
Stoneware and yellow and Rockingham ware . value	(a)				
Miscellaneous . do	$4,229	$2,170	$5,028	$2,300	$2,500
Total value	$1,139,589	$1,176,883	$1,158,139	$1,044,486	$1,020,728
Number of active firms reporting	106	112	101	92	85
Rank of State	27	26	26	26	26

a Included in "Miscellaneous."

CLAY.

INTRODUCTION.

Clay available for the manufacture of clay products is one of the most widely spread of our minerals. Hence, there are clay-working plants scattered over every State and Territory in the Union. Miners of the lower-grade clays are usually also the manufacturers, but as the higher grades of ware are reached, the rule is that fewer and fewer manufacturers are also miners, until in the highest grades of ware the rule is that the manufacturer buys and does not mine the clays he uses. The figures given in the following tables represent clay that is mined and not manufactured by the miner, but is sold as clay. The clay thus sold is small in quantity compared with the total production and includes mainly clay used for high-grade pottery and tile, for paper making, and for refractory products.

The clay-mining industry in 1913 made considerable progress and showed its maximum production and value. Only two varieties decreased in production and value, slip clay (5,437 tons and $3,068) and brick clay (70,416 tons and $66,528); and two varieties, paper clay and fire clay, reached their maximum quantity and value. The miscellaneous item showed an increase in quantity and a decrease in value in 1913. In 1912, two varieties showed decrease in quantity and value, kaolin and stoneware clay, and ball clay showed decrease in output. Kaolin, which is the purest form of clay, and in some respects the most important of our clays, showed a small increase in quantity and value; paper clay and fire clay also showed increase in quantity and value in 1913, as did ball clay and stoneware clay. The average price per ton for five of the varieties of clay increased in 1913, and for two varieties and the miscellaneous item it decreased. The general average increased 2 cents per ton.

Imports of clay showed increase in both quantity and value, though in less proportion than those of the domestic production, and kaolin imports decreased in 1913.

PRODUCTION.

The following table shows the production of clay in 1912 and 1913, by varieties:

Production of clay in the United States in 1912 and 1913, by varieties, in short tons.

Variety.	1912			1913		
	Quantity.	Value.	Average price per ton.	Quantity.	Value.	Average price per ton.
Kaolin	25,852	$220,747	$8.54	28,834	$235,457	$8.17
Paper clay	119,857	522,924	4.36	126,377	567,977	4.49
Slip clay	16,339	27,573	1.69	10,902	24,505	2.25
Ball clay	64,939	227,545	3.50	67,134	237,672	3.54
Fire clay	1,695,337	2,363,357	1.39	1,820,379	2,592,591	1.42
Stoneware clay	124,409	115,522	.93	153,353	143,587	.94
Brick clay	229,306	204,504	.89	158,890	137,976	.87
Miscellaneous	254,226	263,848	1.04	282,120	240,694	.85
Total	2,530,265	3,946,020	1.56	2,647,989	4,180,459	1.58

This table shows that the total quantity of clay mined and sold as such in 1913 was 2,647,989 short tons, as compared with 2,530,265 tons in 1912, an increase of 117,724 tons, or 4.65 per cent; and that the value was $4,180,459, or $1.58 per ton, as compared with $3,946,-020, or $1.56 per ton, in 1912, an increase of $234,439, or 5.94 per cent. Every variety except slip clay and brick clay showed an increase in production and every variety except slip clay, brick clay, and the miscellaneous item showed increase in value. Fire clay showed the largest increase in quantity, 125,042 tons, or 7.38 per cent; stoneware clay increased 28,944 tons, or 23.27 per cent; kaolin increased 2,982 tons, or 11.53 per cent; and paper clay increased 6,520 tons, or 5.44 per cent. Brick clay decreased 70,416 tons, or 30.71 per cent, and slip clay decreased 5,437 tons, or 33.28 per cent. Fire clay showed the largest increase in value, $229,234, or 9.7 per cent; and paper clay showed an increase of $45,053, or 8.62 per cent. Fire clay in 1913, as for many years, was the principal variety, constituting 68.75 per cent of the quantity and 62.02 per cent of the value of all clay marketed as such. Paper clay was the second in value of production, its value constituting 13.59 per cent of the value of all clay mined and sold. The average price per ton varied but little in 1913 compared with 1912, the general average increasing only 2 cents per ton. The greatest change was in slip clay, which advanced 56 cents per ton. Kaolin declined 37 cents a ton, and paper clay advanced 13 cents a ton.

Clay mined and sold in the United States, 1905–1913, in short tons.

Year.	Kaolin.		Paper clay.		Slip clay.		Ball clay.		Fire clay.	
	Quantity.	Value.	Quantity.	Value.	Quantity.	Value.	Quantity.	Value.	Quantity.	Value.
1905	44,675	$326,835	76,339	$307,238	24,565	$33,384	61,345	$167,212	1,229,647	$1,529,468
1906	51,937	369,452	75,963	342,708	21,427	31,546	54,173	199,073	1,380,472	1,878,011
1907	47,645	340,311	66,191	293,943	20,325	37,925	52,413	195,515	1,474,462	2,054,698
1908	28,649	216,243	64,510	310,943	10,087	22,370	40,838	133,770	1,101,579	1,486,139
1909	31,227	241,060	81,586	386,764	18,010	30,527	49,074	214,194	1,463,919	2,082,193
1910	34,221	255,873	85,949	420,476	17,696	29,962	70,637	257,265	1,638,931	2,157,720
1911	27,400	221,045	99,265	454,435	8,393	16,770	65,072	220,710	1,526,921	2,112,827
1912	25,852	220,747	119,857	522,924	16,339	27,573	64,939	227,545	1,695,337	2,363,357
1913	28,834	235,457	126,377	567,977	10,902	24,505	67,134	237,672	1,820,379	2,592,591

Year.	Stoneware clay.		Brick clay.[a]		Miscellaneous clay.		Total.	
	Quantity.	Value.	Quantity.	Value.	Quantity.	Value.	Quantity.	Value.
1905	181,485	$219,767	....	....	188,077	$184,102	1,806,133	$2,768,006
1906	146,861	150,774	....	....	296,619	273,692	2,027,452	3,245,256
1907	125,060	136,576	136,515	$112,003	261,068	277,577	2,183,679	3,448,548
1908	124,192	102,390	210,556	154,575	143,490	173,556	1,723,901	2,599,986
1909	130,757	137,264	222,686	171,183	162,388	186,522	2,159,647	3,449,707
1910	152,942	153,044	173,625	128,039	215,228	223,106	2,389,229	3,625,485
1911	151,384	165,751	142,020	123,900	162,243	165,325	2,182,698	3,480,763
1912	124,409	115,522	229,306	204,504	254,226	263,848	2,530,265	3,946,020
1913	153,353	143,587	158,890	137,976	282,120	240,694	2,647,989	4,180,459

[a] Included in "Miscellaneous" in 1905 and 1906.

This table shows that the maximum quantity and value of clay mined and sold in the period covered were attained in 1913. The production rose steadily, except in 1908 and 1911, from 1,806,133 short tons in 1905 to 2,647,989 tons in 1913, and in value from $2,768,006 to $4,180,459. This was an increase in production of 841,856 tons, or 46.61 per cent, and in value of $1,412,453, or 51.03 per cent. Kaolin reached its maximum production and value in 1906, and its minimum in quantity in 1912 and its minimum in value in 1908. Paper clay and fire clay reached their greatest quantity and value in 1913. Ball clay reached its maximum quantity and value in 1910.

Clay mined and sold in the United States in 1912, by States, in short tons.

State.	Kaolin.		Paper clay.		Slip clay.		Ball clay.		Fire clay.		Stoneware clay.		Brick clay.		Miscellaneous clay.(a)		Total.	
	Quantity.	Value.	Quantity.	Value.	Quantity.	Value.	Quantity.	Value.	Quantity.	Value.	Quantity.	Value.	Quantity.	Value.	Quantity.	Value.	Quantity.	Value.
Alabama									38,552	$31,414					4,500	$2,000	43,052	$33,414
California	(b)	(b)							59,492	77,955	(b)	(b)	31,913	$51,548	6,620	6,000	102,520	139,919
Colorado									22,157	37,512	(b)	(b)	49,476	33,590			72,435	72,105
Delaware	(b)	(b)							(b)	(b)					85	64	13,688	61,754
Florida							(b)	(b)									(c)	(c)
Georgia			48,482	$210,908	(b)	(b)			12,863	8,196			(b)	(b)	13,427	19,941	75,815	244,953
Idaho									(b)	(b)							(c)	(c)
Illinois									92,963	110,204	29,761	$22,605	(b)	(b)	32,150	27,328	176,558	192,663
Indiana									49,915	46,171	(b)	(b)			31,700	24,720	82,035	71,391
Iowa													4,192	1,866	(b)	(b)	7,192	2,166
Kentucky							(b)	(b)	83,789	82,412					(b)	(b)	91,097	93,560
Maryland			(d)	(d)					21,264	32,437	(b)	(b)	370	495	d 2,845	d 2,755	25,279	36,687
Massachusetts									(b)	(b)			(b)	(b)			1,350	2,678
Michigan					2,034	$6,164							(b)	(b)			2,043	6,173
Minnesota											(b)	(b)			(b)	(b)	(c)	(c)
Missouri	740	$3,874			(b)	(b)			287,925	552,514	2,025	2,492	(b)	(b)	(b)	(b)	295,701	562,306
Montana									4,200	4,657							4,200	4,657
New Jersey							2,649	$9,152	291,474	502,053	20,031	39,905	50,186	33,168	74,543	117,730	438,883	702,008
New Mexico									1,943	4,214							1,943	4,214
New York					(b)	(b)			(b)	(b)					1,897	4,924	7,845	18,718
North Carolina	14,950	139,717									88	74	(b)	(b)			15,058	139,821
North Dakota									(b)	(b)							(c)	(c)
Ohio					2,880	3,640			234,600	192,400	62,881	39,998	32,489	17,855	23,598	8,862	356,448	262,755
Oregon									(b)	(b)	(b)	(b)					(c)	(c)
Pennsylvania			27,003	154,799					372,944	537,898	(b)	(b)	35,756	31,075	26,251	16,736	462,605	741,484
South Carolina			44,372	157,217					(b)	(b)			(b)	(b)			47,638	162,974
Tennessee							30,792	87,705	24,060	34,276	1,291	1,322			110	220	56,253	123,523
Texas									1,241	6,038					101	404	1,342	6,442
Utah									(b)	(b)							(c)	(c)
Vermont	(b)	(b)							(b)	(b)							(c)	(c)
Virginia									(b)	(b)					(b)	(b)	2,599	2,006
Washington					(b)	(b)			(b)	(b)							1,570	5,000
West Virginia									(b)	(b)	(b)	(b)					82,768	58,776
Wisconsin													(b)	(b)	(b)	(b)	836	1,172
Wyoming															(b)	(b)	(c)	(c)
Other States (e)	10,162	77,156			11,425	17,769	31,498	130,688	95,955	103,006	8,332	9,126	24,924	34,907	36,399	32,164	f 61,512	f 192,701
Total	25,852	220,747	119,857	522,924	16,339	27,573	64,939	227,545	1,695,337	2,363,357	124,409	115,522	229,306	204,504	254,226	263,848	2,530,265	3,946,020

(a) Including bentonite, modeling clay, pipe clay, terra-cotta clay, and shale.
(b) Included in "Other States."
(c) Included in (f) (61,512 tons, valued at $192,701).
(d) Paper clay for Maryland is included in "Maryland miscellaneous."
(e) Includes all products made by less than 3 producers in 1 State.
(f) Made up of State totals of Florida, Idaho, Minnesota, North Dakota, Oregon, Utah, Vermont, and Wyoming.

Clay mined and sold in the United States in 1913, by States, in short tons.

State.	Kaolin.		Paper clay.		Slip clay.		Ball clay.		Fire clay.		Stoneware clay.		Brick clay.		Miscellaneous clay.[a]		Total.	
	Quantity.	Value.	Quantity.	Value.	Quantity.	Value.	Quantity.	Value.	Quantity.	Value.	Quantity.	Value.	Quantity.	Value.	Quantity.	Value.	Quantity.	Value.
Alabama									49,601	$53,269	(b)	(b)					49,901	$53,419
California									97,793	104,980	6,384	$5,663	24,141	$32,163	25,553	$24,503	153,871	167,309
Colorado									25,910	43,364	(b)	(b)	39,038	26,228			65,579	70,350
Connecticut													(b)	(b)			(c)	(c)
Delaware	6,830	$57,343							(b)	(b)							11,482	66,647
Florida							(b)	(b)									(c)	(c)
Georgia			69,740	$299,110	(b)	(b)			13,650	8,475	(b)	(b)			71,480	9,851	156,374	324,671
Idaho									(b)	(b)							(c)	(c)
Illinois									106,216	125,477	55,001	43,616	(b)	(b)	(b)	(b)	194,937	204,037
Indiana									64,481	57,169	(b)	(b)			5,260	8,760	74,581	70,929
Iowa									(b)	(b)			(b)	(b)	1,737	1,066	2,655	1,900
Kentucky							(b)	(b)	81,029	98,168	(b)	(b)	(b)	(b)	10	200	91,114	113,871
Maryland	(b)	(b)	(d)	(d)					21,235	32,850	2,375	2,075	(b)	(b)	d 759	d 1,180	24,829	36,955
Massachusetts									(b)	(b)			(b)	(b)	100	100	843	1,807
Michigan					1,710	$6,504											1,710	6,504
Minnesota															(b)	(b)	(c)	(c)
Mississippi											(b)	(b)					(c)	(c)
Missouri	304	1,957							235,606	465,900	(b)	(b)	(b)	(b)	520	525	238,032	470,277
Montana									3,410	3,314							3,410	3,314
New Jersey							2,256	$8,522	327,175	576,957	18,231	43,180	35,134	29,941	65,339	111,089	448,135	769,689
New Mexico									3,513	9,906							3,513	9,906
New York					(b)	(b)			(b)	(b)					1,124	902	5,518	9,568
North Carolina	16,332	139,629									(b)	(b)					16,352	139,644
North Dakota									(b)	(b)							(c)	(c)
Ohio					(b)	(b)			250,003	205,407	62,381	40,005	37,341	18,438	31,790	11,900	384,325	277,455
Oregon									(b)	(b)	(b)	(b)					(c)	(c)
Pennsylvania	(b)	(b)	25,069	148,347					421,751	656,825			12,345	15,705	20,333	15,914	479,548	836,916
South Carolina			31,568	120,520					(b)	(b)							32,222	124,249
Tennessee							29,258	85,500	26,470	38,422	250	161			326	489	56,304	124,572
Texas									2,119	8,830	(b)	(b)			2	10	2,746	9,465
Utah									4,969	11,708							4,969	11,708
Vermont	(b)	(b)															(c)	(c)
Virginia									789	2,284					2,000	200	2,789	2,484
Washington					(b)	(b)			754	6,672							2,028	8,837
West Virginia									77,171	65,239							77,171	65,239
Wisconsin													(b)	(b)	305	413	742	1,286
Wyoming															(b)	(b)	(c)	(c)
Other States [e]	5,368	36,528			9,192	18,001	35,620	143,650	6,734	17,375	8,731	8,887	10,891	15,501	55,482	53,592	f 62,309	f 197,451
Total	28,834	235,457	126,377	567,977	10,902	24,505	67,134	237,672	1,820,379	2,592,591	153,353	143,587	158,890	137,976	282,120	240,694	2,647,989	4,180,459

[a] Including bentonite, modeling clay, pipe clay, terra cotta clay, and clay for medicinal use. [b] Included in "Other States." [c] Included in f (62,309 tons, valued at $197,451).
[d] Paper clay for Maryland is included in Maryland miscellaneous. [e] Includes all products made by less than three producers in one State.
[f] Made up of State totals of Connecticut, Florida, Idaho, Minnesota, Mississippi, North Dakota, Oregon, Vermont, and Wyoming.

Thirty-seven States reported sales of clay for 1913, an increase of 2, Connecticut and Mississippi, over 1912. The leading clay-producing State in both quantity and value was Pennsylvania. For 1913 the production of Pennsylvania was 479,548 short tons, valued at $836,916. This was an increase over 1912 of 16,943 tons in quantity, or 3.66 per cent, and of $95,432, or 12.87 per cent, in value. Pennsylvania reported 18.11 per cent of all clay sold in 1913 and 20.02 per cent of the total value. Of Pennsylvania's total clay production in 1913, fire clay was 87.95 per cent of the quantity and 78.48 per cent of the value. New Jersey was the second State, as for 1912, reporting 448,135 short tons of clay, valued at $769,689. This was an increase over 1912 of 9,252 tons, or 2.11 per cent, in quantity and of $67,681, or 9.64 per cent, in value. New Jersey's production was 16.92 per cent of the total clay mined in 1913 and 18.41 per cent of its value. In this State fire clay was also the leading variety, 73.01 per cent of the quantity of clay mined in the State and 74.96 per cent of the value being of this variety. Ohio, the leading clay-manufacturing State, was third in quantity and fifth in value of clay marketed, and Missouri was fourth in quantity and third in value. In 1912 Ohio was third in quantity and fourth in value, and Missouri was fourth in quantity and third in value. In 1913 Ohio showed an increase of 27,877 tons, or 7.82 per cent, in quantity and of $14,700, or 5.59 per cent, in value over 1912. In 1913 Missouri showed decrease in both production and value of clay, the former decreasing 57,669 tons, or 19.5 per cent, and the latter $92,029, or 16.37 per cent. Illinois was fifth in production and sixth in value of clay marketed in 1913, and Georgia was sixth in quantity and fourth in value. Both of these States showed substantial increases in production and value of clay marketed in 1913 over 1912. These six States—Pennsylvania, New Jersey, Ohio, Missouri, Illinois, and Georgia—reported 1,901,351 tons, or 71.8 per cent, of the total quantity, and $2,883,045, or 68.96 per cent, of the total value.

Of the remaining 22 States for which totals are given 10 showed increase in quantity of clay marketed and 12 showed decrease; 14 showed increase in value and 8 showed decrease. Nine States showed increase in production and value and 7 showed decrease in both. Delaware, Maryland, Michigan, West Virginia, and Wisconsin showed decrease in production and increase in value, and North Carolina showed increase in production and decrease in value. Georgia showed the largest increase in production, 80,559 tons, or 106.26 per cent. Pennsylvania showed the largest increase in value. Missouri showed the largest decrease in 1913 in both production and value. In 1912 Pennsylvania showed the largest increase in both production and value, and Kentucky showed the largest decrease in both quantity and value.

In 1913 Pennsylvania was the leading State in the production and value of fire clay, reporting 421,751 tons, valued at $656,825. New Jersey was second, reporting 327,175 tons, valued at $576,957. Ohio was third in production and fourth in value, and Missouri was fourth in production and third in value, and Illinois was fifth in both quantity and value. In 1912 Pennsylvania was first in production and second in value, Missouri was first in value and third in production, and New Jersey was second in quantity and third in value. The average price per ton of fire clay in these States in 1913 was: Illinois,

$1.18; Missouri, $1.98; New Jersey, $1.76; Ohio, $0.82; and Pennsylvania, $1.56. In 1912 the corresponding prices of fire clay were: $1.19, $1.92, $1.72, $0.82, and $1.44, respectively. These 5 States reported 1,340,751 tons, or 73.65 per cent, of the total quantity of fire clay, valued at $2,030,566, or 78.32 per cent, of the total value of fire clay in 1913.

Kaolin was reported from 6 States for 1913, an increase of 1 State. Maryland and Pennsylvania, which reported none for 1912, reentered the list of producers and California dropped out. North Carolina was the leading State, reporting 16,332 tons, or 56.64 per cent, of the total quantity, valued at $139,629, or 59.3 per cent, of the total value.

IMPORTS.

The following table shows the imports of clay from 1907 to 1913:

Classified imports of clay for consumption, 1907–1913, in short tons.

Year.	Kaolin or china clay.			All other clays.						Total.	
				Unwrought.		Wrought.		Common blue.			
	Quantity.	Value.	Average value per ton.	Quantity.	Value.	Quantity.	Value.	Quantity.	Value.	Quantity.	Value.
1907	239,923	$1,582,893	$6.60	31,196	$145,698	2,520	$81,155	12,378	$110,686	286,017	$1,920,432
1908	176,895	1,129,847	6.39	27,730	129,411	1,372	22,990	4,872	37,053	219,869	1,319,301
1909	246,381	1,505,779	6.11	30,147	134,978	1,906	50,632	12,346	104,401	290,780	1,795,790
1910	257,902	1,593,472	6.18	27,890	113,352	1,496	26,205	21,176	181,334	308,464	1,914,363
1911	255,107	1,461,068	5.73	26,086	100,540	1,032	10,436	17,193	124,278	299,418	1,696,322
1912	278,276	1,629,105	5.85	32,473	127,004	794	12,109	23,112	184,018	334,655	1,952,236
1913	268,666	1,623,993	6.04	42,582	155,693	1,889	22,178	24,986	204,911	338,123	2,006,775

The imports of clay, except for kaolin or china clay and the clay designated as "common blue," but which is high-grade fire clay, are unimportant. In 1913 of the clay imported 79.46 per cent of the quantity and 80.93 per cent of the value was kaolin or china clay.

The quantity imported increased 3,468 short tons, or 1.04 per cent, and the value increased $54,539, or 2.79 per cent. Every variety except kaolin showed increase in quantity and value. The imports of kaolin, which in 1912 showed a large increase, showed a decrease of 9,610 tons, or 3.45 per cent, in quantity and of $5,112, or 0.31 per cent, in value in 1913. The average price per ton of imported kaolin in 1913 increased 19 cents.

Tariff.—The tariff act of 1913 reduced the duty on clay 50 per cent. It went into effect late in the year and had, apparently, no effect on imports.

BUILDING OPERATIONS.

The following tables show the building operations of some of the leading cities of the country. Efforts were made to obtain detailed information for all cities of 35,000 or more inhabitants—157 in number. For 108 cities sufficient detail was received to include these cities in a table; for 39 cities only the totals for permits and cost of buildings could be obtained; and for 10 cities no data were procured. In some cases the data furnished were apparently inconsistent and considerable editing of reports was necessary.

The first table shows a comparison between 1912 and 1913 in 48 cities, also the increase or decrease in the cost of building operations. Used as an index of prosperity, the figures here given show that in the building trades it was sporadic in 1913. New York City, the largest building center of the country, showed a large decrease, while Newark, only a few miles away, showed a large increase over 1912. Chicago, which showed the largest decrease in 1912, rallied and showed the largest increase in 1913. Most of the cities that showed increase in 1912 showed decrease in 1913, and a few—9 altogether—that showed decrease in 1912 showed increase in 1913. None of these, except Chicago and Pittsburgh, were of the larger cities. On the whole, therefore, the building industries can not be considered as having been in a very prosperous condition in 1913. Where an exact comparison can be made, there was a decrease in 1913 of 10.75 per cent from 1912 and of 4.07 per cent from 1911. Various causes are assigned for the changes. Many cities ascribe the decrease in 1913 to the fact that in 1912 the structures erected were unusually costly; others to labor troubles; others to financial stringency; and some to overbuilding in previous years. The large increase in Cambridge, Mass., was caused by the erection of college buildings, and that in Grand Rapids, Mich., by the erection of one large building, costing nearly one-third of all operations in that city.

The total cost of building operations in these 48 cities in 1913 was $659,515,746, compared with $738,989,710, in 1912. Of the 48 cities included in this table 20 showed increase in the cost of buildings and 28 showed decrease. The total decrease was $114,985,805; the total increase $35,511,841, a net decrease of $79,473,964, or 10.75 per cent from 1912. In 1912, 31 of these cities showed increase and 17 showed decrease, the net increase being $51,482,749, or 7.49 per cent. Compared with 1911, there was a decrease of $27,991,215, or 4.07 per cent in 1913. The greatest decrease in 1913 was in New York City, $56,414,655, or 34.5 per cent. The greatest proportionate decrease was in Atlanta, 47.86 per cent. The largest increase was in Chicago, $6,492,527, or 7.81 per cent. The largest proportionate increase was in Cambridge, Mass., 123.61 per cent. In 1912, New York City showed the largest increase, $27,815,647, so that the building operations in that city cost very much less in 1913 than in 1911. The city showing the greatest decrease in 1912 was Chicago, $20,096,100.

Building operations in a number of the leading cities of the United States in 1912 and 1913.

City.	1912		1913		Increase (+) or decrease (−) in 1913.	Per centage of increase or decrease in 1913.	Rank of cities in cost of buildings in 1913.
	Number of permits or buildings.	Cost.	Number of permits or buildings.	Cost.			
Atlanta, Ga	3,529	$9,806,836	3,606	$5,112,944	−$4,693,892	− 47.86	37
Boston, Mass	4,410	26,755,652	4,549	22,780,011	− 3,975,641	− 14.86	7
Brooklyn, N. Y	11,408	40,537,784	10,962	34,762,506	− 5,775,278	− 14.25	4
Buffalo, N. Y	4,090	12,992,000	4,059	13,300,360	+ 308,360	+ 2.37	15
Cambridge, Mass	580	2,946,490	527	6,588,685	+ 3,642,195	+123.61	29
Chicago, Ill	10,751	83,175,900	10,792	89,668,427	+ 6,492,527	+ 7.81	2
Cincinnati, Ohio	5,386	8,660,264	2,952	7,543,475	− 1,116,789	− 12.90	26
Cleveland, Ohio	8,790	18,180,078	6,160	22,543,365	+ 4,363,287	+ 24.00	8
Columbus, Ohio	2,656	4,675,303	3,888	5,508,408	+ 833,105	+ 17.82	33
Dayton, Ohio	1,214	3,552,120	1,189	3,288,350	− 263,770	− 7.43	55
Denver, Colo	2,254	5,332,675	2,034	2,797,148	− 2,535,527	− 47.55	62
Detroit, Mich	7,991	25,588,470	9,326	30,434,380	+ 4,845,910	+ 18.94	6
Falls River, Mass	572	1,240,255	557	1,507,855	+ 267,600	+ 21.58	91
Grand Rapids, Mich	1,433	2,456,516	1,726	4,169,000	+ 1,712,484	+ 69.71	45
Hartford, Conn	1,277	7,379,525	1,169	5,784,751	− 1,594,774	− 21.61	32
Indianapolis, Ind	4,781	9,150,407	5,400	9,361,973	+ 211,566	+ 2.31	21
Jersey City, N. J	1,336	5,911,880	1,344	5,413,607	− 498,273	− 8.43	34
Kansas City, Kans	455	795,775	692	1,252,860	+ 457,085	+ 57.44	103
Kansas City, Mo	3,953	12,127,079	3,719	10,578,162	− 1,548,917	− 12.77	18
Los Angeles, Cal	16,455	31,367,995	16,442	31,641,921	+ 273,926	+ .87	5
Louisville, Ky	2,379	6,562,777	2,402	3,617,540	− 2,945,237	− 44.88	52
Lowell, Mass	572	1,291,649	531	969,868	− 321,781	− 24.91	116
Memphis, Tenn	3,657	7,162,214	3,363	3,949,368	− 3,212,846	− 44.86	50
Milwaukee, Wis	4,361	15,257,162	4,015	13,647,624	− 1,609,538	− 10.55	14
Minneapolis, Minn	5,965	14,229,475	6,135	12,857,935	− 1,371,540	− 9.64	17
Nashville, Tenn	1,503	1,378,997	1,458	1,643,486	+ 264,489	+ 19.18	86
Newark, N. J	2,937	11,628,358	3,075	16,317,973	+ 4,689,615	+ 40.33	10
New Bedford, Mass	940	2,400,050	1,245	3,067,700	+ 667,650	+ 27.82	56
New Haven, Conn	1,330	4,762,341	1,100	4,790,151	+ 27,810	+ .58	41
New Orleans, La	1,794	3,309,620	1,857	4,088,261	+ 778,641	+ 23.53	48
New York, N. Y	8,283	163,519,362	9,443	107,104,707	−56,414,655	− 34.50	1
Oakland, Cal	4,058	8,821,950	3,748	8,535,251	− 286,699	− 3.25	23
Omaha, Nebr	1,372	4,546,761	1,236	4,110,733	− 436,028	− 9.59	46
Philadelphia, Pa	11,192	36,392,405	7,700	35,125,810	− 1,266,595	− 3.48	3
Pittsburgh, Pa	3,890	11,530,531	2,943	15,470,955	+ 3,940,424	+ 34.17	11
Portland, Oreg	8,224	14,652,071	6,710	12,956,915	− 1,695,156	− 11.57	16
Providence, R. I	2,856	8,530,800	3,184	7,289,100	− 1,241,700	− 14.56	27
Richmond, Va	1,631	6,255,711	1,501	3,636,476	− 2,619,235	− 41.87	51
Rochester, N. Y	3,888	12,035,466	3,268	9,642,124	− 2,393,342	− 19.89	20
St. Joseph, Mo	850	1,119,797	713	895,079	− 224,718	− 20.07	120
St. Louis, Mo	8,760	20,675,804	8,302	15,340,012	− 5,335,792	− 25.81	12
St. Paul, Minn	3,491	8,051,417	1,972	8,161,887	+ 110,470	+ 1.37	25
San Francisco, Cal	6,316	23,338,563	5,606	21,037,264	− 2,301,299	− 9.86	9
Scranton, Pa	676	1,716,491	628	1,413,559	− 302,932	− 17.65	99
Seattle, Wash	9,819	8,415,325	9,597	9,321,115	+ 905,790	+ 10.76	22
Syracuse, N. Y	1,546	4,487,861	1,855	5,206,768	+ 718,907	+ 16.02	36
Washington, D. C	5,048	17,593,848	4,585	10,499,402	− 7,094,446	− 40.32	19
Worcester, Mass	1,698	6,689,900	1,576	4,780,495	− 1,909,405	− 28.54	42
Total	202,357	738,989,710	190,841	659,515,746	−79,473,964	− 10.75	....

Of the 48 cities included in this table, 11 showed increase in both 1912 and 1913; Buffalo, Cambridge, Cleveland, Columbus, Detroit, Indianapolis, Los Angeles, Newark, New Orleans, St. Paul, and Seattle. Eight cities showed decrease in both years; Cincinnati, Denver, Kansas City, Mo., Lowell, Omaha, Philadelphia, Portland, Oreg., and Scranton. Twenty cities that showed increase in 1912 showed decrease in 1913, namely, Atlanta, Boston, Brooklyn, Dayton, Hartford, Jersey City, Louisville, Memphis, Milwaukee, Minneapolis, New York, Oakland, Providence, Richmond, Rochester, St. Joseph, St. Louis, San Francisco, Washington, and Worcester. Nine cities that showed decrease in 1912 showed increase in 1913, as follows: Chicago, Fall River, Grand Rapids, Kansas City, Kans., Nashville, New Bedford, New Haven, Pittsburgh, and Syracuse.

New York City (boroughs of the Bronx and Manhattan) is the leading city in the cost of building operations. Notwithstanding its large decrease in 1913, in that year the cost of building operations there exceeded by $17,436,280 that of Chicago, the city of second rank in the cost of building operations. In 1913 the building operations of New York City cost $107,104,707, or 16.24 per cent of the total reported for the 48 cities. In 1912 they constituted 22.13 per cent of the total reported for these cities. The maximum cost of building operations in New York was in 1909, $186,047,477. In 1908, the year of general business depression, the cost of building operations in New York City was $117,819,382, so that in 1913 they cost $10,714,675 less than those of 1908 and $78,942,770 less than those of 1909. The cost of building operations in New York City in 1913 was the lowest since 1903. The reason assigned for this decrease is that that city was overbuilt. In the cost of building operations Chicago, the second city, the maximum was attained in 1911—$103,272,000. In 1912 there was a sharp decline, and in 1913 there was an increase but the cost was less then than in any year since 1908, except 1912. The cost of building operations in Los Angeles rose steadily from $9,931,377 in 1908 to $31,641,921 in 1913, an increase of $21,710,544, or 218.61 per cent. This city rose in rank from seventeenth in 1908 to fifth in 1910, which rank it has since maintained.

The total number of permits or buildings in these 48 cities fell from 202,357 in 1912 to 190,841 in 1913, a decrease of 11,516. The number ranged in 1913 from 527 in Cambridge to 16,442 in Los Angeles. The average cost per permit or building in these 48 cities in 1913 was $3,456, in 1912 it was $3,652, and in 1911 it was $3,407. In New York City the average cost was $11,342 in 1913, $19,742 in 1912, and $20,890 in 1911. In Chicago it was $8,309 in 1913, $7,737 in 1912, and $8,205 in 1911. In Philadelphia, the third city in cost of building operations, this city having regained this position in 1913, the average cost per operation was $4,562 in 1913, $3,252 in 1912, and $2,469 in 1911. In Brooklyn, the fourth city, it was $3,171 in 1913, $3,553 in 1912, and $4,035 in 1911. In Los Angeles, the fifth city, it was $1,924 in 1913, $1,906 in 1912, and $1,841 in 1911.

Building statistics of the leading cities of the United States, by character of operations, in 1913.

City.	Wooden buildings.								Fire-resisting buildings.							
									Brick or hollow tile.				Stone.			
	New.		Additions, alterations, and repairs.		Miscellaneous.		Total.		New.		Additions, alterations, and repairs.		New.		Additions, alterations, and repairs.	
	Number of permits or buildings.	Cost.	Number of permits or buildings.	Cost.	Number of permits or buildings.	Cost.	Number of permits or buildings.	Cost.	Number of permits or buildings.	Cost.	Number of permits or buildings.	Cost.	Number of permits or buildings.	Cost.	Number of permits or buildings.	Cost.
Akron, Ohio	1,672	$2,681,525	498	$177,450	......	......	2,170	$2,858,975	314	$2,105,850	110	$278,490	......	......	......	......
Allentown, Pa	50	25,000	28	12,500	......	......	78	37,500	329	1,314,050	90	114,450	......	......	......	......
Altoona, Pa	258	518,219	166	77,602	370	$73,673	794	669,494	26	246,685	14	39,312	......	......	......	......
Atlanta, Ga	1,089	2,436,915	1,820	603,976	......	......	2,909	3,040,891	258	1,248,645	435	223,408	1	$20,000	......	......
Augusta, Ga	419	412,712	1,001	100,993	......	......	1,420	513,705	46	958,324	3	5,600	......	......	......	......
Bayonne, N. J	125	489,008	105	100,430	......	......	230	589,438	38	716,863	25	19,943	......	......	......	......
Berkeley, Cal	490	a 1,684,500	500	277,700	......	......	990	1,962,200	11	82,500	......	......	......	......	......	......
Binghamton, N. Y	435	811,887	b 463	b 202,837	......	......	898	1,014,724	b 95	b 741,941	......	......	......	......	......	......
Birmingham, Ala	1,206	1,715,975	2,062	371,584	......	......	3,268	2,087,559	97	747,254	251	243,295	......	......	......	......
Boston, Mass	1,225	5,369,195	1,386	913,883	......	......	2,611	6,283,078	368	8,374,100	1,353	3,463,805	......	......	44	$159,104
Bridgeport, Conn	662	1,610,245	144	104,633	125	47,205	931	1,762,083	110	1,061,262	40	118,077	......	......	......	......
Buffalo, N. Y	2,458	5,248,000	1,284	891,000	......	......	3,742	6,139,000	223	3,236,000	70	204,300	5	341,000	......	......
Butte, Mont	329	844,622	10	50,000	......	......	339	894,622	......	......	......	......	......	......	......	......
Cambridge, Mass	177	733,070	250	180,375	......	......	427	913,445	c 66	c 5,591,275	c 34	c 83,965	......	......	......	......
Camden, N. J	70	101,850	153	51,065	......	......	223	152,915	654	1,564,320	85	80,225	2	100,000	......	......
Canton, Ohio	385	566,425	87	55,750	9	1,980	481	624,155	65	373,200	4	6,800	......	......	4	1,870
Charleston, S. C	207	288,657	262	59,776	......	......	469	348,433	20	138,813	87	102,030	......	......	......	......
Cincinnati, Ohio	1,085	1,726,900	d1,278	d 997,575	......	......	2,363	2,724,475	......	......	......	......	......	......	......	......
Cleveland, Ohio	2,592	7,643,910	1,928	769,430	442	293,055	4,962	8,706,395	632	e12,603,100	437	1,198,870	1	30,000	......	......
Columbus, Ohio	954	1,272,505	645	132,522	......	......	1,599	1,405,027	500	2,633,425	397	422,480	1	60,000	2	7,500
Covington, Ky	(f)	120,184	(f)	28,573	......	......	(f)	148,757	(f)	416,924	(f)	33,815	......	......	......	......
Dayton, Ohio	854	1,606,820	125	87,120	......	......	979	1,693,940	132	1,002,660	38	117,990	......	......	......	......
Des Moines, Iowa	600	1,140,759	50	75,000	47	90,000	697	1,305,759	9	300,000	......	......	......	......	......	......
Detroit, Mich	6,531	15,182,070	1,411	962,325	......	......	7,942	16,144,395	835	7,624,795	492	1,861,440	......	......	......	......
Dubuque, Iowa	63	104,180	......	......	12	36,800	75	140,980	11	230,100	......	......	......	......	......	......
Duluth, Minn	631	924,226	693	267,396	......	......	1,324	1,191,622	78	521,310	90	205,971	g 13	2,107,108	(g)	(g)
Elizabeth, N. J	408	1,301,130	89	56,631	......	......	497	1,357,761	62	956,012	21	49,559	......	......	......	......
Elmira, N. Y	138	207,000	10	6,000	......	......	148	213,000	29	145,000	......	......	......	......	......	......
Erie, Pa	692	1,139,161	633	417,038	......	......	1,325	1,556,199	95	858,224	......	......	......	......	......	......

Evansville, Ind	552	595,269	394	82,487	......	......	946	677,756	72	876,458	107	310,685	......	......	......	......
Fall River, Mass	346	929,010	146	89,810	24	21,660	516	1,040,480	14	416,400	15	35,475	1	3,500	......	......
Fitchburg, Mass	138	336,913	110	85,249	......	......	248	422,162	9	119,991	14	79,350	1	6,000	3	4,250
Fort Worth, Tex	359	547,513	151	112,142	......	......	510	659,655	62	1,019,665	28	137,450	......	......	......	......
Galveston, Tex	402	437,445	479	67,702	......	......	881	505,147	17	105,979	32	158,055	......	......	......	......
Grand Rapids, Mich	850	1,222,605	650	268,226	......	......	1,500	1,490,831	54	641,898	97	335,896	......	......	......	......
Harrisburg, Pa	48	25,590	50	18,360	......	......	98	43,950	385	1,084,100	88	111,865	7	30,500	......	......
Hartford, Conn	176	990,400	331	229,335	289	66,796	796	1,286,531	h 129	h 3,981,250	h 200	h 433,080	(h)	(h)	(h)	(h)
Haverhill, Mass	184	598,915	49	87,700	......	......	233	686,615	14	190,300	10	111,800	......	......	......	......
Hoboken, N. J	14	7,478	93	36,481	......	......	107	43,959	21	212,100	74	46,981	......	......	......	......
Holyoke, Mass	85	308,500	47	15,605	......	......	132	324,105	28	630,367	50	63,410	......	......	......	......
Houston, Tex	1,221	1,719,512	1,693	461,837	248	21,050	3,162	2,202,399	49	1,390,390	273	188,345	......	......	......	......
Indianapolis, Ind	2,106	3,959,305	2,851	1,104,289	......	......	4,957	5,063,594	101	1,443,292	......	......	......	......	......	......
Jacksonville, Fla	757	1,246,352	203	145,376	......	......	960	1,391,728	i 95	i 1,426,760	i 60	i 156,164	(i)	(i)	(i)	(i)
Kalamazoo, Mich	250	350,000	75	50,000	50	100,000	375	500,000	8	200,000	......	......	......	......	......	......
Kansas City, Mo	1,399	3,378,850	663	300,380	567	247,447	2,629	3,926,677	251	3,407,485	421	567,610	8	81,000	13	16,400
Knoxville, Tenn	69	164,375	449	81,582	......	......	518	245,957	34	124,450	98	40,291	......	......	......	......
Lawrence, Mass	126	602,190	100	106,869	......	......	226	709,059	14	119,870	8	19,700	......	......	......	......
Lincoln, Nebr	313	649,950	87	59,840	......	......	400	709,790	34	746,898	41	157,887	......	......	......	......
Little Rock, Ark	291	598,976	360	125,508	......	......	651	724,484	24	467,375	156	141,464	......	......	......	......
Los Angeles, Cal	10,377	14,485,095	4,441	1,470,505	......	......	14,818	15,955,600	417	6,995,286	1,163	1,160,098	......	......	......	......
Louisville, Ky	882	1,650,560	723	157,480	309	123,740	1,914	1,931,780	105	880,160	379	446,100	1	4,500	......	......
Lowell, Mass	196	330,547	274	140,606	......	......	470	471,153	4	39,000	53	241,715	......	......	2	151,000
Lynn, Mass	353	827,568	228	134,410	......	......	581	961,978	18	574,900	11	32,300	2	2,700	......	......
Manchester, N. H	405	969,162	558	292,717	......	......	963	1,261,879	13	120,620	48	81,185	1	18,000	5	15,350
Milwaukee, Wis	1,090	3,500,000	1,400	1,154,624	......	......	2,490	4,654,624	1,000	6,000,000	500	500,000	......	......	......	......
Minneapolis, Minn	3,051	5,010,320	2,285	997,425	......	......	5,336	6,007,745	215	2,198,040	364	600,795	......	......	19	40,750
Montgomery, Ala	187	200,417	246	76,002	......	......	433	276,419	30	181,596	50	54,288	......	......	......	......
Nashville, Tenn	388	364,235	673	57,731	......	......	1,061	421,966	117	1,138,335	280	83,185	......	......	......	......
New Bedford, Mass	425	1,482,200	437	304,150	345	154,850	1,207	1,941,200	9	396,500	10	225,000	2	400,000	2	25,000
New Britain, Conn	95	428,800	j 264	j 93,840	......	......	359	522,640	55	549,660	(j)	(j)	......	......	......	......
Newton, Mass	300	1,089,069	202	204,702	......	......	502	1,293,771	c 37	c 300,294	......	......	......	......	......	......
New York, N. Y	186	579,945	1,736	427,312	......	......	1,922	1,007,257	1,118	52,178,429	5,553	9,550,262	......	......	......	......

[a] Includes cost of building at the University of California, permits for which were not issued through the city of Berkeley.

[b] Additions, etc., to all classes of buildings for Binghamton, N. Y., Oakland, Cal., Syracuse, N. Y., and Worcester, Mass., are included with additions, etc., to wooden buildings. New concrete buildings for Binghamton are included with new brick or hollow-tile buildings. All classes of new fire-resisting buildings for Worcester are included with new brick or hollow-tile buildings.

[c] New concrete buildings for Cambridge, Mass., and for Newton, Mass., are included with new brick or hollow-tile buildings. Additions, etc., to concrete buildings for Cambridge, Mass., and Sioux City, Iowa, are included, with additions, etc., to brick or hollow-tile buildings.

[d] The total only was given for fire-resisting buildings for Cincinnati, Ohio, i. e., 589 permits or buildings, costing $4,819,000. The percentage for this value, equivalent to seventy-nine one hundredths of 1 per cent, is included in the percentage for total fire-resisting buildings. Additions, etc., to all classes of buildings for Cincinnati are included with additions, etc., to wooden buildings.

[e] The cost of new concrete and of new steel-skeleton buildings for Cleveland, Ohio, is included with the cost of new brick or hollow-tile buildings, and the cost of additions, etc., to concrete buildings and additions, etc., to steel-skeleton buildings is included with additions, etc., to brick or hollow-tile buildings.

[f] The number of permits or buildings for Covington, Ky., and Fort Wayne, Ind., was not given; nor was it given for additions, etc., to concrete buildings for Pittsburgh, Pa.

[g] With new stone buildings for Duluth, Minn., are included additions, etc., to stone buildings; new concrete buildings and additions, etc., to concrete buildings; new steel skeleton buildings and additions, etc., to steel skeleton buildings; and miscellaneous fire-resisting buildings.

[h] New stone and new concrete buildings for Hartford, Conn., are included with new brick or hollow-tile buildings, and additions, etc., to these two classes of buildings are included with additions, etc., to brick or hollow-tile buildings.

[i] New stone buildings for Jacksonville, Fla., are included with new brick or hollow-tile buildings; and additions, etc., to stone buildings are included with additions, etc., to brick or hollow-tile buildings.

[j] Additions, etc., to brick or hollow-tile buildings for New Britain, Conn., are included with additions, etc., to wooden buildings.

Building statistics of the leading cities of the United States, by character of operations, in 1913—Continued.

City.	Wooden buildings.								Fire-resisting buildings.							
									Brick or hollow tile.				Stone.			
	New.		Additions, alterations, and repairs.		Miscellaneous.		Total.		New.		Additions, alterations, and repairs.		New.		Additions, alterations, and repairs.	
	Number of permits or buildings.	Cost.	Number of permits or buildings.	Cost.	Number of permits or buildings.	Cost.	Number of permits or buildings.	Cost.	Number of permits or buildings.	Cost.	Number of permits or buildings.	Cost.	Number of permits or buildings.	Cost.	Number of permits or buildings.	Cost.
Norfolk, Va	275	$634,922	104	$50,615	133	$105,606	512	$791,143	146	$892,334	75	$162,270				
Oakland, Cal	2,012	4,289,016	a1,647	a 860,792			3,659	5,149,808	51	1,717,767						
Oklahoma, Okla	38	76,965	55	19,607			93	96,572	b 26	b 41,365	b 55	b 36,790				
Omaha, Nebr	746	1,877,765	164	39,310	90	33,650	1,000	1,950,725	135	1,547,275	69	302,313				
Passaic, N. J	125	274,295	130	63,975			255	338,270	62	438,100	61	176,894				
Paterson, N. J	275	617,170	273	102,319			548	719,489	60	550,790	58	85,462				
Pawtucket, R. I	206	736,550	223	81,640	49	24,860	478	843,050	c 20	c 291,500	(c)	(c)				
Philadelphia, Pa	169	366,970	56	49,950			225	416,920	5,793	25,305,490	1,636	4,603,545	14	$30,000		
Pittsburgh, Pa	450	2,500,000	246	196,800	694	400,000	1,390	3,096,800	600	6,225,000	848	4,196,000	13	275,155		
Portland, Me	170	453,275	134	162,965			304	616,240	21	783,500	18	76,075				
Portland, Oreg	2,834	4,538,765	2,463	691,740	103	369,940	5,400	5,600,445	143	1,657,385	729	433,715				
Pueblo, Colo	42	56,675	101	24,914			143	81,589	53	206,211	32	64,576				
Quincy, Ill	17	44,450	11	2,200			28	46,650	11	167,200	4	3,600	1	2,200		
Reading, Pa									221	622,000			41	114,350		
Richmond, Va	178	193,847	323	87,127			501	280,974	533	2,902,195	467	453,307				
Rochester, N. Y	1,729	5,072,764	852	457,936	81	22,398	2,662	5,553,098	161	2,645,479	205	596,934	4	219,000		
Sacramento, Cal	653	1,498,459	415	221,722			1,068	1,720,181	44	511,710	165	439,902				
Saginaw, Mich	301	394,956	89	77,636			390	472,592	7	23,100	17	38,323				
St. Paul, Minn	1,226	3,039,897	349	1,983,580	51	77,855	1,626	5,101,332	181	2,041,360	118	356,630	3	345,000		
Salem, Mass	120	227,674	111	71,211			231	298,885	4	65,000	6	33,147				
San Antonio, Tex	1,438	1,063,029	1,061	187,730			2,499	1,250,759	43	223,665	166	189,178	2	6,500		
San Diego, Cal	1,701	3,572,331					1,701	3,572,331	67	1,153,501						
San Francisco, Cal	2,131	7,242,271	2,996	1,128,340			5,127	8,370,611	156	4,253,685	180	590,000	18	3,500,000	3	$537,543
Savannah, Ga	693	367,125	66	27,500	190	204,510	949	599,135	29	728,000	45	156,950	1	50,000		
Schenectady, N. Y	1,067	2,997,673	162	78,396			1,229	3,076,069	84	1,715,612	41	176,039				
Scranton, Pa	240	657,286	215	120,776	111	196,465	566	974,527	11	114,120	50	288,912				
Seattle, Wash	3,621	4,946,110	5,388	1,256,255	240	31,675	9,249	6,234,040	34	742,800	233	366,205				
Sioux City, Iowa	528	1,335,435	185	123,131			713	1,458,566	52	357,402	d 72	d 76,152				

Somerville, Mass	292	1,219,949	81	90,830			373	1,310,779	28	555,650	4	31,300				
South Bend, Ind	319	423,853					319	423,853	40	298,077						
Spokane, Wash	494	500,303	236	67,518			730	567,821	51	478,297	114	200,228				
Springfield, Ill	194	345,005	114	88,805			308	433,810	49	270,050	51	100,154				
Springfield, Mass	638	1,725,130	423	228,949			1,061	1,954,079	125	2,534,248	143	559,138				
Syracuse, N. Y	863	2,500,000	a 748	a1,226,218			1,611	3,726,218	54	802,250			1	90,000		
Tampa, Fla	590	680,776	859	117,623			1,449	798,399	30	552,525						
Utica, N. Y	812	2,514,015	212	250,602			1,024	2,764,617	133	1,477,425	120	212,200				
Washington, D. C	283	829,178	582	120,180	574	36,741	1,439	986,099	1,571	7,510,459	1,563	1,496,804				
West Hoboken, N. J	41	58,654	72	29,760			113	88,414	44	606,122						
Wheeling, W. Va	48	80,963	292	79,979			340	160,942	23	466,300	263	195,959				
Wichita, Kans	116	348,265	16	8,575			132	356,840	30	477,525	19	63,000				
Wilkes-Barre, Pa	186	377,302	106	99,678	128	62,876	420	539,856	62	484,023	62	328,244				
Wilmington, Del									517	1,505,438	305	293,676	4	91,550	1	1,500
Worcester, Mass	908	2,607,849	a 577	a1,247,710			1,485	3,855,559	a 91	a 924,936						
Yonkers, N. Y	401	1,902,600	55	37,300			456	1,939,900	137	2,075,200	45	126,100	5	29,500		
York, Pa	25	50,000	246	123,000			271	173,000	105	262,000	244	207,400				
Youngstown, Ohio		1,464,653		e 65,350			(e)	1,530,003		e 1,319,003				(e)		
Total	82,621	174,197,886	61,967	29,121,690	5,281	2,844,832	149,869	206,164,408	21,494	226,478,584	22,542	42,661,463	153	8,047,563	98	1,260,267
Percentage of total		28.64		4.79		.47		33.89		37.23		7.01		1.32		.21

a Additions, etc., to all classes of buildings for Binghamton, N. Y., Oakland, Cal., Syracuse, N. Y., and Worcester, Mass., are included with additions, etc., to wooden buildings. New concrete buildings for Binghamton are included with new brick or hollow-tile buildings. All classes of new fire-resisting buildings for Worcester are included with new brick or hollow-tile buildings.

b All classes of new fire-resisting buildings for Oklahoma, Okla., are included with new brick or hollow-tile buildings; and additions, etc., to all classes of fire-resisting buildings are included with additions, etc., to brick or hollow-tile buildings.

c Additions, etc., to brick or hollow-tile buildings for Pawtucket, R. I., are included with new brick or hollow-tile buildings.

d New concrete buildings for Cambridge, Mass., and for Newton, Mass., are included with new brick or hollow-tile buildings. Additions, etc., to concrete buildings for Cambridge, Mass., and Sioux City, Iowa, are included, with additions, etc., to brick or hollow-tile buildings.

e The grand total only was given for number of permits or buildings for Youngstown, Ohio. New stone buildings for this city are included in new brick or hollow-tile buildings, and additions, etc., to all classes of buildings are included in additions, etc., to wooden buildings.

Building statistics of the leading cities of the United States, by character of operations, in 1913—Continued.

City.	Fire-resisting buildings.												Grand total.		Rank of cities in cost of buildings erected in 1913.
	Concrete.				Steel skeleton.				Miscellaneous.		Total.				
	New.		Additions, alterations, and repairs.		New.		Additions, alterations, and repairs.								
	Number of permits or buildings.	Cost.	Number of permits or buildings.	Cost.	Number of permits or buildings.	Cost.	Number of permits or buildings.	Cost.	Number of permits or buildings.	Cost.	Number of permits or buildings.	Cost.	Number of permits or buildings.	Cost.	
Akron, Ohio											424	$2,384,340	2,594	$5,243,315	35
Allentown, Pa											419	1,428,500	497	1,466,000	96
Altoona, Pa	2	$113,363							35	$32,576	77	431,936	871	1,101,430	108
Atlanta, Ga	3	580,000									697	2,072,053	3,606	5,112,944	37
Augusta, Ga					2	$610,000					51	1,573,924	1,471	2,087,629	73
Bayonne, N. J	1	65,950							1	5,400	65	808,156	295	1,397,594	100
Berkeley, Cal	4	a 273,500									15	356,000	1,005	a 2,318,200	68
Binghamton, N. Y	(b)	(b)									95	741,941	993	1,756,665	82
Birmingham, Ala	1	15,000			14	2,959,455	10	$377,172			373	4,342,176	3,641	6,429,735	30
Boston, Mass	36	1,006,075	28	$181,612	44	2,713,710	63	298,202	2	325	1,938	16,496,933	4,549	22,780,011	7
Bridgeport, Conn	22	10,225									172	1,189,564	1,103	2,951,647	58
Buffalo, N. Y					19	1,384,000				c1,996,000	317	7,161,360	4,059	13,300,360	15
Butte, Mont	3	150,000									3	150,000	342	1,044,622	111
Cambridge, Mass	(d)	(d)	(d)	(d)							100	5,675,240	527	6,588,685	29
Camden, N. J	2	155,000									743	1,989,545	966	2,142,460	70
Canton, Ohio											73	381,870	554	1,006,025	115
Charleston, S. C											107	240,863	576	589,296	134
Cincinnati, Ohio											e 589	e 4,819,000	2,952	7,543,475	26
Cleveland, Ohio	100	(f)	5	(f)	22	(f)	1	(f)			1,198	13,836,970	6,160	22,543,365	8
Columbus, Ohio	43	668,835	5	1,220					1,341	309,921	2,289	4,103,381	3,888	5,508,408	33
Covington, Ky											(g)	450,739	(g)	599,496	133
Dayton, Ohio	28	458,110			12	15,650					210	1,594,410	1,189	3,288,350	55
Des Moines, Iowa	3	150,000									12	450,000	709	1,755,759	83
Detroit, Mich	39	3,455,800	5	122,400	10	1,192,150	3	33,400			1,384	14,289,985	9,326	30,434,380	6
Dubuque, Iowa											11	230,100	86	371,080	143
Duluth, Minn	(h)	(h)	(h)	(h)	(h)	(h)	(h)	(h)	(h)	(h)	181	2,834,389	1,505	4,026,011	49
Elizabeth, N. J	13	16,467			8	99,837					104	1,121,905	601	2,479,666	65
Elmira, N. Y	74	204,000									103	349,000	251	562,000	136
Erie, Pa											95	858,224	1,420	2,414,423	67

Evansville, Ind.											179	1,187,143	1,125	1,864,899	81
Fall River, Mass.	11	12,000									41	467,375	557	1,507,855	91
Fitchburg, Mass.	5	21,950	1	350	1	6,255			4	21,255	38	259,401	286	681,563	128
Fort Worth, Tex.	10	224,558	3	6,725	1	65,000	2	500			106	1,453,898	616	2,113,553	72
Galveston, Tex.	5	449,200							14	6,135	68	719,369	949	1,224,516	105
Grand Rapids, Mich.	73	397,875	1	2,500	1	1,300,000					226	2,678,169	1,726	4,169,000	45
Harrisburg, Pa.	3	94,650			1	100,000			3	1,975	487	1,423,090	585	1,467,040	95
Hartford, Conn.	(i)	(i)	(i)	(i)					44	83,890	373	4,498,220	1,169	5,784,751	32
Haverhill, Mass.	10	26,400									34	328,500	267	1,015,115	114
Hoboken, N. J.	1	25,000							7	162,000	103	446,081	210	490,040	138
Holyoke, Mass.	5	362,000									83	1,055,777	215	1,379,882	101
Houston, Tex.	21	1,275,700	20	1,415							363	2,855,850	3,525	5,058,249	38
Indianapolis, Ind.	27	274,790			56	2,066,550			259	513,747	443	4,298,379	5,400	9,361,973	21
Jacksonville, Fla.											155	1,582,924	1,115	2,974,652	57
Kalamazoo, Mich.	3	90,000			1	100,000				10,000	12	400,000	387	900,000	119
Kansas City, Mo.	24	2,369,500	1	15,000					372	194,490	1,090	6,651,485	3,719	10,578,162	18
Knoxville, Tenn.											132	164,741	650	410,698	139
Lawrence, Mass.	8	19,500	2	1,100							32	160,170	258	869,229	121
Lincoln, Nebr.	7	24,075							9	39,700	91	968,560	491	1,678,350	84
Little Rock, Ark.											180	608,839	831	1,333,323	102
Los Angeles, Cal.	34	3,163,937			10	4,367,000					1,624	15,686,321	16,442	31,641,921	5
Louisville, Ky.	1	30,000			2	325,000					488	1,685,760	2,402	3,617,540	52
Lowell, Mass.					2	67,000					61	498,715	531	969,868	116
Lynn, Mass.	8	95,000			2	800	3	5,600			44	711,300	625	1,673,278	85
Manchester, N. H.			1	129,000	4	535					72	364,690	1,035	1,626,569	87
Milwaukee, Wis.	20	1,200,000			5	1,293,000					1,525	8,993,000	4,015	13,647,624	14
Minneapolis, Minn.	102	3,438,175	49	132,205	37	371,425	13	68,800			799	6,850,190	6,135	12,857,935	17
Montgomery, Ala.											80	235,884	513	512,303	137
Nashville, Tenn.											397	1,221,520	1,458	1,643,486	86
New Bedford, Mass.	5	50,000							10	30,000	38	1,126,500	1,245	3,067,700	56
New Britain, Conn.											55	549,660	414	1,072,300	110
Newton, Mass.	(d)	(d)									37	300,294	539	1,594,065	88
New York, N. Y.	5	465,000			114	40,819,800	731	3,083,959			7,521	106,097,450	9,443	107,104,707	1

a Includes cost of buildings at the University of California, permits for which were not issued through the city of Berkeley.

b Additions, etc., to all classes of buildings for Binghamton, N. Y., Oakland, Cal., Syracuse, N. Y., and Worcester, Mass., are included with additions, etc., to wooden buildings. New concrete buildings for Binghamton are included with new brick or hollow-tile buildings. All classes of new fire-resisting buildings for Worcester are included with new brick or hollow-tile buildings.

c The total under miscellaneous fire-resisting operations for Buffalo, N. Y., is for municipal work. Under this heading for San Diego, Cal., are included miscellaneous operations" for all classes of buildings.

d New concrete buildings for Cambridge, Mass., and for Newton, Mass., are included with new brick or hollow-tile buildings. Additions, etc., to concrete buildings for Cambridge, Mass., and Sioux City, Iowa, are included, with additions, etc., to brick or hollow-tile buildings.

e The total only was given for fire-resisting buildings for Cincinnati, Ohio, i. e., 589 permits or buildings, costing $4,819,000. The percentage for this value, equivalent to seventy-nine one hundredths of 1 per cent, is included in the percentage for total fire-resisting buildings. Additions, etc., to all classes of buildings for Cincinnati are included with additions, etc., to wooden buildings.

f The cost of new concrete and of new steel-skeleton buildings for Cleveland, Ohio, is included with the cost of new brick or hollow-tile buildings, and the cost of additions, etc., to concrete buildings and additions, etc., to steel-skeleton buildings is included with additions, etc., to brick or hollow-tile buildings.

g The number of permits or buildings for Covington, Ky., and Fort Wayne, Ind., was not given; nor was it given for additions, etc., to concrete buildings for Pittsburgh, Pa.

h With new stone buildings for Duluth, Minn., are included additions, etc., to stone buildings; new concrete buildings and additions, etc., to concrete buildings; new steel-skeleton buildings and additions, etc., to steel-skeleton buildings; and miscellaneous fire-resisting buildings.

i New stone and new concrete buildings for Hartford, Conn., are included with new brick or hollow-tile buildings, and additions, etc., to these two classes of buildings are included with additions, etc., to brick or hollow-tile buildings.

Building statistics of the leading cities of the United States, by character of operations, in 1913—Continued.

City.	Fire-resisting buildings.												Grand total.		Rank of cities in cost of buildings erected in 1913.
	Concrete.				Steel skeleton.				Miscellaneous.		Total.				
	New.		Additions, alterations, and repairs.		New.		Additions, alterations, and repairs.								
	Number of permits or buildings.	Cost.	Number of permits or buildings.	Cost.	Number of permits or buildings.	Cost.	Number of permits or buildings.	Cost.	Number of permits or buildings.	Cost.	Number of permits or buildings.	Cost.	Number of permits or buildings.	Cost.	
Norfolk, Va	7	214,600			2	173,000			25	321,376	255	1,763,580	767	2,554,723	64
Oakland, Cal	29	1,662,649							9	5,027	*a* 89	*a* 3,385,443	3,748	8,535,251	23
Oklahoma, Okla											81	78,155	174	174,727	147
Omaha, Nebr	2	280,000							30	30,420	236	2,160,008	1,236	4,110,733	46
Passaic, N. J											123	614,994	378	953,264	117
Paterson, N. J	27	112,330	8	6,800					3	1,785	156	757,167	704	1,476,656	93
Pawtucket, R. I											20	291,500	498	1,134,550	106
Philadelphia, Pa	29	4,634,855	3	135,000							7,475	34,708,890	7,700	35,125,810	3
Pittsburgh, Pa	14	70,000	(*b*)	208,000	18	1,200,000			60	200,000	1,553	12,374,155	2,943	15,470,955	11
Portland, Me									2	8,500	41	868,075	345	1,484,315	92
Portland, Oreg	73	2,759,595	*c* 140	*c* 357,180	6	2,062,000	(*c*)	(*c*)	219	86,595	1,310	7,356,470	6,710	12,956,915	16
Pueblo, Colo	8	4,525									93	275,312	236	356,901	144
Quincy, Ill	1	80,000			2	2,800					19	255,800	47	302,450	145
Reading, Pa	19	19,500							137	93,000	418	848,850	418	848,850	123
Richmond, Va											1,000	3,355,502	1,501	3,636,476	51
Rochester, N. Y	114	431,471	75	61,532	28	128,740	19	5,870			606	4,089,026	3,268	9,642,124	20
Sacramento, Cal	10	738,500	1	5,765							220	1,695,877	1,288	3,416,058	54
Saginaw, Mich									1	35,000	25	96,423	415	569,015	135
St. Paul, Minn	44	317,565									346	3,060,555	1,972	8,161,887	25
Salem, Mass											10	98,147	241	397,032	142
San Antonio, Tex	20	467,900							3	4,600	234	891,843	2,733	2,142,602	69
San Diego, Cal	23	1,354,573			5	83,200			*d* 1,879	*d* 862,330	1,974	3,453,604	3,675	7,025,935	28
San Francisco, Cal	102	3,745,389	20	40,036							479	12,666,653	5,606	21,037,264	9
Savannah, Ga	2	7,000									77	941,950	1,026	1,541,085	90
Schenectady, N. Y											125	1,891,651	1,354	4,967,720	40
Scranton, Pa					1	36,000					62	439,032	628	1,413,559	99
Seattle, Wash	(*e*)	(*e*)	(*e*)	(*e*)	*e* 26	*e* 1,821,700	*e* 55	*e* 156,370			348	3,087,075	9,597	9,321,115	22
Sioux City, Iowa	3	195,000	(*f*)	(*f*)							127	628,554	840	2,087,120	74
Somerville, Mass	16	38,000	1	800	1	2,000	1	2,000	5	11,650	56	641,400	429	1,952,179	77

South Bend, Ind	23	131,759									63	429,836	382	853,689	122
Spokane, Wash	8	482,700			5	1,700,189					178	2,861,414	908	3,429,235	53
Springfield, Ill											100	370,204	408	804,014	125
Springfield, Mass											268	3,093,386	1,329	5,047,465	39
Syracuse, N. Y	69	147,150							120	441,150	a 244	a 1,480,550	1,855	5,206,768	36
Tampa, Fla	2	70,000			1	50,000					33	672,525	1,482	1,470,924	94
Utica, N. Y											253	1,689,625	1,277	4,454,242	43
Washington, D. C	8	22,600			3	478,842			1	4,598	3,146	9,513,303	4,585	10,499,402	19
West Hoboken, N. J											44	606,122	157	694,536	127
Wheeling, W. Va											286	662,259	626	823,201	124
Wichita, Kans	2	160,000			1	30,000					52	730,525	184	1,087,365	109
Wilkes-Barre, Pa	8	34,225			5	536,000					137	1,382,492	557	1,922,348	79
Wilmington, Del											827	1,892,164	827	1,892,164	80
Worcester, Mass											a 91	a 924,936	1,576	4,780,495	42
Yonkers, N. Y	12	71,300							4	20,800	203	2,322,900	659	4,262,800	44
York, Pa											349	469,400	620	642,400	131
Youngstown, Ohio											(g)	1,319,003	g 1,225	2,849,006	59
Total	1,437	39,684,821	369	1,408,640	472	68,161,638	901	4,031,873	4,599	5,534,245	h 52,654	h 402,088,094	g 203,748	608,252,502	
Percentage of total		6.53		.23		11.21		.66		.91		h 66.11		100.00	
Atlantic City, N. J													1,773	2,827,422	60
Baltimore, Md													13,321	14,053,802	13
Bay City, Mich													421	402,515	140
Brockton, Mass													469	1,240,960	104
Brooklyn, N. Y													10,962	34,762,506	4
Chattanooga, Tenn													2,213	1,102,775	107
Chester, Pa													322	623,200	132
Chicago, Ill													10,792	89,668,427	2
Dallas, Tex													2,233	8,480,580	24
Davenport, Iowa													377	1,428,921	98
Denver, Colo													2,034	2,797,148	62
East St. Louis, Ill													652	1,021,118	113
El Paso, Tex													1,025	1,444,264	97
Flint, Mich													469	668,733	130
Fort Wayne, Ind													(b)	2,114,757	71

a Additions, etc., to all classes of buildings for Binghamton, N. Y., Oakland, Cal., Syracuse, N. Y., and Worcester, Mass., are included with additions, etc., to wooden buildings. New concrete buildings for Binghamton are included with new brick or hollow-tile buildings. All classes of new fire-resisting buildings for Worcester are included with new brick or hollow-tile buildings.

b The number of permits or buildings for Covington, Ky., and Fort Wayne, Ind., was not given; nor was it given for additions, etc., to concrete buildings for Pittsburgh, Pa.

c Additions, etc., to steel-skeleton buildings for Portland, Oreg., are included with additions, etc., to concrete buildings.

d The total under miscellaneous fire-resisting operations for Buffalo, N. Y., is for municipal work. Under this heading for San Diego, Cal., are included miscellaneous operations for all classes of buildings.

e New concrete buildings for Seattle, Wash., are included with new steel-skeleton buildings; and additions, etc., to concrete buildings are included with additions, etc., to steel-skeleton buildings.

f New concrete buildings for Cambridge, Mass., and for Newton, Mass., are included with new brick or hollow-tile buildings. Additions, etc., to concrete buildings for Cambridge, Mass., and Sioux City, Iowa, are included, with additions, etc., to brick or hollow-tile buildings.

g The grand total only was given for number of permits or buildings for Youngstown, Ohio. New stone buildings for this city are included in new brick or hollow-tile buildings, and additions, etc., to all classes of buildings are included in additions, etc., to wooden buildings.

h The total only was given for fire-resisting buildings for Cincinnati, Ohio, i. e., 589 permits or buildings, costing $4,819,000. The percentage for this value, equivalent to seventy-nine one hundredths of 1 per cent, is included in the percentage for total fire-resisting buildings. Additions, etc., to all classes of buildings for Cincinnati are included with additions, etc., to wooden buildings.

Building statistics of the leading cities of the United States, by character of operations, in 1913—Continued.

City.	Fire-resisting buildings.												Grand total.		Rank of cities in cost of buildings erected in 1913.
	Concrete.				Steel skeleton.				Miscellaneous.		Total.				
	New.		Additions, alterations, and repairs.		New.		Additions, alterations, and repairs.								
	Number of permits or buildings.	Cost.	Number of permits or buildings.	Cost.	Number of permits or buildings.	Cost.	Number of permits or buildings.	Cost.	Number of permits or buildings.	Cost.	Number of permits or buildings.	Cost.	Number of permits or buildings.	Cost.	
Jersey City, N. J	......	......	......	......	......	......	......	......	......	......	......	......	1,344	$5,413,607	34
Kansas City, Kans	......	......	......	......	......	......	......	......	......	......	......	......	692	1,252,860	103
McKeesport, Pa	......	......	......	......	......	......	......	......	......	......	......	......	117	208,905	146
Macon, Ga	......	......	......	......	......	......	......	......	......	......	......	......	376	679,177	129
Malden, Mass	......	......	......	......	......	......	......	......	......	......	......	......	296	722,561	126
Memphis, Tenn	......	......	......	......	......	......	......	......	......	......	......	......	3,363	3,949,368	50
Mobile, Ala	......	......	......	......	......	......	......	......	......	......	......	......	201	400,000	141
Newark, N. J	......	......	......	......	......	......	......	......	......	......	......	......	3,075	16,317,973	10
New Haven, Conn	......	......	......	......	......	......	......	......	......	......	......	......	1,100	4,790,151	41
New Orleans, La	......	......	......	......	......	......	......	......	......	......	......	......	1,857	4,088,261	48
Peoria, Ill	......	......	......	......	......	......	......	......	......	......	......	......	695	4,092,412	47
Providence, R. I	......	......	......	......	......	......	......	......	......	......	......	......	3,184	7,289,100	27
St. Joseph, Mo	......	......	......	......	......	......	......	......	......	......	......	......	713	895,079	120
St. Louis, Mo	......	......	......	......	......	......	......	......	......	......	......	......	8,302	15,340,012	12
Salt Lake City, Utah	......	......	......	......	......	......	......	......	......	......	......	......	779	2,055,860	76
Superior, Wis	......	......	......	......	......	......	......	......	......	......	......	......	325	1,574,857	89
Tacoma, Wash	......	......	......	......	......	......	......	......	......	......	......	......	1,896	2,474,364	66
Terre Haute, Ind	......	......	......	......	......	......	......	......	......	......	......	......	658	1,027,889	112
Toledo, Ohio	......	......	......	......	......	......	......	......	......	......	......	......	2,566	5,863,321	31
Topeka, Kans	......	......	......	......	......	......	......	......	......	......	......	......	532	928,767	118
Trenton, N. J	......	......	......	......	......	......	......	......	......	......	......	......	1,178	2,068,093	75
Troy, N. Y	......	......	......	......	......	......	......	......	......	......	......	......	1,047	2,564,178	63
Waterbury, Conn	......	......	......	......	......	......	......	......	......	......	......	......	572	1,945,300	78
Woonsocket, R. I	......	......	......	......	......	......	......	......	......	......	......	......	171	2,825,525	61
Grand total	......	......	......	......	......	......	......	......	......	......	......	......	285,850	859,657,250	......

This table shows that the 147 cities included reported building operations costing $859,657,250 in 1913. Of these, 108 cities reported sufficient detail to permit the publication of statistics of building operations by classes of structures. These 108 cities reported 203,748 permits or buildings, work on which cost $608,252,502. Of this total, new buildings of every variety as reported cost approximately $516,570,492, or 84.93 per cent of the total; additions, alterations, and repairs cost $78,483,933, or 12.90 per cent; and miscellaneous operations cost $8,379,077, or 1.38 per cent, of the total—$4,819,000, or 0.79 per cent, having been reported as fire-resisting buildings unclassified.

It should be borne in mind, however, these statistics of building operations by kinds, especially in the totals, are only approximate, as many cities were unable to report strictly in accordance with the classification as given in the table. It is believed, however, that the figures as published are accurate enough to give a good idea of the relative importance of the various kinds of operations enumerated.

Taken by classes, the new wooden buildings in 1913 cost $174,197,886, or 28.64 per cent of the total cost, and new brick buildings cost $226,478,584, or 37.23 per cent of the total cost; all other new buildings cost $115,894,022, or 19.05 per cent of the total. Of the total cost of new buildings, those built of wood constituted 33.72 per cent, and those of fire-resisting material cost $342,372,606, or 66.28 per cent. Of the cost of all new fire-resisting buildings, 66.15 per cent was for brick buildings, 2.35 per cent for stone buildings, 11.59 per cent for concrete buildings, and 19.91 per cent for steel-skeleton buildings. Of the cost of all additions, alterations, and repairs—$78,483,933—37.11 per cent was for wooden buildings and 62.89 per cent for fire-resisting buildings. Of the additions to fire-resisting buildings—$49,362,243—86.43 per cent was for brick buildings, 2.55 per cent for stone buildings, 2.85 per cent for concrete buildings, and 8.17 per cent for steel-skeleton buildings.

Operations on brick buildings (new, additions, alterations, and repairs) cost $269,140,047, or 44.25 per cent of the entire cost of all operations in these 108 cities, all other fire-resisting buildings contributing $132,948,047, or 21.86 per cent. In addition to the brick or hollow tile used in the construction of brick buildings large quantities are used in foundations, chimneys to wooden buildings, and in the construction of nearly all fire-resisting buildings.

The average cost of new wooden buildings in the 108 cities shown in this table in 1913 was $2,108; of new brick buildings, $10,537; of new stone buildings, $52,598; of new concrete buildings, $27,616; and of steel-skeleton buildings, $144,410.

Wooden buildings.—Los Angeles reported, as for several years, the largest number of new wooden buildings, 10,377, in 1913, a decrease of 295 buildings from 1912. The average value per building was $1,396 in 1913, compared with $1,541 in 1912, a decrease of $145. Detroit was second in 1913, as for several years, reporting 6,531 new wooden buildings at an average cost of $2,325. This was an increase of 846 in the number of wooden buildings in 1913, and an increase of $248 in the average cost. Seattle was third in 1913, as for 1911 and 1912. The others of the first 10 cities in number of new wooden buildings in the order of their rank were: Minneapolis, Portland (Oreg.), Cleveland, Buffalo, San Francisco, Indianapolis, and Oakland.

Detroit was the leading city in 1913 in the cost of new wooden buildings, displacing Los Angeles (which was second), reporting their cost at $15,182,070, an increase of $3,378,660 over 1912. Los Angeles's new wooden buildings in 1913 cost $14,485,095, a decrease of $1,957,067 from 1912 and $696,975 less than the cost of Detroit's new wooden buildings in 1913. Cleveland, which was sixth in number of permits or buildings of this class in 1913, was third in cost; San Francisco, which was eighth in number of permits or buildings, was fourth in cost; and Boston was fifth in cost. The next cities in the cost of new wooden buildings in the order of their importance were: Buffalo, Rochester, Minneapolis, Seattle, and Portland (Oreg).

Of the leading 10 cities in the cost of all operations on wooden buildings, 5 cities, Boston, Los Angeles, Minneapolis, Rochester, and San Francisco, showed a decrease in the cost of this class of operations; and 4 cities, Buffalo, Cleveland, Detroit, and Seattle, showed increase; in one, Portland, Oreg., comparison can not be made, as the cost of operations on wooden buildings was not given for 1912. The wooden buildings reported from New York City were erected principally in the Borough of The Bronx.

Fire-resisting buildings.—New York City reported the greatest cost of fire-resisting buildings, including additions, alterations, etc., for 1913—$106,097,450, or more than one-fourth of the total cost of this class of buildings in these 108 cities. This was a decrease of $56,096,443, or 34.59 per cent, from 1912. Of the other leading 9 cities in this class of structures, 4 showed decrease compared with 1912—Boston, $3,036,543; Philadelphia, $1,354,800; San Francisco, $1,210,812; and Washington, $6,906,691; and 5 showed increase—Cleveland, $3,934,433; Detroit, $1,259,555; Los Angeles, $2,068,395; Milwaukee, $888,877; and Pittsburgh, $3,508,624.

Brick or hollow-tile buildings.—New York was the leading city in new buildings of this class in 1913, reporting 1,118 at a cost of $52,178,429, or nearly half the cost of all building operations in that city. The average cost of these buildings was $46,671. This was a decrease of 671 in number and of $96,945,607 in cost from 1912. The second city in cost of this class of buildings in 1913, as shown in the table, was Philadelphia, which reported 5,793 permits or buildings costing $25,305,490, or an average cost of $4,368. This was a decrease in number of 79, but an increase of $1,018,205 in cost, compared with 1912. The next 8 cities in cost of brick or hollow-tile buildings, in order of their rank were: Cleveland, Boston, Detroit, Washington, Los Angeles, Pittsburgh, Milwaukee, and Cambridge.

These ranks are probably relative and not actual, as some of the cities that reported no details may have exceeded these cities in the cost of this and other classes of buildings.

Stone buildings.—New stone buildings were reported from 29 of the 108 cities giving figures by classes of buildings. Of these, San Francisco reported the highest cost, $3,500,000, but was second in number of buildings, 18. This was an increase of 4 in number and of $1,203,696 in cost of buildings of this class over 1912.

Concrete buildings.—New concrete buildings were reported by 71 cities. Philadelphia was the leading city in this class of buildings in 1913, reporting them at a cost of $4,634,855, an average of $159,823, a decrease of 1 in number, but an increase of $2,134,655 in cost compared with 1912. San Francisco was the second city in this class of buildings, reporting them at a cost of $3,745,389 in 1913, a decrease of 21 in number and of $438,070 in cost from 1912. The other important cities in the construction of concrete buildings were: Detroit, Minneapolis, and Los Angeles.

Steel skeleton buildings.—New steel-skeleton buildings were reported by 37 cities. New York was the leading city in this class of buildings in 1913, the first year for which figures were procured. It reported 114 new buildings of this class, costing $40,819,800, an average of $358,068. This was more than half of the cost of all new steel-skeleton buildings reported. Los Angeles was the second city in the cost of this class of buildings, $4,367,000, in 1913. Birmingham was third, Boston fourth, and Indianapolis fifth.

SURVEY PUBLICATIONS ON CLAYS, FULLER'S EARTH, ETC.

In addition to the papers named below, certain of the geologic folios also contain references to clays, fuller's earth, etc.

These publications, except those to which a price is affixed or which are out of print, can be obtained free by applying to the Director, United States Geological Survey, Washington, D. C. The priced publications may be purchased from the Superintendent of Documents, Government Printing Office, Washington, D. C.

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NOTES ON THE OCCURRENCE AND USE OF FLINT CLAY.

By J. H. Hance.

INTRODUCTION.

Flint clay has been defined as a hard, dense clay, having conchoidal fracture and of high refractory character. Little, if any, plasticity can be developed in it even by fine grinding. It is unique for its hardness, its resemblance to flint, and the peculiar markings which are present in the clay of some localities. These markings may be dark spots producing a mottled effect, or irregular bands resembling contorted laminæ, or closed curves suggesting concretionary action. The color ranges from light gray, grayish-brown, and slate, to black, and all of these shades may appear in a single hand specimen. In many cases it closely resembles limestone both in fracture, hardness, and its peculiar ring under the hammer. Its massive nature and lack of bedding planes are also characteristic. Joint planes are well developed in some places and resemble the cleats in coal beds.

Iron pyrites and marcasite may be present in some specimens as well formed crystals nearly three thirty-seconds of an inch in diameter, in roughly spherical nests up to 2 or 3 inches across. Near the outcrop so-called "ore-pockets" are found, consisting of soft arenaceous clay with a large amount of hematite and limonite. These probably result from oxidation of the pyrite and marcasite by surface waters. Bright-red stains of hematite are also found in some places where surface waters have descended along the joint planes and brecciated faces of a flint clay bed. In such cases the iron stain seems to be confined entirely to the hard clay.

Chemically some of the flint clay appears to resemble kaolinite closely in composition, although in some samples the alumina is too high, whereas in other samples the silica is in marked excess. Following are a few analyses which bring out these relations:

Analyses of flint clay.

	$Al_2O_3.SiO_2.2H_2O$ (kaolinite).	1	2	3	4	5	6
SiO_2	46.3	61.0	41.93	44.55	46.75	44.60	34.76
Al_2O_3	39.8	26.36	38.14	39.00	38.17	40.65	48.50
Fe_2O_3	0.0	.83	1.31	1.44	.29	.80	1.26
CaO	0.0	.21	Trace.	.028	.57	.27	.76
MgO	0.0	.10	.17	.072	.12	....	.11
Alkalies	0.0	Trace.	K_2O .49, Na_2O .42	.530	.07	....	....
TiO_2	0.0	....	....	1.7	....	....	....
H_2O	13.9	11.60	12.62	13.66	14.03	14.23	14.08

1. Swallow Falls, Md., flint clay. Maryland Geol. Survey, vol. 9, p. 449, 1902.
2. Mount Savage, Md., flint clay. Am. Inst. Min. Eng. Trans., vol. 25, p. 14, 1895.
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4. Carter Co., Ky., flint clay. Pennsylvania Top. and Geol. Survey Com. Rept., p. 314, 1906–8.
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6. Olive Hill, Ky., aluminite. Kentucky Geol. Survey, series 4, vol. 1, pt. 2, p. 618.

The clay is low in fluxes and is extremely refractory, but has very high fire shrinkage. This latter feature can be overcome by first calcining the flint and then using it as grog. Preburning, however, is done only when such shrinkage is prohibitive, for it requires an extra burn, and this adds to the cost of the finished product.

USES.

Flint clay is used in a variety of ways, but is in greatest demand where refractory qualities are required. For structural purposes it finds some use in fireproofing materials, but in most cases a less refractory and more plastic clay satisfies the requirements for such products. A minor application of it is in sanitary engineering, but this small use is due to the high cost of the finished product when made with this kind of clay, and a nonrefractory clay serves the purpose just as well. For the manufacture of refractory materials, its most important use, it is generally mixed with a plastic clay, the proportions of flint to plastic clay varying with the use of the product. If toughness and resistance to abrasion are desired, the proportion is about 2 parts of plastic clay to 1 of flint. If heat resisting qualities alone are desired, the ratio is about 1 of plastic to 2 of flint. These ratios, however, depend upon so many factors, such as the properties of individual clays, both of flint and soft, and the exact treatment to be accorded the products, including shipment as well as conditions in use, that the manufacturer has to determine the proportions which best meet the requirements of each case. Its value in the refractory material industries depends chiefly on two properties—resistance to the fluxing action of molten glass and furnace melts and ability to withstand high temperatures. Silica and magnesite brick possess these properties under certain conditions, and hence can be used to some extent instead of ordinary fire brick.

HISTORY.

Flint clay seems to have been discovered in this country about 1836 or 1837, although there is some question as to whether it was first discovered in Pennsylvania or Maryland. In 1839 the Union Mining Co. at Mount Savage, Md., began operations which have been contionued ever since. The Clarion flint clay was worked at this time at Rochester, Pa., and in 1842 James Glover discovered and developed the Bolivar flint clay at Bolivar, Pa. Since that time the fire brick and other refractory material industries have been developed until the present time when next to the iron ore and the fuel they are the most essential to the steel industry.

GEOLOGIC OCCURRENCE.

The term "clay" as applied to this raw material is somewhat of a misnomer. Its specific gravity, hardness, fracture, and lack of plasticity place it in sharp contrast with clay as ordinarily defined, but its occurrence in nature and its place in the ceramic world apparently justify the usage of the term.

Although flint clay occurs in beds between shales, sandstones, coal, and soft clay, it presents some unique features. In most cases it grades above and below into soft clay, a bituminous shale, or an argillaceous shale. The change may be abrupt or it may be a gradual transition. In some mines the flint occupies the upper portion of the clay bed; it may be present exclusively in the middle or lower portion of the bed; it may occur in any or all of these positions. Slips, squeezes, and the like are ordinary features in most clay mines, and are what might be expected when such an incompetent bed lies between more competent ones of sandstone, and deformation has followed deposition. Coal may or may not accompany the clay, but the conditions under which its material was deposited were apparently somewhat similar to those favoring vegetal accumulation. In the cycle of conditions which alternately favor the formation of sands, muds, and swamps are evidently included those furnishing part or all of the material in flint clay. These conditions were rather widespread in Carboniferous time in the area occupied by the eastern extension of the interior sea of North America. The surface of the land was then close to sea level, having but lately emerged; in fact, it underwent more than one resubmergence. The general consensus of opinion is that at that time the climate was more uniform and genial than at present, and was oceanic. Under these conditions laterization was favored, and deposits rich in alumina were probably formed, both of precipitated and of transported material. In some places this material may have been accumulated under specially favorable conditions. Coastal swamps greatly restricting water currents and, at the same time, furnishing abundant organic material for reduction processes and complete rock disintegration would satisfy the requirements; also a slight oscillation of sea level would readily change the balance so as to favor successively vegetal, sand, or mud accumulation. Such an order of progression apparently did exist in Carboniferous time in this region.

Conditions of accumulation postulate a very finely comminuted particle or a precipitate, and where alumina and silica were present in about equal quantities (or the right proportions to form a compound in this case), in a physical state approaching that of a colloid, intimately mixed, and subjected to the leaching action of reducing solutions, a combination of the two radicles and that of water is most reasonable. Some hydrated aluminum silicate was undoubtedly present in the original sediment, and this probably aided in bringing about further combination. Later, under indurating conditions, part of this hydrated aluminum silicate recrystallized, forming the flint clays. The Pittsburgh coal bed was continuous at one time over most of this eastern area, and indicates a minimum thickness of sediment which overlay the clays now flint. Of the flint clays, the Bolivar and the Mount Savage appear most widely distributed, and of these two the latter seems to consist more largely of flint. This latter bed underlies the Homewood sandstone, which is uniform and persistent over wide areas. This is also the basal flint clay of importance and was subjected to the greatest load of overlying sediments; hence, induration and recrystallization would be most favored.

The so-called Cheltenham flint clays in Missouri and Illinois are regarded by Wheeler as having probably been precipitated, at least in part. The theory is plausible.

The flint clays of Missouri occur in pockets or lenses in the base of the Pennsylvanian. The flint clays of Pennsylvania, Maryland, Connecticut, and Ohio occur in beds, the more important ones underlying massive sandstones. This latter feature is important in prospecting for the clay, as the sandstone outcrops in bold ridges or strews the ground with huge bowlders and makes a good key horizon. Although flint clay is less resistant than sandstone, the nodular variety does form permanent ledges, as near Stronach, Pa. Ordinarily, however, the clay, like the coal, weathers faster and forms reentrant outcrops, which can be examined best in road or railroad cuts and stream beds. Trenches, pits, drifts, and drill holes are frequently resorted to, and assist, not only in demonstrating the presence of the clay, but also in determining its thickness, lateral extent, and character.

SAMPLING AND TESTING.

Sampling and testing constitute a feature which is extremely important and should not be neglected. At the present time there are ceramic schools and a Government bureau where such samples are handled at cost and the results are trustworthy, but a sample must be properly taken or else these analytical results mean little, or worse than nothing. The sample should be as carefully taken as that of a coal bed. It should represent the working face and not merely a thin layer. If there are portions of the bed which can be kept separate in the mining, these should be sampled separately, especially if their thicknesses are considerable, their continuity established, and their values of special note.

If the sample is taken at the outcrop, the face should be cleaned of weathered material as nearly as practicable, so as not to introduce surface contamination. One method is to take a uniform strip a foot or so wide and 2 or 3 inches deep clear across the workable portion of the bed. This workable portion should be sufficiently great to include entry and room height. The fragments of clay should then be reduced to about walnut size and be quartered to a final sample of about 60 pounds. This much is desirable if complete tests are to be made, as there is enough to replace possible losses in kiln tests. A chemical analysis is of course desirable, but the kiln and machine tests of the clay are of far more importance. Without them the chemical analysis is of little value except as an indicator.

DEVELOPMENT.

After finding and testing the clay, it is extremely important to know something of its continuity or lateral extent. This can be accomplished most cheaply by drilling and should be resorted to before any large development policy is adopted. In some districts it has been deemed sufficient merely to locate the bed, such as the Bolivar or the Mount Savage, and then start development openings; but this has resulted in some places in greater expense than a careful drilling program would have entailed. Flint clay is extremely variable in thickness and quality within very short horizontal and vertical intervals. The Mount Savage and Bolivar clays, both of unusually wide distribution, are of very low grade in most of the area involved. One company found, after a very detailed drilling program, in an area of approximately 70 square miles considered unusually productive in high-grade flint clay, that less than 5 per cent of the drill cores showed flint clay of sufficient value to mine profitably.

In this connection it is interesting to note a statement common among the producers of this kind of clay that the best flint clay is usually found near the outcrop. As greater depth of cover is attained, the clay is said to contain more silica and fluxes, and a smaller proportion of the clay itself is high-grade flint. The exact reasons for this are not clear to the writer, but they may prove to throw some light on the relations of nonplastic to plastic fire clay. The leaching action of the ground and surface waters undoubtedly plays an important part, but just what chemical actions are involved is not understood.

Another good reason for adopting a drilling program where much cover is involved, is the possible presence of good clay and coal at other horizons. This is important not only to the landowner, but also to the producer, for it may render possible a combined development which is more efficient and economical.

Raw clay is a cheap article and mining economics should be carefully attended to. The plant should be on a railroad with good shipping facilities. It is desirable to have the mine mouth near the plant, if possible. Steam, rope and gravity trams, inclines, and wagon haulage, are used to bring the mine product to the plant. Cost of installment and subsequent maintenance of a long tram line add very materially to the cost of production, and, in most cases, such a system is not used to its maximum capacity, but rather to a small percentage of it. In too many cases, therefore, this addition to the cost of production is unduly large.

The longwall retreating system of mining or a combination of this with the room and pillar system seems to the writer the most efficient for the following reasons: (1) It insures a maximum production; (2) it permits of most rapid development after the entries and headings are driven; (3) production can be maintained at a uniform rate; (4) trackage and entry maintenance are reduced to a minimum and less timber is needed underground.

The more rapidly the clay is mined the greater the efficiency effected and the longer can the clay be weathered or seasoned, features which seem to be overlooked by many producers. Storage space is required for large dumps, but surface rights are usually obtainable at small cost in such territory; for in many localities the land is valuable for its clay content only. It is true that for such mining more capital is needed at the start, and that, if the clay is mined on a royalty basis, the interest charges are greater; but this should be more than offset by the lowered cost of production. The royalty charge is the most serious and may prohibit rapid production of the raw material or practically limit it to the rate of disposal or manufacture. Seasoning the clay and increasing its uniformity would lower the cost of manufacture and thus generally improve the quality of the products.

Mule haulage is probable the cheapest method of underground transportation for this material, but track and entry conditions in many of the old clay mines are such that the mule works against too great odds and by no means attains his real capacity. It is because of the low value of raw clay that its cost laid down at the plant should be a matter of engineering science and not of the mining methods of yesterday. The miner is paid from 30 to 45 cents per ton of clay loaded on the cars underground. To this outlay must be added the cost of development, royalties, mine management and maintenance, including dead work, and transportation to the plant. A ton of flint clay laid down at the factory usually costs the company

$1 or more, a figure which seems unduly large and which might be reduced 20 or 25 per cent by adopting modern mining methods.

In regard to the care used in sorting clay much might be written. Suffice it to say that those manufacturers who are most scrupulous in permitting only the best to enter into the high-grade refractory material are those who are most successful and whose product is more in demand each year. Such producers are usually working at full capacity, even in slack times.

FUTURE DEVELOPMENT.

Flint clay resources can be roughly approximated only, except possibly by some of the larger companies interested. Much drilling and prospecting have been done, but the results are retained in private reports. The quantity available in central and western Pennsylvania is probably much greater than that which has been mined. Improved methods and combined systems of mining will, however, be necessary to obtain part of this clay at a profitable figure. There is enough already developed to last, at the present rate of consumption, for many years, but the increase in consumption is proceeding more rapidly than development. In 1913 the increase of production of fire clay over that in 1912 was 7.38 per cent. The same general relations probably hold for flint clay, so that allowing for a normal increase of production, the clay developed or in sight should last for years. In addition there is much territory which is known to be underlain by these horizons and which is as yet relatively unprospected. This, with the flint clay now known which is not worked because by itself it can not be mined at a profit but which with the accompanying soft clays and shales should yield good returns, constitutes a reserve supply for many years.

Maryland has been a steady producer of flint clay and, except for an occasional year, has increased annually in its production of the raw flint clay at the rate of about 10 per cent. (Estimated from its total fire clay production.) The clay developed or in sight will probably last for at least 25 or 30 years, allowing for a normal rate of increased production. The amount of territory unprospected but which is underlain by these beds is considerable in proportion to the area now developed, so that this State should remain an important producer for the remainder of this century at least.

Kentucky has a supply of flint clay which has scarcely been touched. Five counties in the northeastern part of the State are known to contain valuable deposits, but it is doubtful if any approximate estimate is possible. Some ground is developed along the Chesapeake & Ohio Railway, but this area is only a small part of what is still more or less inaccessible to the producer, a large part of which should contain valuable clay.

Missouri still has a large quantity of flint clay, but its deposits are probably not as extensive as those in the Eastern States.

Ohio includes the northern extension of the northeastern Kentucky field and is known to have flint-clay beds at those same horizons, but developed at few places. Its main clay resources, however, are in the plastic varieties.

BIBLIOGRAPHY OF OCCURRENCES OF FLINT CLAY.

The following bibliography contains references to most of the important articles on flint-clay occurrences in this country, but is scarcely complete. Many brief comments exist scattered through various geological reports, especially those of the State surveys, but most of these merely mention certain occurrences and do not go into any detail as to the character of the clay developed, the geological relations, or the quantity available. Aside from its technology, the clay is none too well understood. The most detailed discussions and those throwing most light on the origin of the clay are by H. A. Wheeler, T. C. Hopkins, G. H. Ashley, and S. Galpin. Other writers have contributed many details of occurrences and properties which are of value to the producer, the manufacturer, and the geologist. It is to be hoped that future study may enable us to determine the exact relations between the flint and the soft fire clay, as these will prove of considerable value to the industry, both the producing and the manufacturing ends.

Stevenson, J. J., Second Pennsylvania Geol. Survey, Ligonier Valley, KKK, 1878.

Cites a few known outcrops of the Bolivar flint clay in this valley and notes its erratic characteristics. Locates outcrops of it in Fairfield, Ligonier, Stewart, Springfield, and Wharton townships. Two analyses are given on page 249.

Kentucky Geological Survey, Analyses A, 1885–1888.

Contains analyses of a number of samples of flint clay from northeastern Kentucky and a brief comparison of this flint with some German clay as adapted to glass pot manufacture.

Cook, R. A., Am. Inst. Min. Eng. Trans., vol. 14, p. 698, 1885.

A short article on the mining and manufacture of fire brick at Mount Savage, Md. Mentions some of the peculiarities of occurrence, such as the presence of soft and hard clay in the same bed. The article is devoted principally to the technical side of the clay industry.

Kinnicutt, L. P., and Rogers, J. F., Jour. Analyt. and Appl. Chemistry, vol. 5, p. 542, 1891.

A short contribution on the fire clay at Mount Savage, Md. Gives a complete analysis, differentiating between free and combined silica. Suggests that the clay might be considered as: free sand or silica, 31.84 per cent; kaolin ($2Al_2O_3.3SiO_2.4H_2O$), 67.07 per cent; iron oxide, 0.89 per cent.

Orton, E., Jr., Ohio Geol. Survey, vol. 7, p. 218, 1893.

Notes the similarity in composition to pure kaolin (kaolinite) but states that some flint clays have a composition like that of common plastic fire clay. Also calls attention to the fact that the flinty structure accompanies clay of impure chemical character and with an absence of any of the refractory qualities. The essential feature is lack of plasticity. Quotes analyses of flint clays from Ohio, Maryland, and Kentucky. Some of these show the presence of considerable free silica with corresponding low alumina content.

Hofman, H. O., Am. Inst. Min. Eng. Trans., vol. 25, p. 14, 1895.

Gives some analyses and the results of some tests on some standard American fire clays.

Blatchley, W. S., Indiana Dept. Geology and Nat. Res., Twentieth Ann. Rept., p. 27, 1896.

Discusses the properties of refractory clays, such as insolubility, infusibility, etc. Emphasizes the importance of a low content of fluxes. Contains a general discussion of clays, with special reference to their occurrence in Indiana.

Wheeler, H. A., Missouri Geol. Survey, vol. 11, p. 201, 1896.

An excellent discussion of the mode of occurrence, chemical composition, and physical and chemical properties of nonplastic fire clays, including details of various occurrences in Missouri. Its similarity in composition to kaolinite and pholerite, its high specific gravity, hardness, compact nature, lack of plasticity, and association with deposits of hematite, all suggest the chemical precipitate theory, whereas the lenticular phases, as in Maryland, Ohio, and elsewhere, indicate secondary crystalization subsequent to deposition. Several analyses are given and the illustrations of flint clay working faces are typical.

HOPKINS, T. C., Clays and clay industries of Pensylvania, pt. I, p. 50, 1897.
Mentions details in occurrence and properties of the Bolivar flint clay. Calls attention to the concentric weathering phase, in which respect the Bolivar clay somewhat resembles basalt. Considers that this peculiarity is independent of, although in some places accompanied by, iron. Near the surface this iron is an oxide, but in the interior of the bed it is in the form of a carbonate. Contrasts the Pennsylvania occurrences with those in Missouri. Discusses the varieties of fire clay and the unique characteristics of flint clay. Suggests that the induration is due to pressure, chemical deposit, recrystallization, or a combination of these agencies. Many analyses are quoted and short descriptions of various workings of the Bolivar clay are given, accompanied by instructive photographs. Gives many interesting facts, both historical and technical, relating to the fire-brick industry, which is largely concerned with flint clay.

——— Mines and Minerals, vol. 19, p. 53, September, 1898.
A short description of plastic and flint fire clays based on their occurrence in Pennsylvania, Ohio, and West Virginia. The Bolivar and Brookville clay beds are said to produce the best flint clay in these States. The article includes a short summary of the methods of testing, mining, preparation, and manufacture, and of the uses of the clays, with a paragraph as to possible future development in the direction of working coal and clay together.

CLARK, W. B., Maryland Geol. Survey, Allegany County, p. 181, 1900.
Contains a brief description of the flint clays in this county, all of which are said to underlie the Homewood sandstone. A paragraph on mining and manufacture is included. Conditions of sedimentation in this region during Carboniferous time are sketched.

——— Maryland Geol. Survey, Garrett County, p. 213, 1902.
Gives a short description of the Mount Savage and Bolivar flint clays as known in this county, with several sections showing the stratigraphic position of each, and includes three analyses.

RIES, HEINRICH, Report on the clays of Maryland: Maryland Geol. Survey, vol. 4, p. 351, 1902.
Defines the flint clay. Speaks of the nonplasticity of flint clays and their irergular occurrence; in some places mixed with the plastic fire clay in the bed. Also notes the presence of concretionary masses of iron in the flint. Quotes some at Olive Hill. Gives analyses of the flint and high alumina clays. Other fire clays in the Pottsville and Allegheny formations near Ashland and Willard are mentioned, and a few measured sections are given. The association of some of this clay with limestone is pointed out. Except for a small band of flint, most of the clay is plastic. Brief mention is made of the uses to which these fire clays are put.

GREAVES-WALKER, A. F., Flint fire clay deposits in northeastern Kentucky: Am. Cer. Soc. Trans., vol. 9, p. 461, 1907.
Contains some notes on the flint clays in this region which the writer considers bear out the theory that flint fire clays were laid down in ponds. The occurrences in each of the five counties (Greenup, Carter, Elliott, Lewis, and Rowan) are taken up and treated in a brief manner. A number of analyses are included. Mention is made of the "aluminite" or "high alumina" flint which is present in one mine in Carter County. The writer considers that railroad extension in this region will open flint clay resources of great importance.

ASHLEY, G. H., Pennsylvania Top. and Geol. Survey Comm. Rept., 1906–8, p. 313.
Mentions the dependence of the great furnace industries of Pennsylvania upon flint clays and the resulting high value placed upon suitable refrectory material. Notes the similarity between analyses of flint clays, indianaite, and pure kaolinite. Indianaite, which is pure white, occurs at the base of the coal measures in Indiana, and may have an origin similar to that of flint clay. The Olive Hill, Ky., clay and that at Sciotoville, Ohio, occur at the base of the coal measures and are both overlain by massive sandstone or conglomerate. It is much nearer the composition of kaolinite than is shale or ordinary clay. Speaks of its smooth, fine grain, conchoidal fracture, sharp edges, and resemblance to limestone. Peculiar occurrence as an original deposit in a regular sequence of layers; in others, deposits as a secondary alteration. Cites the fact that in Clearfield, Cambria, Jefferson, and other counties, the shale between the Upper Freeport and the Mahoning coals grades in places imperceptibly into flinty shale and in other places into typical flint clay.
The widespread occurrence of a thin bed of nearly black flint clay a few inches thick within a lighter Lower Kittanning or Clarion clay in northeastern Kentucky is described. Here the gradation is rather abrupt. Attention is called to peculiar

occurrences near Sligo, and between Curwensville and Clearfield, where irregular bodies of flint clay occur in plastic clay beds, which are difficult to understand on the bases of differences of character in the original deposit. The flint clays usually occur in association with coal from which they are generally separated by some plastic clay. In such cases the flint clay may lie between, above, or below plastic clay and may occupy the entire thickness.

A peculiar mode of occurrence is described in which flint clay occurs as irregular fragments, from pellet size up to lumps 6 to 8 inches through, scattered throughout a sandstone. In other places the clay is in large masses, which grade into sandstone within short distances. It is suggested that peculiar sedimentary differences may have resulted in some of the flint clay beds. The irregular deposits are not understood, however. It has been suggested that these may be subaerial deposits.

Attention is called to the fact that these flint clays occur at a limited number of horizons only, and, although not persistent, yet over very wide areas. This vertical range is from a short distance below the Lower Kittanning coal up to 130 feet above the Upper Freeport coal. Flint clays of known or probable commercial importance are described and a few analyses are given.

Ries, Heinrich, Clays, occurrences, properties, and uses, 1908.

Discusses the various theories regarding plasticity such as (1) the water of hydration; (2) texture; (3) plate; (4) interlocking grain; (5) ball; (6) colloid; (7) molecular attraction; (8) effect of bacteria; and (9) weathering. Outlines in detail various methods of mechanical analyses and tests. The relation of chemical composition to properties and the effect of free silica and titanium are also discussed. Some of the more important physical properties are taken up. Quotes analyses of several high-grade flint clays. A brief note as to the occurrence and distribution of the fire clays, including the flint variety, and some of the various uses to which it is put. A general discussion of the methods of mining and manufacture is supplemented by illustrations of American practice. It includes also a brief statement of the known clay occurrences in each State.

Ries, Heinrich, and Leighton, H., History of the clay-working industry in the United States, 1909.

Makes brief mention of the discoveries of flint clay and subsequent development in Ohio, Missouri, Pennsylvania, Kentucky, and Maryland.

Galpin, S. L., Studies of flint clays and their associates: Am. Cer. Soc. Trans., vol. 14, p. 301, 1912.

A detailed study undertaken to determine the nature of the differences between plastic and nonplastic fire clays. The following summary is based upon geologic occurrences, dehydration tests, and microscopic examination: (1) Flint clays have been formed by the setting and recrystallization of fine-grained, largely colloidal sediments, which have been purified mainly through the agency of carbon dioxide in the waters transporting and depositing them and by the leaching action of plant roots. The products of recrystallization are mainly kaolinite with minor amounts of hydrated micas; (2) the "semiflint" or "soft clays" have been derived from the flint clays through metamorphism by pressure and heat, resulting in a conversion of much kaolinite into hydromicas and the development of a completely microcrystalline structure of coarser texture than that of the original flint clay; (3) the plastic fire clays associated with flint clays have resulted from long weathering of the "semiflint" or "soft clays" and are structurally more crystalline than the fire clays which have never been "set." They also differ from those clays in containing a higher percentage of hydromica, kaolinite in all probability forming the basis of other plastic fire clays; (4) the change from muscovite through hydrated or hydromicas to kaolinite may take place without the destruction of the original structure, indicating the possibility of an isomorphous series embracing all of these minerals; (5) knowledge of the micro structure and composition of a clay may be used to explain and predict peculiarities in its physical and chemical behavior.

Hoeing, J. B., Kentucky Geol. Survey, ser. 4, vol. 1, pt. 2, 1913.

Contains a short historical sketch of the Olive Hill and Ashland districts of eastern Kentucky. The two districts are considered separately because of the difference in origin, quality, and geologic age of the fire clays which are associated with the Mississippian limestone. The Olive Hill district includes approximately the western half of Greenup and Carter counties, the eastern and southeastern parts of Rowan County, and the northwestern part of Elliott County. The Ashland district includes the higher fire clays found in the coal measures in Carter, Greenup, and Boyd counties, the most prominent beds occurring near the horizon of the "Ferriferous" limestone.

The author considers that part of the coal at least "has been formed from decomposition and solution of the Mississippian limestone in place, the other deposits have been formed as a redeposition product from the breaking up of limestone and flint clays." A distinction is drawn between "residual flint clay" and "transported or sedimentary flint clays," the deposits in and below the conglomerate being referred to the latter class. The evidence indicating the sedimentary origin of some of the fire-clay deposits of the Olive Hill district and of the residual origin of a large per cent of the bowlder flint clays is summarized. Mention is made of the flint clays of Missouri, Kentucky, Pennsylvania, Ohio, and Maryland, and the author concludes that the flint of the Olive Hill district is lower stratigraphically than that of the last three States named. Tables showing the results of fire shrinkage, porosity, and melting-point tests on various flint and plastic clays and on special brick are quoted.

The geologic occurrence of the clays is briefly discussed and the various deposits are considered, many analyses being quoted. Short descriptions are given of the various plants in each district. One chapter is devoted to the origin and nature of clay, its classification as to origin and use, minerals present, and chemical and physical properties of clays.

A report on the technology of Kentucky clays, including chemical and mechanical analyses and burning tests, by H. D. Easton, is included in this volume.

GEMS AND PRECIOUS STONES.

By Douglas B. Sterrett

INTRODUCTION.

The precious and semiprecious stone mining industry of the United States in 1913 was marked by a fairly large output of sapphire, a real advance in the work of testing the Arkansas diamond field, a greater activity in the Nevada opal field, and by a decrease in the output of the majority of the other gem minerals mined. The sapphire came chiefly from Montana and consisted of both blue and varicolored gems and culls for mechanical purposes. In Arkansas one diamond-washing plant was in operation about three months and recovered several hundred diamonds, and the construction of another plant was pratically completed. Many new claims were located in the Nevada opal field, development of which, along with those previously opened, resulted in a fairly large output of beautiful gems.

Prospecting work at the emerald mine near Shelby, N. C., was continued during the first part of 1913, but the last find of emeralds was made in August, 1912. Prospect work was renewed at the Ruby mine in Cowee Valley, Macon County, N. C., and is being continued into 1914. The output of the gem minerals tourmaline, spodumene, etc., in southern California was small, but some good gem material was obtained. The exploitation of the less valuable native semiprecious stones has continued with fair success, but the increasing use of cheap, artificial products is making big inroads on this industry.

ACKNOWLEDGMENTS.

The writer wishes here to express his appreciation of the assistance given by a large number of people in the preparation of this report. It is not possible to name individually all of those who have supplied information, such as statistics of production and names of new producers, but such help is greatly appreciated. Other persons have assisted either by supplying detailed information, loaning specimens, or rendering personal assistance in the examination of mines and prospects, and acknowledgment is here made of the kindness of F. M. Myrick, of Johannesburg, Cal.; Joseph Ward, of Barstow, Cal.; Scott Lewis, of Los Angeles, Cal.; Don Maguire, of Ogden, Utah; A. L. Delkin, of Seattle, Wash.; J. H. Mosher, of Glendive, Mont.; Paul E. Hanson, of Billings, Mont., George Howe, Robert Bickford, and C. B. Hamilton, of Norway, Me.; Perien Dudley, of Buckfield, Me.; F. H. C. Reynolds, of Boston, Mass.; Leon Allen, of Keene, N. H.; F. M. Lynch, of Birmingham, Ala.; A. Q. and H. L.

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AGATE.

CALIFORNIA.

A deposit of fine blue chalcedony or agate was prospected during 1913, by F. M. Myrick, about 37 miles east of Johannesburg and about 2 miles northeast of Lead Pipe Spring, in the Death Valley region, California. The deposit was discovered by Joe L. Foisie and located in January, 1911, as the Sard claim. The title was allowed to lapse and new locations were made by Mr. Myrick, with the approval of Mr. Foisie, in May, 1913, under the names Blue Moonstone and Moonstone claims. The region is desert with rough lava capped hills and washfilled valleys, which drain northward. The chalcedony deposits are about 3,000 feet above sea level.

White to gray ash and conglomeratic tuff beds occupy the lower ground, with a heavy flow of dark-red rhyolite overlying and capping the hills. This rhyolite is vesicular in places and has been badly fractured and crushed. Other lava flows occupy higher hills and mountains to the south. In places a layer of gray perlite is exposed at the base of the rhyolite, but the contact between the rhyolite and the underlying ash beds is generally concealed by loose débris and talus. Blue chalcedony has been found over parts of three claims in the lower portion of the rhyolite or loose in the talus below. The best deposit is on the Blue Moonstone claim on the north side of a small knob. The lower contact of the rhyolite capping this knob is concealed by talus, and, so far, the blue chalcedony from this claim has been picked up from the talus where it occurs in lumps of less than an ounce to several pounds weight associated with the red rhyolite matrix. It is probable that prospecting above the talus bearing the chalcedony would uncover the matrix in place. The occurrence on the other claims is similar, but a little of the chalcedony was found in place in the vesicular rhyolite.

The blue chalcedony occurs as fillings in joints, fractures, and vesicular cavities in the rhyolite forming veins and irregular masses. Much of it is very delicately banded, showing straight, curved, or angularly bent layers as in fortification agate. In some specimens the agate passes into crystal quartz, lining or filling geode cavities. In others, the cavities are lined with rounded mammillary deposits of chalcedony. Small fragments of red rhyolite are inclosed in some of the deposits of chalcedony.

Various grades of chalcedony are found ranging from dull semi-translucent to highly translucent. The range of colors noted are dull bluish-gray, bluish-gray with a tint of green, blue tinted with lavender, and lavender. The brighter colors are not so common as the dull ones, and a quantity of the chalcedony which appears strongly colored in the hand specimens proves dull and uninteresting when cut. The apparent depth of color of the rough material is due, in many cases, to the bulk of the chalcedony or the shading caused by the inclosing shells of rhyolite.

The cut stones show the various colors mentioned above with or without banding. The dull-colored stones have no special beauty, but the stronger colored gems are very pretty and can be used in various forms of jewelry, such as cuff buttons, scarf pins, brooches, pendants, and bead necklaces. Very pretty bead necklaces have been made up with beads of the lavender-blue chalcedony alternating with rose quartz. The color of the blue chalcedony is not so pleasing under artificial light, but the better gems are not devoid of beauty even there. Some gems have been cut inclosing patches of the red rhyolite matrix with odd effects. Cut gems sold at the California beaches have been hailed as "blue moonstone," the people recognizing the similarity of this chalcedony and the white or gray varieties wrongly sold as "moonstone" along the California coast.

A deposit of cloudy amethyst-colored chalcedony associated with a peculiar leathery-white asbestos-like mineral was opened by Mr. Myrick near his bloodstone deposit described later under jasper. The chalcedony occurs in lenses in a gash vein cutting altered basalt. The vein filling consists chiefly of the chalcedony and a mashed asbestos-like material. The latter is hydrous silicate of magnesium of leathery claylike consistency when moist. It may be an impure hornblendic mineral or possibly allied to meerschaum. This chalcedony has not been tested as a possible ornamental stone, though the color is rather attractive. Lumps of the chalcedony left exposed to the desert sun for several months bleached to a dull gray to a depth of about one-fourth of an inch.

Agate or chalcedony, containing bright-red inclusions, found in the Death Valley region of San Bernardino County, Cal., was mentioned in this report for 1911. It was discovered by F. M. Myrick, after whom it was locally called "myrickite." The deposit is about 45 miles north of east of Johannesburg and about 15 miles northeast of Lead Pipe Spring. According to Mr. Myrick the mineral is obtained from a shallow shaft in a rough lava-capped hill. The chalcedony occurs in bunches and small masses scattered through the lava. The mineral consists of translucent gray chalcedony and a little white chalcedony through which bright red spots and patches of color are irregularly distributed. The majority of the color occurs in irregular mosslike patterns and is exceptionally bright vermilion-red. Robert Masterson, of Johannesburg, suggested that the coloring was due to cinnabar (mercury sulphide) and that was found to be the case on making blowpipe tests on the mineral. The cut gems show striking contrasts between gray, white, and vermilion-red and should satisfy the desire of the wearer for bright colors.

Mr. Myrick has hesitated placing too much of the "myrickite" on the market since he has discovered that the rich color darkens after long exposure to light. Material left on the dump exposed to the desert sun for a year was discolored, showing a dull purplish red. To what extent the color will deteriorate under conditions of wear in jewelry is not known, but it is not believed the discoloration will be sufficiently rapid to cause the material to be discarded for gem use. The deposit will be tested for its value as a possible source of quicksilver as well as for gem material.

Specimens of chalcedony from the Mohave desert region of California were received from Mr. Scott Lewis, of Los Angeles, Cal. Some of this material was translucent, dimly banded pale lilac or amethystine agate. Specimens cut approximately parallel with the banding show a mottled, cloudlike effect, which is best seen in transmitted light. This lilac-tinted chalcedony has been sold under local name of "Mohave moonstone." Another variety is translucent gray chalcedony with pure white patches or tufts, like snowflakes, scattered through it. The white may be opal occupying pore space in the chalcedony. This variety has been sold as "frost stone" in California. The "Mohave moonstone" and "frost stone" are found on a malpais-capped hill, about 10 miles from Muroc station, on the Santa Fe Railway. Another variety consists of translucent chalcedony mottled with white and dark leek-green streaks, possibly due to inclusions of chloritic material. This comes from near Rosamond, Kern County.

Various types of chalcedony were sent to the Survey by Mr. Joseph Ward, of Barstow, Cal., from deposits he had discovered in the Death Valley region. Among these were gray, blue, red, yellow, and yellowish-green chalcedony. Some of this material was banded like agate, with or without colored layers. Most of the yellowish-green variety contained inclusions of white tufts or patches resembling opal. Several of these varieties of agate were suitable for cutting for the semiprecious stone trade, and the yellowish-green variety, which Mr. Ward calls "amberine," might meet a good sale in the tourist trade.

COLORADO.

Blue chalcedony has been handled by J. D. Endicott, of Canon City, Colo., for several years. Mr. Endicott obtains his supply from his claims on Thirty-one Mile Mountain, about 7 miles west of Guffy, in Park County.

MONTANA.

The fine quality of the Montana moss agate and mocha stone was mentioned in this report for 1911, with a brief description of a collection loaned to the Geological Survey by Mr. J. H. Mosher, of Glendive, Mont. Mr. Mosher has again kindly loaned the Survey another collection of selected cut gems, some of which are mounted in filigree gold settings. Mr. Paul E. Hanson, of Billings, Mont., also kindly loaned a collection of cut stones and furnished rough specimens of the agate, with notes on their occurrence.

All the moss agates cut for jewelry are obtained from pebbles and cobbles gathered along Yellowstone River and its tributaries and from the mesas and buttes for many miles away from the river. These agates are derived from gravel beds, but their original source is not known. They occur in rounded cobbles, some of which are covered with a chalklike but hard coating of silica. Some of the cobbles are geodes composed of chalcedony or agate containing cavities lined with quartz crystals. Such geodes are found in calcareous formations at some localities. Mr. Hanson states that he has observed many such geodes in place, at the headwaters of Boulder River, in some of which a man could stand upright. Nowhere has he observed in the chalcedony of the geodes in place the mosslike markings which are found in similar goedes and fragments in the gravel beds lower down the rivers. He therefore believes that the dendritic markings have been imparted to the agate after it has been liberated from the original rock matrix in the mountains.

The dendrite stains of the moss agate are due to thin films and deposits of oxides of manganese and iron in the seams and pores of the chalcedony. These stains are introduced into the agate by the solutions which spread by capillary action through every seam from the larger channels into still other channels and finally into the pore spaces of the chalcedony. In this way various markings of black, brown, and red in dendritic shapes are produced. The quality of the gems that a fragment of rough agate will yield depends in a large measure on the skill of the lapidary. The rough agates are broken or sawed into slices and gems are developed from those parts which are favorably marked. The majority of the dendrites are black or dark brown. Red stained agates are less common, but furnish beautiful gems. Much of the agate is of fine quality, with pure translucent light-gray to bluish-gray color. Some of the agate is banded but much of it is not visibly so.

Among the cut stones loaned by Mr. Mosher, of Glendive, are the following:

A flat rectangular stone 7.6 centimeters long and 2 centimeters wide, with beveled edges and corners. This contains about 20 black dendrites ranging from 1 to 8 millimeters high, occupying scattered positions, such as may be seen in a group of wooded isles in a lake or along the coast of a northern country. The agate is slightly banded and shows a hazy effect before distant islands and trees.

An oval stone 2.9 by 2.0 centimeters shows a landscape with or without water, according to the fancy of the viewer, with a group of trees to one side and smaller trees or shrubbery in the middle and to the other side. This agate is delicately banded and of fine, pure translucent gray quality.

Another slightly smaller oval gem portrays a lake with narrows in the distance, wooded shore lines, and islands with perfect reflections of the trees in the water. The dendrites are reddish-brown and there is a slight brownish clouding of the water area.

In two closely matched oval stones about 2 by 1.4 centimeters there are marsh scenes with a dead tree, sedge grass in autumn colors, and water.

A small cabochon gem 1.8 by 1.2 centimeters contains a perfect representation of an Indian tepee under two tall slender trees. Even the poles of the tepee are plainly visible..

Another small cabochon gem 2.0 by 0.9 centimeters shows a perfect grove of small bushy trees with brown foliage and black trunks. The lower part of agate contains a peculiar yellowish stain.

A beautiful pendant, 3.7 centimeters long, 1.5 centimeters wide at the lower end and tapering to 3 millimeters at the top, shows a dendrite-like pine tree in fine translucent gray agate.

A number of gems contain one or more dendrites resembling many varieties of moss, ferns, or seaweeds with delicate spreading branches. Among them is a thin, round cabochon stone 2.3 centimeters in diameter, which shows three branching ferns or seaweeds with extremely delicate structure. In other stones various objects, such as the "Mexican eagle" with spread wings, the Austrian eagle, a battleship with fighting top, etc., are readily recognized.

Among the cut stones loaned by Mr. Hanson, of Billings, are some showing beautiful dendrites resembling trees, patches of moss, or ferns, and a few with good landscapes. Mr. Hanson's collection of rough and cut agates was prepared with a view to showing the mode of occurrence of the moss agate and the method of elaboration.

OREGON.

Mr. Don Maguire, of Ogden, Utah, reports the occurrence of fine brown-stained moss agate on McAllisters Butte, near Ochoco River, in Crook County, Oreg.

WASHINGTON.

Specimens of rough and cut lavender-blue chalcedony were received from Mr. A. L. Delkin, of Seattle, Wash. The rough agate was gathered from the sage-brush country around Ellenburg and is reported to be rare. The material is very similar in appearance to that from Myrick's prospect in California, described above. Mr. Delkin reports a good sale for the cut gems.

AMETHYST.

MAINE.

Of the several localities where amethyst has been found in Maine one was examined in June, 1913. This is on Deer Hill in the town of Stow, 1¾ miles N. 30° E. of North Chatham, N. H. Deer Hill was also visited by E. S. Bastin [1] in 1906, but more prospects have been opened since that time. The deposit is on the land of Chester Eastman in the ridge extending south from Deer Hill. One of the new prospects is 20 feet long and 8 feet deep, and other similar pits have been opened within a distance of 150 feet northeast along the west side of the ridge. The old work consisted of numerous small pits in the gravelly soil of the ridge for a distance of about 100 yards northeast of the later work.

The country rock is chiefly granite gneiss, but pegmatite covers much of the ridge at the amethyst locality and is the rock opened by the prospects. A large ledge of quartz is inclosed in the pegmatite having a strike of N. 40° E. and a dip of 35° SE. Geode-like pockets of quartz crystals were opened in the later work along the contact of

[1] Geology of the pegmatites and associated rocks of Maine: U. S. Geol. Survey Bull. 445, p. 102, 1911.

the quartz ledge with the feldspathic part of the pegmatite. No amethysts were left around the new openings, if any were found there, but abundant opaque white and transparent colorless quartz crystals are scattered over the dumps. Numerous pale amethyst-colored quartz crystals were observed around the earlier pits to the northeast. Some of these are quite clear.

An amethyst crystal measuring 2½ by 3 inches was plowed up in a field on the land of Ezra Healds, 1 mile north of North Chatham and about half a mile southwest of the Deer Hill locality. This crystal is irregular in shape and consists of both amethyst and smoky quartz. The colors are not evenly distributed, but are streaked together in parts of the crystal. A portion of the crystal has a rich amethyst color.

Specimens of fine amethyst were seen in the possession of George Howe, of Norway, Me., obtained from a prospect on Pleasant Mountain, in the town of Denmark. These amethysts were rich dark purple and showed a strong garnet-red under artificial light, like the better Siberian amethysts.

NORTH CAROLINA.

A few amethystine quartz crystals and one amethyst of good quality have been found on the R. C. McConnell place, about 3 miles southwest of Mount Ulla, in Iredell County, N. C. The good specimen was found some 20 years ago by the late N. H. Marsh. This was a partly water-worn crystal about 2 inches long and 1¾ inches thick. A large part of it was flawless, with pleasing medium dark purple color. The value of this crystal was not large, but the possibility of a deposit being found should not be overlooked.

SOUTH CAROLINA.

Earle Sloan [1] has mentioned the occurrence of amethyst at several places in the Piedmont counties of South Carolina, especially in Abbeville and Anderson counties. Two localities were visited in 1913 in Greenwood County where amethyst had been reported found. These were on the land of R. M. Haddon, of Abbeville, 1½ miles southeast of Shoals Junction, and of R. W. Dunn, 1 mile southwest of Shoals Junction, both about 3 miles southeast of Donalds.

Amethystine quartz is found at several places on the Haddon plantation, but the best indications are in an area of about 100 feet wide and 250 feet long, north and south, in a field near the road leading to Donalds. The soil in this field is light, sandy, and gravelly, formed by the disintegration of mica gneiss and granite. Numerous crystals of amethystine to nearly colorless quartz were found in the field. Some of these were clear, but none were of sufficient depth of color to warrant cutting for gems. No prospect work has been done at this place and only surface specimens were seen. A trench should easily locate the vein or veins and a little digging would show whether amethysts of value could be expected.

On the R. W. Dunn place amethystine and colorless quartz crystals have been found in the cultivated fields at several places. No regular

[1] Catalogue of the mineral localities of South Carolina: South Carolina Geol. Survey Bull. 2, ser. 4, p. 157, 1908.

prospecting has been done for them and accordingly only surface specimens have been found. The fields have light sandy soil with scattered blocks of hornblende gneiss through it, such as might be derived from the disintegration of granite with hornblende gneiss inclusions.

Amethyst is also reported on the place of J. T. Algary, about 4 miles south of east of Donalds. A good specimen consisting of a cluster of clear pale amethyst crystals from the Algary place was seen at the home of T. F. Drake, of Shoals Junction. This cluster measured 8 inches across and 3 inches thick, and contained some crystals 2 inches thick.

BERYL.

NEW ENGLAND.

Beryl suitable for specimens and gems have been found at many localities in New England. Some of these have been mined for that mineral alone and others have been worked for feldspar and the beryl has been saved as a valuable accessory mineral. In Connecticut fine golden beryl has been obtained from near New Milford, Litchfield County, and during 1913 good aquamarine was found near East Hampton, in Middlesex County. In Maine beryl is widespread in the pegmatites worked for feldspar. Several localities have yielded gem beryl, and among these are prospects in the towns of Buckfield and Stoneham. In Massachusetts Goshen and Royalston have afforded beautiful gem beryl. In New Hampshire beryl is abundant in many of the mica-bearing pegmatites, and some of these have yielded good gems.

A brief examination of several of the New England beryl localities was made in June, 1913. Unfortunately time for this work was so limited that none of the Connecticut localities were visited.

MAINE.

Exceptionally fine beryl gems have been found in the town of Stoneham, Me., at scattered localities. Some of these were visited, but very little local interest was shown in the possibilities of these deposits at that time and only outcrops and old prospects were available for examination. The writer was fortunate in having Mr. Wesley Adams, of North Lovell, guide him to some of the many prospects with which he is familiar. Among these were Sugar Hill, Durgin Mountain, and Chapman Hill or Thousand Acre Hill.

Sugar Hill is about 3 miles northwest of North Lovell. Beryl and associated minerals have been found at several places on the south side of the hill on the land of Edwin McAllister. At one place a prospect pit had been opened in loose talus or drift material a few yards below a rather flat-lying cliff-forming ledge of pegmatite. In this loose drift were found fragments and crystals of beryllonite, a phosphate of beryllium and sodium, beryl, smoky, clear, and transparent gray quartz, mica, and potash feldspar. E. S. Bastin[1] mentions also apatite, cassiterite, columbite, and triplite as having been found here. The pegmatite ledge outcrops about 40 feet higher up on the hillside and, at a distance of about 150 feet northeast of

[1] Geology of the pegmatites and associated rocks of Maine: U. S. Geol. Survey Bull. 445, p. 99, 1911.

the pit, incloses numerous beryl crystals. These crystals are exposed in the bare rock associated with feldspar, opaque and translucent quartz, and a little mica. They range up to 2½ inches in diameter, and one crystal measured about 1½ inches by 10 inches. The pegmatite is exposed for thicknesses of 6 to 12 feet along its outcrop and was followed about 200 feet farther northeast. In places along this outcrop nodules or small masses of translucent quartz are exposed. The pegmatite is in contact with coarse granite above, but the country rock is chiefly mica gneiss intruded by granite and pegmatite in masses of various sizes. About one-third of a mile farther northeast a large pegmatite forms the floor of a bench on the hillside and outcrops as a wall around its lower side. Several prospects have been opened within a distance of 200 feet east and west in the floor of the bench and in these, greenish, yellowish-green, and pale-golden beryl has been found. Most of the crystals are opaque, but some contain translucent and clear portions suitable for gems. The pegmatite is composed of coarse potash feldspar crystals, massive quartz, in part translucent, and muscovite mica. In the wall of the pegmatite below the bench there was an impression in the pegmatite from which a hexagonal crystal, evidently beryl, 3 by 12 inches had been removed. This crystal was larger than those found in the prospects on the bench.

Durgin Mountain is 4 miles N. 30° W. of North Lovell. The prospect visited is on the east side of the mountain on the land of Ernest Bartlett, of East Stoneham. A small prospect had been blasted out of an outcrop of hard pegmatite on the slope of the hill. The pegmatite above the pit is covered with soil and grass. Potash feldspar crystals, 1 to 2 feet thick, are exposed in the pit along with large quartz segregations, some of which are beautifully translucent. Muscovite and biotite mica are both present. Beryl is abundant in crystals ranging up to more than 2 inches thick. They are mostly opaque or only translucent, but some fragments of crystals were seen on the dump having small brilliant transparent portions that were dark golden yellow, yellowish green, bluish green, and nearly colorless. Most of the beryl crystals seen were exposed for a distance of 15 feet in a streak or belt extending north across the pegmatite outcrop.

The beryl locality on Chapman Hill is about 3 miles due north of North Lovell. Two prospects have been opened on the summit of the hill near the east side, one in a field and the other one-fourth mile south in the woods. At both places the openings are small, not over 8 feet deep. The country rock at each place is biotite granite gneiss, but the relations between it and the pegmatite were not exposed. At both prospects rough crystals of orthoclase or microcline, coarse quartz segregations, and crystals of mica, black tourmaline, cleve-landite, and beryl were observed. Small pieces of blue and bluish-green beryl of good color were found on the dumps, and these prospects are reported to have yielded blue beryl of fine color.

Fine golden beryl and aquamarine are reported to have been found on the land of Charles Andrews, on Speckled Mountain, in the town of Stoneham, about 5 miles northwest of North Lovell.

George F. Kunz[1] described two fine beryls picked up in pastures in Stoneham in 1881. One of these was cut into a bluish green brilliant gem weighing 133¾ carats of nearly perfect quality and into

[1] Gems and precious stones of North America, pp. 92–93.

smaller gems weighing altogether over 300 carats. The other crystal was smaller, one half having a transparent faint green and the other a translucent green color.

Beryl has been prospected at several places in the town of Buckfield, Me. Besides the more common aquamarine varieties, golden beryl and colorless to bluish caesium beryl are found. Some of the localities which have yielded chiefly cæsium beryl along with a few other minerals of interest were visited.

The Lewis mine, worked by Perien Dudley, is about 2 miles southwest of Buckfield. It is in the eastern side, near the summit of a low but steep-faced hill. The work consists of two connecting open cuts extending up and down the hillside for a distance of about 120 feet. The lower cut has a direction of N. 20° W. and the upper one N. 80° W. up the hill. They range from 5 to 15 feet in depth and 10 to 20 feet in width. The country rock is quartz-biotite gneiss with layers of typical biotite schist. The gem-bearing rock is pegmatite lying approximately conformable with the gneiss which strikes about N. 30° E. and dips 30° SE. Biotite schist overlies the pegmatite on the south side of the cut, but north of this the pegmatite appears to outcrop as a blanket ledge. It had not been cut through in the open cuts and the thickness is therefore not exposed. The pegmatite is rather coarse, but uneven grained. Orthoclase or microcline occurs in rough crystals several inches across and in graphic intergrowth with quartz. Translucent green and bluish-green tourmaline with occasional pink crystals have been found frozen in the pegmatite along with muscovite, biotite, and clevelandite. Pockets ranging from small size to 2 feet in diameter are reported to occur scattered irregularly through the pegmatite. Colorless cæsium beryl was found frozen in the pegmatite and also in pockets. Arsenopyrite, or the related mineral löllingite, is present in the pegmatite associated with various minerals.

Very fine cæsium beryls have been obtained from the mine of J. H. Fletcher, a little over 2 miles southwest of Buckfield, Me., and about one-fourth mile west of the Lewis mine. The Fletcher mine was also worked by Perien Dudley and was opened by a cut extending north into the hillside. The beryls occur in pegmatite inclosed in quartz-biotite gneiss. The feldspar of the pegmatite is grayish othoclase or microcline which occurs in crystals up to 2 feet thick. Dark greenish-black tourmaline and clear light yellowish-green muscovite are abundant. Many small fragments of brilliant transparent colorless and pale greenish beryl were observed in the workings. Similar beryl in larger pieces would yield gems of exceptional brilliance. The largest beryl crystal found is reported to have been nearly 4 inches in diameter with one end composed of clear gem material.

Beryl with other interesting minerals has been found in several prospects on the north slope of a hill 2½ miles southwest of Buckfield, Me., and about half a mile south of the Fletcher cæsium beryl mine. These different prospects have been opened by Perien Dudley and W. S. Robinson. Much of the beryl found in these prospects is nearly colorless or pale greenish, and contains cæsium. At two or more of the prospects, pollucite, a hydrous silicate of cæsium and magnesium, is found along with beryl. In one opening masses of pollucite 8 to 10 inches across were found. A few crystals of opaque or translucent colored tourmaline have also been found in the pegmatites in this hill, but most of the tourmaline is dark green or nearly black. Among other minerals associated with the beryl are amblygonite, clevelandite, muscovite, arsenopyrite or löllingite, and cassiterite.

MASSACHUSETTS.

Beryl of especially fine quality has been mined at Beryl Hill, 2½ miles N. 68° E. of Royalston, Mass., by F. H. C. Reynolds, of Boston. Beryl Hill is a low, flat topped hill partly cleared for pasture on the summit and west side. Five openings have been made, four on the summit and one a short distance below, on the west side. The openings are on two approximately parallel outcrops of pegmatite about 80 yards apart extending in a northwest direction across the summit of the hill. A small glacier-made depression lies between the two outcrops. Two pits are located on the pegmatite on the southwest, one at the brow of the hill and the other on the slope about 30 yards northwest. This pegmatite outcrops for about 100 yards southeast to the opposite side of the summit. The northeast pegmatite outcrop extends 100 yards from a pit on the east side of the hill across the summit to a trench on the west side with another pit between these. From the trench the outcrop extends more than 100 yards about N. 20° W. along the edge of the hill. None of the openings are large, the deepest being only 12 feet deep and the largest a shallow trench 60 feet long.

The country rock is chiefly mica gneiss cut by biotite granite. The strike of the gneiss varies from northwest to N. 15° E. and the dip is also variable. The relation between the mica gneiss and granite are not well exposed in the workings, but the granite appears to merge into the pegmatite in places. In one of the openings biotite diorite is in contact with the pegmatite and granite. The texture of the pegmatite ranges from that of coarse granite to rock in which the individual minerals are more than a foot across. Most of the feldspar of the pegmatite is the buff-colored to pink potash variety, but some albite is present. Some of the feldspar occurs in rough crystals and other is graphically intergrown with quartz. Much of the quartz occurs in light smoky gray masses or segregations. Among other minerals of the pegmatite besides beryl are muscovite in crystals up to 3 inches across, a little biotite, black tourmaline, and dark-red garnets.

Beryl has been found in hexagonal crystals ranging from small size up to 2 inches in diameter and of varying length. One fine specimen crystal, of good bluish-green color with some gem material in one end, is 11 inches long and 1½ inches thick, This crystal is a nearly perfect hexagon, but has been broken into three sections. With the exception of a small fragment at the lower end the whole has been preserved and cemented together and appears practically perfect. The crystal is attached to a mass of granular gray quartz with a little mica adhering. Another crystal in a quartz matrix has pyramidal terminations. Many perfect crystals of one-half inch to three-fourths inch in diameter have been obtained, most of them in the granular smoky gray quartz. Another fine gem specimen attached to quartz, feldspar, and mica measures seven-eighths inch by 3¾ inches long. Part of this crystal is flawed, but good blue perfect gems of several carats weight could be cut from the clear portions.

The Beryl Hill gems range in color from light to dark aquamarine, fine blue, yellowish green, to golden. Many very fine bluish-green stones have been cut, and among those seen was a table-cut stone of 13¾ carats. The blue beryls of better quality are rarely excelled by those from other localities in brilliance or beauty of color. Among cut gems of this quality a 12½ carat brilliant cut stone was especially beautiful.

NEW HAMPSHIRE.

A deposit has been worked for gem beryl on Melvin Hill, 2¼ miles S. 25° W. of Grafton, N. H., by F. H. C. Reynolds, of Boston. Two openings were made about 150 feet apart at the east side of the hill and about 400 feet higher than the valley below. The principal working is a quarry with a working face over 80 feet long in a N. 60° W. direction along the hillside and 5 to 15 feet high. The country rock is quartz-biotite gneiss which strikes north with a nearly vertical dip and some folding. The pegmatite cuts across the foliation of the gneiss with a north of west strike and a dip of about 20° N. The contact with the gneiss is not regular but rolling, with a few smaller beds of pegmatite extending out into and parallel with the foliation of the gneiss. The bottom of the pegmatite is not exposed in the workings.

The pegmatite is composed of the usual minerals, potash feldspar, quartz, and mica, with other associated minerals. The feldspar occurs in large pure crystal masses or graphically intergrown with quartz. The quartz is mixed through the pegmatite in grains and massive irregular segregations. It is either white or smoky and some of it is quite translucent. Muscovite mica of good quality occurs rather abundantly and would pay part of the mining cost if saved. Much biotite mica was observed on the dumps, and in many specimens biotite was intergrown with muscovite. Among other minerals in the pegmatite are black tourmaline, red garnets, green apatite, and beryl. Beryl was evidently rather plentiful for there were many fragments of broken crystals on the dumps. Some of the crystals measured several inches across, and most of them were opaque or only translucent. In some of the crystals Mr. Reynolds reports clear gem beryl was found, the golden variety of which was especially finely colored. Light golden beryl gems weighing several carats were cut from some of the crystals, but the dark golden beryl crystals yielded only gems of less than 1 carat weight. The colors observed in the beryl fragments on the dumps were light yellow to rich golden yellow, yellowish-green, and light to dark aquamarine green and greenish-blue.

The other opening of the Reynolds Beryl mine is south of the main working. A pit was made in pegmatite cutting biotite granite and quartz-biotite gneiss. The pit and dump were overgrown with brush and little could be seen.

Another beryl deposit was worked about one-third of a mile west of the Reynolds mine, near the summit of Melvin Hill, by the Columbian Gem Mining Co. The gem beryl found was mostly the aquamarine variety. Another beryl prospect has been worked about 2 miles west of the Reynolds mine and about 1 mile south of Prescott Hill, by Franklin Playter, of Boston.

None of these mines was in operation during 1913.

A new beryl prospect was opened in 1913 on the old Porter K. Filbert farm, 1½ miles S. 75° W. of South Danbury, in the town of Wilmot, N. H. The work was done by J. E. Lovering, of Grafton, N. H., for Charles Murphy, of Detroit, Mich., the present owner. The deposit is on the west end of an elongated rounded hill about 200 feet higher than the road on the west. At the time of examination the pegmatite had been stripped of soil covering for about 200 feet and small prospects had been blasted out. The country rock is chiefly coarse porphyritic biotite gneiss which strikes northeast with a variable but high southeast dip. This gneiss is cut by a medium-grained granite, and the gem-bearing pegmatite cuts both rocks near their contact. The pegmatite strikes about N. 75° E. and has a nearly vertical dip. Through most of the exposed parts the pegmatite varies from 6 inches to 2 feet in thickness, but in one place it bulges to nearly 8 feet in thickness. The texture is fairly coarse, potash feldspar crystals up to 8 inches thick being observed. Much of the quartz is smoky gray, and some occurs crystallized along with small albite crystals in pockets. Black tourmaline and muscovite are other minerals associated with the beryls. The beryl crystals occur unevenly distributed through the pegmatite. They range from small size up to more than 2 inches in diameter. Most of the crystals are opaque or translucent yellowish green, pale green, or good aquamarine in color, but some clear gem crystals are found. Mr. Lovering reported finding a crystal nearly 2 inches in diameter and containing some aquamarine of gem quality.

A small prospect has been opened for feldspar and beryl on Stuart Hill, 3 miles southeast of Grafton, in the town of Wilmot. This hill is called Severance Hill on Hitchcock's Atlas of New Hampshire. The hill is composed chiefly of course porphyritic biotite gneiss which strikes about north with an east dip. A large pegmatite cuts across the north end of the hill forming a small cliff or break in the hill slope. The south contact of the pegmatite with the gneiss approximates east and west, with many minor irregularities. The pegmatite is of very uneven grain which ranges from coarse, with potash feldspar crystals 4 feet thick, down to a texture resembling coarse granite. A dike of medium-grained granite cuts the porphyritic gneiss and the pegmatite into which it appears to merge. Among the minerals observed in the pegmatite, besides feldspar and quartz, were black tourmaline, muscovite and biotite mica, and beryl. The beryl was rather plentiful in crystals ranging up to 4 inches in diameter. They were aquamarine-colored, yellowish-green, and yellow, but mostly opaque or translucent. A few pieces nearly clear enough for cutting into small faceted gems were observed and some of the translucent aquamarine-colored would serve for cabochon gems.

Gem beryl has been found at the Island mica mine, 2 miles N. 20° E. of Gilsum, N. H. During the course of mica mining a large number of beryl crystals and fragments, some of which contained gem material, were thrown on the dumps. The dumps have since been picked over by collectors and the best beryl removed. The mine was worked by three open cuts and a short tunnel. Two of the open cuts were at the east foot of a small knoll (glacial "roche moutonée") standing about 25 feet above the surrounding swampy ground. These open cuts were 20 and 25 feet deep, respectively, but are now filled with water. The third cut was made back into the knoll at a level a few feet above the lower cuts, but still 18 or 20 feet lower than the summit of the knoll. The country rock is biotite gneiss carrying much black tourmaline near the pegmatite. The gneiss has been strongly folded and crinkled near the pegmatite and accordingly has a variable strike and dip. The pegmatite is very irregular in shape, having a westerly trend across the knoll. It incloses streaks of biotite gneiss, and the surrounding gneiss has been injected by many small lenses and streaks of pegmatite. The pegmatite contains large segregations of gray and smoky quartz, some graphic granite, orthoclase and albite feldspar, pockets or bunches of mica (both muscovite and biotite), black tourmaline, green apatite, a few red garnets, and numerous beryl crystals. A quantity of mica of good quality was obtained during mining. The beryl crystals range up to a foot in diameter and are vari-colored; some are bluish, bluish green, yellowish green, and light and dark golden yellow. Much of the beryl is translucent, and parts of some of the crystals are transparent and flawless so that perfect gems can be cut from them. Small dark golden beryl of exceptional beauty has been cut from clear portions of large crystals. Much of the translucent beryl could be used to advantage for cabochon gems and beads.

Beryl Mountain, in the town of Acworth, N. H., has long been famous for the size and abundance of its beryl crystals. According to Mr. Eugene Crossett [1] owner of the prospect, an attempt was made in 1884 to quarry a large beryl crystal here for use as a tombstone over the grave of Emerson at Concord, Mass. Difficulty was experienced in removing a crystal without fracturing and the attempt was abandoned. Later a bowlder of rose quartz was adopted for this purpose. Mr. Crossett states that some specimen beryl was removed at this time and a quantity of feldspar and quartz were shipped for the manufacture of pottery, glass, and sand paper.

Beryl Mountain is a steep-faced hill or ridge rising about 200 feet above the road around its base. It has a north-northeast trend and is narrow near the summit. Prospects have been opened on the east side of the northern end about 25 feet below the summit and on the summit above. The work on the summit consists of several pits now badly overgrown by vegetation. The principal work is an open cut or small quarry about 25 feet long, 15 feet wide, and 10 to 12 feet high in the hillside. This cut has a cavern-like face 8 to 10 feet high with an overhanging ledge above.

The beryl occurs in a pegmatite mass cutting the mica gneiss country rock. The pegmatite and the inclosing formations appear to strike with the trend of the hill, but no minerals of interest were observed in the outcrop to the south of the prospects. The open cut has been made in a deposit of mixed oligoclase feldspar and quartz through which are scattered numerous beryl crystals and a little muscovite mica. This deposit is capped by a massive bed of granular sugar quartz mostly pure white or tinted with pink. In places this quartz is glassy and translucent, and some has a pale rose color. The contact between the massive quartz and the beryl matrix is not distinct, but the massive quartz grades into that associated with the feldspar and beryl. Several feet below the massive quartz, feldspar is more plentiful than near the quartz. In an exposure of the quarry face measuring about 16 feet long and 8 feet high 35 large beryls

[1] Personal communication, dated South Acworth, N. H., Mar. 2, 1914.

were counted. These ranged from 3 inches to 16 inches in diameter, and sections over 3 feet long were exposed. Each beryl is surrounded by a layer of oligoclase feldspar one-half inch to 3 inches thick. The beryl crystals are variously colored pale bluish green and yellowish green, and light and dark golden yellow. Most of them are opaque, but some contain translucent portions. Many crystals have been broken, either in mining or by collectors looking for gem material, and hundreds of fragments of beryl are scattered over the dump. No transparent gem beryl was observed, but the impression gained by a study of the deposit was that gem beryl might be found by further excavation.

SOUTH CAROLINA.

A prospect opened on the place of J. N. S. McConnell, 3¼ miles east of north of Anderson, is reported to have yielded specimens of green beryl crystals of good color, almost emeralds. When examined in October, 1913, the prospect consisted of a trench 45 feet long in a N. 70° E. direction, 15 feet wide, and 5 feet deep, with a crosscut trench entering at the west end. The country rock is weathered to a dark reddish-brown sandy soil and no outcrops were seen near the prospect. The soil has probably formed by the weathering of a biotite or hornblende granite, and carries small blocks of diorite. The pegmatite is not now exposed, but the dump contains kaolinized feldspar, blocks of massive white quartz, smoky and colorless quartz in rough crystals, weathered plates of mica 8 inches across, large dark red garnets, black tourmaline, limonite pseudomorphs after pyrite, and black manganese oxide stains. No beryl was seen on the dumps.

DIAMOND.

ALABAMA.

A beautiful diamond crystal was sent to the Survey by Mr. F. M. Lynch, of Birmingham, Ala., along with notes on its history, and further information regarding its discovery was furnished by Mr. J. H. Watkins, geologist for the Southern Railway. This diamond is reported to have been found by J. W. Kerr on the property of J. S. Isbell, at Prescott siding, St. Clair County, 1¼ miles east of Brompton on the Southern Railway, about eight years ago. The nature of the stone was not recognized until it came into the hands of Mr. Lynch, who sent it to George F. Kunz,[1] of New York, for identification. This diamond measures a little over 8 millimeters high and 5.5 millimeters in smallest diameter. It weighs 2.41 metric carats and is clear and flawless, with a slight greenish cast. The crystal is so rounded that its form can not be definitely determined. It is slightly flattened parallel with one of the possible octahedral planes.

ARKANSAS.

The Arkansas diamond field received more active development in 1913 than in any previous year. The nature of the work was not such as to definitely prove or disprove the value of the deposits, but

[1] Jewelers' Circular-Weekly, Jan. 7, 1914.

it served to show in what ways improvements could be made in the mills and machinery so far used to treat the peridotite. The companies making the tests have not seen fit to announce the results of their work, but they kindly allowed examination of their mines and mills at the time of the writer's visit in July, 1913. Two washing plants were built, one by the Ozark Diamond Mining Corporation on their holdings at the northeast side of the original peridotite area, and the other by the Kimberlite Diamond Mining & Washing Co., on the west side of Prairie Creek.

The Ozark Co. operated its washing plant about three months during 1913. Mr. Warren, the superintendent, estimated that about 5,000 loads of 16 cubic feet of decomposed peridotite from the original area and about 1,000 loads of gumbo and wash gravel from the west foot of Twin Knobs were washed. The last of this gumbo and gravel were being washed at the time of the writer's visit, but no diamonds had been found in it. Several hundred diamonds were recovered in washing the peridotite from the original area. This peridotite was obtained from an open cut 300 feet long, 15 to 35 feet across, and 8 to 20 feet deep, with tracks leading to the mill. A quantity of surface material was washed in sluice boxes with riffles and yielded a larger per cent of diamonds than the underlying peridotite. Most of the peridotite, even from the bottom of the open cut, was found to be so decomposed as to be ready for washing as mined.

The mill is equipped with a stationary boiler and engine, a trommel separator feeding an elevator to a large storage bin, sizing screens, jigs, and a stationary grease plate table. The oversize is passed through a jaw crusher and then to the storage bin. After necessary changes have been made in the mill further experiments are to be made in washing the peridotite.

The Kimberlite Diamond Mining & Washing Co.'s plant is nearly a mile from its lease holdings on the original peridotite area. A tram has been built from the mine at this place to the mill and another tram will be built to the company's holdings, 3 miles east of Murfreesboro, if success is met with in prospecting and preliminary washing. The mill is substantially constructed with a large storage floor. The earth to be treated will be fed through a revolving screen and into a 10-foot diamond concentrating pan of South African pattern. It is estimated that this pan will treat from 100 to 150 loads of 16 cubic feet per day, reducing 100 tons of earth down to about 1 ton of concentrates. The concentrates will be further screened and then treated on jigs, and the final concentrates examined on metal covered tables in a well-lighted room. Oversize from first screening will be subjected to further weathering. Tailings will be conveyed by flume to Prairie Creek. Final equipment of the mill with automatic handling machinery, grease table, and other improvements will be carried out after the value of the property is proved.

The Arkansas Diamond Co. was idle during 1913, but since the writer last visited the property in 1908 several changes have been made. The peridotite hills have been stripped of timber and a dozen or more new pits and shafts have been made, some of which were of value in showing the depth of decomposition over various parts of the peridotite area. Weathered peridotite has been scraped off of a small area and washed in improvised machinery which proved wasteful in operation. A large area of ground sloping south toward Little

Missouri River could be readily washed by hydraulic methods for which power pumps would be required. Between the peridotite outcrop and Little Missouri River is a large area of bottom land which may prove to be workable placer ground.

Only a small amount of prospecting was done on the property of the American Diamond Mining Co., but Mr. Fuller states that the company reports the finding of one stone.

The best information on the diamond-bearing peridotites of Pike County has been given by Hugh D. Miser.[1] This report contains a carefully prepared map of the known peridotite exposures, with sections and detailed information concerning them. A good résumé of the developments in the diamond field during 1913 has been given by John T. Fuller.[2]

CALIFORNIA.

Mr. M. J. Cooney, of Oroville, Cal., reports the finding of a first quality white diamond by John McGregor on the old placer grounds of the U. S. Diamond Mining Co., at Cherokee, in December, 1913, and of several other smaller stones of inferior quality in the same area. Mr. McGregor states that the stone weighed 1¼ carats and is valued at $75 in the rough state.

Press reports [3] mention a diamond found by Ed. Bryan, a miner at Sawpit Flat, in Plumas County, Cal. In a personal communication Mr. Bryan states that the stone was very similar to a diamond found at the same locality several years ago and known to be authentic. Both stones were found in old hydraulic mining ground similar to the old placers of Butte County, where a number of diamonds have been obtained. Through misplaced confidence the stone was lost to Mr. Bryan before he could be positive of its determination.

IDAHO.

Mr. Frank E. Johnesse, of Boise, Idaho, reports the discovery of three small fragments of diamond in the Rock Flat mine in Adams County, Idaho. The largest of these fragments weighed a little less than one-eighth of a carat. The diamonds were found during placer mining for gold. Other possible gem minerals in the form of sapphire, garnets, and zircon are also found in the clean ups. Robert N. Bell, State mine inspector of Idaho, states that the rock formation of this area is chiefly gneiss with a dike rock of basic composition which has weathered to a soft yellowish earth in places. Mr. Johnesse is installing a hydroelectric plant to treat the concentrates from placer mining for the various minerals of value they may contain, such as monazite, zircon, etc.

INDIANA.

Messrs. Perry Bradford and R. L. Royse, of Centerton, Ind., have furnished information concerning the finding of five diamonds during 1913 on Gold Creek and Highland Creek, in Morgan County. Two of these were found by Hugh Marshall, two by Fred Doyle, and

[1] New areas of diamond-bearing peridotite in Arkansas: U. S. Geol. Survey Bull. 540, pp. 534–546, 1914.
[2] Eng. and Min. Jour., Jan. 10, 1914.
[3] Sacramento Union, Cal., Aug. 17, 1913.

one by R. L. Royse. Mr. Royse describes the one he found as a small green diamond with fine luster, weighing 0.20 metric carat. One of the stones found by Hugh Marshall is described as colorless or white and weighing 0.73 metric carat. Mr. Bradford kindly sent one of the stones found by Fred Doyle to the Survey for examination. It is a yellowish stone, only partly transparent, and weighed 0.69 metric carat. The crystal form is that of a distorted trisoctahedron truncated by the octahedron. A point projecting from one side of the stone indicates that it is probably a twinned crystal.

NEW YORK.

Specimens from two peridotite outcrops in Syracuse, N. Y., were received from Mr. Edwin C. Dinturff, of that city. Some of these were from Green Street and James Street, on the "south crater," and the others from Griffith Street and Highland Street, on the "north crater." Mr. Dinturff states that at the "south crater" exposure peridotite has been found over an area of about 800 feet by 1,200 feet and that at the "north crater" peridotite has been found for about 300 feet in sewer excavations with another exposure, possibly part of the same mass, about 400 yards farther north. The two localities are about three-fourths of a mile apart. In a small hill on Green Street in the "south crater" the peridotite is seen in contact with shale. This is in the peridotite area which has been known for a number of years.

The peridotites of Syracuse bear a marked resemblance to those of South Africa, Arkansas, and Kentucky in composition, texture, inclusions, and weathering. The material from Highland Street was hard when first excavated, but much of it has disintegrated on exposure to the atmosphere. No careful search for diamonds has been made in the peridotite of Syracuse, though the nature of the material would seem to justify such attempts as much as the peridotite of Kentucky, on which considerable work has been expended. Concentrates from panning the altered rock contained garnet, zircon, olivine, diopside, and other minerals. The zircon occurs in minute crystals, which are best separated by treating the peridotite with hydrofluoric acid. In this separation fine particles of ilmenite or rutile are also obtained.

VIRGINIA.

Information on the reported finding of a diamond in Tazewell County, Va., was kindly supplied by Messrs. Charles H. Reynolds, of North Tazewell; H. W. Pobst, a jeweler, of Tazewell; and J. Sanders Gillespie, of Cliffield. This diamond is reported to have been found by Frank Brewster on the farm of Mr. Gillespie, near Pounding Mill, while plowing in a cornfield. The stone was sold to Mr. Pobst, who had it cut by J. R. Wood & Sons, of New York. The cut stone weighs 0.83 metric carat and is considered to be of very fine color and quality by Mr. Pobst. Little has been done toward prospecting for other diamonds.

AFRICA.

UNION OF SOUTH AFRICA.

The production of diamonds during the fiscal year 1913 by the De Beers Consolidated Mines [1] amounted to 2,293,468 carats, as compared with 2,087,392 carats in 1912. Actual sales of diamonds, plus the increase of stocks taken at the cost of production, amounted to £6,297,782. In round numbers, 2,034,000 carats of diamonds were sold. The total production of blue ground in 1913 amounted to 7,382,216 loads, as compared with 7,950,442 loads in 1912. The total quantity of blue ground and tailings washed during 1913 was 8,702,289 loads, as compared with 7,995,953 loads in 1912. The yield in carats of diamonds per load of blue ground washed decreased from 0.31 to 0.29 in the De Beers and Kimberly mines and from 0.29 to 0.27 in the Wesselton mine, and increased from 0.41 to 0.42 in the Bultfontein mine. In the Dutoitspan mine the yield remained the same, at 0.23 carat per load. The De Beers mine remained closed during the year, with the exception of a small amount of development work.

The Premier Diamond Mining Co. (Ltd.) had a successful year during 1913.[2] The company's report for the year closing October 31, 1913, shows 10,434,680 loads of earth washed, yielding 2,107,983 carats of diamonds. The average value per carat was $5.32 and the value of the total production amounted to $11,216,000, as compared with $9,620,000 in 1912.

The output of diamonds from alluvial diggings has increased greatly, and during the first six months of 1913 the value of the diamonds produced amounted to $1,354,882.[3] Some valuable stones have been found in the alluvial workings, and among those registered were a 64½ carat diamond, valued at $2,092, a 32½ carat diamond, valued at $1,897, and a 16 carat stone, valued at $1,094.

A diamond weighing 229 carats [4] was found in the Pniel diggings by F. J. Van Zyl in the latter part of 1913. This stone is a fine octahedron crystal with a slight tinge of yellow. It brought £2,300.

GERMAN SOUTHWEST AFRICA.

According to Consul General Henry W. Diederich,[5] of Antwerp, Belgium, the output of diamonds in German Southwest Africa amounted to about 1,440,000 carats. During the first half of the year the Antwerp Syndicate purchased about 760,000 carats, for which it paid about $8,330,000, or approximately $10.94 per carat. The German imperial chancellor ordered that the output or sales should be limited to less than 1,000,000 carats in 1914 in order not to overstock the market with diamonds of small size and break prices. During the spring of 1914 the output of the German Southwest Africa diamonds for the year was purchased by the London Diamond Syndicate,[6] which therefore practically controls the market of small as well as large diamonds.

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[1] De Beers Consolidated Mines Twenty-fifth Ann. Rept. for year ending June 30, 1913.
[2] Min. and Sci. Press, Apr. 4, 1914.
[3] Consul Edwin N. Gunsaulus, Johannesburg, Transvaal; Daily Cons. and Trade Repts., Oct. 17, 1913, p. 310.
[4] Jewelers' Circular-Weekly, Feb. 4, 1914.
[5] Daily Cons. and Trade Repts., Mar. 28, 1914, p. 1170.
[6] Jewelers' Circular-Weekly, Apr 8, 1914.

KONGO.

Consul General Henry W. Diederich [1] of Antwerp, Belgium, reports that in January, 1914, 6,795 carats of rough diamonds from Kongo River were sold at auction for $39,372. These diamonds come from the country along Kasai River, a tributary of Kongo River.

FELDSPAR GEMS.

AMAZON STONE.

COLORADO.

The amazon stone and associated minerals of the Pikes Peak region, Colorado, have been a source of interest to mineral collectors and gem dealers for many years. George F. Kunz [2] states that an exhibit of Colorado amazon stone at the World's Fair in Philadelphia, in 1876, occasioned much surprise because of its beauty. There are two general localities where the amazon stone is found, one to the east of Pikes Peak, in the Crystal Park region near Manitou Springs, and the other about 18 miles northwest of Pikes Peak around Crystal Peak, about 4 miles north of Florissant.

In the Crystal Peak region prospects have been opened over an area more than 2 miles square by various prospectors and collectors. The Crystal Peak region is mountainous and timbered, with occasional rocky knobs or domes standing above the ridges and valleys. The prospects examined are situated at elevations ranging from about 9,000 to 9,400 feet above sea level, Crystal Peak having an altitude of 9,668 feet. Crystal Peak is the highest of a range of small knobs along a divide. Other lower knobs are Little Crystal Peak, one-fifth of a mile west of north; Deer Mountain, about one-half of a mile northwest; and Sheeps Head, about two-thirds of a mile northwest of Crystal Peak. Wide ridges and rather gentle slopes extend from the foot of these knobs, but most of these are cut into by valleys within a half mile of the knobs.

The prospects are in both the gentle slopes and in the steeper walled valleys. Among the numerous people who have worked in the Crystal Peak region George Copelen, of Gillette, Colo., was one of the pioneers. Mr. Copelen commenced prospecting here over 35 years ago, but has now abandoned that work. Numerous claims have been filed and some of these are still in force, but others have lapsed. Among the prospects visited in August, 1913, some were on the claims of J. D. Endicott, of Canon City; The Crystal Peak Gem Co., of Cripple Creek; A. Fries, George H. Weed, and Whitmore & Sanders. The claims of J. D. Endicott lie chiefly north of Crystal Peak. One claim is in the gap between Little Crystal Peak and Deer Mountain. A. Fries owns patented ground about one-half of a mile northeast of Crystal Peak and claims other prospects between this and Little Crystal Peak. The claims of the Crystal Peak Gem Co. are scattered, most of them lying north and northwest of Little Crystal Peak with one, the "Pinacoid claim," nearly a mile to the north of Crystal Peak. A claim covering the topaz workings, about 1¼ miles southwest of

[1] Daily Cons. and Trade Repts., Mar. 28, 1914, p. 1170.
[2] Gems and precious stones: Scientific Publishing Co., p. 165, 1890, New York.

Crystal Peak, is held by Whitmore & Sanders, both members of the Crystal Peak Gem Co. G. H. Weed, of the same company, holds a homestead claim at the foot of Crystal Peak on the southeast side, on which some promising amazon stone was found in digging for water.

The best amazon stone was seen in place on the claim of J. D. Endicott, on the northeast side of the gap between Little Crystal Peak and Deer Mountain. In one prospect trench, about 40 feet long on this claim, amazon stone is exposed along the footwall of a pegmatite vein striking N. 20° E. with a dip 30° E. The crystals in this wall range from small size to 4 or 5 inches thick, and the exteriors of some are exceptionally bright bluish green. Good amazon stone has been found on many other claims in the Crystal Peak region, but the exposures were not sufficiently good to determine what prospects are the most promising.

The various workings for amazon stone and other minerals cover considerable ground, but none of them are deep. On some of the claims there are pits every few feet over an area of an acre or more. Practically all of the work has consisted of pits, small open cuts, and occasional tunnels. Most of the workings are less than 12 feet deep, and many have become partly filled with rubbish. In all probably 200 pits were seen, and there are many more in the region that were not visited.

The country rock of the Crystal Peak region is chiefly coarse reddish biotite granite, more or less porphyritic in places. A finer-grained aplitic granite was closely connected with the mineral deposits noted in some of the prospects. Over most of the country the coarse granite has been partly disintegrated and broken down to coarse angular gravelly soil. An accumulation of leaf mold with this has furnished a soil covering for part of the area, so that good outcrops are not abundant. In places the granite outcrops in hard ledges, large bowlders, or gravelly soil without much vegetation, so that that prospecting is easier. Many of the deposits can be mined without blasting because of the disintegrated nature of the granite and the gem-bearing rock, but some of them have to be blasted almost from the outcrop down.

The amazon stone and associated minerals occur in pocket-like deposits more or less irregularly distributed through certain parts of the massive coarse granite of the region. The pockets are miarolitic cavities lined with coarse and often nearly perfectly crystallized microcline and albite feldspar, smoky and colorless quartz, and biotite mica, with occasional crystals of topaz, phenacite, fluorite, columbite, and göthite. Deposits and stains of limonite are abundant. The layer of coarsely crystallized minerals lining the pockets varies from a fraction of an inch to more than a foot in thickness in some places. These pocket linings are typical pegmatite aggregations, which may grade into the surrounding granite or have rather sharp contacts with it. Some of the contacts are plainly banded and the gradation from the pegmatite to the granite is so gradual that it is difficult to determine the actual contact. This is especially true where the pockets are associated with aplitic granite. Some of the gem pockets occur in streaks as in pegmatite veins, but others appear to bear no definite relation to one another.

Amazon stone is widely distributed in the Crystal Peak region, but most of the deposits yield but little material suitable for gem purposes. This is due to inferior color of the crystals, excessive fracturing, or discoloration by iron rust. The amazon stone and other microline occurs in stout crystals with the characteristic prominent cleavage of that mineral. The crystals range from small size to several inches in diameter and project from the walls of the cavities with crystals of smoky quartz, biotite, and the other minerals of the pockets. In some cases clusters of fine amazon stone crystals, with or without other minerals, can be removed from the prospects for cabinet specimens. Most of the pockets contain grayish microcline crystals as well as those of green color.

The amazon stone occurs in various shades of bluish green, some of which are very bright. Occasional specimens of nearly pure pale blue are found. Most of the crystals show color variations, the best color commonly lying near the outside of the crystals. Such crystals may have bright bluish-green exteriors with successively paler colors toward the middle, either in layers or by gradual change. The middle of these crystals is generally gray or only pale bluish green. The outside shell of good color may range from a small fraction of an inch to an inch in thickness in large crystals. This color variation must be taken into consideration in the choice of cutting material, as it occasions large waste.

The amazon stone can be cut in a variety of shapes for gem purposes, such as stones for brooches, scarfpins, pendants, and beads for necklaces. The bright colors are pleasing and blend well with gold mountings. Some of the cut stones exhibit a silvery sheen in certain lights from partly developed cleavage planes. In considering the class of semiprecious and imitation stones sold to the tourists in Colorado each year, it seems that the possibilities of beautiful amazon stone from the Pikes Peak region are almost neglected. A quantity of amazon stone is sold in the rough in the form of crystals and bright-colored specimens to the tourist trade and many fine crystals are sold by mineral dealers for cabinet specimens elsewhere; but the sale of cut gems could be increased by displaying tastefully cut stones of good color.

SUNSTONE.

CALIFORNIA.

Specimens of sunstone were received from the Pacific Gem Co., of Los Angeles, Cal. The rough material is reported to have come from Modoc County and a quantity has been cut for gem purposes. It consists of labradorite feldspar, rather high in calcium, with many minute inclusions that reflect a bright coppery red light. The inclusions are too minute to be readily recognized. Their arrangement is only partly governed by crystal structure. The body of the feldspar is colorless and clear; in some specimens the particles are almost submicroscopic but sufficiently abundant to impart a red color to the labradorite. The cut gems are very pretty and have been sold under the name of both goldstone and sunstone. Owing to the quantity of artificial goldstone, falsely sold as a natural mineral, it seems better to call this beautiful natural product sunstone.

JADE.

ALASKA.

P. S. Smith [1] has given a few notes on the occurrence of nephrite in Alaska. Bowlders of a hard, green, slightly translucent rock are plentiful in nearly all of the streams of the Shungnak region north of the Kobuk. These are commonly called jade, but the majority are probably serpentine and green quartzite and some may be nephrite. None of the nephrite seen was of gem quality, since it contained many imperfections in the way of cleavage and inclusions, of which magnetite is so abundant as to give the mineral a spotted appearance. Several unsuccessful attempts have been made to work the jade in the Jade Mountains, west of Ambler River; but the inferior quality of the mineral, combined with its inaccessible location, will probably prove too great obstacles for its exploitation for some time to come.

JASPER.

ARKANSAS.

Mr. Francis Holstein reports an occurrence of jasper on sec. 23, Hot Springs County, Ark., near Morrison Springs. This jasper is stated to be beautifully colored and susceptible of receiving a high polish, but the deposit has so far received no development.

CALIFORNIA.

The variously marked and colored jaspers of the San Francisco region, especially the "kinradite" variety, are meeting with increasing appreciation in that city and among tourists. Some of the best of these jaspers have been found on the beaches along the southern part of Marin peninsula, between Point Bonita and Lime Point. Most of the southern end of Marin peninsula terminates abruptly in cliffs at the water's edge, but narrow beaches have formed in a few places below the cliffs and on these the jasper can best be found. Some of the beaches are exposed only at low tide and are difficult to reach.

The rocks along this part of the peninsula belong to the Franciscan group and consist of sandstone and radiolarian chert with intrusive basalt and diabase. The formations strike generally north or northwest chiefly with high dips. The radiolarian chert is a rather thin bedded jaspery rock. The diabase and basalt may have a common origin presenting only variations in texture. Near the water's edge they outcrop in fresh dark greenish-black cliffs which show a large amount of jointing. Fifteen feet above the water and higher up on the hills they have reddish-brown weathered surfaces. These rocks contain jaspery inclusions, some of which may be altered masses of radiolarian chert. Veins and deposits of quartz have formed in joints and fissures in the diabase and basalt. Some of this quartz grades into jaspery material and other is greenish through chloritic or actinolite-like inclusions. It should be possible to find good jasper in the rock, but the greater part is obtained from the beaches where the jasper inclusions have fallen from the cliffs. The force of the waves has ground off much of the adhering matrix and rounded

[1] The Noatak-Kobuk region, Alaska: U. S. Geol. Survey Bull. 536, pp. 154–155, 1913.

the jasper into pebbles and bowlders, which display their color and markings very well when wet.

The jaspers show a wide range of colors, with both dark and light red, yellow, brown, and green. Some of the red and yellow jaspers are very bright colored. A variety of markings or patterns are met with, of which the most interesting is that called "kinradite," after J. J. Kinrade, of San Francisco, who discovered and first used it for gems. This variety shows spherulites, generally of one color, scattered through jasper of another color. The spherulites are composed of radiated aggregates of quartz, with concentric color bands in some specimens. The spherulites resemble chalcedony, but under the microscope, between crossed nicols they have the positive elongation characteristic of quartz. The spherulites range in diameter from microscopic dimensions to over an inch. In cutting kinradite the gem may contain only one large spherulite or there may be several spherulites of various sizes. Some gems may contain 25 or more smaller spherulites. The colors, the variations in texture, and the interesting structure of the spherulites in kinradite render it an attractive gem and ornamental stone.

Some of the other jasper found with kinradite is of good gem quality. Among specimens seen were some showing very bright crimson red in small streaks and patches through yellow and dark dull green. This would yield gems showing the three colors in strong contrast. Almost innumerable other color patterns can be cut from these associated jaspers.

A deposit of bloodstone and jasper was discovered by F. M. Myrick, of Johannesburg, Cal., in the Death Valley region of San Bernardino County, in February, 1908. Considerable prospecting since that time has resulted in promising finds of gem minerals. Many cut gems have been sold in several towns of southern California where they have been favorably received.

The deposit is about 45 miles northeast of Johannesburg and 4 miles S. 20° E. of Brown Mountain in the rough mountains about 12 miles west of Death Valley. Prospects have been opened over an area about 300 yards across among the gulches at the head of three valleys draining west and northwest. The prospects are at elevations of about 3,300 feet above sea level, or 200 feet higher than the camp in the draw to the west. The principal work consists of a cut, 15 feet across and 12 feet deep, and a prospect tunnel in the side of a draw. Over a dozen other pits have been made on outcroppings of bloodstone or associated jasper.

The geology around the bloodstone deposits is complex. Basaltic lava and andesitic rock predominate, but some sedimentary rocks are exposed close to the prospects. The basalt is dark reddish brown, through the oxidation of ferruginous constituents and quite vesicular in places. The andesitic rocks are fine grained and in places they are greenish from the presence of epidote and chloritic alteration products. The sediments consist of gray to white shaly calcareous rock with interbedded sandy and sintery layers. These rocks contain fossil mud cracks, ripple marks, raindrop marks, and a few markings resembling worm tracks. A portion of the sediments contain pebbles and angular inclusions, like a tuff or volcanic ash formation, and such is their general appearance. It is probable that these rocks were formed as ash beds in shallow pools of water. The carbonate of lime may have been deposited either at the same time from lime-saturated water of the pools or later by solutions penetrating somewhat porous rock. Later action, possibly by hot springs, has apparently leached portions of the tuffaceous rock to porous vesicular masses.

The sedimentary rocks contain a bed of vesicular basalt near their top, and in this basalt the bloodstone occurs. The strata have been tilted and broken by block faulting and contacts are covered with talus slopes in many places, so that it is difficult to trace any horizon far.

The jasper and bloodstone occur in irregular nodular and kidney-shaped masses unevenly distributed through altered phases of the vesicular basalt. The nodules range from about an inch across up to nearly 1 foot in thickness, and most of them are surrounded by shells of dark-green impure opal or soft yellowish-green, rather porous material, which is probably a clayey aggregate. In the largest pit some of the nodular masses occur irregularly distributed in a warped layer having a northwest strike and a northeast dip. The various openings in which bloodstone and jasper have been found, however, do not indicate any definite occurrence in veins or belts of separate deposits.

Red, yellow, and green jasper are the most common, but in places the red and the green are so blended as to yield bloodstone. The bloodstone shows hard, dense, dark-green plasma or jasper with blood-red spots, patches, and streaks. The heliotrope variety of bloodstone, in which the red occurs in small round spots in the green, is rare in the Myrick prospects, but a quantity of bloodstone showing irregular patches and streaks of red in green is found. Jasper of various shades of red, brown, and yellow occurs in nodules several inches across, with or without the green. In some specimens yellow or brownish spots and streaks are scattered through the green, similar to the red in the bloodstone. Some of the larger lumps of jasper show mottlings in various shades of red with or without brown and yellow. Some of the patches of color in the bloodstone are formed by a crushing of the larger pieces and later a cementing by chalcedony or jasper fillings. Such bloodstone shows an abundance of small faults with straight contacts between the red and the green. Occasional seams and veinlets of gray chalcedony cut the jasper and bloodstone, filling fracture lines and joints.

The jasper and bloodstone from this locality take a high polish, and the cut gems show a wide range of patterns and color variations. Stones may be cut showing dark, bright, or dull red, brown, yellow, or green, or pleasing combinations of these colors. The gems are suitable for various forms of jewelry, especially for persons not desiring flashy gems. In cutting, the lapidary should exclude all of the dark-green opal shell surrounding the jasper and bloodstone, for this is brittle and will crack after cutting.

Numerous specimens of jasper with more or less associated chalcedony have been received from Mr. Joseph Ward, of Barstow, Cal. Mr. Ward has collected these from several claims which he has located in the Death Valley region of San Bernardino County, and some of the specimens may have come from Nevada. The jasper shows a wide range of color and markings and would furnish very attractive gems. Some of the jasper shows mosslike patterns of red, brown, or yellow, with patches of gray or blue chalcedony. In other specimens these markings are in nearly pure chalcedony. There were a few pieces of greenish jasper, both with and without red markings. Some of the bluish chalcedony with bright-red jasper inclusions was particularly attractive. Of the several pounds of specimens received, the colors were bright enough for gem purposes in only a small part.

OREGON.

Mr. Don Maguire, of Ogden, Utah, reports the occurrence of a deposit of bloodstone discovered by him in Harvey County, Oreg., about 15 miles east of the town of Burns. The bloodstone occurs in a ledge over 3 feet thick cutting a trap dike. Some of the rough material was shipped for cutting during 1913.

UTAH.

Richly colored jasper, showing various shades of red in laminations or other structures, is reported by Mr Don Maguire, of Ogden, Utah, from the Wasatch Mountains in that State. Some of this jasper has been cut with very pleasing results in Salt Lake City.

JET.

TEXAS.

Prof. J. A. Udden, of Austin, Tex., reports the occurrence of jet in Presidio County, Tex. The jet occurs as compressed and flattened trunks of trees in a thin layer of coal from 100 to 200 feet below the San Carlos coal bed.

LAPIS LAZULI.

CALIFORNIA.

An occurrence of lapis lazuli in California has been described by Gordon Surr,[1] and the following notes are taken from his description. Mr. Surr also kindly sent a specimen to the Survey for examination. The locality is on the north slope of the south fork of Cascade Canyon, 1½ miles south of east of the "Hogback," a well-known landmark in San Antonio Canyon, to which Cascade Canyon is tributary. The deposit is about 12 miles from Upland, a town on the Santa Fe Railway, about 20 miles west of San Bernardino. The "blue rock" was long thought by prospectors to carry silver, and the deposit was opened with this idea. A pit 15 feet deep apparently went through the "blue rock," and work was abandoned.

The mineral was identified by John T. Reed, an assayer in San Bernardino, whose son made an attempt to open the deposit further. The locality was visited by several persons subsequently, and in 1913 by Mr. Surr and his associates. No lapis lazuli was found in place, but probably 150 pounds of loose rock with some of the blue intermixed were found in the talus on the slope and in the drift in the stream bed.

The country rock consists chiefly of quartzites and limestones, which strike east with a high northerly dip near the old workings. At

[1] Lapis-lazuli in southern California: Min. and Eng. World, Dec. 27, 1913.

the latter place there is a layer of light-gray quartzite carrying pyrite and iron oxide stains. Above this is dark quartzite with pyrite, then a few inches of soft shaly rock with limestone overlying. The lapis lazuli was apparently found in the layer of dark quartzite. It is not of good quality, being mixed with a number of other minerals difficult of determination. Under the microscope in thin section two varieties of pyroxene, fine sericite, calcite, pyrite, clinozoisite, and other minerals not identified, were observed besides bright-blue lazurite. The matrix consists of a granular mass of these minerals with blue lazurite as a filling in interstices. The specimen furnished by Mr. Surr is about 2 inches thick, showing alternating bands of dark grayish black, lighter gray, pale to dark bright blue, and yellowish streaks of pyrite crystals. It is probable that the bands containing the most blue could be cut into rather pretty matrix gems.

LAZULITE.

ARIZONA.

Specimens of lazulite (false lapis lazuli) were received from Mr. James Shea and Dr. Burt Ogburn, of Phoenix, Ariz., along with a few notes on its occurrence. The deposit is about 12 miles north of Phoenix, in a small hill near the edge of Paradise Valley. A good wagon road passes near the locality. The lazulite is inclosed in quartzite, in which rock it occurs disseminated in small grains and clusters and in larger crudely shaped crystals. The matrix is white, gray, pinkish, brownish, and greenish from staining. Fine mica or sericite has developed through the quartzitic country rock, and some is associated with the lazulite. Of the specimens seen, only a few could be cut into pure blue gems, but a quantity would yield matrix stones showing dark ultramarine-blue patches of various sizes. The presence of a little pyrite in small crystals heightens the resemblance of this material to lapis lazuli.

OBSIDIAN.

UTAH.

A small specimen of obsidian from Millard County, Utah, was received from Mr. Maynard Bixby, of Salt Lake. This is glassy reddish brown with jet-black streaks and patches through it. The black appear as rounded spots in one position and as streaks in a position at right angles showing the direction of flow of the molten volcanic glass. The mottled effects of the brown and black are very pretty, and Mr. Bixby states that this obsidian takes a high polish.

OPAL.

CALIFORNIA.

Two deposits of opal have been prospected by F. M. Myrick, about 35 miles east of Johannesburg, Cal. One of these is in the side of the same knob as Lead Pipe Spring and about 100 yards northwest of the spring; and the other is about a mile and a half to the northeast on the north side of a steep hill slope. Only small prospects have been opened at each locality.

Opal from the Lead Pipe Spring locality has been called "sobrisky" opal. It occurs in nodular masses at the contact of a red rhyolite flow with underlying white tuffaceous beds. The rhyolite is perlitic near the contact and has been partly decomposed. It contains an abundance of nodules and clusters of siliceous balls varying in size to over 2 inches in diameter. When these are broken open they are found to contain cores of red rhyolite, chalcedony, common or white opal, and occasionally precious opal. Mr. Myrick states that it is sometimes necessary to break open hundreds of these nodules to find a few inclosed precious opals. The cores of precious opal are rarely over three-fourths of an inch thick, but some of the specimens seen had very good color showing flashes of red, blue, and green in gray or milky white background. Many of these cores included fragments of chalcedony or rhyolite, so that pure gems could not be cut from them. If larger pieces of the precious opal can be found and in greater abundance than up to the present time, the prospect would prove of value.

The other locality has so far not yielded any precious opal, and the claim has been called the "white opal" claim after the variety first found. The deposit occupies the same relative position with the rock formations as at Lead Pipe Spring; that is, in partly decomposed perlitic rhyolite forming the contact between a rhyolite flow and underlying tuffaceous beds. The decomposed perlitic layer is about 10 feet thick, and in this are numerous nodules or balls of common opal from 1 to 5 inches in diameter. White opal was found first and later greenish, yellow, and red opal without fire. A small spring has been opened by Mr. Myrick, on the "white opal" claim.

These opal deposits are in the same region as the blue chalcedony already described, and are associated with the same reddish rhyolite flow as the chalcedony. The White Opal claim is about two-thirds of a mile southwest of the Blue Moonstone claim.

Very pretty clusters of clear colorless glassy hyalite opal have also been found by F. M. Myrick in the rhyolite flows east of Granite Springs and about 30 miles east of Johannesburg, Cal. These are not only very pretty specimens, but a few have been mounted in their natural state as gems. Many of the specimens consist of cup-shaped aggregates of small globules of clear limpid hyalite.

Mr. Joseph Ward, of Barstow, Cal., furnished specimens of opal he has found in the desert region of San Bernardino County. Among these were white and cherry red common opal, botryoidal incrustations of clear glassy hyalite, and thin layers of precious opal in rhyolite matrix. The hyolite was very pretty as specimens, forming clusters of bright globules in cavities in spherulitic rhyolite. The other specimens consisted of dark reddish-brown flow-banded rhyolite cut by seams of precious opal mostly less than 1 millimeter thick, both parallel with the banding and at angles to it. Some of the seams showed bright green and red fire. Other specimens of the rhyolite contained common bluish opal and translucent chalcedony. If precious opal can not be obtained in larger pieces from this locality, opal matrix showing seams of gem opal in the red rhyolite might prove of sufficient beauty to cut for gems.

NEVADA.

Considerable prospecting and development work was done in 1913 in the opal field in the valley of Virgin Creek, Humboldt County, Nev., about 25 miles southwest of Denio, Oreg. A number of new claims were located, which extended the known opal-bearing area. Precious opal was discovered in this region in 1908, in which year several claims were located. Other claims have been located successively each year since, and some of them have been worked on a small scale. The yield of precious opal from some of the prospects has been very encouraging in regard to both quality and quantity. Other claims are still of doubtful value.

This opal field was visited in August, 1913, but only three days were available for examination of the deposits. Under favorable conditions the region can best be reached from Jungo, Nev., a station on the Western Pacific Railway, by automobile stage to Denio, Oreg. From Denio the trip can be completed by automobile or other conveyance.

Virgin Creek drains northward, joining Beet Creek at the head of a narrow canyon below which place it is called Thousand Creek. The valleys above the canyon form an irregular-shaped basin with outlet into Thousand Creek. The opal deposits are in certain formations exposed in the sides of the valley of Virgin Creek.

The opal claims examined lie at elevations ranging from 5,100 feet to 5,400 above sea level. Some of them are in rather gently sloping ground in the foothills along the sides of the valley and others are in the steep valley walls. The plateau country in which Virgin Valley has been carved has an elevation of over 6,000 feet above sea level. The region is desert, but water supplied by several large springs, some of which are hot springs, flows into Virgin Creek and Beet Creek. The creek waters are used for irrigation and supply several large meadows for the different ranches.

Four groups of claims were visited, the location of which will be given with respect to McGee's ranch, about a mile south of the junction of the creeks. The principal group is that in which the claims of Ivan Dow, George D. Mathewson, Alfred Thompson, and others are located, about 3 miles southwest of McGee's ranch in the west side of the valley. Among these claims are the Cracker Jack, Bonanza, Opal Queen, and Opal Queen Fraction. Most of the opal from this group of claims has been handled by the International Gem Co., of New York. Another group of claims belonging to D. Roop, E. McGee, and George T. Hill is situated about 5 miles south of McGee's ranch. W. B. Seitz and C. A. Howard hold claims to a third group about 5 miles southwest of McGee's ranch. In the fourth group is the Stone Tree claim, owned by several parties, about a mile and a half north of west of McGee's ranch.

Bateman & Boyd have the Big Horn claim nearly half a mile east of the Stone Tree claim. George W. Brown has located a claim about 2¼ miles west of W. K. Ebeling's ranch, or 3½ miles north of west of McGee's ranch. A large number of other claims have been located in the opal field, some of which may prove of value.

Developments have not been large, and most of the work is limited to pits, small open cuts, and trenches. Some of the deposits are so situated that practically all of the mining can be done by open cuts, but in other places continued work would require the driving of tunnels and the sinking of shafts. As a general rule all excavations can be made without the aid of dynamite, but in some places the work of loosening the claylike earth could be facilitated by blasting. Much of the work could be done by pick and shovel aided by horse scrapers to remove overburden.

The general geology of the Virgin Valley region has been described by Prof. J. C. Merriam [1] and the following notes have been abstracted from his description and supplemented by a few personal observations. The rocks of Virgin Valley are in a synclinal basin of older formations consisting largely of tuffs, ashes, and rhyolitic lavas. The "Virgin Valley beds," as Prof. Merriam tentatively calls them, consist chiefly of ash and tuff of variable induration which weather into characteristic badland topography. They may be rather arbitrarily divided into upper, middle, and lower beds. The lower beds are the hardest, and the badland sculpture developed in them is characterized by steep-walled gulches. The strata are white, greenish, and bright red. The middle beds are brownish and gray and weather into rounded hills and knolls. The upper beds are softer cream-colored ash. A dark-gray vesicular lava flow caps the upper beds along the rims of the valley. Various fossil mammals have been found in the upper beds, including a mastodon, a horse, camels, and a cat. The middle beds contain many plant remains and petrified wood is abundant. Fossil evidence points to the Miocene age of the beds.

The formations have been broken by extensive block faulting, some of the blocks having dropped several hundred feet. Tilting of the strata has also produced differences in elevation of parts of the same horizons.

The opal occurs in ash or fine tuff beds associated with petrified wood. The ash beds are grayish and greenish-gray with a hard claylike consistency. The surface material is dry and crumbling, but some of the same material below the surface if moist resembles hard sticky gumbo. The ash contains variable quantities of sand, pebbles, and cobbles. Among these inclusions quartz, a little obsidian, and rhyolite were observed. On the Cracker Jack claim two horizons about 75 feet apart, vertically, have been worked for opal. These were separated by harder ash beds. At most of the horizons carrying opal considerable petrified wood is found in which common opal and silica are the petrifying agents. The ash beds have been somewhat altered by solutions, probably those which were active in depositing the opal.

The opal occurs in a variety of shapes most of which are associated with petrified wood. Petrified wood is abundant in the form of logs, limbs, twigs, bark, and roots, in which the petrifying material is opal and other forms of silica. This wood is in various stages of petrification ranging from partly silicified lignite to material completely replaced by silica or opal. A quantity of wood has been petrified with common opal by a replacement process retaining minutely the texture and grain of the wood. This variety occurs in petrified wood, bark, roots, and other structures, among which Mr. Roop has found spruce or pine cones.

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[1] Science, new ser., vol. 26, pp. 380-382, 1907.

The precious opal occurs chiefly as casts of different parts of trees and as coatings and fillings in cracks in ordinary petrified wood. The precious opal casts rarely retain the texture or grain of the wood, but may show such structure as bark and inclosed wood by slight color variations or other lines of demarcation. Mr. Roop has found two very interesting specimens of opalized cones, one measuring about 1 inch long that has been perfectly cast by milky opal and the other, a slightly larger cone of milky color, completely inclosed in a mass of translucent precious opal 2½ inches thick. Twigs and limbs of trees 2 and 3 inches thick have been reproduced in precious opal of beautiful colors. Logs several inches in diameter have been cast with common jet-black or dark-brown opal, parts of which show fire. The black opal gives off water and tarry matter smelling of pyroligneous acid when heated in a closed tube. A quantity of other variously colored common opal occurs with gem variety, as translucent purplish, reddish-brown, gray, and white. Some precious opal has been found as fillings in cavities in the volcanic ash. Among such specimens are small patches of gray or white opal with a beautiful play of green, yellow, blue, and red fire, but exceedingly brittle so that the small pieces can be crushed between the fingers into powder. The minute grains still display their fine color and fire after the opal has been crushed. Opal, both in casts and in veinlets filling cracks in petrified wood, is used for gem purposes, and some of the petrified wood containing seams and veinlets of precious opal would yield very good matrix opal.

The best gem opal from Virgin Valley is unexcelled in variety and brilliance of fire and color by that from other localities. The cut gems exhibit superb flashes of green, blue, yellow, and red of various shades with milky white, gray, bluish, or brownish background which may be opaque, translucent, or nearly transparent. In some the color is uniform over the whole stone or over large areas, changing, as the gem is turned, from green to red, or from red to blue, and so on. Some of the gems show a rich ultramarine blue in one position, and green or red in another. Many gems display various bright colors arranged in patches, and each patch changes color as the stone is turned. The brilliant flashes of peacock-feather colors exhibited by the opal of dark color yield a gem which might be called black opal, but most of it is not like the Australian gem of that name, since it occurs in thick pieces and the colors are less localized. Most of the dark-colored gems, no matter how beautiful in reflected light, become a rich reddish-brown in transmitted light. The more opaque bluish-gray and milky opal with good fire also yields especially beautiful gems.

A quantity of brittle opal which checks and cracks considerably after removal from the mines has been found. Some of this opal has magnificent color and fire, but close inspection shows that it contains fine cracks, some of which are sufficiently pronounced to allow the stone to fall apart. In many cases this tendency to check could be partly overcome by a careful handling of the rough material, that is, by a rather slow seasoning process in which the opal is not immediately exposed to the dry atmosphere and considerable temperature changes of the desert, but is kept in a moderately cool place or in moist wrapping.

At the suggestion of H. D. McCaskey, of the United States Geological Survey, specimens of opal containing cinnabar were cut with a view to determining their suitability for gem purposes. This material came from a quicksilver mine operated by J. B. Kiernan, of Beatty, Nev. Specimens of the rough mineral were kindly supplied by Mr. Kiernan and general information on the deposit was given by A. A. Turner, a mining engineer of Boston, Mass.

The mine is in Bare Mountain in southwestern Nevada, the nearest point being about 10 miles from the California State line. The Amargosa Desert lies west of the mountain and Crater Flat to the east, the highest point being approximately 6,235 feet above sea level, or 3,300 feet above the surrounding plains. The formations around the cinnabar deposit are limestone, quartzite, schist, and a volcanic rock, probably dacite. The deposit lies between two dacite dikes and is apparently a replacement deposit. Opal impregnated with cinnabar was found within a few feet of the surface and extended to a depth of 61 feet, the depth of the workings at the time last examined by Mr. Turner. The opal is an associated mineral but much of it contains sufficient mercury to smelt with the regular ore. The opal bodies are surrounded by a fine white sand resulting from the decomposition of impure opal. The nature of the deposits and the presence of small vent holes in the sand near the ore bodies indicate that they have resulted from past hot spring activity.

Most of the material that can be cut as a semiprecious stone consists of milk-white to slightly translucent gray opal impregnated with bright vermilion-red cinnabar. The cinnabar occurs in minute particles disseminated or grouped in irregular tufts, patches, and streaks through the opal. Specimens were seen in which the cinnabar was in a duller chalcedonic material, probably altered quartzite. The contrast between the red and the white or gray, with the variations of markings displayed by the cut stones, make this an attractive semiprecious stone which could be readily used in the western tourist trade. The possibility of the cinnabar losing some of the brightness of its color, as in the "myrickite" described under agate, will have to be taken into consideration.

OREGON.

Mr. Don Maguire, of Ogden, Utah, reports the occurrence of semiprecious opal along Deschutes River, Crook County, Oreg. This opal is reported to be abundant and very pretty. A limited quantity was shipped to Portland, Oreg., for gem purposes during 1913.

TEXAS.

Specimens of opal found near Alpine, Tex., were received from Mr. A. D. Hudson, of El Paso. They consisted of small patches of white and bluish opal in a dark red rhyolite-like matrix. Some of the opal showed flashes of rich green and bluish fire. The reddish matrix might be cut showing patches of precious opal, if pure gem can not be obtained in larger pieces.

QUARTZ.

ARKANSAS.

Mr. Francis Holstein, of De Roche, Ark., states that a quantity of the quartz crystals from near that place are still sold to visitors and jewelers at Hot Springs. These quartz crystals range in size from small specimens up to fine cabinet specimens. They vary from colorless and limpid to light and very dark smoky brown. Inclosures of phantom crystals and bubbles are present in some specimens. Bright lustrous faces are characteristic of these Hot Spring County quartzes, and occasional crystals show an unusual development of planes. Others are variously etched. Mr. Holstein states that the quartz crystals are obtained chiefly from pockets where they are imbedded in red clay.

MAINE.

Minerals of interest because of their semigem nature are found at the J. A. Hibbs feldspar and mica quarry, a little over a mile northeast of Hebron, in Oxford County, Me. These minerals are translucent quartz and beryl. The quartz varies from colorless to pale rose, light and dark smoky brown, and yellowish. Specimens were seen in which there were rounded patches of dark smoky brown in quartz of lighter color. The beryl is mostly opaque grayish-green. Other associated minerals are potash feldspar, mica, and black tourmaline.

RHODONITE.

COLORADO.

Mr. J. D. Endicott, of Canon City, Colo., reports the discovery of a deposit of rhodonite about 10 miles southeast of that place. He states that the deposit will yield a quantity of mineral with good pink color and of fine texture.

RUBY.

NORTH CAROLINA.

Tests were made on the ruby deposits along Caler Fork of Cowee Creek in Macon County, N. C., during the last part of 1913. Prospecting was under the charge of N. E. Isbell, of Cincinnati, who had charge of the developments here several years before. Mr. Isbell used a churn drill during this work, going to a depth of 65 feet at the "In Situ" Hill locality. Some ruby and sapphire of marketable color were found along with opaque corundum. During the first part of 1914 better equipment in the way of a 3-inch core drill operated by a 10-horsepower gasoline engine was installed, and a number of holes will be sunk at the "In Situ" Hill locality to a depth of about 150 feet.

SPODUMENE.

CALIFORNIA.

Operations of the Pala Chief Gem Mining Co., at the Pala Chief mine and the Tourmaline Queen mine, near Pala, San Diego County, Cal., resulted in a production of more of the lilac-colored spodumene and tourmaline. Although the spodumene has heretofore been called kunzite, as a compliment to Dr. George F. Kunz, the owners of the mine have given their permission to European jewelry firms to sell it under the name of "California iris" as being appropriately descriptive of its native home and its remarkable coloring. Mr. R. Fenton, secretary of the Pala Chief Gem Mining Co., states that the mineral is being well received under this name in many countries of Europe. Much of this spodumene will be sold as "California iris" in the United States also, especially in the West, where the name is considered especially appropriate.

TOPAZ.

GEORGIA.

Two gems, cut from crystals found in the Williams mica mine near Two Run, Ga., were loaned for examination by Mr. L. M. Richard, of Stamford, Tex. One of these was ordinary quartz with a slight brownish tint. The other was colorless topaz, a crystal of which was found inclosed in a cavity in a large crystal of mica. This is a new locality for topaz and an unusual mode of occurrence.

MAINE.

No new work has been done at the topaz prospects on Harndon Hill, in the southwest corner of the town of Stoneham, Me. This locality has been described by George F. Kunz [1] and E. S. Bastin.[2] At the time of examination by the writer, in June, 1913, there were three pits within about 75 feet of one another on three sides of a projecting point of the hill. These pits were 6 to 10 feet deep and from 10 to 35 feet long. They were made in the edge of a body of pegmatite capping the summit of the hill. The rock outcropping below on the hillside is quartz-mica schist or gneiss injected by pegmatite. The pegmatite exposed in the openings is coarse and of uneven grain. Orthoclase or microcline is the principal feldspar, but some albite is present, especially as clevelandite. Quartz occurs in large white masses and muscovite in greenish crystals and bunches of crystals measuring several inches across were seen. Numerous fragments of pale-green, white, and colorless beryl were left on the dumps and scattered over the hill top. Kunz states that some of the beryl crystals found were about a yard long and over a foot across. The only topaz observed was a fragment of an opaque white crystal, an inch and a half thick, attached to a mass of clevelandite and greenish scaley muscovite. According to Kunz, most of the topaz crystals were found in one pocket with clevelandite. The crystals ranged from those small in size to large rough opaque ones, weighing 10 to 20 kilograms. The better crystals measured 10 to 60 millimeters across and were colorless or faintly tinted with green or blue. Some were transparent only in parts. A few reddish garnets and blocks of bluish-green triplite were observed on the dumps. Among other minerals found during operations on Harndon Hill, Kunz mentions apatite, columbite, fluorite, montmorillonite (a variety of kaolin), herderite, and bertrandite.

[1] Topaz and associated minerals at Stoneham, Me.: Am. Jour. Sci., 3d ser., vol. 27, pp. 212-216, 1884.
[2] Geology of the pegmatites and associated rocks of Maine: U. S. Geol. Survey Bull. 445, pp. 100-102, 1911.

NEW HAMPSHIRE.

The discovery of topaz on Baldface Mountain, N. H., was made, according to George F. Kunz,[1] by E. A. Andrews, in May, 1888. Baldface Mountain is about 4 miles northwest of North Chatham. It rises to an elevation of 3,585 feet above sea level or some 3,000 feet above the valley of Cold River on the east. Only rock is exposed on the steep cliff-like slopes of the upper part of the mountain, but the lower part is heavily timbered. Two knobs or shoulders project from the mass of the mountain half a mile northeast and southeast, respectively, of the main summit and 500 to 600 feet lower down. It is on these knobs or shoulders of the mountain that the topaz has been found.

The bare rock of the upper part of the mountain is composed of biotite granite, partly broken into great loose blocks and partly showing the effects of rounding and erosion by the ice of the glacial epoch. Near the east foot of the mountain outcrops of mica schist and gneiss were observed in the hollows.

No systematic mining has been carried on for the topaz and associated minerals, but most of the crystals have been obtained at various times by prospectors and mineral collectors working only a few days at a time. Considerable prospecting for topaz and associated minerals on Baldface Mountain has been done by John Chandler, of North Chatham. Mr. Chandler acted as guide for the writer, and three prospects were visited. Two of these were on the northeast shoulder of the mountain in the steep cliff-like slope, and the other was on the southeast shoulder of the mountain. The two prospects on the northeast shoulder are a few hundred feet apart in a northeast-southwest direction with a difference of elevation of 200 to 300 feet. At the upper prospect the topaz occurs with crystals of smoky quartz, orthoclase or microcline, biotite, muscovite, and a little phenacite lining the walls of miarolitic cavities or pockets of pegmatite in the granite. These pockets range from small to large size, one measuring 10 feet deep (or high) and 2 by 3 feet across at the top and 4 by 7 feet across near the bottom. The pockets have been worked in a northeast course down the mountain side for a distance of nearly 50 feet. The granite near the pockets is medium to coarse grained, rich in biotite and smoky quartz. The crystals lining the walls of the pockets range from small size to 2 or 3 inches across, in the case of the feldspar. The transition from the ordinary granite to the coarser, more crystallized deposit forming the walls of the pockets is gradual in some places, and in other places there is a layer of fine tufted graphic granite between.

Some of the feldspar crystals have a faint bluish-green color, like pale amazon stone. Others are buff colored, but present well-developed crystal faces. Most of the quartz crystals found in the pockets are smoky brown and many are clear. Some occur in single well-developed crystals and others in aggregates of crystals in parallel growths. In the cavities biotite occurs in sharply developed prismatic crystals with hexagonal outlines. The topaz occurs in crystals of minute size up to those more than an inch thick. The majority of them are translucent, or transparent only in places, but some perfectly transparent crystals are found. Some of the topaz is suitable

[1] Gems and precious stones of North America, p. 70, 1890.

for cutting into gems but the most of it is worth more as specimens, because of the perfection of the crystals. They range from colorless to pale bluish green, and some are yellow from iron stains on the surface. Phenacite was observed in small transparent colorless crystals only, which were attached to or partly imbedded in feldspar, quartz, or topaz. Crystals of phenacite measuring over half an inch across are reported to have been found. The phenacite crystals from Baldface Mountain have been described by O. C. Farrington[1] and W. T. Schaller.[2]

At the lower prospect on the northeast shoulder of Baldface Mountain, topaz occurs in a thin pegmatite vein cutting the granite with a strike of N. 35° W. and a dip of 45° SW. This vein has been exposed for about 75 feet by the dropping away of the northeast side attached to a huge block of granite. Crystals have also been obtained from the vein attached to the loose block about 50 feet lower down the mountain side. The vein contains fine graphic granite in places and small miarolitic cavities with mineral associations similar to those at the first prospect described.

TEXAS.

The occurrence of topaz in Mason County, Tex., has been mentioned in these reports for previous years and some of the deposits have been described by H. Conrad Meyer.[3] Several of the localities were visited in July, 1913, when the notes for the following description were obtained. The discovery of topaz was made in 1904 by R. L. Parker. Other prospects were found and all were developed on a small scale between 1908 and 1910. The owners of the different prospects failed to realize on the topaz found on their property and therefore forbade further work. Since that time a limited amount of prospecting has been done by the property owners, in some places with promising results. Meyer first recorded the occurrence of cassiterite or stream tin associated with the topaz of Mason County.

Mason County is in the broken plateau country of central Texas. Much of the county is a basin-like area with included ridges and hills. The county is drained chiefly by Llano River, on which the lowest elevation is less than 1,200 feet above sea level. The topaz localities examined are at elevations of from 1,600 to 1,800 feet above sea level. Water is scarce and only the larger streams flow the whole year.

The basin-like portion of Mason County is part of the pre-Cambrian basin described by Sidney Paige.[4] The surrounding rim rock or scarp is part of a dissected plateau composed chiefly of Paleozoic rocks, among which limestone is prominent. The pre-Cambrian rocks in the topaz areas consist largely of granite, but a belt of rock composed of mica schist and mica gneiss was observed between the two groups of deposits. The principal granite of the topaz region is a coarse red granite, with porphritic texture locally developed. The feldspar phenocrysts of this granite measure over an inch long in some places. A finer grained granite, also reddish, was observed in the region but not associated with the topaz deposits. Pegmatite is

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[1] Notes on various minerals in the Museum collection: Field Columbian Mus. Pub., Geol. Ser., vol. 3, pp. 157-158, 1908.
[2] Notes on crystallography of phenacite: U. S. Geol. Survey Bull. 490, p. 53, 1911.
[3] Topaz and stream tin in Mason County, Tex.: Eng. and Min. Jour., Mar. 8, 1913, pp. 511-512.
[4] U. S. Geol. Survey Geol. Atlas, Llano-Burnet folio (No. 183), 1912.

associated with the coarse granite, chiefly in irregular masses or streaks, with or without miarolitic cavities, and is the source of the topaz. The coarse granite weathers out in rounded bowlders or flat floors. The products of weathering are angular gravelly to coarse sandy soil becoming finer with more extended weathering. Quartz and feldspar grains are the principal constituents of this soil.

Two groups of topaz deposits were examined, one about 8 miles west of Mason, between Streeter and Grit, and the other about 8 miles west of north of Mason or 4 miles west of south of Katemcy. In the first group the topaz prospects of C. J. Worlie, half a mile east of Streeter, and J. W. Bishop, 2 miles northeast of Streeter, were visited. Other prospects were reported on the land of Dan Blickenbach, 2½ miles northeast of Streeter, and on Alexander Smart's place near Grit. In the second group the prospects of Sam Awalt, Lee McGehee, and D. E. Amarine were visited.

The Worlie prospect is about a quarter of a mile east of the house in the wash of a dry stream. All of the work has been done within a distance of 200 feet along stream channel or within 50 feet from it. Several small pits and diggings 1 to 3 feet deep have been made in sand, gravel, and alluvium among large bowlders, and one pit 6 feet deep and 15 feet long was made in rock. The country rock is coarse red granite with porphyritic texture in places. Locally there are pegmatitic phases around miarolitic cavities. Some of the granite is friable and partly decomposed, but much of it has weathered out into large spheroidal bowlders, or is exposed in hard flat ledges or floors. The prospect pits were dug through the drift to the granite floors where all depressions and crevices were carefully cleaned out. The pit in the solid rock opened irregular miarolitic cavities in the granite. The minerals of value lining these cavities had been removed, but some of the matrix was left in contact with the granite. The matrix contained much biotite in thin flat scales ranging from small size to more than 1 inch across, a little graphic granite with red feldspar, some albite in the form of clevelandite, gray microcline and pale amazon stone in stout crystals, muscovite, and colorless and smoky quartz crystals. Topaz is reported to have been found in these pockets also. The best topaz crystals were found loose in the gravel and sand beds. Most of these were partly broken and the edges were rounded by attrition, but beneath the roughened surface most of the crystals were of fine transparent quality. A few crystals were found which had not been badly disfigured by abrasion and would serve as fine cabinet specimens Many of the topaz crystals were tinted pale bluish or bluish green and a few were rather strongly colored.

Several prospects were opened on the land of J. W. Bishop. The one examined is about a quarter of a mile northeast of the house in a low rocky hill. The work consists of a crescent-shaped open cut 40 feet long and 4 to 10 feet deep and of another small pit about 40 yards to the southwest. The country rock is coarse porphyritic red granite which outcrops in large rounded bowlders and ledges The open cut was blasted out of an outcrop of hard granite following a pegmatitic vein. This vein was irregular in shape and carried miarolitic cavities or pockets, in which the topaz was found. A portion of such a pocket was left exposed in one end of the cut. It measured about 2 feet wide and 1½ feet high; the length was not exposed. It is reported this pocket contained much red clay with some of the crystals loose in the clay. The walls were crumbling and soft with no crystals left attached. A few small colorless topaz crystals were found on the dump at the time of examination. These crystals were long and slender, measuring less than a centimeter in thickness The prospect is reported to have yielded many transparent finely tinted bluish-green crystals. The pit to the southwest was made on a small vein of pegmatite 1 to 3 inches thick, cutting the granite in a N. 70° E. direction, but apparently little topaz was found The pegmatite vein was traced over 100 feet toward the main working. Four other prospects were opened on the Bishop place and good topaz is reported to have been found at some of them.

The topaz prospect of Sam Awalt is in low ground between the forks of a dry wash about 250 yards southeast of the house. About a dozen prospect pits have been made within an area 125 feet wide and 200 feet long east-northeast. The pits are irregular in shape and none of them are more than 25 feet across or 8 feet deep. The presence of water within a few feet of the surface made more difficult the working of the prospects. They are in part in gravel beds, but chiefly in deposits of pegmatite, which, with the coarse granite country rock, form a floor over part of the flat. No definite structure or relation between the pegmatite and the granite was observed, and the impression gained was that the pegmatite occurs as irregular masses developed around miarolitic cavities in the granite. The workings are scattered and it could not be ascertained whether the pegmatite exposed in each is all part of one flat-lying sheet or consists of a number of disconnected masses in a nearly horizontal zone. In the largest pit the pegmatite exposed ranges from a few inches to nearly 4 feet in thickness, and the deposit dips about 10° S. The texture of the pegmatite in this pit is coarse, and pockets were opened which measured over 3 feet across and 1 foot high. Besides massive quartz and microcline feldspar, rough crystals of each measuring as much as 1 foot across were found projecting from the walls of the cavities. Most of the quartz crystals had drusy surfaces but were transparent within. They were colorless to smoky, and some contained inclusions of many small cavities with or without bubbles. Most of the feldspar crystals were red, but some of a gray and pale bluish-green amazon stone variety were observed. A little black tourmaline in long acicular crystals was associated with the quartz, penetrating some of the crystals in many directions. No topaz had been left exposed in the matrix at this prospect.

In another pit 200 feet to the northeast the topaz-bearing rock is peculiar and different from that observed at the other prospects in Mason County. The pit exposed a large mass of fine red felsitic rock through which were scattered red, gray, and greenish microcline, radiated groups or tuffs of clevelandite, colorless and smoky quartz, muscovite, and topaz crystals. The felsitic rock is dense grained and composed chiefly of feldspar, quartz, and fine needles of black tourmaline. It appears to be molded around the larger crystals of quartz and other minerals, in some cases showing a partial banding parallel to their surfaces. The microcline, quartz, muscovite, and topaz are in crystals of varying degrees of perfection. All are frozen in the felsitic rock and are generally badly fractured by attemps to separate them. The radial groups of clevelandite measure several inches across, and many of them are aggregated around quartz crystals. The felsite has the appearance of growing secondarily around the larger crystals of the different minerals—that is, of filling portions of previously existing miarolitic cavities.

The majority of the topaz from the Awalt prospect is colorless and of beautiful transparency, but a little clear delicately tinted bluish topaz was also found.

The topaz prospect of Lee McGehee is about half a mile northwest of the Awalt prospect in a flat along a dry branch. Shallow pits have been dug over about an acre of ground on the west side of and a few feet higher than the bed of the dry stream. The pits are scattered here and there without any definite arrangement. The country rock is the coarse porphyritic red granite characteristic of the region and outcrops in flat ledges and large rounded bowlders. A coarse angular gravelly soil formed by the decomposition of the granite covers much of the surface. The topaz occurs in a bed of such soil which has been transported a short distance only and deposited in its present position along with coarser gravel and small angular bowlders. The wash material has been deposited on disintegrated granite and because of the sharp edges of its components it is difficult to determine the line of demarcation between wash material and soil in place. So far all the topaz has been found loose in the wash along with other minerals commonly found associated with it. No gem pockets have been found in the granite, though the topaz-bearing wash has not been transported far from its source. Granite outcrops project above the wash within 100 yards to the southwest, and the dry stream has cut into the granite close to the topaz prospects. Among the minerals which have evidently come from the topaz-bearing pockets are quartz crystals, red, gray, and bluish-green microline feldspar, muscovite, and a small quantity of cassiterite. A number of the dark smoky quartz crystals one-half inch to 2 inches in diameter were coated with a thin layer of reddish-gray microcline. Topaz of very good quality, chiefly colorless but some of pale bluish-green tint has been taken from the McGehee prospect. Many of the crystals have been partly fractured or rounded by attrition so that they are not suitable for fine cabinet specimens. Some large, imperfect transparent crystals and fragments of crystals have been obtained, and among them the largest topaz found in the county. This specimen is now in the collection of the United States National Museum. It weighs 1,296 grams, or 45.7 ounces avoirdupois, and is mostly transparent and colorless. Two opposite corners are tinted a faint bluish green. The crystal has a large cleavage plane base, with some of the other faces fairly well developed but partly dulled by etching and attrition by sand and water.

The Amarine prospects are a few hundred yards southwest of the Awalt prospect. Three pits 8 to 15 feet deep were opened at one place, and another pit 12 feet deep was made about 200 yards to the northwest. All of the workings are in hard rock and required blasting to open. In each opening red pegmatite was encountered in coarse porphyritic red granite. In the southeast prospects large red microcline feldspar crystals, massive and crystal quartz, muscovite, black tourmaline, and purple and gray fluorite were observed. In the northwest prospect a pegmatite vein with an east strike and a 10° S. dip was exposed in coarse red granite. This pegmatite inclosed a vein of gray quartz 5 to 12 inches thick. In other parts of the pegmatite there were coarse crystals of quartz and feldspar. No topaz was observed at the Amarine prospects, but Mr. Amarine reports that some was found.

TOURMALINE.

CALIFORNIA.

Mr. J. W. Ware, of San Diego, Cal., reports the discovery of a deposit of beautiful "Nile green" tourmaline at his "Mountain Lily" mine on Aguanga Mountain, in San Diego County. Many of these tourmaline crystals are of fine gem quality and have yielded beautiful cut stones. The tourmaline has not been found in large deposits and the associated minerals, quartz, lepidolite, orthoclase, and albite are similar to those in other tourmaline mines of San Diego County.

MAINE.

There was but little activity in the mining of tourmaline in Maine during 1913. A few discoveries of crystals were made in the course of feldspar mining on Mount Apatite near Auburn, but none of these were of great value. Brief visits were made to some of the Maine tourmaline deposits in June, 1913, and the information gained has been used along with abstracts from a report by E. S. Bastin.[1]

Developments have been limited at the Mount Mica tourmaline mine, 1½ miles east of Paris, Maine, during the last two years, and the results of these operations have not been very promising. A good description of this mine has been given by Bastin, and the earlier history by A. C. Hamlin.[2]

A large area on the summit of the hill has been worked over by an open quarry, which has progressed from the northwest to the southeast, with an irregular working face over 200 feet long. The early work was close to the surface but the dip of the formation has carried the work to the southeast deeper, until it is now 20 to 30 feet deep along the face of the cut. No work was in progress at the time of examination in June, 1913, and the deeper parts of the cut were filled with water. Waste rock was rolled from the quarry floor to the hillside at the southwest end of the cut. Near the middle it was hoisted by derrick and piled back to the northwest on worked out ground or run on car and track conveniently located for such purpose.

The country rock is mica gneiss composed of layers or bands of schist, with varying texture and composition, injected by numerous layers and sheets of pegmatite. The schists are composed of numerous minerals, among which are quartz, muscovite, biotite, feldspar, garnet, and a finely columnar or fibrous mineral, probably fibrolite. The strikes measured on the schist were quite variable from nearly east and west to west of north, with dips of 10° to 25° to the south and east. The vein rock is pegmatite, the gems occurring in the upper part of a large mass of this rock, the thickness of which is not exposed. The gem-bearing layer of pegmatite is about 7 feet thick in places. It contains numerous cavities or pockets ranging from less than a pint in capacity to several feet across. This gem-bearing layer

[1] Geology of the pegmatites and associated rocks of Maine: U. S. Geol. Survey Bul. 445, 1911.
[2] The history of Mount Mica, Bangor, Maine, 1895.

differs from the ordinary pegmatite below in being slightly coarser grained and in containing pockets and lithia minerals. A thin layer of garnetiferous rock is present at the base of the gem zone in many places, and no pockets are reported to have been found below this layer. The following notes on the mineral associations at Mount Mica are abstracted from Bastin's report:

The principal constituent minerals of the pegmatite are quartz, orthoclase, and microline, muscovite, biotite, and black tourmaline with the clevelandite variety of albite, lepidolite, and colored tourmalines in the gem-bearing zone. Graphic intergrowths of feldspar and quartz, so common in many of the other tourmaline-bearing pegmatites of New England, is comparatively rare here. Quartz is present in small irregular masses of white to slightly smoky color through the pegmatite and in groups of colorless crystals in the pockets. Orthoclase and microcline are the principal feldspars of the pegmatite and have been gathered up from the dumps for use in pottery. Muscovite occurs in graphic intergrowths with quartz, in bunches of "wedge" and "A"-shaped crystals, and in flat crystals a few of which measure more than a foot in diameter. Some of the mica has a clear light rum color and good cleavage and is purchased by mica manufacturing companies.

Lepidolite is plentiful in the gem-bearing zone and occurs in scattered crystals and in large aggregations or masses of crystals. One mass of lepidolite weighing nearly 10 tons was encountered during the work. Among other minerals of the pegmatite are amblygonite, spodumene, apatite, beryl, cassiterite, columbite, arsenopyrite, triphylite, zircon, and kaolin.

Black tourmaline is very plentiful and occurs in elongated crystals, which range from small size up to 5 inches in diameter and over 2 feet in length. They occur only in the solid portions of the pegmatite. The colored tourmalines are found in the pockets and frozen in the solid pegmatite near the pockets. Nearly all of those of gem quality are found in the pockets, either loose in the bottom with kaolin and cookeite or attached to the walls. Some of the crystals are fresh and sound; others have been fractured; and still others have been found which appeared perfect but crumbled to pieces when handled. Some of these contained hard fresh nodules or cores of fine gem tourmaline inside.

The color and quality of the better tourmaline from Mount Mica are excellent. The crystals range in size to over a foot in length and 6 inches in thickness. Green is the predominant color of the gem tourmalines but the mine has yielded some very fine rubellite, indicolite, and achroite gems. The green tourmaline shades in color from olive green through emerald green to blue green. From colorless the achroite crystals grade into delicate pink, green, or blue. The indicolites are greenish blue and nearly sapphire-blue. The rubellite tourmaline from Mount Mica grades from pale to deep pink and nearly ruby-red. The combinations of the various colors mentioned in single crystals, either in shells of one or more colors around a core of another color or in layers across the crystal, have furnished some remarkable specimens now scattered through mineral collections in many parts of the world. A large number of unusually fine gems have been cut from the tourmalines of Mount Mica.

A small amount of work has been done on the land of James E. Bowker adjoining the land of Mount Mica Co. on the east. There is a good outcrop of the pegmatite on this property, and the reported results of the little work done would justify further development. Pockets with fine green gem tourmaline were found with the same association as in the main quarry.

A number of quarries have been opened for feldspar and gems on Mount Apatite, about 3½ miles west of Auburn, Maine. The early work was sporadic and chiefly in the nature of prospecting for gems, but in 1912 the Maine Feldspar Co. reopened some of the old prospects and started new work for feldspar. Other parties have also supplied feldspar to the Maine Feldspar Co. and have handled the gem and specimen minerals themselves. Some of these are E. Y. Turner, J. S. Towne, P. P. Pulsifer, and H. U. Greenlaw. The Maine Feldspar Co. and the Greenlaw quarries are on the east side of Mount Apatite, the Turner and the older workings on the south side, and the Towne and the Pulsifer quarries on the west side.

As far as seen the whole summit of Mount Apatite, where opened by quarries, is composed of pegmatite, but the relations of this rock to the country rock are not exposed. Bastin [1] gives evidence tending to show that the pegmatite is a large flat-lying mass occupying the summit of the hill.

The Maine Feldspar Co. has worked several quarries for feldspar to depths of 5 to 25 feet, and one quarry to nearly 50 feet in depth. Occasional pockets with gem tourmaline have been found in some of the quarries, and in places the surrounding rock carries colored tourmaline. The majority of the gem tourmaline was found in earlier days by N. H. Perry, Thomas F. Lamb, and other people prospecting on the old Hatch farm on Mount Apatite. The discoveries of gems by the Maine Feldspar Co. have not been especially important. The tourmaline crystals found during earlier mining are described by G. F. Kunz [2] as colorless, light pink, light blue, light puce-colored, bluish-pink, and light green, and at times nearly all these colors are found in one crystal. E. S. Bastin [3] states that later work by Thomas F. Lamb yielded tourmalines which cut into gems of nearly emerald-green color. Still later work by the Maine Feldspar Co. on the east side of the top of Mount Apatite developed two gem-bearing pockets from which deep-blue indicolite crystals with a greenish tint were obtained. M. L. Keith, of Auburn, cut some gems of fair quality from them. In another quarry of this company on the east side of the hill, no gem pockets were found, but considerable massive beryl was obtained from the solid pegmatite.

Three quarries have been worked on the land of H. U. Greenlaw on the east side of the top of Mount Apatite, and at one of these, adjoining one of the quarries of the Maine Feldspar Co., a quantity of dark-pink lepidolite, talcose-like altered pink and blue tourmaline, cookeite, and other alteration products of original lithia minerals are found. Small pockets with a few colored tourmaline and a pink beryl crystal are reported to have been opened here during the summer of 1913.

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[1] Geology of the pegmatites and associated rocks of Maine: U. S. Geol. Survey Bull. 445, p. 53, 1911.

[2] On the tourmalines and associated minerals of Auburn, Maine: Am. Jour. Sci., 3d ser., vol. 27, pp. 303-305, 1884.

[3] Op. cit., p. 52.

In the J. S. Towne quarry, on the west side of Mount Apatite, pegmatite has been worked for both feldspar and gem tourmaline. The gems occur in a pocket-bearing zone dipping to the east with a low angle. The pegmatite in the gem-bearing layer is stated by Bastin to be slightly coarser grained than the rest of the pegmatite and to contain clevelandite, lepidolite, and semitransparent green tourmaline frozen in the pegmatite near the pockets. The gem pockets yielded dark grass-green tourmaline and light-green crystals tipped with pink. Among other minerals of interest found in this quarry are amblygonite, zinc spinel, columbite, cassiterite, and herderite.

A number of pits have been opened on the Pulsifer place from 100 to 200 yards north of the Towne quarry. One of these was worked by W. R. Wade [1] and has been described by him along with other gem deposits of Maine. Bastin has given a good description of the Pulsifer quarries also. The pegmatite is approximately flat. It consists of graphic intergrowths of quartz with orthoclase and microcline. Near the base of the gem zone is a layer carrying fine garnets. The garnet-bearing layer is nowhere over 1½ inches thick and has been traced continuously for more than 50 feet. Lepidolite is abundant near the pockets and considerable green, bluish-green, and blue indicolite and pink tourmaline are frozen in the pegmatite in places. Some of the pockets carry good crystals of partly transparent tourmaline of the same colors. A number of pockets have been opened, especially toward the south part of the quarry, which yielded transparent purple, bluish, and pink apatite crystals. Besides those found by Mr. Wade some 10 or 12 years ago, other pockets with purple apatite have been opened by Mr. Pulsifer within the last two years. These apatite crystals are best suited for cabinet specimens. They could be cut as gems, but owing to the comparative softness of the apatite, they would not wear well.

Pockets carrying gem tourmaline have been found irregularly distributed through the A. R. Berry quarry, 1½ miles southeast of Minot, in the town of Poland. The quarry is situated in a large outcrop of pegmatite on the north end of a low ridge, a few hundred yards south of Little Androscoggin River. Mr. Berry has opened a number of pockets in this quarry, some of which yielded gem tourmaline, chiefly green and blue, with a little pink. Among other minerals of interest found here are crystals of herderite, lepidolite, greenish-blue and pale-lavender apatite, beryl, and amblygonite.

The best gem discoveries were made in 1910 to 1912 by F. L. Havey, of the Maine Feldspar Co., who worked a part of the Berry quarry on a lease. Several pockets yielding tourmaline of especially fine quality were found. From the last pocket, opened in October, 1912, 11 pounds of crystals were obtained. Sufficient tourmaline was obtained by Mr. Havey to arrange several characteristic collections showing the variations in crystal development and color with gem and semigem material and to supply an abundance of material suitable for cutting into gems of fine quality. The crystals grade from small size to those more than an inch thick and several inches long. Some have nearly hexagonal outlines, but the majority are more triangular with rounded cross section. The terminations are present on the end of the crystals only in most specimens and consist of

[1] The gem-bearing pegmatites of western Maine: Eng. and Min. Jour., vol. 87, pp. 1127-1129, 1909.

scalenohedrons capped by rhombohedrons. Most of the crystal faces do not show a high polish but are slightly etched and pitted. Green is the predominant color of the tourmaline, and many of the crystals are rich bluish to nearly emerald-green. The crystals from the last pocket opened were said to be darker and to have more of an olive-green color than those from pockets found earlier. A few of the crystals are pink; but where pink is present in the tourmalines it occurs for the most part only in the terminations. The crystals from the last pocket opened have less pink than those taken from the earlier pockets and some of them are salmon-pink.

The gems cut from the best tourmalines, found by Mr. Havey, are brilliant and have a fine deep-green color. The lighter colored stones with shades of blue are also beautiful. Most of these tourmalines are cut by lapidaries in the State and are held for local sale at good prices.

At Mount Rubellite, 1½ miles northeast of Hebron, several small openings have been made on the northwest slope of the hill. Most of them are now partly filled with rubbish and nearly concealed by a thick growth of saplings and brush. Mount Rubellite is a low rounded hill, rising about 150 feet above the valley on the northwest. Pegmatite ledges outcrop over large areas on the summit of the hill and along the west side. Streaks of quartz-mica gneiss are included between the layers of pegmatite with a north to northwesterly strike and an indeterminate dip. Pale translucent rose quartz and masses of graphic granite were observed in several outcrops of pegmatite on the summit of the hill. The main working consists of an open cut with a 50-foot face half way up the hillside. Some of the minerals commonly associated with gem tourmaline were seen on the dump, such as white clevelandite, greenish apatite, and altered pink and green tourmaline. Bastin states that most of the tourmaline was found frozen in the pegmatite and was therefore removed with difficulty. Rubellite-colored tourmalines were common, whence the name of the hill.

A small quantity of gem tourmaline was found in the Mills feldspar quarries on Number Four Hill near the line between the towns of Hebron and Paris. Two pits were opened, about a quarter of a mile apart in a northwest-southeast direction. Gem tourmalines appear to have been found only in the northwest opening, the other pit yielding, besides the feldspar, only opaque beryl and bunches of wedge-shaped mica crystals. The northwest pit was operated by the Mount Marie Mining Co., the last operations being in 1911. Most of the feldspar is very light colored orthoclase or microcline, but some albite and clevelandite are found. Graphic granite and masses of quartz occur in large thick bodies. A few colored tourmalines, mostly opaque, are scattered through parts of the pegmatite, the majority being inclosed in or associated with muscovite and lepidolite. Bastin states that pockets were encountered in the earlier workings, and from these transparent tourmaline was obtained. Quartz occurs in transparent to translucent masses of white, gray, smoky-brown, amber, and rose colors. Among other minerals observed were pale-green beryl, columbite, and blue and green apatite.

TURQUOISE.

ARIZONA.

Turquoise Mountain, in Cochise County, Ariz., has been a point of interest for a number of years. W. P. Blake [1] mentions the locality in 1883, describing extensive ancient workings on the south face of the mountain. Large piles of waste had been thrown out from them and on this débris century plants and various desert cacti were growing. Blake was of the opinion that the deposits were worked before the day of the Apaches. He was successful in finding only light apple-green and pea-green specimens of turquoise on the dumps and a very little with a suggestion of blue. From this he believed the deposits were not so rich as at Cerrillos where there were much larger prehistoric excavations. Remains of ancient workings can still be seen, and hammers made of quartzite and some of basic igneous rocks can be found on Turquoise Mountain. Very little has been published regarding the modern operations at this locality.

Turquoise Mountain (now sometimes called Turquoise Hill) is 1 mile northwest of Courtland. It is a ridgelike prominence about half a mile long in a N. 25° W. direction, with steep cliff-like sides. The greatest elevation is nearly 5,400 feet above sea level, or 300 to 400 feet above the surrounding valleys. The highest parts are near the ends, the southern end of the hill being a knob and wider than the northern end. The region is desert, vegetation on Turquoise Mountain consisting chiefly of cacti, grease wood, and sage brush.

The majority of the workings for turquoise are along the west side of the hill, but other openings have been made on the summit and on the east side. All the openings are within an area about 1,200 feet long and 400 feet wide. There are four principal groups of workings, with other scattered prospects. Three of these are on the west side of the ridge, one about 100 yards northwest of the knob at the south end, another near the middle of the ridge about 400 feet to the north, and the third 200 to 300 feet farther north. The fourth group is on the east side of the ridge about 500 feet north of the knob at the south end or nearly 100 yards northeast of the first group. More than 20 openings have been made, consisting of prospects, pits, shafts, open cuts, and tunnels with stopes. Over 1,500 feet of tunnels have been driven in the hill with stopes and winzes.

In the first group of workings there are two open cuts, a shaft 50 feet deep, and about 500 feet of tunnels with large stopes. The shaft connects with drifts from the crosscut tunnel from the hillside below. In the second group there are over 300 feet of tunnels, a shaft 50 feet deep, and an open cut. In the third group there is an open cut about 40 feet long, 15 to 30 feet wide, and 30 feet deep, with over 400 feet of tunnels and a shaft 60 feet deep in the bottom of the cut. In the fourth group on the east side of the hill there are two open cuts and nearly 200 feet of tunnels with stopes from the lower one. Other workings consist of numerous pits, a few small open cuts, and several tunnels, some on the knob south of the workings described and others to the north.

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[1] New locality of the green turquoise known as chalchuite: Am. Jour. Sci., 3d ser., vol. 25, p. 197, 1883.

The summit and steep upper slopes of Turquoise Hill are composed of massive quartzite, considered to be of Cambrian age by F. L. Ransome.[1] Some of this quartzite is fairly coarse grained and feldspathic with the feldspar partly decomposed. Along the western slope of the hill, below and close to the turquoise deposits, there is an igneous rock so badly altered that it can not be readily identified. Ransome has called it granite, stating that a similar rock to the southwest is intrusive into the quartzite. The contact exposed in some of the turquoise workings is that of an intrusive rock, but it was not possible to distinguish between this altered granite and altered quartz monzonite outcropping a few hundred yards to the west. In hand specimen the rock consists of numerous gray quartz grains in a soft kaolin-like matrix. Under the microscope the matrix is found to consist almost entirely of fine sericite. Owing to the fracturing in the quartzite and granite along their contact and the abundance of claylike material in the joints it is not easy to distinguish the contact in some places. The contact measured in one of the tunnels had a north strike and a dip of 75° E. The quartzite strikes nearly north and south with a dip of 60° to 70° E. A prominent system of bedding joints with a north strike and a dip about 70° E. with less prominent cross joints has been developed through the whole quartzite. Many of these joints have been filled with veinlets of white claylike material, which the microscope shows consists largely of massive fine sericite. Brown limonite stains are present in some of the joints and veins

The turquoise occurs in seams and veinlets as a filling in the joints and as nodular or concretionary masses in the sericite veins. Most of the material mined is in the quartzite, but some turquoise was found in the decomposed granite. The veinlets of turquoise are rarely as much as an inch thick and but little of the fine gem turquoise occurs in veinlets over one-fourth of an inch thick. The sericite veins are as much as 2 inches thick, and in places carry rough nodular or botryoidal aggregates of turquoise over an inch thick. A study of the deposits shows that the best turquoise occurs in veinlets, most of which are less than one-eighth of an inch thick. The thicker veins and some of the nodular turquoise is commonly greenish-blue or greenish and some is very pale blue and soft.

From a careful examination of the dumps and workings it was evident that turquoise of exceptional quality was found in Turquoise Mountain. The smaller pieces of fine gems found were translucent, pure dark blue with a fine dense texture. Such turquoise would cut into gems of the finest quality. A quantity of good matrix was undoubtedly obtained, for many small fragments of turquoise mottled with limonite were seen around the workings.

CALIFORNIA.

Several large turquoise mines have been operated in the northeastern part of San Bernardino County, Cal., and in adjoining parts of Nevada. Among these mines were West Camp of the Himalaya Mining Co., Middle Camp and East Camp of the Toltec Gem Mining Co., in California, and the Wood's mine, in Nevada. West Camp, of the Himalaya Mining Co., was described in this report for 1911 It is near the head of Riggs Wash, 12 miles N. 60° E. of Silver Lake, a

[1] The Turquoise copper-mining district: U. S. Geol. Survey Bull. 530, pp. 126-127, 1912.

station on the Tonopah & Tidewater Railroad. Middle Camp is 2 or 3 miles east of West Camp, and East Camp is 8 miles due east, or about 12 miles by road, of West Camp. These mines have not been operated for several years and as they are in a desert region, the writer has had difficulty in obtaining guides competent to take him to the camps in the brief time available for such trips. West Camp was reached from Silver Lake in 1911, but the teamster was not acquainted with the location of the other mines or springs, so that search for them had to be abandoned. A trip was made from Nipton, Cal., a station on the San Pedro, Los Angeles & Salt Lake Railway, to East Camp in August, 1913, but again the location of Middle Camp was not known. Nipton is 31 miles N. 85° E. of East Camp. All the camps can best be reached from Silver Lake if proper equipment for the trip and a guide familiar with the location of the few wells and springs afforded by this region can be obtained.

The Ivanpah topographic sheet, issued by the United States Geological Survey, is an excellent map of the region around the turquoise deposits and the country to the east, beyond Nipton. Unfortunately the region west of the mines toward Silver Lake is not included in this map. The turquoise mines are located in a range of rough hills or mountains extending east of south from Shadow Mountains. The crest of the range is near the east side and from it long valleys, the lower parts filled with wash material, drain westward into Silver Lake. Along the western side of the range, the relief between valleys and hills is greater than on the eastern side. The elevation of West Camp is about 3,700 feet and of East Camp about 4,300 feet above sea level.

There is no water supply near the mines of the Toltec Gem Mining Co., and water had to be hauled several miles for camp use. Water was obtained from a well 80 feet deep at the Himalaya Mining Co.'s mine. The vegetation is that typical of the desert, of which coarse branching yucca cacti, almost large enough to be called trees, are plentiful.

According to the information furnished by Mr. Gus Hamstadt, of Nipton, the turquoise deposits were discovered by an Indian named Prospector Johnnie, who located them in 1894 in partnership with G. Washington and Peter Phifer. Mr. Hamstadt carried some of the turquoise to New York in 1896, selling a quantity and getting parties interested in the deposits. The various interests in the claims were purchased by J. R. Wood, of New York, and operations were commenced at East Camp in 1897 under the name of the Toltec Gem Mining Co. Later Middle Camp and West Camp were opened.

East Camp is located in a draw, draining southwest toward Halloran Springs, about three-quarters of a mile west of the point where the road to the old Valley Wells copper smelter crosses the summit. The draw is not deep, and part of the workings are in a low gap between it and the head of another valley on the north, which drains east. Prospects have been opened for a distance of half a mile along both sides of the draw, but the principal workings are within 250 yards of the mine buildings. There were numerous prehistoric workings, but many of them have been obliterated by recent operations, and only a few of the smaller ancient pits can now be seen. A number of broken stone hammers used by the ancients were seen around some of the workings. The prehistoric workings were widely scattered and served as guides to the modern workings. Mr. Hamstadt states they were chiefly pitlike holes rarely over 15 feet deep and from 10 to 25 feet across.

Probably the most important workings were those 250 yards northwest of the camp, in the hillside near the summit of the low gap. An open cut 100 feet long in a N. 60° W. direction, 30 feet wide, and 15 to 20 feet deep, two shafts about 40 feet deep, at least 300 feet of tunnels, and stopes were made at this place. Tunnels were driven in from the hillside to the south and connected with the bottom of the open cut by shafts or stopes. Other tunnels were made from each end of the open cut. Among other large workings were deep shafts near the camp, open cuts and tunnels north and also west of the camp on both sides of the draw. Some of these openings were large, consisting of open cuts 20 to 40 feet long and 10 to 25 feet deep and tunnels aggregating several hundred feet in length.

Varied types of rock are exposed in the turquoise region. Along the road to Valley Wells coarse porphyritic biotite granite, inclosing masses of diorite outcrops for a distance of several miles. In the hills south of the mine is a metamorphic series containing hard quartzite, biotite schist, mica gneiss, etc. The turquoise-bearing area is bounded by biotite schist on the west also, and this in turn is overlain by a mesa-forming basalt flow. The turquoise deposits are in coarse porphyritic granite and a porphyry which is probably the monzonite type, slightly quartzose, occurring in the form of dikes. One of these dikes about 250 feet wide cuts the granite with a northwest strike on the north and within a few feet of the mine buildings.

Both the coarse granite and the porphyry have been so fractured and decomposed near the turquoise deposits that it is difficult to distinguish between them. Decomposition has resulted in sericitization and kaolinization of the feldspars of the rocks with a deposition of a quantity of limonite iron stains and probably also some secondary silica. Extensive fracturing or jointing opened many channels for the passage of the water or solutions which caused the decomposition. Later solutions carrying the elements of turquoise and passing through the same channels deposited turquoise in seams and veinlets and in nodular masses imbedded in kaolin or sericite in larger veins. Some of the turquoise is in light-colored matrix, but in other places the matrix is heavily stained with limonite. The abundance of limonite stains in the altered rocks, with which the turquoise is associated, indicates that a quantity of pyrite or other iron sulphides have been decomposed during the weathering. Limonite pseudomorphs and rusty cavities left by weathered pyrite were observed in the fracture zones near the turquoise veins. Veins of chrysocolla and limonite stains were found in a prospect nearly 300 yards east of the camp buildings in another small body of porphyry.

The majority of the gem turquoise found at East Camp was in nodules or nuggets. These ranged in size from small specimens to those over an inch across, as a rule the larger pieces being of poorer grade. Some large nuggest of high-grade turquoise are reported to have been found, however. George F. Kunz [1] mentions one specimen

[1] Gems, jewelers' materials, and ornamental stones of California: California State Min. Bur. Bull. 37, p. 153, 1905

mined by the Toltec Gem Mining Co., which cut into a perfect oval gem of rather pale blue, measuring 32 by 45 millimeters and weighing 203 carats. The best turquoise ranged from pale pure blue to fairly dark nearly pure blue. A quantity of off-colored greenish-blue and some soft pale-bluish semiturquoise was observed around the workings The best gem turquoise was hard and had a dense texture. Besides fine pure gems, some very pretty matrix was obtained during mining.

NEVADA.

The Wood turquoise mine, near Crescent, Nev., also called one of the Toltec mines, was opened by J. R. Wood, of New York, about the same time as the other deposits of the Toltec Gem Mining Co. in California. The mining was conducted by Milton Mundy, now of Hart, Cal. The remains of prehistoric workings, with stone hammers scattered about them, served as a guide for modern development. Parts of these ancient workings and a few broken stone hammers can still be seen near the recent excavations. The region is rough, rocky, and desert with the characteristic vegetation consisting chiefly of cacti and sage brush. The mine is 3 miles S. 75° E. of Cresent, in a gulch-broken valley south of Crescent Peak. Openings have been made over an area about a quarter of a mile wide and half of a mile long and extending north up on the side of Crescent Peak. The elevations at the different openings range from 5,100 to 5,400 feet, Crescent Peak being 6,001 feet above sea level. Two principal groups of workings were made, one on the side of Crescent Peak and the other along both sides of a gulch draining southwest about one-third of a mile to the south. A camp had been established on a ridge between the two groups of workings and a few hundred yards southwest.

There were two sets of workings in the south group, one on the southeast side of the gulch and the other about 100 yards northwest across the gulch. On the southeast side of the gulch a tunnel has been driven east into the hillside 150 feet, about 15 feet above the bottom of the gulch and about 75 feet below a small rocky knoll. There were branching tunnels and stopes connecting with an open cut about 50 feet higher. This open cut was 60 feet long and 10 to 20 feet deep, with short tunnels and a shaft feeding a chute into the tunnel below. Other smaller tunnels and pits were made on the hillside and near the summit of the knoll where there were several small ancient workings.

On the northwest side of the gulch 3 principal workings were made within an area of about 200 feet square, the upper one an open cut 20 by 40 feet across and 15 feet deep, another, 50 feet lower down on the hillside, an open cut 50 feet long and 10 feet deep with short tunnels, and the third 25 feet still lower down, a tunnel 240 feet long driven northwest under the other workings.

In the group on the side of Crescent Peak the principal workings consisted of an open cut 50 feet long and 20 feet deep, a tunnel 100 feet long driven into the side of a gulch under and about 20 feet lower than the cut, and an inclined shaft 200 feet deep on a dip of 50° NW. Other workings were a 75-foot tunnel across the gulch to the east, a 25-foot shaft on the ridge about 100 yards to the east, an open cut 30 feet long in the east side of another gulch about 200 yards to the west, and several smaller prospect pits scattered over the mountain side.

Other prospects were made in the gulch north of the camp and on the hills south of the workings described above. The small developments at these places indicate that no finds of importance were made.

The rock exposed in the turquoise-bearing area is a decomposed porphyry of granitic or quartz monzonitic nature. In some of the less decomposed phases both pink orthoclase or microcline and white plagioclase can be distinguished in hand specimens along with quartz and biotite. In some of the more altered phases there are grains of quartz scattered through chalky white masses of sericite, kaolin, or other alteration products of the original rock. Fracturing and jointing of the rock have been extensive, doubtless rendering more easy the decomposition and the spreading of the alteration products. In places brown and yellowish stains of limonite and jarosite are abundant. The decomposed rock along some of the fracture zones has been hardened by limonite acting as binding material or cement. Secondary quartz is scattered through the rock in veinlets and small irregular masses and in places sericite has developed plentifully. Clay gouge seams and veinlets have formed in many of the joints and fractures.

The occurrence of the turquoise in the different workings is very similar. A large proportion of it occurs in nugget or nodular form in fractured portions of the rock, and some occurs in seams and veinlets. In many places several nodules are grouped together. The nodular turquoise is embedded in the white claylike masses of the gouge veins or in similar material in badly altered parts of the rock along fracture zones. The turquoise nodules removed from this matrix are coated with white chalklike shells, which have to be chipped or ground off before the quality of the gem can be determined. Sericite is an important constituent of much of the white claylike gouge deposits. In places the claylike matrix and associated turquoise have been cemented into hard masses by limonite. Quartz, in rough crystals, is occasionally associated with turquoise in some of the veinlets. A quantity of soft nodular, pale-blue to bluish-green turquoise or semiturquoise, was found in several of the prospects, especially on the steep spur east of the main working on the side of Crescent Peak. Limonite stains were abundant in the surface rock on this spur and indications seemed favorable for the opening of a good deposit of turquoise. The prospect shaft at this place failed to locate any good gem material, however. The nodules of turquoise range in size up to more than an inch across and generally yield pure turquoise and but little matrix. The better turquoise ranges from light to medium dark pure blue of a shade sometimes called "baby blue." The texture is dense and the mineral over 6 in hardness.

Owing to the occurrence of most of the turquoise in nodular masses embedded in claylike matrix, it was difficult to save all the gem material in mining and a quantity of good turquoise passed to the dumps. Some of these dumps might be profitably worked yet, though their surfaces have been picked over many times by visitors to the mine. Evidently turquoise was rather plentiful in the larger workings, as so much was allowed to go over the dumps and it was still found profitable to carry on extensive operations.

Other turquoise prospects are reported to have been opened by Smithson & Phillips about a mile east of the Wood mine on the east side of the divide extending south from Crescent Peak.

A turquoise prospect was opened several years ago, 1 mile south of Crescent near the head of a small valley. This deposit is now owned by G. W. Morgan, of Crescent, Nev. The workings consist of a tunnel 75 feet long driven southward into a hillside and connecting with a shaft 35 feet deep on an incline of about 70° E. with two smaller pits. The country rock is a dark granular igneous rock of granitic or quartz monzonitic nature. It is cut by a finer grained light colored rhyolite. Both rocks have partly altered, and the rhyolite has been hardened by secondary quartz. The turquoise occurs in seams and veinlets, chiefly in the rhyolite. In places the turquoise shows a tendency to nodular development in the veinlets. Fragments of greenish, pale-blue, and some good nearly pure-blue turquoise were observed around the workings. Mr. Morgan states that about 200 pounds of turquoise and matrix were obtained, for some of which offers of $20 a pound were received.

NEW MEXICO.

The turquoise deposits of the Jarilla mining district have been mentioned in several of these reports by George F. Kunz. They have been referred to as near Las Cruces, for many years the nearest railroad point. W. E. Hidden [1] furnished one of the best early descriptions of the locality. He mentions at least 10 prehistoric workings and states that mining was in progress at the time of his visit in 1893.

The following information was furnished by Mr. Allen Culver, of Brice: The mine known as the Tiffany mine was worked by David King about 20 years ago and yielded a quantity of good turquoise. The De Meules mine was worked two years preceding 1898, when De Meules, the owner, was murdered by José Flores as the result of a quarrel over a payment for Flores's services as a witness at Las Cruces. The property is reported to have yielded $60,000 worth of turquoise in the last year of operation by De Meules. Later it was leased by Cy Ryan and Tom Kelly, yielding a large quantity of good turquoise. The claim of Luna, Moreno & Ascarate was worked about 13 years ago and proved fairly productive. For the last several years only assessment work has been done. The Tiffany mine has been patented under the name of the Alabama claims, the only patented turquoise claims in the district.

The turquoise deposits of the Jarilla mining district are in two groups, about 2 and 4 miles, respectively, northwest of Oro Grande, a station on the El Paso & Southwestern Railroad, about 60 miles northeast of El Paso. One group of claims is about one-third of a mile west of Brice, a post office on a spur from the railroad 2 miles from Oro Grande. The other group is 1½ to 2 miles north of Brice. Prominent among the deposits of the northern group are the old De Meules mine and the Laura claim of F. B. Stuart, of El Paso. In the southern group are the Alabama claims (locally called the "Tiffany" mine) and the claim of Luna, Moreno & Ascarate.

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[1] Two new localities for turquoise: Am. Jour Sci., 3d ser., vol. 46, pp. 400-401, 1893.

The group of hills in which the Jarilla mining district is situated rises several hundred feet above the plains country on the east. In the region around the turquoise mines the hills are steep, with basin-like valleys among them. The northern group of turquoise deposits is in such a basin with outlet to the east, and the southern group is in a smaller basin with outlet also on the east through a draw draining into the main gulch through Brice. The turquoise deposits lie chiefly around the edges of the basins near the foot of the steeper slopes, at an elevation of approximately 4,600 feet above sea level. The country is arid, and vegetation is slight and typical of the desert.

According to Waldemar Lindgren[1] the Jarilla Hills consist of carboniferous limestone strata domed up by an irregular intrusive mass of fine-grained monzonite porphyry. Interesting deposits of andradite garnet, diopside, quartz, epidote, hematite, and pyrite have been formed along the contacts between the limestone and porphyry. Observations by the writer show sill-like sheets of porphyry interbedded with the limestone with contact mineral zones between each. There has been faulting, so that the outcrops of the strata do not retain symmetrical positions around the sides of the basins. The turquoise deposits are in the lowest sill or possibly in the top of the main part of the laccolith intrusion exposed in the basins.

The De Meules mine consists of two sets of workings near the western part of the basin, one on the north side of a draw and the other about 175 yards to the south across the draw. Both are in gentle sloping ground at the foot of the hills. At the north workings an open cut 40 to 50 feet across and 20 feet deep has been filled up, but some of the branching tunnels extending northeast from it are still open. These tunnels probably aggregate over 300 feet in length and open into irregular rooms and small stopes, some of which extend to the surface. They are probably nowhere more than 25 feet deep. Other prospects were opened around the workings. At the south workings a dozen or more irregular cuts, pits, and shallow shafts with ground-hog tunnels were made. One old shaft was about 40 feet deep. The dumps of waste rock from both sets of workings are large, and it is probable there have been more extended underground workings than could be seen at the time of examination.

The rock at the De Meules mine is decomposed monzonite porphyry. The stage of decomposition varies but is more advanced near the turquoise deposits than at some distance from them. The less altered porphyry is a dark-gray rock, showing white feldspar and biotite phenocrysts. The altered phases are light-gray to light brownish-gray with numerous white spots. In the turquoise-bearing areas the porphyry has been broken into small blocks by numerous joints. The jointing has aided in the decomposition of the rock by furnishing channels for the passage of water. The joints cut the rock in several directions, but in the north workings the tunnels followed two sets of joints carrying turquoise and striking northeast and northwest with high to vertical dips. Here one prominent joint or fissure striking northwest across the end of the tunnels carried both quartz and chrysocolla, with a small amount of turquoise. Prospects to the north and to the west of the underground workings exposed much chrysocolla in seams and veins with but little turquoise. The joints

[1] The ore deposits of New Mexico: U. S. Geol. Survey Prof. Paper 68, p. 185, 1910.

and seams in the rock exposed in the south workings are heavily stained with brown limonite, but those in the north workings are less heavily stained with iron oxides. Numerous small, fresh pyrite crystals were observed in the partly decomposed monzonite wall rock at the north workings.

The turquoise at the De Meules mine occurs as fillings in joints, small fissures, and fracture zones. Some of it forms solid veinlets, and some shows a tendency to nodular development in the veins with limonite-stained sericite or kaolin filling the interstices. Turquoise of various grades was found ranging from pale blue to dark blue, bluish green, and green. Some of the good blue turquoise was dense and hard and yielded gems of good grade. Very pretty matrix was observed, in which the turquoise was mottled with irregular patches of limonite and limonite-stained quartz in the veinlets. A little soft pale-blue "semiturquoise" was observed, especially in seams cutting the decomposed monzonite, in which there was very little limonite stain.

The prospects on the Laura claim, belonging to F. B. Stuart, of El Paso, are about a third of a mile east of south of the De Meules mine. There are two sets of workings, one in the gently sloping ground at the foot of a hill and the other about 200 yards northwest in the hillside. In the south workings three shallow shafts or pits, 15 to 20 feet deep, were made in decomposed spotted grayish monzonite porphyry. The rock has been strongly fractured, and limonite stains filled many of the joints and pore spaces. Turquoise was found rather plentifully in veinlets and nodular masses and some of it was dense and hard with a fairly pure blue color. The best may be designated as "baby-blue." A quantity of pale-blue and soft or semiturquoise had been left on the dumps. There was much turquoise suitable for matrix, which would yield gems of good blue handsomely mottled with brown limonite stains.

At the north prospect there are some pits and a tunnel driven into the hillside near the contact of the porphyry with overlying siliceous slate. Both rocks have been strongly fractured and are heavily stained with limonite. A quantity of rather soft pale-blue and bluish-green turquoise had been thrown out on the dumps, and some was still exposed in the workings. The intimate association of this turquoise with limonite would furnish a quantity of mottled matrix of medium grade. If better turquoise was found during operations, as may have been, it would yield a beautiful matrix. One of the prospect pits a few feet south of the tunnel exposed a vein of gypsum cutting the rock formation. Turquoise occurs in seams, veinlets, and nodules both in the porphyry and in adjacent siliceous slate.

A little turquoise was found in a prospect opened for copper and other minerals by Allen Culver on the southeast side of the basin about two thirds of a mile southeast of the De Meules mine. Several open cuts, a 60-foot tunnel driven southeast into the hillside, and a shaft at least 100 feet deep were made here. The rock formation is quite similar to that at the De Meules mine, consisting of partly decomposed monzonite porphyry. No turquoise was seen in place in the rock, but there were many small pieces scattered around the dumps. Some of the rock was heavily stained with limonite along fractured zones. A little turquoise of pure light blue was seen, but the majority had a greenish cast and some was very soft. Specimens on the dumps showed that the turquoise occurred in seams and veinlets with nodular development in places.

The Alabama claims are on the southeast side of the smaller basin. There are two principal sets of workings, one in the steep hillside on the south of the draw draining the basin and the other about 250 yards south-southwest in a low walled hollow, forming part of the basin. The latter workings are the most important and occur in three groups about 100 yards apart. The principal ones are in the hollow and consist of an open cut 60 feet long in a northwest direction and 20 feet deep, with several crosscut trenches and pits. Turquoise occurs in seams and veinlets cutting the rock in all directions. Limonite stains are abundant both in the turquoise veinlets and through the rock. A deposit of pale bluish (copper) tinted alum had formed in one part of the open cut. Turquoise of a fine dark-blue color and hard dense texture was obtained from this working, along with some of poorer quality. Beautiful matrix could be cut from some of the veinlets containing intermixed limonite.

Two small open cuts and a shaft were made on the hillside about 100 yards east of south, but turquoise of an inferior grade only was seen around the workings. In another place about 100 yards north of west of the main working two shafts had been sunk in an open cut. Turquoise was found rather plentifully in these openings and a quantity of soft pale-blue semiturquoise had been thrown on the dumps. There was much nugget or nodular turquoise here as well as that in veinlets. The decomposed rock in this prospect is not heavily stained by limonite as at the other openings.

In the other group of workings on the south side of the draw, 5 small open cuts and pits and a shaft over 100 feet deep were made in a height of 75 feet in the hillside. Remnants of prehistoric workings can still be seen but most of them had been obliterated by modern excavations. Evidently numerous veinlets of turquoise had been followed in the open cuts, but apparently little turquoise was obtained from the lower part of the deep shaft.

The claim of Luna, Moreno, and Ascarate is across the draw about 150 yards north of the north workings of the Alabama claims. Several pits and open cuts have been made in the hillside within an area of 75 by 125 feet in a northwest direction. One of the cuts is 50 feet long and 18 feet in greatest depth, with short tunnels driven from it. The joints and fracture zones have been heavily stained with limonite. The turquoise veinlets had been carefully gouged out during the last operations and little of the mineral had been allowed to go on the dumps. Turquoise of good grade is reported to have been found, however. A deposit of limonite or copper gossan 2 feet thick had been opened in a prospect about 75 feet west of the turquoise workings.

The country rock exposed in this smaller basin is dark-gray monzonite porphyry, in some places showing but little decomposition. Around the turquoise deposits it has been fractured and decomposed to varying degrees. In some places it is a rather light gray or white, with or without limonite stains, and as such it is difficult to see any relation to the fresh rock. In other places it is spotted gray or brownish gray and shows in part the texture of the original monzonite porphyry. In the north working of the Alabama claims much of the surface rock is strained brown with limonite, but the rock from the deep shaft is hard, altered, light-gray porphyry carrying disseminated pyrite.

TEXAS.

Turquoise has been mined intermittently during the last four years in Culberson County, Tex., about 5 miles west of Van Horn, by the Texas Turquoise Co., of El Paso. The mine is in the smaller hills on the northeastern side of the Carrizo Mountains about 1 mile south of the Texas & Pacific Railway. Developments are small and consists of two openings at the south end of a low oval-shaped hill, one near the bottom of a draw and the other about 70 feet N. 15° E. up the hill. Both are open cuts, the upper one about 25 feet long and 6 feet deep and the lower one an irregularly shaped opening about 10 feet deep.

The turquoise occurs in an area of Algonkian (?) rocks, mapped as the Carrizo formation by G. B. Richardson.[1] This formation consists of quartz-mica schists, quartzite, slates, a little chlorite schist, and some igneous rocks. The turquoise occurs in a hard light-gray to pink rock in which feldspar and quartz are prominent constituents. Two phases of this rock were encountered in the workings—one with a rather fine even granular texture resembling a rhyolite porphyry, the other being a dense rhyolite-like rock with flow texture. To all appearances these rocks are of igneous origin, but a possibility exists that the finely granular rock is a metamorphosed feldspathic sandstone. The rhyolite porphyry, with associated rhyolite, is at least 60 feet thick, passing into a grayish rock of indeterminate nature on the northwest and in contact with an apparently altered basic igneous rock, like diorite, a few feet southeast of the turquoise deposits. The strike of the inclosing formations is N. 45° E., with a high southeast dip. The porphyry has been broken by joints in several directions in which different minerals have been deposited. Among these minerals are quartz, sericite, pyrite, turquoise, limonite, and carbonate of lime. Fracturing followed by deposition of minerals occurred in more than one period. The older joints were filled with quartz and probably some sericite. It is probable sulphides were also deposited contemporaneously with this quartz, for pyrite crystals were observed completely embedded in it. Turquoise was deposited in later joints, apparently contemporaneously with limonite. Both of these minerals probably result from the surficial alteration of older minerals in the rock. The carbonate of lime was the last mineral to be deposited and fills cracks and surfaces with seams and dull white incrustations.

The turquoise first mined at this locality was described by Prof. W. B. Phillips,[2] of the University of Texas, as having a slight greenish tinge, but yielding an odd and attractive matrix of "speckled blue, blue-green, and faint green against a light chocolate background." This description serves very well for a large part of the turquoise, but some has been found in which the green is very slight and the turquoise may be classed with that from other localities as nearly pure blue. No real dark-blue turquoise was observed, but some of that from the seams has a very pretty light-blue color. The turquoise has

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[1] U. S. Geol. Survey Geol. Atlas, Van Horn folio (No. 194). (In press.)
[2] Jewelers' Circular-Weekly, Nov. 9, 1910 (from Houston Post, Tex.).

a hard dense texture necessary for good gems. Brown stains of limonite coat the faces of some of the veinlets and have permeated cracks and seams in them. Such material furnishes attractive matrix gems with varied markings.

A little turquoise has been found in a prospect at the Maltby silver-copper mine, about 1 mile south of west of the Texas Turquoise Co.'s mine. Hardened black siliceous slate is the principal rock at the Maltby mine, but the turquoise occurs in a small dike or sill of white partly altered porphyry a few feet thick, which is inclosed in the slate. A few pieces of greenish-blue turquoise were seen. These were associated with brecciated porphyry rather heavily stained with limonite. The only work done for turquoise at this locality consisted of a small prospect pit 2 feet deep, and, until further work has been done, the discovery must be considered merely an indication of possible gem material.

MISCELLANEOUS.

ASTERIA QUARTZ.

Asteria quartz of exceptionally good quality has been applied to use in jewelry by Bell & Birknir, of New York. The source of the rough mineral has not been revealed. The gems are cut round cabochon and are sold as asteria or star stone. They show a fine bright 6-ray star in reflected light on a nearly colorless highly translucent background. The cut stones are very pretty and may be mounted simply or in a girdle of small diamonds.

HELIODOR.

A species of beryl has been introduced to the gem world under the name of "heliodor."[1] This material has been very scarce so far and most of it is in the possession of the Emperor of Germany. It comes from Rossing, German Africa. Heliodor differs from most beryl in containing a small percentage of uranium oxide and in being weekly radioactive. The color by day is golden yellow and by artificial light a delicate bluish green.

HETAEROLITE.

A specimen of hetaerolite from Leadville, Colo., was sent in by Mr. W. C. Hart, of Manitou Springs. This mineral, containing zinc and manganese oxides, occurs in botryoidal and mammillary deposits with radiated columnar structure. According to Dana, it has a hardness of 5 and a specific gravity of 4.93. The specimen sent by Mr. Hart was cut cabochon. It is a brilliant black and in certain lights the radiated structure can be seen.

ICELAND SPAR.

Prof. J. P. Rowe, of the University of Montana, at Missoula, reports the occurrence of crystallized calcite, of sufficient transparency to be classed as "Iceland spar," in Sweet Grass County, Mont.

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[1] Houdelet, A., Deutsche Goldschmiede Zeitung, abstracted in Jewelers' Circular-Weekly, Apr. 22, 1914. Hauser, Otto, and Herzfeld, H., Chem.-Zeitung, June 2, 1914.

This calcite occurs in a vein cutting igneous rock. Different grades have been found suitable for chemical standardizing, specimens, and optical purposes. The latter variety has been sold in rhombs measuring from 2 to 10 centimeters long for from $2 to $3.50 a pound.

INTERNATIONAL OR METRIC CARAT.

The new international or metric carat of 200 milligrams, adopted by the National Jewelers' Board of Trade for the United States, beginning with July 1, 1913, has been favorably received by the majority of the trade. The difficulties, due to a readjustment of weights and prices of stones already catalogued, have not proved great. Easily applicable tables and conversion formulas have been supplied by many publications, such as the Jewelers' Circular-Weekly, of New York; Manufacturing Jeweler, of Providence, R. I.; and private advertising catalogues. A complete discussion of the steps leading up to the adoption of the international carat by the jewelers of the United States has been given by George F. Kunz.[1] The metric carat has already been adopted by a number of European countries, among which are Germany, France, Holland, Belgium, Switzerland, Italy, and Spain. Beginning with April 1, 1914, the metric carat was adopted by jewelers of Great Britain.[2]

The new international or metric carat of 200 milligrams replaces a carat of about 205.3 milligrams weight in the United States and carats of varying weights in several other countries. The new carat weights used by jewelers are marked 0.01 cm. to 100 cm., etc.

PUBLICATIONS.

CURIOUS LORE OF PRECIOUS STONES.

A recent book[3] by George F. Kunz will prove of interest to all lovers of gems. This work is handsomely published and contains 86 illustrations, 5 in color. A good outline of the contents is contained on the title page: "The curious lore of precious stones, being a description of their sentiments and folk lore, superstitions, symbolisms, mysticism, use in medicine, protection, prevention, religion, and divination, crystal gazing, birthstones, lucky stones and talismans, astral, zodiacal, and planetary."

RUBY.

A 16-page pamphlet on ruby, giving some practical hints on the detection of artificial and imitation stones, has been issued by the Burma Ruby Mines (Ltd.), of London. The pamphlet contains two colored plates comparing the crystal form and structure of the rough and cut natural ruby and of the manufactured ruby. The points emphasized in the natural ruby are that bubble cavities are generally irregular and angular in shape; color variations are common and generally arranged in bands either parallel or irregular; striations are straight or bend in angles; inclusions of foreign particles of various

[1] The new international diamond carat of 200 milligrams: Am. Inst. Min. Eng. Trans., Butte meeting, August. 1913.
[2] Jewelers' Circular-Weekly, Dec. 10, 1913.
[3] The curious lore of precious stones, J. B. Lippincott Co., Philadelphia, Pa., 1913.

sizes are arranged irregularly; and silk caused by numerous minute parallel canals or tubes arranged in three directions giving a silky sheen in reflected light is often present in the natural stones. Corresponding points in the artificial ruby are that the bubble cavities are generally perfectly round or only slightly elongated and are never angular; the color is commonly uniform but when varied is in curved bands; striations consist of a series of concentric curves; inclusions of foreign particles are generally arranged in curves following the lines of striations; and silk is never found. A simple jeweler's microscope and other apparatus useful in distinguishing between the natural and the manufactured ruby are described and hints are given on how to make the tests with them. Much of the same information has also been given on a wall chart showing the same colored plates.

TURQUOISE.

A very comprehensive work on the ethnology of turquoise has been published by Berthold Laufer,[1] associate curator of Asiatic ethnology of the Field Museum, of Chicago, Ill. Dr. Laufer discusses at length the use of turquoise by the early peoples of India, Tibet, and China. The esteem in which turquoise was held by these people and the meanings attached to the wearing of it proves interesting reading.

Another work on turquoise, by J. E. Pogue,[2] of Northwestern University, formerly of the United States National Museum, is in press as this report goes to press. Dr. Pogue's paper deals with the ethnology, mythology, mineralogy, geology, and technology of the turquoise, and will prove very instructive on these subjects.

PRODUCTION.

The total production of gems and precious stones during 1913 reported to the Geological Survey amounted to $319,454, or approximately the same as in 1912. The value of the production has been estimated in part from the quantities of rough mineral reported as produced, but the majority of values have been given by the producers. The production of sapphire in Montana was the largest ever reported to the Survey and the value is conservatively estimated at $238,635, or $43,130 more than in 1912. This increase was offset by decreases in the output of other gem minerals, such as spodumene, tourmaline, peridot, emerald, and many other gems of less importance. The statistics represent as nearly as possible the first values of the rough mineral. The value of the finished gem material may several times greater.

[1] Notes on turquois in the East: Field Mus. Nat. Hist. Pub. 169, Anthrop. ser., vol. 13, No. 1, July, 1913.
[2] Turquois: Nat. Acad. Sci., 3d Mem., vol. 12, 1914.

Production of precious stones in the United States, 1907–1913.

	1907	1908	1909	1910	1911	1912	1913
Agates, chalcedony, onyx, etc.	$650	$1,125	$750	$2,268	$8,128	$9,978	$8,895
Amethyst	850	210	190		725	363	389
Benitoite	1,500	3,638	500			150	
Beryl, aquamarine, blue, pink, yellow, etc.	6,435	7,485	1,660	5,545	2,505	1,765	1,615
Californite	a 25,000		a 18,000	a 8,000	150	275	152
Catlinite	25						
Chiastolite	20				25		
Chlorastrolite		25	2,400	a 2,000	1,992	350	
Copper ore gems, chrysocolla, malachite, etc.	400	6,050	2,300	550	800	1,085	2,350
Chrysoprase	a 46,500	a 48,225	a 84,800	a 9,000	a 13,550	220	
Cyanite	100					10	
Diamond	2,800	a 2,100	2,033	a 1,400	a 2,750	a 1,475	a 6,315
Diopside		120					
Emerald	1,320		a 300	a 700	a 9,500	2,375	
Epidote	60		15			10	
Feldspar, amazonstone, sunstone, etc.	1,110	2,850	a 2,700	2,510	175	1,310	1,285
Garnet, almandine, pyrope, hyacynth, etc.	6,460	13,100	1,650	3,100	2,065	860	4,285
Gold quart	1,000	1,010		1,000	1,700	1,900	300
Jasper, petrified wood, bloodstone, etc.	1,000		100	475	2,240	6,005	5,275
Opal	180	50	200	270	a 1,875	a 10,925	a 15,130
Peridot	1,300	1,300	300		360	8,100	375
Phenacite	25	95	50	50			
Prase				100			25
Pyrite	400					265	50
Quartz, rock crystal, smoky quartz, rutilated quartz, etc.	2,580	3,595	2,689	1,335	2,140	2,448	1,640
Rose quartz	6,375	568	2,970	2,537	1,744	865	337
Rhodocrosite	150						
Rhodonite		1,250	125	a 6,200	1,300	550	165
Ruby	2,000				210	2,260	200
Rutile	200		25				
Sapphire	a 229,800	a 58,397	a 44,998	52,983	a 215,313	a 195,505	238,635
Smithsonite	800	a 1,200	300		25	650	50
Spodumene, kunzite, hiddenite	14,500	a 6,000	15,150	33,000	75	18,000	6,520
Thomsonite		35	100	610	1,500	450	
Topaz	2,300	4,435	512	884	2,675	375	736
Tourmaline	a 81,120	a 90,000	a 133,192	a 46,500	16,445	a 28,200	7,680
Turquoise and matrix	23,840	a 147,950	a 179,273	a 85,900	a 44,751	10,140	8,075
Variscite, amatrice chlorutahlite, utahlite	7,500	14,250	35,938	a 26,125	a 5,750	a 8,450	a 6,105
Miscellaneous gems			1,060	2,755	3,224	4,408	2,920
Total	471,300	415,063	534,380	295,797	343,692	319,722	319,454

a Estimated or partly so.

IMPORTS.

The imports of precious stones into the United States during the calendar year 1913, as reported by the Bureau of Foreign and Domestic Commerce, were the largest ever recorded, $45,431,998, and exceeded those of 1912 by $4,068,673 and those of 1906, the year of next largest imports, by $1,829,522. The principal increase was in diamonds, the greatest increase being in rough or uncut stones. On the other hand, the imports of precious stones during the fiscal year ending June 30, 1914, decreased over $15,000,000 in value[1] from those of 1913. The large decrease may be explained by heavy importations during the middle of 1912–13 to take advantage of the duty then prevailing, since the increase of duty under the new law was expected.

The following table shows the value of the diamonds and other precious stones imported into the United States from 1906 to 1913, inclusive:

[1] Jewelers' Circular-Weekly, July 8, 1914.

Diamonds and other precious stones imported and entered for consumption in the United States, 1906–1913.

Year.	Diamonds.					Diamonds and other stones not set.	Pearls.	Total.
	Glaziers.	Dust or bort.	Rough or uncut.	Set	Unset.			
1906	$104,407	$150,872	$11,676,529	$305	$25,268,917	$3,995,865	$2,405,581	$43,602,476
1907	410,524	199,919	8,311,912	......	18,898,336	3,365,902	680,006	31,866,599
1908	650,713	180,222	1,636,798	......	9,270,225	a 1,051,747	910,699	13,700,404
1909	758,865	50,265	8,471,192	......	27,361,799	a 3,570,540	24,848	40,237,509
1910	213,701	54,701	9,212,378	......	25,593,641	4,003,976	1,626,083	40,704,487
1911	199,930	110,434	9,654,219	......	25,676,302	3,795,175	1,384,376	40,820,430
1912	452,810	94,396	9,414,514	......	22,865,686	3,405,543	5,130,376	41,363,325
1913	471,712	100,704	12,268,543	......	24,812,604	2,775,811	5,002,624	45,431,998

a Including agates. Agates in 1906, $20,130; in 1907, $22,644.

Tariff.—Changes in the duty on precious stones imported into the United States under the tariff act of October 3, 1913, include the following: Under paragraph 357, diamonds and other precious stones, rough or uncut, not advanced in condition, including bort and diamond dust, are removed from the free list and are made dutiable at 10 per cent ad valorem. Pearls, diamonds, and other precious stones, cut but not set, suitable for the manufacture of jewelry, are raised from 10 per cent to 20 per cent ad valorem.

It may be of interest to know that paragraph 333, on beads and spangles of all kinds, imitation pearls, etc., strung for transportation purposes only, dutiable at 35 per cent ad valorem, refers to imitation products and does not include beads cut from semiprecious stones such as agate, rose quartz, amazon stone, etc. These are rated as cut gem stones and are therefore dutiable at 20 per cent ad valorem under paragraph 357.

COAL.

By Edward W. Parker.

INTRODUCTION.

GENERAL STATEMENT.

The coal-mining industry of the United States in 1913 was without spectacular features, the increase in production as compared with 1912 being about normal and indicative of general industrial activity throughout the country. Out of 30 States which contributed to the production in 1913 there were only 6 among the important States in which the output was less than in 1912, and, as the increases varied in percentage from 0.33 in Wyoming to 19 in Kentucky, with an average of 6.66, it can be seen that the business activity was well distributed over the country.

There were a few labor disturbances in 1913, but they were local in extent and effect. The most pronounced labor disaffection was in Colorado, where a general strike was called about the middle of September, and coal production in that State during the last quarter of the year was but little more than 50 per cent of normal. The wage contracts in the "organized" States usually date from April 1 of the "even" years, and as 1913 was an "odd" year, there was no general suspension of work pending the adjustment of the scale, and the loss of time by strikes was negligible. There was some complaint, particularly in the Eastern States, of shortage of labor and inability on the part of the operators to keep their mines working at full capacity. This was probably the reason for less than the usual complaint of the inadequate or insufficient transportation service. Coal mining, like all other industries in the Ohio Valley States, was seriously interfered with by the floods in that region during the spring of 1913, and probably from 5,000,000 to 10,000,000 tons of coal would have been added to the year's output but for that great disaster. The demand by the blast furnaces, steel works, and other manufacturing industries, particularly during the first nine months of the year, was good, and the production of coal for those purposes showed a normal increase. The continued decrease in the use of fuel oil in the Mid-Continent oil field and the strike in the Colorado coal mines resulted in an increased output of coal in the Central and Southwestern States.

With the exception of Illinois, in the first six States, which together produce over 80 per cent of the total output, values ranged higher than in 1912, or in any normal recently preceding year. An unfortunate record was an increase in the number of fatalities among the mine workers, the reports to the Bureau of Mines showing a total of 2,785 fatal accidents in the coal mines in 1913 against 2,360 in 1912. There were three disastrous explosions of coal dust in the bituminous mines in 1913, the worst of which at Dawson, N. Mex., in October, caused the death of 261 men. The other two were at the Cincinnati mine in Pennsylvania and at the Vulcan mine in Colorado, the former resulting in the death of 96 men and the latter, 37. The returns for 1913 show a gratifying decrease in the quantity of coal shot off the solid, though there is still much room for improvement in that respect. The more frequently and emphatically the practice is condemned by writers and speakers, and the more it is prohibited by law and by company rules, the better it will be for the industry and for the safety of the miners. Legislation which provides for the payment of miners' wages on the mine-run basis, however, does not tend to reduce the practice.

The report for 1910 contains sectional maps of the coal fields of the United States, with brief descriptions prepared by geologists of the Survey. Copies of that report are still available and can be secured free of charge upon application to the Director of the United States Geological Survey.

ACKNOWLEDGMENTS.

The statistics of coal production, as of other branches of the mining industry, are compiled from direct returns by the operators. They could not be secured in the completeness in which they are presented without the hearty good will and cooperation of the corporations, firms, and individuals engaged in the industry, and the author desires to reiterate and emphasize his appreciation of the assistance received from those sources. Acknowledgments are due also to the State Geological Surveys of Alabama, Georgia, Illinois, Iowa, Kansas, Maryland, New Mexico, Oklahoma, Oregon, Pennsylvania, Virginia, and Washington for efficient cooperation in the collection of coal-mining statistics in those States; to the mine inspectors of Alabama, Ohio, and West Virginia; and to the secretaries of boards of trade or other local authorities for contributions on the coal trade of some of the principal cities. Recognition of these contributions is also given in connection with their contributions under the caption, "Coal-trade review." Not the least of the writer's acknowledgments are due to his faithful and efficient clerical and stenographic assistants in the United States Geological Survey. The entire statistical compilations in the following pages, with the exception of Pennsylvania anthracite, have been prepared by Miss Lida Mann. The anthracite tables were prepared by Miss E. H. Burroughs.

UNIT OF MEASUREMENT.

The standard unit of measurement adopted for this report is the short ton of 2,000 pounds, although it is necessary in a few instances to use the long ton. All of the anthracite product is mined and sold on the basis of the long ton of 2,240 pounds. Hence, when the production of Pennsylvania anthracite is considered, the long ton is used. The long ton is also used in the statistics of imports and exports. In all other cases where the production is reported in long tons the figures have been reduced to short tons, and unless otherwise expressly stated, the short ton is meant where any statement of quantity is made in the text.

SUMMARY OF STATISTICS IN 1913.

Total production in 1913, 570,048,125 short tons; spot value, $760,488,785.

Pennsylvania anthracite.—Total production in 1913, 81,718,680 long tons (equivalent to 91,524,922 short tons); spot value, $195,181,127.

Bituminous coal and lignite.—Total production in 1913, 478,523,203 short tons; spot value, $565,307,658.

Production.—In a preliminary review of the coal-mining industry in 1913, given to the press on December 29 of that year, the production was estimated at between 565,000,000 and 575,000,000 short tons, which indicated an increase of 30,000,000 to 40,000,000 tons over the previous record-breaking production of 1912. With less than one-half of 1 per cent of the total tonnage unreported on July 1, 1914 (the delinquent production being estimated on the basis of previous years or from reliable sources of information), the output in 1913 is found to have amounted to 570,048,125 short tons, or almost exactly midway between the extremes estimated six months before. The increase over 1912, when the production amounted to 534,466,580 short tons, was 35,581,545 short tons, or 6.7 per cent. The year 1912 had also established a new record for normal years in the total and unit values for the product, the average value per ton having exceeded that of any year for which statistics are available, with the single exception of 1903 when, because of the fuel famine caused by the great strike in the anthracite region of Pennsylvania and in the "organized" bituminous States, the prices of all kinds of coal were advanced above any figures reached in recent history. The higher values in 1912 were not only maintained but generally improved upon in 1913, the general average value per ton showing an advance of 3 cents over 1912, and reaching within 8 cents of the record high average of 1903. A notable exception to the higher prices obtained in 1913 among the more important producing States was in Illinois, where, because of peculiar local conditions, the average value showed a decline. The total value of the combined production of anthracite and bituminous coal in 1913 was $760,488,785 which, compared with 1912, when it amounted to $695,606,071, showed a gain of $64,882,714, or 9.3 per cent.

The production of anthracite in Pennsylvania increased from 75,322,855 long tons (84,361,598 short tons), valued at $177,622,626, in 1912 to 81,718,680 long tons (91,524,922 short tons), valued at $195,181,127, in 1913. The increase in quantity was 6,395,825 long tons (7,163,324 short tons), or 8.5 per cent, and the gain in value was $17,558,501, or 9.9 per cent.

The total production of bituminous coal and lignite increased from 450,104,982 short tons in 1912 to 478,523,203 tons in 1913, the increase in quantity amounting to 28,418,221 tons, or 6.3 per cent, with an increase in value of $47,324,213, or 9.14 per cent, from $517,983,445 in 1912 to $565,307,658 in 1913.

The increase in the production of anthracite was somewhat exceptional and due to the fact that the output in 1912 was reduced nearly 5,500,000 long tons by a "suspension" in April and May, practically the entire region being idle pending an agreement on the renewal of the terms of employment. Compared with 1911, when there was no general strike or suspension in the region, the production in 1913 showed an increase of less than 1,000,000 long tons. The advance in price and relatively larger gain in value were the result of the advance in wages granted in the new agreement.

Increases in bituminous production were generally distributed over the country, there being only six States where the production in 1913 was less than in 1912, and in one of those States, Colorado, the dercease was due entirely to labor troubles. During the first nine months of the year the activity in the iron and steel trades which had developed in 1912 was well maintained and created activity in the coking-coal districts. This fell off somewhat sharply during the last quarter of the year, but the demands from other lines of manufacture and from the railroads were well sustained. In the Central and Southwestern States the production of coal was stimulated through the continued decrease in the production of natural gas in the northern part of the mid-continent field and the withdrawal of large quantities of fuel oil from the markets. There was some complaint of labor shortage, but in that respect also there was an improvement, compared with 1912, many of the mine workers who had returned to Europe to enlist in the Balkan war having resumed their places in the coal mines throughout the country, and particularly in the Western States. Such deficiency as existed was not altogether an injury, however, for it enabled operators to maintain prices and prevented an output in excess of market requirements. It was also probably responsible for fewer complaints of insufficient transportation facilities.

In the production of both anthracite and bituminous coal the gain in output was accompanied by a larger proportionate gain in value. The largest increase in the production of bituminous coal was in Pennsylvania where 11,915,729 tons were added to the output, as compared with 1912. West Virginia showed the second largest gain, 4,522,295 tons. But the most significant increase was in Kentucky, which showed the third largest gain—3,126,079 tons, and the largest percentage of increase among the important coal-producing States. Indiana came fourth with an increase of 1,879,953 short tons; Illinois fifth, with 1,733,518 tons; Ohio sixth, with 1,671,800 tons; and Alabama seventh, with 1,577,922 tons. No other State increased its production as much as a million tons and only one State, Virginia, approached within 60 per cent of that figure. The only important State to show a decrease was Colorado, whose production fell off nearly 1,750,000 tons on account of labor troubles. One State, Wyoming, showed an increase in production and a decrease in value, and one State, Maryland, had a decrease in quantity of output and an increase in value.

Production per capita.—The development of the coal-mining industry in the United States, considered with the increase in the population, presents some interesting comparisons. The use of mineral fuel became an important factor in the manufacture of iron, about the middle of the last century. In 1855 anthracite exceeded charcoal as a blast-furnace fuel, and 20 years later was superseded by coke. In 1850 the production of coal amounted to 7,018,181 short tons, or at the rate of 0.3 ton for each of the 23,191,876 inhabitants. In 1860 the population had increased to 31,443,321 persons and the production of coal to 14,610,042 tons, or an average of 0. 46

ton per person. In 1880 when the population had increased to 50,189,209, the production of coal had increased to 71,481,570 tons, or an average of 1.42 tons per capita. In the closing year of the nineteenth century, according to the Twelfth Census, the total number of inhabitants in the United States was 76,303,387, an increase of a little over 50 per cent, as compared with 1880, while the production of coal was nearly four times that of 20 years before and amounted to 269,684,027 short tons, or an average of 3.53 tons for each inhabitant. At the taking of the Thirteenth Census, in 1910, the population of the United States numbered 91,972,266 persons, and as the production of coal in that year amounted to 501,596,378 short tons, the per capita production was 5.45 tons. From this it appears that in the 50 years from 1850 to 1900 the per capita production of coal in the United States has increased from less than one-third of a ton to nearly 5½ tons. The Bureau of the Census estimates that the population of the continental United States in 1913 was 97,163,330 persons, and the production for each inhabitant was 5.87 tons. In addition to the production of coal in recent years the output of petroleum and natural gas, both mineral fuels, should also be considered. Large quantities of petroleum, crude or residual, are used for fuel purposes, and by far the larger part of the natural gas is also used as a manufacturing fuel. The consumption of petroleum fuel in 1913 was probably equivalent to between 23,000,000 and 24,000,000 short tons of coal and the quantity of coal displaced by natural gas was probably more than half as much. If these liquid and gaseous fuels were convertible into their equivalents in coal and that factor were added to the total coal production, the per capita consumption of coal in 1913 would easily exceed 6 tons, or, in other words, the consumption of mineral fuel per capita at the present time is 20 times what it was in 1850.

Men employed.—The coal mines of the United States gave employment in 1913 to an army of nearly three-quarters of a million men. The anthracite mines of Pennsylvania gave employment to 175,745 men and the bituminous mines to 571,899 men, the total being 747,644 men. As 1913 was not a year in which the wage agreements terminated, there was no general suspension among the organized miners although two desperate struggles to force the recognition of the union were carried on, one in the Kanawha field in West Virginia had been inaugurated in 1912 and kept on well into 1913; the other in Colorado was begun in September, 1913, and continued into 1914. The number of men affected by these struggles was less than 5 per cent of the total number of mine workers, and the idleness did not materially influence the average working time for the bituminous-mine workers as a whole. The average number of days made by the employees in the bituminous mines was, with three exceptions, 1899, 1900, and 1907, the largest made in any year in the history of the industry. The average time made in the bituminous mines in 1913 was 232 days against 234 days in each of the three years mentioned. In 1912 the bituminous mines were operated an average of 223 days. The average time made in the anthracite mines in 1913 was the best on record, 257 days. In 1901 the anthracite operators adopted the policy of allowing discounts on coal sold during the spring and summer months, the idea being to encourage consumers to lay in their winter supplies at a time when transportation is not hampered by unfavorable weather and when otherwise a large number of men would be idle. The effect of this has been to give much steadier employment through the year and to prevent to a large extent congestion of orders and traffic in the fall and winter months. The fluctuations in the number of days worked from year to year in the anthracite region since the discount policy was put into effect have been due principally to suspensions pending adjustments of wage agreements. Anthracite, being almost entirely a domestic fuel, is not affected to the same extent as bituminous coal by trade conditions. On account of the larger number of days made in the anthracite mines in 1913, the average production per man increased to 520 tons, compared with 485 tons in 1912, but the decreasing daily production which has been noted in previous reports did not show any improvement in 1913, the average for 1913 being a small fraction of a ton less than in 1912. The average production per man in the bituminous mines increased from 820 tons in 1912 to 837 tons in 1913, both being record-making averages. As in the anthracite mines, however, the bituminous workers showed a slight falling off in the average daily production per man, the figures being 3.68 tons for 1912 and 3.61 tons for 1913.

Mining machines.—It is doubtful if the great tonnage records made by the bituminous mines of the United States in the last two decades could have been attained with the supply of labor available but for the use of machines in the mining of the product. To the mechanical production of bituminous coal may be attributed the marked increase in the average tonnage mined by each employee, as shown in another part of this report. The percentage of machine-mined bituminous coal to the total production has increased regularly since 1896, the first year for which the statistics of this feature of the coal-mining industry have been collected. In 1913 the quantity of bituminous coal mined by machines was 242,476,559 short tons, or 50.7 per cent of the total, against 210,538,822 tons, or 46.8 per cent of the total in 1912. In 1896 the production of coal by machines was 16,424,932 tons, or not quite 12 per cent of the total. The increase of this item in 1913 over 1912 was 31,937,737 short tons, or 3,519,516 tons more than the total increase in the production of bituminous coal. The prevailing type of machines are punchers, chain-breast, long-wall, short-wall, and continuous-cutter machines for relatively flat-lying beds, and radially-actuated punching machines mounted on rigidly fixed posts for beds of too steep inclination for the other types of machines. The machines of the puncher type, as the name implies, cut the coal by a chopping action; in the others the action is that of sawing. A new type of machine introduced in 1913 has the cutting bits arranged spirally upon a tapered arm which revolves and reciprocates at the same time, combining a boring and sawing action. The total number of machines reported in use in 1913 was 16,381 against 15,298 in 1912. The average production for each machine increased from 13,763 tons to 14,802 tons, the latter being the highest record ever made.

The increase in the production of machine-mined coal in 1913 reduced not only the percentage but the quantity of coal "shot off the solid," that item showing a decrease from 76,241,575 short tons, or 17 per cent, in 1912 to 75,155,707 tons, or 15.7 per cent, in 1913. These figures are gratifying and indicate that the warfare waged by speakers and writers against the pernicious practice of "making the powder do the work" has not been been without result. The practice can not be too vigorously condemned and the campaign against it should be rigorously prosecuted until it has been entirely abolished. It is dangerous to the mines and miners, seriously vitiates the quality of the product, and is contrary to every tenet of conservation. The worst offenders in this regard are the States of the western and southwestern regions of the interior province, where, above all, because of the low value of the slack coal produced, careful mining should be the rule. Yet fully 80 per cent of the coal produced in the western and southwestern regions is powder mined.

Labor troubles.—As the wage scale agreements in the "organized" bituminous coal-mining States are continued from April 1 to March 31, of the "even" years, there was no general strike or suspension in the States operating under contracts with the mine-workers' union. In the the anthracite region of Pennsylvania after an idleness of about seven weeks, from April 1 and May 15, 1912, a third renewal of the Anthracite Strike Commission's awards was effected, with some modifications and with an advance of 10 per cent in wages, the extension in this instance being for a period of four years, or until March 31, 1916. The year 1913 was not, however, without serious conflicts between employers and employees. The state of warfare in the Paint and Cabin creeks districts of West Virginia, which made a blot on the record of 1912, was carried over into 1913 and when peace was finally effected it proved to be simply of a temporary character, but lasted through the remainder of the year. The conflict was renewed in the early part of 1914, and at the time of writing this report is still undetermined. The most serious difficulty of the year was in Colorado, where in an attempt to force recognition of the union upon the operators a strike was called to take effect on September 23, and from that date until the close of the year a state of affairs bordering on civil war existed. The fair name of the State was besmirched by acts of bloodshed, arson, and other excesses which the military arm of the State was unable to stop, and it was finally necessary to call in the aid of the United States troops to reestablish law and order. In the entire State of Colorado 7,324 men out of a total of 11,990 were idle for an average of 75 days, and the production for the year was reduced about 16 per cent. The trouble in West Virginia was more localized and affected only 8,800 men out of a total of 74,786, and the deficiency in the production of Kanawha County was made up by increased tonnage from other districts in the State.

Local labor disturbances will continue as long as coal continues to be mined, and 1913 was no exception to the rule, although there were ten States in which no strikes or suspensions were reported during the year. The most conspicuous instance was Virginia, which produced a total of nearly 9,000,000 tons of coal with not a case of strike, suspension, or lockout reported. Wyoming also with a production of nearly 7,500,000 tons, had a clean labor score. The other eight States were relatively unimportant producers, namely, Alaska, California, Georgia, Idaho, Nevada, North Dakota, Oregon, and Texas. Local troubles in the anthracite fields were most numerous, but not prolonged, 64,086 men, more than one-third the total number, being on strike for an average of 8 days each. Among the bituminous States

Pennsylvania had the largest number of idle men, and Illinois had the largest number of idle days.

Accidents.—The record of fatalities in the coal mines of the United States compiled by the Bureau of Mines for 1913 showed an unfortunate increase over the preceding year, the number of men killed increasing from 2,360 in 1912 to 2,785 in 1913. Of the total number of fatalities in 1913, 618 were in the anthracite mines of Pennsylvania, and 2,167 in the bituminous and lignite mines. As is usually the case, the most prolific cause of death was falling roofs and coal which claimed 1,264 victims, or 45.4 per cent of the total number of deaths. In 1912 the deaths due to falls of roof and coal were 1,151, or 48.8 per cent of the total. The increase in the number of fatalities in 1913 over the preceding year was due principally to three explosions of dust in the bituminous mines, the worst of which was the disastrous explosion at Dawson, N. Mex., in October, the immediate result being the death of 261 mine employees. Next to this in the number of men killed was the explosion in the Cincinnati mine in Washington County, Pa., which occurred in April and resulted in the death of 96 men. On December 16 an explosion at the Vulcan mine, near Newcastle, Colo., killed 37 employees. The total number of men who lost their lives by dust explosions in 1913 was 423, against 137 in 1912. There was a decrease in the number of men killed by explosions of gas from 164 in 1912 to 91 in 1913. Of the 91 victims in 1913, 50 were in the anthracite mines of Pennsylvania, and 41 were in the bituminous mines of Alabama (3), Illinois (8), Indiana (7), Kansas (1), Ohio (15), Oklahoma (2), and Washington (5). Mine cars and locomotives underground killed 424 men in 1913 against 362 in 1912, and 78 men were killed from that cause on the surface in 1913 against 68 in 1912. Premature blasts and other accidents incident to the use of explosives killed 138 men in 1913 and 133 in 1912. The total number of fatal accidents underground increased from 2,119 in 1912 to 2,562 in 1913. Shaft accidents increased from 54 to 62, and the total number of fatalities on the surface decreased from 187 to 161. The death rate per thousand employees in the anthracite region was 3.52 against 3.35 in 1912. In the bituminous regions the death rate per thousand was 3.79 in 1913 against 3.24 in 1912, and the death rate for the entire country in 1913 was 3.73 against 3.28 in 1912. The quantity of anthracite mined for each life lost in 1913 was 132,231 long tons (148,098 short tons) against 128,978 long tons (144,455 short tons) in 1912, and the quantity of bituminous coal mined for each fatality in 1913 was 220,823 tons against 253,437 tons in 1912. The total of anthracite and bituminous coal mined for each life lost in 1913 was 204,685 tons against 226,469 tons in 1912.

Washed coal.—The production of anthracite in Pennsylvania includes an appreciable quantity of usable fuel recovered from the old culm banks by washeries, and the unsightly monuments to the wasteful methods of early times are disappearing from the landscape in the anthracite region. The quantity of coal recovered in the 24 years since the first washery was constructed (in 1890) has amounted to about 49,300,000 long tons, considerably more than the annual production of anthracite at the beginning of the period. In 1913 the washery product amounted to 2,860,021 long tons. In addition to the coal recovered from the culm banks, 133,986 long tons in 1913, and 85,722 long tons in 1912, were recovered from the bottom of

Susquehanna River by dredges. The quantity of coal recovered from the old culm banks by washeries in 1913 was 1,305,267 tons less than in 1912, and decreasing proportions of this product may be anticipated in the future, as the culm banks disappear.

In the bituminous regions the principal use of washeries is to improve the quality of the slack coal used in the manufacture of coke by reducing the ash and sulphur, although considerable quantities, particularly in Illinois, are washed in the preparation of sized coal for household use. The quantity of bituminous coal washed at the mines in 1913 was 25,051,801 short tons. The washeries yielded 22,069,691 tons of cleaned coal and 2,982,110 tons of refuse.

Consumption.—More than 95 per cent of the total production of anthracite and bituminous coal in the United States continues to be consumed within the country, although the efforts to build up an export trade, particularly for the high-grade bituminous coals, has resulted in a considerable expansion of business done with foreign countries. The total quantity of coal exported from the United States increased from 20,326,619 short tons (18,148,767 long tons) in 1912 to 24,798,080 short tons (22,141,143 long tons) in 1913. Of the latter, 4,652,912 short tons (4,154,386 long tons) were anthracite, and 20,145,168 short tons (17,986,757 long tons) were bituminous. The imports in 1913 amounted to 1,583,560 short tons, which, added to the consumption of domestic coal, made the total consumption in that year 546,833,605 short tons, which is equivalent to 95.9 per cent of the domestic production. In this statement no account is taken of the stock on hand at the beginning and at the end of the year. The coal-mining industry is at best of a hand-to-mouth character, and stocks do not figure in the trade. Considerable quantities of anthracite are sometimes put into storage yards during the summer months, or in anticipation of extended suspensions, but they are usually disposed of in the same year that they are mined and stored, and affect neither production nor prices.

Most of the coal imported into the United States is classed as bituminous or shale, only a comparatively small quantity of anthracite being brought into this country. The imports of bituminous coal are principally to points on the Pacific coast and to the port of Boston, where considerable quantities of bituminous slack are imported from Canada and used at the Otto-Hoffmann coke ovens at Everett, near Boston. The exports of both anthracite and bituminous coal are principally to Canada.

Marketable product.—The statistics of coal production presented in these reports include not only the coal marketed, either by shipment to distant points, or sold locally, but that consumed by mine employees and by the mine owners in the operation of the colliers. The latter item is usually considered and reported as colliery consumption. There are occasional exceptions in the bituminous fields, where the operators, who use only slack, an otherwise waste product, do not report this item in their statements of production and do not deem it of any value; it is not considered as a portion of the mine product, nor is the miner paid for it in wages. Such exceptions are few and the quantity is negligible. The quantity of coal consumed in the manufacture of coke is also considered in this report.

The quantity of coal consumed in the manufacture of coke at the mines in 1913 was 49,458,320 short tons, against 47,958,332 short tons in 1912, an increase of 1,499,988 short tons, or 3.1 per cent, as compared with an increase of 6.31 per cent in the total production of bituminous coal, and of 6.66 per cent in the increase of anthracite and bituminous coal combined. The coal shipped to market, used in the manufacture of coke, and sold locally, amounted in 1913 to 548,764,919 short tons, as compared with 514,318,429 tons in 1912. This is usually considered the marketable product. The colliery consumption, which represents the difference between the marketable product and the total output, amounted in 1913 to 21,283,206 short tons. The colliery consumption in the anthracite region, consisting almost entirely of culm or waste material, averages something over 10 per cent of the total anthracite production. In 1913, out of a total output of 81,718,680 long tons, 8,581,694 long tons were used at the mines for steam and heat. The colliery consumption in the bituminous regions amounts to about 2.4 per cent of the total output, and in 1913 was 11,671,709 short tons out of a total production of 478,523,320 tons.

PRODUCTION.

STATISTICS FOR 1912 AND 1913.

The statistics of the production of coal in the United States in 1912 and 1913, by States, with the distribution of the product for consumption, are shown in the tables following.

Coal production of the United States in 1912, by States, in short tons.

State.	Loaded at mines for shipment.	Sold to local trade and used by employees.	Used at mines for steam and heat.	Made into coke.	Total quantity.	Total value.	Average price per ton.	Average number of days active.	Average number of employees.
Alabama	13,372,521	147,586	664,019	1,916,474	16,100,600	$20,829,252	$1.29	245	22,613
Arkansas	1,996,822	15,111	88,886		2,100,819	3,582,789	1.71	157	4,536
California and Alaska	3,748	3,960	3,625		11,333	26,441	2.33	184	52
Colorado	9,527,149	331,570	352,551	766,554	10,977,824	16,345,336	1.49	227	13,000
Georgia and North Carolina	108,135	1,504	6,141	111,923	227,703	338,926	1.49	254	450
Idaho and Nevada	500	2,414	50		2,964	9,313	3.14	253	20
Illinois	55,304,530	2,793,861	1,786,835		59,885,226	70,294,338	1.17	194	78,098
Indiana	14,179,686	704,229	401,803		15,285,718	17,480,546	1.14	182	21,651
Iowa	6,519,307	590,206	180,016		7,289,529	13,152,088	1.80	188	16,370
Kansas	6,662,834	129,978	192,595	775	6,986,182	11,324,130	1.62	202	11,646
Kentucky	15,159,515	632,629	438,378	259,999	16,490,521	16,854,207	1.02	201	24,304
Maryland	4,836,391	61,507	66,140		4,964,038	5,839,079	1.18	259	6,162
Michigan	1,080,319	62,411	63,500		1,206,230	2,399,451	1.99	183	3,113
Missouri	3,808,332	432,051	99,473		4,339,856	7,633,864	1.76	206	9,704
Montana	2,818,503	82,052	147,940		3,048,495	5,558,195	1.82	220	3,440
New Mexico	2,620,932	25,300	51,328	839,264	3,536,824	5,037,051	1.42	274	3,928
North Dakota	354,895	132,951	11,634		499,480	765,105	1.53	232	622
Ohio	31,710,928	2,197,368	610,566	9,865	34,528,727	37,083,363	1.07	201	45,527
Oklahoma	3,415,958	74,059	185,401		3,675,418	7,867,331	2.14	174	8,785
Oregon	14,361	19,646	7,630		41,637	108,276	2.60	239	222
Pennsylvania, bituminous	116,477,708	3,850,895	3,657,367	37,879,518	161,865,488	169,370,497	1.05	252	165,144
Tennessee	5,802,779	85,654	137,382	447,413	6,473,228	7,379,903	1.14	234	10,309
Texas	2,084,254	41,760	62,598		2,188,612	3,655,744	1.67	230	5,127
Utah	2,528,513	36,509	106,401	344,726	3,016,149	5,046,451	1.67	285	3,328
Virginia	6,027,712	107,657	182,870	1,528,399	7,846,638	7,518,576	.96	251	8,678
Washington	3,041,277	80,295	162,619	76,741	3,360,932	8,042,871	2.39	226	5,519
West Virginia	60,549,194	1,209,142	1,251,670	3,776,681	66,786,687	62,792,234	.94	266	68,248
Wyoming	6,993,263	83,388	291,473		7,368,124	11,648,088	1.58	238	8,036
Total bituminous	377,000,066	13,935,693	11,210,891	47,958,332	450,104,982	517,983,445	1.15	223	548,632
Pennsylvania, anthracite	73,056,766	2,367,572	8,937,260		84,361,598	177,622,626	2.11	231	174,030
Grand total	450,056,832	16,303,265	20,148,151	47,958,332	534,466,580	695,606,071	1.30	225	722,662

Coal production of the United States in 1913, by States, in short tons.

State.	Loaded at mines for shipment.	Sold to local trade and used by employees.	Used at mines for steam and heat.	Made into coke.	Total quantity.	Total value.	Average price per ton.	Average number of days active.	Average number of employees.
Alabama	15,094,036	163,180	752,686	1,668,620	17,678,522	$23,083,724	$1.31	255	24,552
Arkansas	2,117,358	7,987	108,762		2,234,107	3,923,701	1.76	174	4,652
California and Alaska	16,432	2,256	8,223		26,911	95,173	3.54	302	40
Colorado	7,136,633	365,216	328,249	1,402,412	9,232,510	14,035,090	1.52	229	11,990
Georgia	122,499	1,303	7,518	124,306	255,626	361,319	1.41	261	500
Idaho and Nevada	15	2,107	55		2,177	5,285	2.43	183	12
Illinois	57,329,079	2,568,957	1,720,708		61,618,744	70,313,605	1.14	189	79,529
Indiana	16,034,285	663,018	468,368		17,165,671	19,001,881	1.11	190	22,235
Iowa	6,824,933	535,170	165,833		7,525,936	13,496,710	1.79	195	15,757
Kansas	6,903,287	117,303	181,620		7,202,210	12,036,292	1.67	197	12,479
Kentucky	18,029,826	739,622	454,718	392,434	19,616,600	20,516,749	1.05	212	26,332
Maryland	4,666,758	49,349	63,732		4,779,839	5,927,046	1.24	248	5,645
Michigan	1,111,990	58,251	61,545		1,231,786	2,455,227	1.99	188	3,305
Missouri	3,765,534	457,114	95,477		4,318,125	7,468,308	1.73	187	10,418
Montana	3,022,298	111,130	107,545		3,240,973	5,653,539	1.74	228	3,630
New Mexico	2,685,880	27,511	56,983	938,432	3,708,806	5,401,260	1.46	289	4,329
North Dakota	349,832	129,496	15,992		495,320	750,652	1.52	221	641
Ohio	33,525,096	1,996,382	674,288	4,761	36,200,527	39,948,058	1.10	206	45,815
Oklahoma	3,841,096	59,475	265,199		4,165,770	8,542,748	2.05	197	9,044
Oregon	31,582	8,617	5,864		46,063	116,724	2.53	283	203
Pennsylvania, bituminous	127,958,404	4,122,430	3,806,529	37,893,854	173,781,217	193,039,806	1.11	267	172,196
Tennessee	6,125,821	78,796	160,180	538,987	6,903,784	7,883,714	1.14	241	11,263
Texas	2,358,578	12,188	58,378		2,429,144	4,288,920	1.77	253	5,101
Utah	2,527,110	46,635	110,896	570,187	3,254,828	5,384,127	1.65	273	4,158
Virginia	6,615,481	83,432	175,792	1,953,363	8,828,068	8,952,653	1.01	280	9,162
Washington	3,520,554	62,702	175,937	118,698	3,877,891	9,243,137	2.38	260	5,794
West Virginia	64,812,324	1,309,163	1,335,229	3,852,266	71,308,982	71,872,165	1.01	234	74,786
Wyoming	7,003,990	83,673	305,403		7,393,066	11,510,045	1.56	232	8,331
Total bituminous	403,530,711	13,862,463	11,671,709	49,458,320	478,523,203	565,307,658	1.18	232	571,899
Pennsylvania, anthracite	79,904,353	2,009,072	9,611,497		91,524,922	195,181,127	2.13	257	175,745
Grand total	483,435,064	15,871,535	21,283,206	49,458,320	570,048,125	760,488,785	1.33	238	747,644

The relative growth in the production of anthracite and bituminous coal in comparison with the increase in population is graphically illustrated in the accompanying diagram (fig. 18), the starting point for the

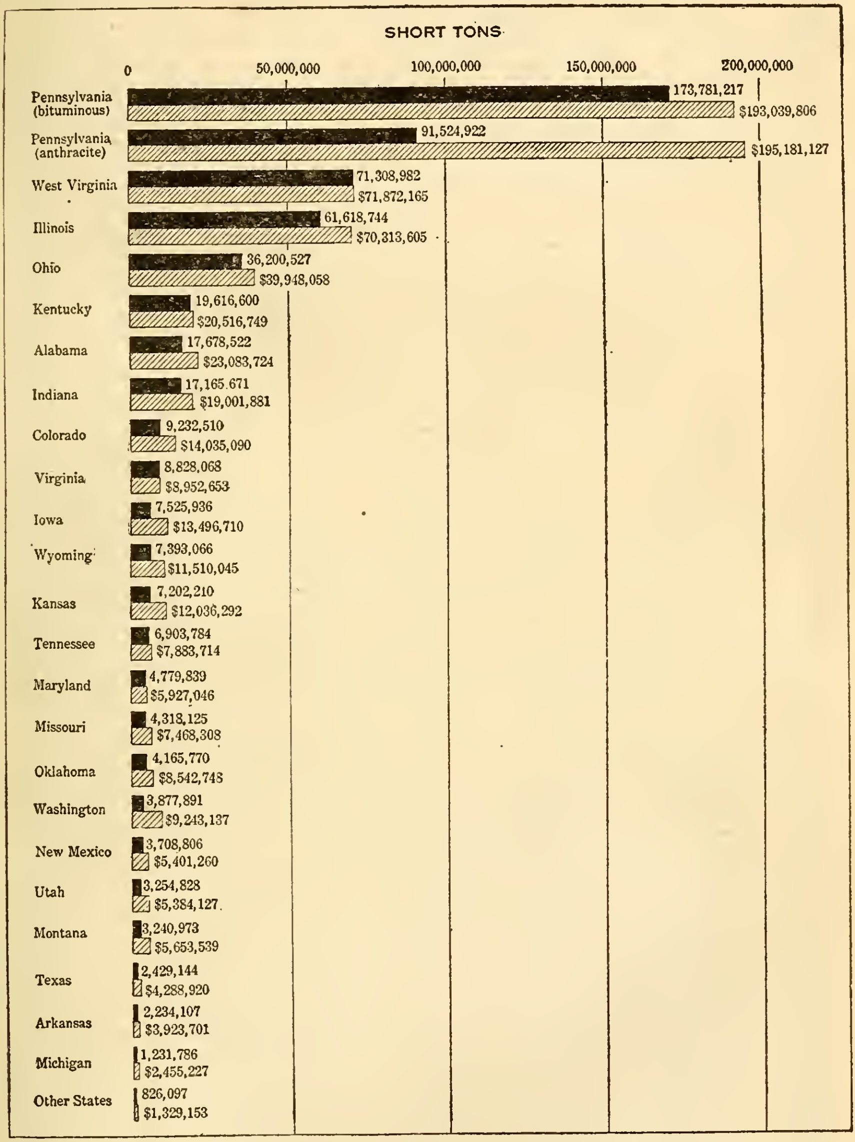

FIGURE 17.—Production of coal in the United States in 1913, by States, in short tons.

population being taken at 1870 when approximately 1 ton of coal was produced for each inhabitant, and when the production of anthracite and bituminous coal were about equal. It will be observed that the curve illustrating the production of anthracite (which has been practically eliminated as a manufacturing fuel and is now restricted mainly to domestic consumption) follows a line approximately parallel with the curve of population, and has been fairly regular in its course. The

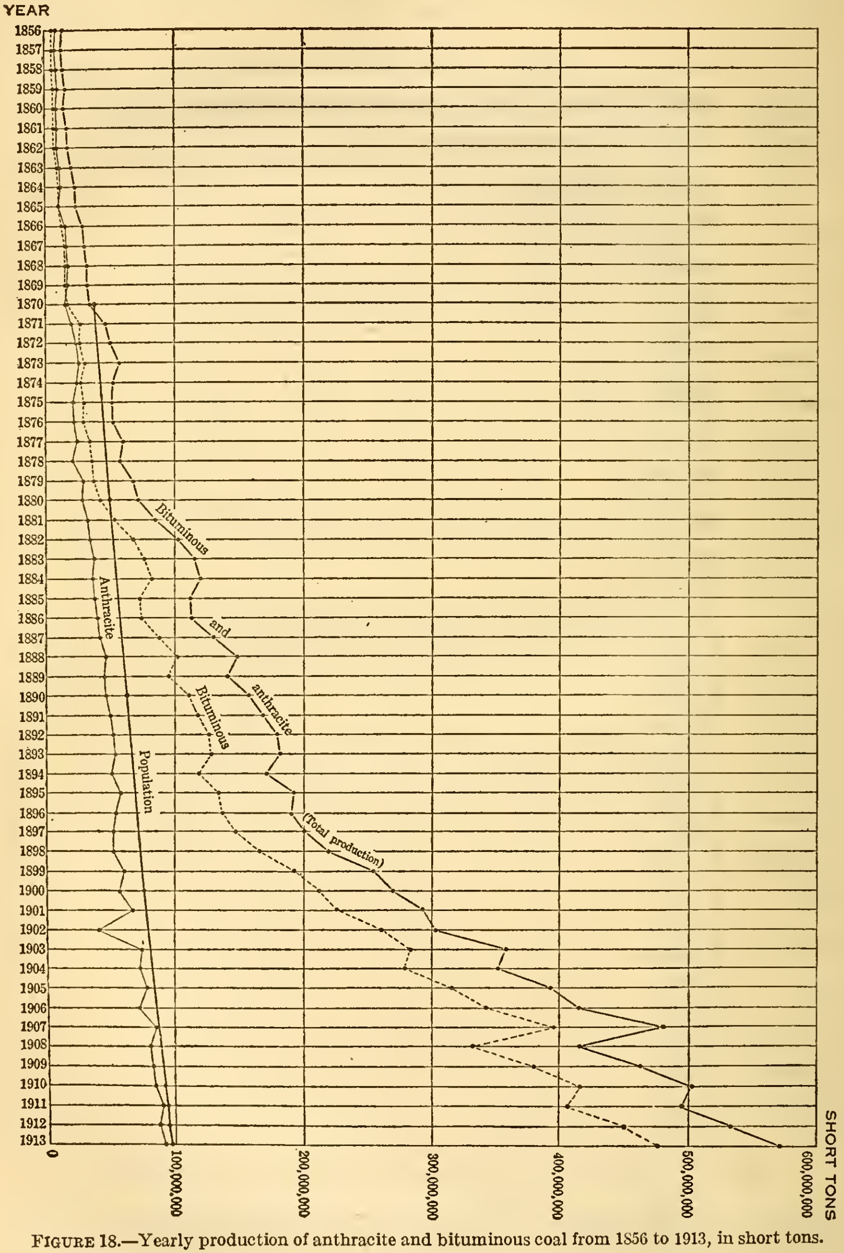

FIGURE 18.—Yearly production of anthracite and bituminous coal from 1856 to 1913, in short tons.

variations in the production of anthracite have been due principally to labor troubles and not, as is the case with bituminous coal, to trade conditions. The most violent change in anthracite curve was in 1902 when, because of the great strike of that year, the production dropped below that of any year since 1886. The breaks in the upward trend of bituminous-coal production are noted in the years of business depression, particularly in 1908, when the production of anthracite was scarcely affected. During the last 25 years the production of bituminous coal has grown by leaps and bounds, and there has in this period been only one instance when it has taken two years to recover from the effects of a business depression. This was in 1908 and 1909 and followed the boom year, 1907, when the largest increase over a preceding year in the history of the industry had been recorded. In the last 25 years, or since 1888, the production of anthracite has increased from 46,619,564 short tons to 91,524,922 tons, or nearly 100 per cent, while the production of bituminous coal has increased from 102,040,093 tons to 478,523,203 tons, or nearly 370 per cent. The total production of coal in the United States at the present time is nearly four times what it was 25 years ago. In this rapid development the United States has far outstripped the other countries of the world. The rate of increase in the production of all kinds of coal in Great Britain and France has been about the same as that of anthracite in Pennsylvania. Germany's production has increased at a much more rapid rate, but at a considerably slower rate than the production of bituminous coal or the total production in the United States.

There is good reason for the opinion held by many that the curve of production of anthracite will not continue to show an upward movement for many years longer, or that, if continued for any length of time, it will be on a gradually lessening scale until the inevitable period of practical constancy and then decline begins. In other words, the maximum yearly production of anthracite is almost attained and the industry may be said to be "in its prime." Some authorities are of the opinion that before the period of decline begins an output of 100,000,000 long tons (112,000,000 short tons) a year will be mined. This would mean an increase over the record for 1913 of about 18,000,000 long tons (20,000,000 short tons). To attain this may not be physically impossible, but it seems improbable. The number of days (257) worked in the anthracite mines of Pennsylvania in 1913 was more than in any year in the history of the region. The average production for each working day was approximately 318,000 long tons. At this rate, if the mines had been worked full 300 days in the year, the production would have amounted to about 95,400,000 long tons. At the daily rate of production in 1912 (326,000 tons a day), had the mines been operated full 300 days the output would have amounted to 97,800,000 long tons. It is not probable, however, that the average working time of 1913 will be much exceeded; some days of idleness are necessary and inevitable, and as there is little, if any, virgin territory to be developed, the output can not be expected to show very material increase in the years to come.

The average daily production of bituminous coal in 1913 was approximately 2,060,000 short tons, from which it appears by the same method of deduction, that the capacity of the bituminous mines, with the same number of employees as in 1913, if worked full 300 days in the year, would be about 618,000,000 tons.

In the following table the production and value of anthracite and bituminous coal in the United States are given for each five years from 1870 to 1910, and in 1911, 1912, and 1913, in both long and short tons:

Production of coal in the United States each five years from 1870 to 1910 and in 1911, 1912, and 1913.

Year.	Pennsylvania anthracite.			Bituminous coal.		
	Quantity.		Value.	Quantity.		Value.
	Long tons.	*Short tons.*		*Long tons.*	*Short tons.*	
1870	13,985,960	15,664,275	$38,360,616	15,510,094	17,371,305	$40,585,915
1875	20,076,577	22,485,766	a 44,000,000	26,662,994	29,862,554	a 55,000,000
1880	25,580,189	28,649,812	42,196,678	38,242,641	42,831,758	58,443,718
1885	34,228,548	38,335,974	76,671,948	65,021,715	72,824,321	82,347,648
1890	41,489,858	46,468,641	66,383,772	99,377,073	111,302,322	110,420,801
1895	51,785,122	57,999,337	82,019,272	120,641,244	135,118,193	115,779,771
1900	51,221,353	57,367,915	85,757,851	189,567,957	212,316,112	220,930,313
1905	69,339,152	77,659,850	141,879,000	281,306,058	315,062,785	334,658,294
1910	75,433,246	84,485,236	160,275,302	372,420,663	417,111,142	469,281,719
1911	80,771,488	90,464,067	175,189,392	362,417,017	405,907,059	451,375,819
1912	75,322,855	84,361,598	177,622,626	401,879,448	450,104,982	517,983,445
1913	81,718,680	91,524,922	195,181,127	427,252,860	478,523,203	565,307,658

Year.	Total.		
	Quantity.		Value.
	Long tons.	*Short tons.*	
1870	29,496,054	33,035,580	$78,946,531
1875	46,739,571	52,348,320	a 99,000,000
1880	63,822,830	71,481,570	100,640,396
1885	99,250,263	111,160,295	159,019,596
1890	140,866,931	157,770,963	176,804,573
1895	172,426,366	193,117,530	197,799,043
1900	240,789,310	269,684,027	306,688,164
1905	350,645,210	392,722,635	476,537,294
1910	447,853,909	501,596,378	629,557,021
1911	443,188,505	496,371,126	626,565,211
1912	477,202,303	534,466,580	695,606,071
1913	508,971,540	570,048,125	760,488,785

a Estimated.

As shown in the following table, there were only three States whose coal production exceeds half a million tons, in which the ouput in 1913 was less than in 1912. The three exceptions to the general increase in production among the important States were Colorado, Maryland, and Missouri, one of these being in the eastern province, one in the central, and one in the Rocky Mountain. The decreased production of Colorado was due solely to labor troubles, brought on by an attempt to organize the mine workers in the Trinidad field, the most important coal producing area in the State. In Maryland the smaller production is attributed to the gradual exhaustion of the larger mines operating on the principal source of supply, "the Maryland Big Vein," and the decreasing production is likely to continue until conditions warrant extensive development of the lower and thinner beds whose aggregate reserves largely exceed the original contents of the famous "Big Vein." The decrease in Missouri was insignificant (one half of 1 per cent) and was due to exceptionally mild weather in February and March, which cut down the production for those two months 135,000 tons, compared with the same period in 1912.

The largest increase was in the production of bituminous coal in Pennsylvania, which showed a gain of 11,915,729 short tons, or 7.36 per cent, in quantity and of $23,669,309, or 14 per cent, in value. Second in the quantity of increase was Pennsylvania anthracite, whose production increased 6,395,825 long tons (7,163,324 short tons), or 8.5 per cent in quantity and $17,558 501 or 9.9 per cent in value. West Virginia came next with an increase of 4,522,295 short tons or 6.8 per cent in quantity and of $9,079,931, or 14.5 per cent in value. Kentucky had the largest percentage of increase of the important coal-producing States, with a gain of 3,126,079 short tons or 19 per cent in quantity and of $3,662,542, or 21.7 per cent in value. It will be noted that in each of these instances the percentage of increase in value was more than in that of quantity of coal produced. Indiana and Illinois were two notable exceptions to the larger proportionate gain in value the former showing an increase of 1,879,953 tons, or 12.3 per cent in quantity and of $1,521,335, or 8.7 per cent in value, while Illinois gained 1,733,518 tons, or 2.9 per cent in quantity and only $19,267, or 0.03 per cent in value. Ohio showed an increase of 1,671,800 tons, or 4.8 per cent in quantity and of $2,864,695, or 7.7 per cent in value; Alabama, a gain of 1,577,922 short tons, or 9.8 per cent in quantity and of $2,254,472, or 10.8 per cent in value, and Virginia, with an increase in quantity of 981,430 tons, 12.5 per cent, gained $1,434,077, or 19 per cent in value. Iowa and Oklahoma, of the eastern province, Montana and Utah, in the Rocky Mountain province, and Washington and Oregon, of the Pacific province, showed smaller relative gains in value than in production, and Wyoming, one of the Rocky Mountain States, was the only one to show an increase in production and a decrease in value. Georgia, the least important of the Appalachian States, was the only one of that region to show a relative loss in value.

The total production and value in the last five years, by States, with the increase and decrease in 1913, as compared with 1912, are shown in the following table:

Quantity and value of coal produced in the United States, 1909–1913, in short tons.

State.	1909		1910	
	Quantity.	Value.	Quantity.	Value.
Alabama	13,703,450	$16,306,236	16,111,462	$20,236,853
Arkansas	2,377,157	3,523,139	1,905,958	2,979,213
California and Alaska	48,636	107,342	12,164	33,336
Colorado	10,716,936	14,296,012	11,973,736	17,026,934
Georgia and North Carolina	[a] 211,196	[a] 298,792	[a] 177,245	[a] 259,122
Idaho	4,553	19,459	4,448	17,426
Illinois	50,904,990	53,522,014	45,900,246	52,405,897
Indiana	14,834,259	15,154,681	18,389,815	20,813,659
Iowa	7,757,762	12,793,628	7,928,120	13,903,913
Kansas	6,986,478	10,083,384	4,921,451	7,914,709
Kentucky	10,697,384	10,079,917	14,623,319	14,405,887
Maryland	4,023,241	4,471,731	5,217,125	5,835,058
Michigan	1,784,692	3,199,351	1,534,967	2,930,771
Missouri	3,756,530	6,183,626	2,982,433	5,328,285
Montana	2,553,940	5,036,942	2,920,970	5,329,322
New Mexico	2,801,128	3,619,744	3,508,321	4,877,151
North Dakota	422,047	645,142	399,041	595,139
Ohio	27,939,641	27,789,010	34,209,668	35,932,288
Oklahoma	3,119,377	6,253,367	2,646,226	5,867,947
Oregon	87,276	235,085	67,533	235,229
Pennsylvania, bituminous	137,966,791	130,085,237	150,521,526	153,029,510
Tennessee	6,358,645	6,920,564	7,121,380	7,925,350
Texas	1,824,440	3,141,945	1,892,176	3,160,965
Utah	2,266,899	3,751,810	2,517,809	4,224,556
Virginia	4,752,217	4,251,056	6,507,997	5,877,486
Washington	3,602,263	9,158,999	3,911,899	9,764,465
West Virginia	51,849,220	44,661,716	61,671,019	56,665,061
Wyoming	6,393,109	9,896,848	7,533,088	11,706,187
Total bituminous	379,744,257	405,486,777	417,111,142	469,281,719
Pennsylvania anthracite	81,070,359	149,181,587	84,485,236	160,275,302
Grand total	460,814,616	554,668,364	501,596,378	629,557,021

[a] Georgia only.

Quantity and value of coal produced in the United States, 1909–1913, in short tons—Con.

State.	1911		1912	
	Quantity.	Value.	Quantity.	Value.
Alabama	15,021,421	$19,079,949	16,100,600	$20,829,252
Arkansas	2,106,789	3,396,849	2,100,819	3,582,789
California and Alaska	11,647	23,297	11,333	26,441
Colorado	10,157,383	14,747,764	10,977,824	16,345,336
Georgia and North Carolina	165,330	246,448	227,703	338,926
Idaho	[a] 1,821	[a] 4,872	2,964	9,313
Illinois	53,679,118	59,519,478	59,885,226	70,294,338
Indiana	14,201,355	15,326,808	15,285,718	17,480,546
Iowa	7,331,648	12,663,507	7,289,529	13,152,088
Kansas	6,178,728	9,473,572	6,986,182	11,324,130
Kentucky	14,049,703	14,008,458	16,490,521	16,854,207
Maryland	4,685,795	5,197,066	4,964,038	5,839,079
Michigan	1,476,074	2,791,461	1,206,230	2,399,451
Missouri	3,836,107	6,603,066	4,339,856	7,633,864
Montana	2,976,358	5,342,168	3,048,495	5,558,195
New Mexico	3,148,158	4,525,925	3,536,824	5,037,051
North Dakota	502,628	720,489	499,480	765,105
Ohio	30,759,986	31,810,123	34,528,727	37,083,363
Oklahoma	3,074,242	6,291,494	3,675,418	7,867,331
Oregon	46,661	108,033	41,637	108,276
Pennsylvania, bituminous	144,561,257	146,154,952	161,865,488	169,370,497
Tennessee	6,433,156	7,209,734	6,473,228	7,379,903
Texas	1,974,593	3,273,288	2,188,612	3,655,744
Utah	2,513,175	4,248,666	3,016,149	5,046,451
Virginia	6,864,667	6,254,804	7,846,638	7,518,576
Washington	3,572,815	8,174,170	3,360,932	8,042,871
West Virginia	59,831,580	53,670,515	66,786,687	62,792,234
Wyoming	6,744,864	10,508,863	7,368,124	11,648,088
Total bituminous	405,907,059	451,375,819	450,104,982	517,983,445
Pennsylvania anthracite	90,464,067	175,189,392	84,361,598	177,622,626
Grand total	496,371,126	626,565,211	534,466,580	695,606,071

State.	1913		Increase (+) or decrease (−), 1913.		Percentage of increase or decrease, 1913.	
	Quantity.	Value.	Quantity.	Value.	Quantity.	Value.
Alabama	17,678,522	$23,083,724	+ 1,577,922	+$2,254,472	+ 9.80	+ 10.82
Arkansas	2,234,107	3,923,701	+ 133,288	+ 340,912	+ 6.34	+ 9.52
California and Alaska	26,911	95,173	+ 15,578	+ 68,732	+137.46	+259.94
Colorado	9,232,510	14,035,090	− 1,745,314	− 2,310,246	− 15.90	− 14.13
Georgia	255,626	361,319	+ 27,923	+ 22,393	+ 12.26	+ 6.61
Idaho and Nevada	2,177	5,285	− 787	− 4,028	− 26.55	− 43.25
Illinois	61,618,744	70,313,605	+ 1,733,518	+ 19,267	+ 2.89	+ .03
Indiana	17,165,671	19,001,881	+ 1,879,953	+ 1,521,335	+ 12.30	+ 8.70
Iowa	7,525,936	13,496,710	+ 236,407	+ 344,622	+ 3.24	+ 2.62
Kansas	7,202,210	12,036,292	+ 216,028	+ 712,162	+ 3.09	+ 6.29
Kentucky	19,616,600	20,516,749	+ 3,126,079	+ 3,662,542	+ 18.96	+ 21.73
Maryland	4,779,839	5,927,046	− 184,199	+ 87,967	− 3.71	+ 1.51
Michigan	1,231,786	2,455,227	+ 25,556	+ 55,776	+ 2.12	+ 2.32
Missouri	4,318,125	7,468,308	− 21,731	− 165,556	− .50	− 2.17
Montana	3,240,973	5,653,539	+ 192,478	+ 95,344	+ 6.31	+ 1.72
New Mexico	3,708,806	5,401,260	+ 171,982	+ 364,209	+ 4.86	+ 7.23
North Dakota	495,320	750,652	− 4,160	− 14,453	− .83	− 1.89
Ohio	36,200,527	39,948,058	+ 1,671,800	+ 2,864,695	+ 4.84	+ 7.73
Oklahoma	4,165,770	8,542,748	+ 490,352	+ 675,417	+ 13.34	+ 8.59
Oregon	46,063	116,724	+ 4,426	+ 8,448	+ 10.63	+ 7.80
Pennsylvania, bituminous	173,781,217	193,039,806	+11,915,729	+23,669,309	+ 7.36	+ 13.97
Tennessee	6,903,784	7,883,714	+ 430,556	+ 503,811	+ 6.65	+ 6.83
Texas	2,429,144	4,288,920	+ 240,532	+ 633,176	+ 10 99	+ 17.32
Utah	3,254,828	5,384,127	+ 238,679	+ 337,676	+ 7.91	+ 6.69
Virginia	8,828,068	8,952,653	+ 981,430	+ 1,434,077	+ 12.51	+ 19.07
Washington	3,877,891	9,243,137	+ 516,959	+ 1,200,266	+ 15.38	+ 14.92
West Virginia	71,308,982	71,872,165	+ 4,522,295	+ 9,079,931	+ 6.77	+ 14.46
Wyoming	7,393,066	11,510,045	+ 24,942	− 138,043	+ .33	− 1.19
Total bituminous	478,523,203	565,307,658	+28,418,221	+47,324,213	+ 6.31	+ 9.14
Pennsylvania, anthracite	91,524,922	195,181,127	+ 7,163,324	+17,558,501	+ 8.49	+ 9.89
Grand total	570,048,125	760,488,785	+35,581,545	+64,882,714	+ 6.66	+ 9.33

[a] Includes production of Nevada.

PRODUCTION OF COAL IN THE UNITED STATES FROM THE EARLIEST TIMES TO THE CLOSE OF 1913.

The earliest mention of coal in the territory which afterwards became the United States is recorded in the journal of Father Louis Hennepin, a French missionary, who in 1679 recorded the site of a "cole" mine on Illinois River, near the present city of Ottawa, Hennepin having passed through that region 10 years before. The next mention of bituminous coal in the United States territory is in the writings of Col. William Boyd, who in a report made to the Virginia Assembly in 1701, mentioned the discovery of coal in what is now known as the Richmond Basin, near Richmond, Va. The first actual mining of coal was from this Virginia locality. Authorities differ as to the date the first coal was mined, but it was some time between 1720 and 1750. During the Revolutionary War the mining of coal in the Richmond Basin was a comparatively important industry. Ohio probably ranks second in priority of production, as coal was discovered there in 1755, but the records of production date back only to 1838. The earliest record of coal mining in the bituminous regions of Pennsylvania is for the year 1760, five years after the discovery of coal in Ohio, when Capt. Thomas Hutchins visited Fort Pitt (now Pittsburgh) and found a coal mine on the opposite side of Monongahela River, the product being used by the resident garrison. In 1768 the Penn Proprietaries purchased from the Six Nations the whole of the bituminous coal field of Pennsylvania except that portion which lies northward of Kittanning, which was purchased 16 years later. The mining of anthracite began in the last half of the eighteenth century. Its earliest discovery was in 1762 when settlers from Connecticut found "stone" coal in the Wyoming Valley. The first use of it, so far as known, was made in 1768. It was first used in a forge in 1769. Mining may be said to have begun near Pittston in 1775, and in 1776 to 1780 anthracite was mined on the banks of Susquehanna River near Wilkes-Barre and shipped by barges to Carlisle and Columbia. Anthracite was used in making nails in 1788, all of these instances occurring in the Wyoming region, the discovery of coal in that region having antedated the discovery in the Schuylkill region by 28 years. In 1807 a shipment of 55 long tons of anthracite was made by Abijah Smith & Co., from Plymouth to Columbia, and it is estimated that from 1807 to 1820, when the first shipments were made from the Lehigh region, about 12,000 tons had already been shipped from the Wyoming Valley. Coal was discovered in the Lehigh region in 1791, and the first anthracite company, the Lehigh Coal Mining Co. (now the Lehigh Coal & Navigation Co.), was organized in 1792. In 1820 the shipments from the Lehigh region began, 13 years after the first shipments were made from the Wyoming region. In 1814, six years before the Lehigh region was opened, some coal was mined at Carbondale and shipped via Lackawaxen and Delaware rivers to Philadelphia. The records of the bureau of anthracite statistics began in 1820, when the first rail shipments were made from Lehigh region, one long ton for each day of the year. In addition to having the credit for priority of discovery and mining of anthracite, the Wyoming region, although the latest of the three large regions to report regular shipments of coal has contributed considerably more than one-half of the total quantity of coal sent out of the anthracite fields of Pennsylvania. According to the reports of the bureau of anthracite statistics, the total quantity of anthracite

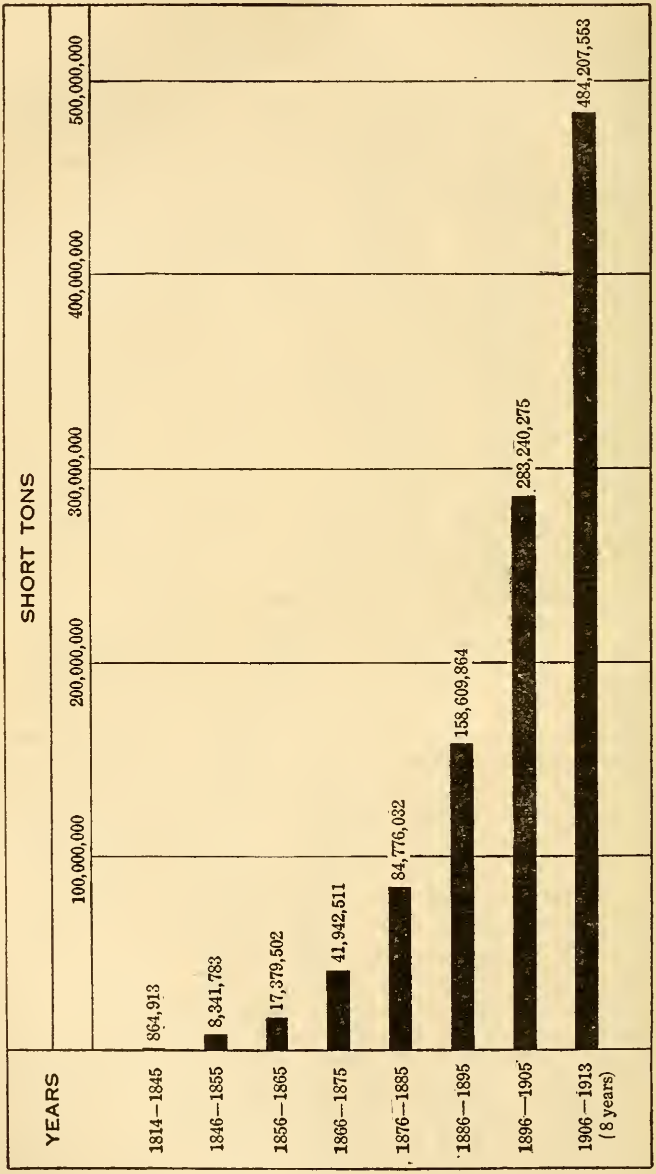

FIGURE 19.—Average yearly production of coal in the United States for 1814–1845 and for each decade since 1845, in short tons.

shipped, up to the close of 1913, was approximately 1,952,030,000 tons, of which 1,036,760,000 tons had been sent out from the Wyoming region. The following table shows the total production of anthracite in Pennsylvania, in short tons, since 1807, the total production of bituminous coal since 1820, and the total annual production up to the close of 1913. During the period covered by the table the total production of anthracite in Pennsylvania has amounted to 2,446,696,010 short tons; the country's production of bituminous coal to 7,397,551,833 tons, and the aggregate production to 9,844,247,843 tons. Of the grand total the anthracite mines of Pennsylvania have contributed a little less that 25 per cent and the rest of the country a little more than 75 per cent. The annual production of coal in each State from the time of earliest record until the close of 1913 is given in connection with the discussion of production in the several States. (See also chart in pocket.)

Production of coal in the United States from 1807 to the close of 1913, in short tons.

Year.	Pennsylvania anthracite.	Bituminous.	Total.
1807–1820	12,000	3,000	15,000
1821	1,322	....	1,322
1822	4,583	54,000	58,583
1823	8,563	60,000	68,563
1824	13,685	67,040	80,725
1825	42,988	75,000	117,988
1826	59,194	88,720	147,914
1827	78,151	94,000	172,151
1828	95,500	100,408	195,908
1829	138,086	102,000	240,086
1830	215,272	104,800	320,072
1831	217,842	120,100	337,942
1832	447,550	146,500	594,050
1833	600,907	133,750	734,657
1834	464,015	136,500	600,515
1835	690,854	134,000	824,854
1836	842,832	142,000	984,832
1837	1,071,151	182,500	1,253,651
1838	910,075	445,452	1,355,527
1839	1,008,322	552,038	1,560,360
1840	967,108	1,102,931	2,070,039
1841	1,182,441	1,108,700	2,291,141
1842	1,365,563	1,244,494	2,610,057
1843	1,556,753	1,504,121	3,060,874
1844	2,009,207	1,672,045	3,681,252
1845	2,480,032	1,829,872	4,309,904
1846	2,887,815	1,977,707	4,865,522
1847	3,551,005	1,735,062	5,286,067
1848	3,805,942	1,968,032	5,773,974
1849	3,995,334	2,453,497	6,448,831
1850	4,138,164	2,880,017	7,018,181
1851	5,481,065	3,253,460	8,734,525
1852	6,151,957	3,664,707	9,816,664
1853	6,400,426	4,169,862	10,570,288
1854	7,394,875	4,582,227	11,977,102
1855	8,141,754	4,784,919	12,926,673
1856	8,534,779	5,012,146	13,546,925
1857	8,186,567	5,153,622	13,340,189
1858	8,426,102	5,548,376	13,974,478
1859	9,619,771	6,013,404	15,633,175
1860	8,115,842	6,494,200	14,610,042
1861	9,799,654	6,688,358	16,488,012
1862	9,695,110	7,790,725	17,485,835
1863	11,785,320	9,533,742	21,319,062
1864	12,538,649	11,066,474	23,605,123
1865	11,891,746	11,900,427	23,792,173
1866	15,651,183	13,352,400	29,003,583
1867	16,002,109	14,722,313	30,724,422
1868	17,003,405	15,858,555	32,861,960
1869	17,083,134	15,821,226	32,904,360
1870	15,664,275	17,371,305	33,035,580
1871	19,342,057	27,543,023	46,885,080
1872	24,233,166	27,220,233	51,453,399
1873	26,152,837	31,449,643	57,602,480
1874	24,818,790	27,787,130	52,605,920
1875	22,485,766	29,862,554	52,348,320
1876	22,793,245	30,486,755	53,280,000
1877	25,660,316	34,841,444	60,501,760
1878	21,689,682	36,245,918	57,935,600
1879	30,207,793	37,898,006	68,105,799
1880	28,649,812	42,831,758	71,481,570
1881	31,920,018	53,961,012	85,881,030
1882	35,121,256	68,429,933	103,551,189
1883	38,456,845	77,250,680	115,707,525
1884	37,156,847	82,998,704	120,155,551
1885	38,335,974	72,824,321	111,160,295
1886	39,035,446	74,644,981	113,680,427
1887	42,088,197	88,562,314	130,650,511
1888	46,619,564	102,040,093	148,659,657
1889	45,546,970	95,682,543	141,229,513
1890	46,468,641	111,302,322	157,770,963
1891	50,665,431	117,901,238	168,566,669
1892	52,472,504	126,856,567	179,329,071
1893	53,967,543	128,385,231	182,352,774
1894	51,921,121	118,820,405	170,741,526
1895	57,999,337	135,118,193	193,117,530
1896	54,346,081	137,640,276	191,986,357
1897	52,611,680	147,617,519	200,229,199
1898	53,382,644	166,593,623	219,976,267
1899	60,418,005	193,323,187	253,741,192
1900	57,367,915	212,316,112	269,684,027
1901	67,471,667	225,828,149	293,299,816
1902	41,373,595	260,216,844	301,590,439
1903	74,607,068	282,749,348	357,356,416
1904	73,156,709	278,659,689	351,816,398
1905	77,659,850	315,062,785	392,722,635
1906	71,282,411	342,874,867	414,157,278
1907	85,604,312	394,759,112	480,363,424
1908	83,268,754	332,573,944	415,842,698
1909	81,070,359	379,744,257	460,814,616
1910	84,485,236	417,111,142	501,596,378
1911	90,464,067	405,907,059	496,371,126
1912	84,361,598	450,104,982	534,466,580
1913	91,524,922	478,523,203	570,048,125
	2,446,696,010	7,397,551,833	9,844,247,843

COAL FIELDS OF THE UNITED STATES.

The coal areas of the United States are divided, for the sake of convenience, into two great divisions—anthracite and bituminous.

The areas in which anthracite is produced are confined almost exclusively to the eastern part of Pennsylvania, and usually when the anthracite fields of the United States are referred to those of eastern Pennsylvania are meant. These fields are included in the counties of Susquehanna, Lackawanna, Luzerne, Carbon, Schuylkill, Columbia, Northumberland, Dauphin, and Sullivan, and underlie an area of about 480 square miles. In addition to these well-known anthracite fields of Pennsylvania there are two small areas in the Rocky Mountain region where the coal has been locally anthracited, although the production from these districts has never amounted to as much as 100,000 tons in any one year. One of these localities is in Gunnison County, Colo., and the other in Santa Fe County, N. Mex. The coal, although only locally metamorphosed, is a true anthracite and of a good quality. In previous years some coal which was classed as anthracite was mined and sold in New England. The productive area was confined to the eastern part of Rhode Island and the counties of Bristol and Plymouth in Massachusetts.

The bituminous and lignite fields are scattered widely over the United States and include an area of more than 450,000 square miles. The previous classification of these coal areas published in earlier volumes of the report Mineral Resources of the United States has been changed as a result of conferences among the geologists working under Marius R. Campbell on the economic geology of coal. The areas are divided, primarily, into six provinces, as follows:

(1) The eastern province, which includes all of the bituminous areas of the Appalachian region; the Atlantic coast region, which includes the Triassic fields near Richmond and the Deep River and Dan River fields of North Carolina, and also the anthracite region of Pennsylvania. (2) The Gulf province, which includes the lignite fields of Alabama, Mississippi, Louisiana, Arkansas, and Texas. (3) The interior province, which includes all the bituminous areas of the Mississippi Valley region and the coal fields of Michigan. This province is subdivided into the eastern region, which embraces the coal fields of Illinois, Indiana, and western Kentucky; the western region, which includes the fields of Iowa, Missouri, Nebraska, Kansas, Arkansas, and Oklahoma; and the southwestern region, which includes the coal fields of Texas. The Michigan fields are designated as the northern region of the interior province. (4) The northern or Great Plains province, which includes the lignite areas of North Dakota and South Dakota, and the bituminous and subbituminous areas of northeastern Wyoming and of northern and eastern Montana. (5) The Rocky Mountain province, which includes the coal fields of the portions of Montana and Wyoming which are in the mountainous districts of those States, and all the coal fields of Utah, Colorado, and New Mexico. (6) The Pacific coast province, which includes all of the coal fields of California, Oregon, and Washington.

The report on the production of coal in 1910 contains brief descriptions of the coal fields of the several States and maps of the known coal areas. Copies of this report are still available and may be obtained free of charge upon application to the Director of the United

States Geological Survey, Washington, D. C. The geologic work done by the Geological Survey in the coal-mining States of the Rocky Mountain region has greatly advanced the knowledge of the coal reserves in those States, and the areas now known to contain workable coal exceed by many square miles and the reserves by many million tons the earlier estimates published in this series of reports. From the information thus obtained Mr. Campbell has revised the table showing the areas and the original supplies. This revision indicates that the total coal reserves of the United States exceed by about 17 per cent the previously compiled estimates. Some of this increase is in the States of the western and southwestern regions and in the State of Washington, but most of them are in the public-land States of the Rocky Mountain and northern or Great Plains provinces. In the table presented herewith the Rocky Mountain and Great Plains States are shown to have contained originally a total of 2,514,415,-900,000 short tons of coal. The report for 1912 (the revised figures were not then available) showed that these areas were estimated to contain about 1,970,000,000,000 tons. The known coal areas of the United States aggregate a total of 339,887 square miles, to which may be added 89,482 square miles supposed to contain workable coal, but knowledge of them is not sufficient to warrant a definite statement to that effect. In addition, there are 28,470 square miles where the coal lies at depths of 3,000 feet or more, and is not considered available under present conditions. In the 1912 and preceding reports the known coal areas of the United States were stated to embrace 310,296 square miles, and the unknown areas about 160,000 square miles, but it is seen that definite knowledge of the coal contents has been extended over an additional area of nearly 30,000 square miles, and that the areas about which little is known have been nearly cut in half. The supply of coal before mining began is now estimated to have been 3,554,383,400,000 tons. Classified according to the character of the coal, the original supply consisted of 21,000,000,000 short tons of anthracite (exclusive of the small areas in Colorado and New Mexico); 1,834,100,000 tons of semianthracite; 1,444,036,500,000 tons of bituminous coal; 47,913,500,000 tons of semibituminous coal; 948,084,900,000 tons of subbituminous coal, or black lignite; and 1,087,514,400,000 tons of lignite, or brown coal. The coal lying from 3,000 to 6,000 feet below the surface is estimated at about 675,000,-000,000 short tons.

It will be observed from these figures that nearly 60 per cent of the entire reserve is composed of subbituminous and lignite, and that barely 40 per cent is represented by the higher grades—anthracite, semianthracite, and bituminous coal.

The total production at the close of 1913 has amounted to 2,446,696,010 short tons of anthracite and 7,397,551,833 short tons of bituminous coal, an aggregate of 9,844,247,843 short tons. It is usual to consider that for every ton of coal that has been mined and marketed a half ton has been lost through necessary waste in mining. In the early history of mining in both the anthracite and bituminous regions the percentage of loss was considerably more than half a ton for every ton mined. In the anthracite region it was estimated by the Anthracite Waste Commission, which made its report in 1893, that the recovery was only 40 per cent, or, in other words, a ton and a half was lost for every ton sold. At the present time the recovery in the anthracite region is from 60 to 65 per cent, so that conditions are reversed, and for every ton of coal lost a ton and a half is sold or used. In some parts of the bituminous regions the recovery approaches 100 per cent. In other cases it is less than 50 per cent, where the beds are very thick or lie at great depth and it is necessary to leave large quantities of coal in pillars to support the roof. Half a ton of coal lost for each ton mined is doubtless a fair average. The exhaustion in the anthracite region of Pennsylvania is probably equivalent to double the production; that is, for every ton of coal mined 1 ton has been lost, and the exhaustion in the anthracite region consequently amounts to 4,847,000,000 tons. In the mines of the bituminous fields, estimating a half ton lost for every ton produced, the exhaustion is equivalent to about 11,100,000,000 tons; hence the total exhaustion amounts to about 16,000,000,000 short tons, or about 0.5 of 1 per cent of the original supply. In other words, the quantity of coal still remaining to be mined amounts to approximately 3,527,700,000,000 tons, or a little more than 99.5 per cent of the original supply. Upon the same basis of a two-thirds recovery, something over 2,250,000,000,000 tons of coal are still available, a little less than 4,000 times the rate of production in 1913.

The following table shows the area known to contain coal in the various States, by fields, the estimated original supply, the total production of each State and field in 1913, the total production in each to the close of 1913, and the estimated supply still available:

Areas of the coal fields by States, estimates of original and present supply, and the production to the close of 1913.

	Area.	Estimated original supply.	Production in 1913.	Total production to close of 1913.	Total exhaustion to close of 1913.	Estimated available supply.
ANTHRACITE.	*Square miles.*	*Short tons.*	*Short tons.*	*Short tons.*	*Short tons.*	*Short tons.*
Pennsylvania	480	21,000,000,000	91,524,922	2,446,696,010	4,847,000,000	16,153,000,000
Colorado and New Mexico	(a)	(a)	(a)			
Total	480	21,000,000,000	91,524,922	2,446,696,010	4,847,000,000	16,153,000,000
BITUMINOUS.[b]						
Eastern province.						
Atlantic coast region:						
Virginia	150	(c)	(c)	(c)	(c)	(c)
North Carolina	60	200,000,000		477,125	715,700	199,284,300
Appalachian region:						
Pennsylvania	14,200	112,574,000,000	173,781,217	2,731,945,059	4,100,000,000	108,474,000,000
Ohio	12,660	93,967,900,000	36,200,527	682,678,546	1,024,000,000	92,943,900,000
Maryland	455	8,044,000,000	4,779,839	175,653,679	263,500,000	7,780,500,000
Virginia	1,750	22,500,000,000	8,828,068	96,287,781	134,500,000	22,365,500,000
West Virginia	17,000	151,544,900,000	71,308,982	787,543,870	1,181,300,000	150,363,600,000
Eastern Kentucky	10,270	67,787,000,000	11,098,960	93,423,911	140,000,000	67,647,000,000
Tennessee	4,400	25,665,000,000	6,903,784	123,793,965	186,000,000	25,479,000,000
Georgia	167	933,000,000	255,626	9,425,298	14,200,000	918,800,000
Alabama	8,455	67,583,000,000	17,678,522	254,954,358	382,400,000	67,200,600,000
Total	69,357	550,598,800,000	330,835,525	4,955,706,467	7,425,900,000	543,172,900,000
Interior province.						
Northern region:						
Michigan	11,000	12,000,000,000	1,231,786	22,911,711	34,400,000	11,965,600,000
Eastern region:						
Indiana	6,500	53,051,000,000	17,165,671	251,632,098	377,500,000	52,673,500,000
Western Kentucky	6,400	55,540,000,000	8,517,640	114,704,743	172,000,000	55,368,000,000
Illinois	35,600	201,399,800,000	61,618,744	965,516,323	1,448,300,000	199,951,500,000
Total	48,500	309,990,800,000	87,302,055	1,331,853,164	1,997,800,000	307,993,000,000

a Included in Rocky Mountain and Northern Great Plains provinces.
b Includes brown coal or lignite, semianthracite, semibituminous, etc., and scattering lots of anthracite.
c Included in production of Appalachian region.

Areas of the coal fields by States, estimates of original and present supply, and the production to the close of 1913—Continued.

	Area.	Estimated original supply.	Production in 1913.	Total production to close of 1913.	Total exhaustion to close of 1913.	Estimated available supply.
BITUMINOUS—continued.						
Interior province—Continued.						
Western and southwestern regions:[a]	*Squaer miles.*	*Short tons.*	*Short tons.*	*Short tons.*	*Short tons.*	*Short tons.*
Iowa	12,560	29,160,000,000	7,525,936	186,603,097	280,000,000	28,880,000,000
Missouri	23,960	84,000,000,000	4,318,125	120,168,472	180,000,000	83,820,000,000
Kansas	18,600	30,000,000,000	7,202,210	129,696,761	194,500,000	29,805,500,000
Arkansas	7,580	1,887,000,000	2,234,107	36,559,588	55,000,000	1,832,000,000
Oklahoma	10,000	54,951,500,000	4,165,770	59,474,164	89,200,000	54,862,300,000
Texas	68,500	31,000,000,000	2,429,144	26,649,290	40,000,000	30,960,000,000
Total	141,200	230,998,500,000	27,875,292	559,151,372	838,700,000	230,159,800,000
Rocky Mountain and Northern Great Plains provinces.						
Arizona	3,610	14,151,400,000	....	....	....	14,151,400,000
North Dakota	35,980	697,929,400,000	495,320	5,423,516	8,200,000	697,921,200,000
Montana	39,532	381,115,800,000	3,240,973	41,400,059	62,000,000	381,053,800,000
South Dakota	10,980	1,020,300,000	....	....	....	1,020,300,000
Wyoming	41,540	670,723,100,000	7,393,066	118,740,918	178,000,000	670,545,100,000
Utah	11,176	88,345,500,000	3,254,828	34,252,834	51,400,000	88,294,100,000
Colorado	19,754	317,852,600,000	9,232,510	175,361,698	263,000,000	317,589,600,000
New Mexico	14,220	191,840,100,000	3,708,806	41,496,606	62,200,000	191,777,900,000
Idaho	1,230	700,000,000	[b] 2,177	48,623	73,000	699,927,000
Total	178,022	2,363,678,200,000	27,327,680	316,724,254	624,873,000	2,363,053,327,000
Pacific coast province and Alaska.						
Washington	1,800	63,873,100,000	3,877,891	64,459,440	96,700,000	63,776,400,000
Oregon	230	1,000,000,000	46,063	2,165,821	3,250,000	996,750,000
California	40	44,000,000	24,839	5,153,264	7,733,000	36,267,000
Alaska	....	....	2,072	47,969	....	....
Total	2,070	64,917,100,000	3,950,865	71,826,494	107,683,000	64,809,417,000
Total production, including colliery consumption	[c] 450,839	3,553,383,400,000	570,048,125	9,844,247,843	15,877,071,700	3,538,506,328,300

[a] Including Arkansas and Texas lignite fields of Gulf province.
[b] Includes a little coal from Nevada.
[c] Includes 89,482 square miles supposed, but not definitely known, to contain usable coal, and 28,470 square miles in which the coal lies under cover 3,000 or more feet in thickness.

The following statistics cover the annual production of coal in each of the various regions from 1887 to the close of 1913:

Total production of each region, 1887–1913, in short tons.

	Anthracite.	Bituminous.		
		Atlantic coast.	Appalachian.	Northern.
Area [a] ....square miles..	[b] 509	210	69,332	11,000
Year.				
1887	39,548,255	30,000	55,888,088	71,461
1888	43,971,688	33,000	60,966,245	81,407
1889	45,600,487	49,633	62,972,222	67,431
1890	46,468,641	29,608	73,008,102	74,977
1891	50,665,931	37,645	77,984,563	80,307
1892	52,537,467	43,889	83,122,190	77,990
1893	54,061,121	36,878	81,207,168	45,979
1894	51,992,671	68,979	76,278,748	70,002
1895	58,066,516	82,682	90,167,596	112,322
1896	54,425,573	103,483	90,748,305	92,882
1897	52,680,756	116,950	97,128,220	223,592
1898	53,429,739	38,938	114,239,156	315,722
1899	60,514,201	28,353	129,843,906	624,708
1900	57,466,319	57,912	142,298,208	849,475
1901	67,538,536	12,000	150,501,214	1,241,241
1902	41,467,532	39,206	173,274,861	964,718
1903	74,679,799	35,393	185,600,161	1,367,619
1904	73,228,783	9,100	182,606,561	1,342,840
1905	77,734,673	1,557	212,633,324	1,473,211
1906	71,342,659	....	233,473,524	1,346,338
1907	85,666,404	....	266,501,527	2,035,858
1908	83,310,412	....	216,499,163	1,835,019
1909	81,070,359	....	251,630,500	1,784,692
1910	84,485,236	....	287,816,446	1,534,967
1911	90,464,067	120	275,212,234	1,476,074
1912	84,361,598	200	307,410,102	1,206,230
1913	91,524,922	....	330,835,525	1,231,786

	Bituminous.			
	Eastern.	Western and Southwestern.	Rocky Mountain, etc.	Pacific coast and Alaska.
Area [a] ....square miles..	48,500	141,200	178,022	2,070
Year.				
1887	14,478,883	10,172,634	3,646,280	854,308
1888	19,173,167	11,842,764	4,583,719	1,385,750
1889	16,240,314	10,036,356	5,048,413	1,214,757
1890	20,075,840	10,470,439	6,205,782	1,435,914
1891	20,327,323	11,023,817	7,245,707	1,201,376
1892	23,001,653	11,635,185	7,577,422	1,333,266
1893	25,502,809	11,651,296	8,468,360	1,379,163
1894	22,430,617	11,503,623	7,175,628	1,221,238
1895	23,599,469	11,749,803	7,998,594	1,340,548
1896	25,539,867	11,759,966	7,925,280	1,391,001
1897	26,414,127	13,164,059	8,854,182	1,641,779
1898	25,816,874	13,988,436	10,042,759	2,104,643
1899	33,181,247	15,320,373	11,949,463	2,278,941
1900	35,358,164	17,549,528	13,398,556	2,705,865
1901	37,450,871	19,665,985	14,090,362	2,799,607
1902	46,133,024	20,727,495	16,149,545	2,834,058
1903	52,130,856	23,171,692	16,981,059	3,389,837
1904	51,682,313	23,273,482	16,344,516	3,328,803
1905	55,255,541	23,265,750	19,303,188	3,055,391
1906	59,457,660	23,086,348	22,064,003	3,386,746
1907	71,598,256	26,856,622	23,929,155	3,775,602
1908	65,774,700	23,645,983	21,644,307	3,133,064
1909	71,598,795	25,821,744	25,158,772	3,735,375
1910	72,634,356	22,276,364	28,857,413	3,991,596
1911	75,041,014	24,502,107	26,044,387	3,631,123
1912	83,044,272	26,580,416	28,449,860	3,413,902
1913	87,302,055	27,875,292	27,327,680	3,950,865

[a] Known to contain workable coal. [b] Includes 29 square miles in Colorado and New Mexico.

The following table shows how the production in the six principal bituminous areas has developed since 1887 and how the percentages of the total produced in each during the last two years compare with one another. The production in the northern region of Michigan shows the largest percentage of increase in the period since 1887, and the percentage of the total contributed by the Pacific coast has decreased:

Production of the six principal bituminous coal regions in 1887, 1912, and 1913, compared, in short tons.

Region.	1887		1912		1913	
	Quantity.	Percentage of total.	Quantity.	Percentage of total.	Quantity.	Percentage of total.
Appalachian	55,888,088	63.11	307,410,102	68.30	330,835,525	69.14
Eastern	14,478,883	16.50	83,044,272	18.45	87,302,055	18.24
Western	10,172,634	11.49	26,580,416	5.90	27,875,292	5.83
Northern	71,461	.08	1,206,230	.27	1,231,786	.26
Rocky Mountain	3,646,280	4.15	28,449,860	6.32	27,327,680	5.71
Pacific coast	854,308	1.00	3,413,902	.76	3,950,865	.82

Region.	Increase in 1913 over 1887.		Increase in 1913 over 1912.	
	Quantity.	Percentage.	Quantity.	Percentage.
Appalachian	274,947,437	491.96	23,425,423	7.62
Eastern	72,823,172	502.96	4,257,783	5.13
Western	17,702,658	174.02	1,294,876	4.87
Northern	1,160,325	1,623.72	25,556	2.12
Rocky Mountain	23,681,400	649.47	[a] 1,122,180	[a] 3.94
Pacific coast	3,096,557	362.46	536,963	15.73

[a] Decrease.

RANK OF COAL-PRODUCING STATES.

In the following table the States are arranged according to their rank as coal producers—first, in the quantity of coal mined, and second, in the value of the product.

In the quantity of coal produced the first nine States held the same relative positions in 1913 as in 1912, but in the value of the product West Virginia, for the first time in its history, outranked Illinois. Kentucky superseded Alabama as fifth in rank of production in 1912 and maintained the lead in 1913, but the latter State remains fifth in the value of the product. Iowa, in 1913, displaced Wyoming in tenth place in the quantity of coal mined, and Kansas displaced the same State in value. Washington went ahead of New Mexico in quantity produced and Utah supplanted Montana. In the value of the product Virginia advanced from fifteenth to thirteenth place, displacing Oklahoma and Missouri, and the last State was also outranked by Tennessee. In the combined production of anthracite and bituminous coal in 1913 Pennsylvania was credited with 46.6 per cent of the total for the United States in quantity, and 51.1 per cent in value, both being slight gains over 1912, when these percentages were, respectively, 46.1 and 50. West Virginia's percentage of the total quantity was about the same in 1912, but showed an increase from 9 to 9.5 in the percentage of the total value. Illinois's percentage of the total output decreased from 11.2 in 1912 to 10.8 in 1913, with a decrease in the value from 10.1 to 9.2 per cent. Ohio's percentages in both quantity and value were about the same in both years, as were also those of Alabama. Kentucky's percentage of quantity increased from 3.1 to 3.4, and of value from 2.4 to 2.7.

Rank of coal-producing States in 1912 and 1913, with quantity and value of product and percentage of each.

1912.

Production.				Value.			
Rank.	State.	Quantity (short tons).	Percentage of total production.	Rank.	State.	Value.	Percentage of total value.
1	Pennsylvania:			1	Pennsylvania:		
	Anthracite	84,361,598	15.8		Anthracite	$177,622,626	25.6
	Bituminous	161,865,488	30.3		Bituminous	169,370,497	24.4
2	West Virginia	66,786,687	12.5	2	Illinois	70,294,338	10.1
3	Illinois	59,885,226	11.2	3	West Virginia	62,792,234	9.0
4	Ohio	34,528,727	6.4	4	Ohio	37,083,363	5.3
5	Kentucky	16,490,521	3.1	5	Alabama	20,829,252	3.0
6	Alabama	16,100,600	3.0	6	Indiana	17,480,546	2.5
7	Indiana	15,285,718	2.8	7	Kentucky	16,854,207	2.4
8	Colorado	10,977,824	2.0	8	Colorado	16,345,336	2.4
9	Virginia	7,846,638	1.5	9	Iowa	13,152,088	1.9
10	Wyoming	7,368,124	1.4	10	Wyoming	11,648,088	1.7
11	Iowa	7,289,529	1.4	11	Kansas	11,324,130	1.6
12	Kansas	6,986,182	1.3	12	Washington	8,042,871	1.2
13	Tennessee	6,473,228	1.2	13	Oklahoma	7,867,331	1.1
14	Maryland	4,964,038	.9	14	Missouri	7,633,864	1.1
15	Missouri	4,339,856	.8	15	Virginia	7,518,576	1.1
16	Oklahoma	3,675,418	.7	16	Tennessee	7,379,903	1.1
17	New Mexico	3,536,824	.7	17	Maryland	5,839,079	.8
18	Washington	3,360,932	.6	18	Montana	5,558,195	.8
19	Montana	3,048,495	.6	19	Utah	5,046,451	.7
20	Utah	3,016,149	.6	20	New Mexico	5,037,051	.7
21	Texas	2,188,612	.4	21	Texas	3,655,744	.5
22	Arkansas	2,100,819	.4	22	Arkansas	3,582,789	.5
23	Michigan	1,206,230	.2	23	Michigan	2,399,451	.3
24	North Dakota	499,480	.1	24	North Dakota	765,105	.1
25	Georgia and North Carolina	227,703	.1	25	Georgia and North Carolina	338,926	.1
26	Oregon	41,637		26	Oregon	108,276	
27	California and Alaska	11,333		27	California and Alaska	26,441	
28	Idaho and Nevada	2,964		28	Idaho and Nevada	9,313	
	Total	534,466,580	100.0		Total	695,606,071	100.0

Rank of coal-producing States in 1912 and 1913, with quantity and value of product and percentage of each—Continued.

1913.

Production.				Value.			
Rank.	State.	Quantity (short tons).	Percentage of total production.	Rank.	State.	Value.	Percentage of total value.
1	Pennsylvania:			1	Pennsylvania:		
	Anthracite	91,524,922	16.1		Anthracite	$195,181,127	25.7
	Bituminous	173,781,217	30.5		Bituminous	193,039,806	25.4
2	West Virginia	71,308,982	12.5	2	West Virginia	71,872,165	9.5
3	Illinois	61,618,744	10.8	3	Illinois	70,313,605	9.2
4	Ohio	36,200,527	6.3	4	Ohio	39,948.058	5.3
5	Kentucky	19,616,600	3.4	5	Alabama	23,083,724	3.0
6	Alabama	17,678,522	3.1	6	Kentucky	20,516,749	2.7
7	Indiana	17,165,671	3.0	7	Indiana	19,001,881	2.5
8	Colorado	9,232,510	1.6	8	Colorado	14,035,090	1.8
9	Virginia	8,828,068	1.5	9	Iowa	13,496,710	1.8
10	Iowa	7,525,936	1.3	10	Kansas	12,036,292	1.6
11	Wyoming	7,393,066	1.3	11	Wyoming	11,510,045	1.5
12	Kansas	7,202,210	1.3	12	Washington	9,243,137	1.2
13	Tennessee	6,903,784	1.2	13	Virginia	8,952,653	1.2
14	Maryland	4,779,839	.8	14	Oklahoma	8,542,748	1.1
15	Missouri	4,318,125	.8	15	Tennessee	7,883,714	1.0
16	Oklahoma	4,165,770	.7	16	Missouri	7,468,308	1.0
17	Washington	3,877,891	.7	17	Maryland	5,927,046	.8
18	New Mexico	3,708,806	.7	18	Montana	5,653,539	.7
19	Utah	3,254,828	.6	19	New Mexico	5,401,260	.7
20	Montana	3,240,973	.6	20	Utah	5,384,127	.7
21	Texas	2,429,144	.4	21	Texas	4,288,920	.6
22	Arkansas	2,234,107	.4	22	Arkansas	3,923,701	.5
23	Michigan	1,231,786	.2	23	Michigan	2,455,227	.3
24	North Dakota	495,320	.1	24	North Dakota	750,652	.1
25	Georgia	255,626	.1	25	Georgia	361,319	.1
26	Oregon	46,063		26	Oregon	116,724	
27	California and Alaska	26,911		27	California and Alaska	95,173	
28	Idaho and Nevada	2,177		28	Idaho and Nevada	5,285	
	Total	570,048,125	100.0		Total	760,488,785	100.0

PRODUCTION BY CLASSES OF MINES.

Since 1909 the chapters on the production of coal have included statements showing the distribution of the output according to the importance of the producing mines in the various States. In these statements the mines have been divided into five classes, those of the first class including the mines producing 200,000 short tons or more during the year; mines of the second class, those producing from 100,000 to 200,000 tons; mines of the third class, those having a production of from 50,000 to 100,000 tons; mines of the fourth class, those producing from 10,000 to 50,000 tons; and mines of the fifth class, those producing less than 10,000 tons. In these compilations only the commercial mines have been considered. No account has been taken of the number or production of country banks operated for purely neighborhood consumption, nor of the anthracite recovered from old culm banks or river beds. Some producers in making their reports to the Geological survey combine the production of two or more mines, if located in the same county, on one schedule; in such cases the production of each mine has been assumed to be the average of all of the mines covered by the schedule.

The statistics for 1913 furnish comparisons of these compilations for a period of five years, and it is interesting to note how, even in this short period of time, the tendency toward concentration of operations into large units has progressed in the bituminous mines. In the anthracite region of Pennsylvania such concentration had already been practically accomplished to the limit when the first attempt at this compilation was made, but it is to be observed that even in this highly centralized industry there has been an increase in the number and percentage of the mines of the first class and in the average yearly production by them. In 1909, 55.9 per cent of the anthracite mines were of the first class, and they produced 85.6 per cent of the total production, with an average production of 386,688 short tons by each mine; in 1913 the first class mines represented 62.6 per cent of the total munber, and contributed 89.5 per cent of the total output, with an average per mine of 453,730 short tons. The number and the total production of all the other classes in the anthracite region were less in 1913 than in 1909. The total number of producing mines in the anthracite region has decreased from 304 in 1909 to 278 in 1913, and yet the total production of the commercial mines has increased from 76,813,562 short tons to 88,171,634 tons, and the average production of all mines in the region was 317,164 short tons in 1913, against 252,676 tons in 1912. The average production per mine in the anthracite region is nearly four times the average production of the bituminous mines.

The total number of mines of the first class in the anthracite region in 1913 was 174, an increase of 4 over 1909, but the number of all the other classes of mines has decreased from 134 to 104, indicating clearly that the concentration into larger units in that region has been effected by the closing down of about 25 per cent of the smaller mines and operating the larger properties at greater capacity. In the bituminous regions, with an increase of nearly 100,000,000 tons in the production from commercial mines, there was one more mine in 1913 than in 1909, the total number being 5,775 in the earlier years and 5,776 in the later. The most significant change was in the number and production of the mines of the first class. They were 539 in number in 1909 and 694 in 1913, the increase in the latter year being 155 mines or 29 per cent. The total production from them showed an increase of over 80,000,000 tons, from 160,929,762 tons in 1909 to 241,463,241 tons in 1913, and constituted 80 per cent of the total increase in the five years. The average production per mine increased from 300,426 short tons to 347,930 tons, and the percentage of the total production contributed by them increased from 42.5 to 50.5. The number of mines of the second class increased from 731 to 837, but there has been relatively no change in the average production from mines of this class, the average during the five years ranging between 140,000 and 145,000 tons and the average in 1913 being a little less than in 1909. The same constancy of averages is exhibited in the production of mines of the third, fourth, and fifth classes as in mines of the second class. The number of mines of the third class increased from 915 in 1909 to 960 in 1913, but, although the number of fourth-class mines was larger in 1913 than in 1909, it was less than in either of the three intervening years. The number of mines in the fifth class, which include those producing less than 10,000 tons and which are operated for relatively local trade, has decreased from 2,054 in 1909 to 1,726 in 1913.

In the following table is presented a statement of the number and the percentage of mines of each class, their total and their average production, and the percentage of the total output contributed by each class during the last five years:

Production of coal in the United States in 1909–1913, according to classes of mines, in short tons.

	First class. (Mines producing over 200,000 tons.)					Second class. (Mines producing from 100,000 to 200,000 tons.)					Third class. (Mines producing from 50,000 to 100,000 tons.)				
	Mines.		Production.			Mines.		Production.			Mines.		Production.		
	Number.	Percentage.	Total.	Average per mine.	Percentage.	Number.	Percentage.	Total.	Average per mine.	Percentage.	Number.	Percentage.	Total.	Average per mine.	Percentage.
1909.															
Bituminous	539	9.3	160,929,762	300,426	42.5	731	12.7	104,451,750	142,889	27.6	915	15.8	65,689,994	71,792	17.3
Pennsylvania anthracite	170	55.9	65,736,966	386,688	85.6	50	16.4	8,226,848	164,537	10.7	25	8.2	1,955,821	78,233	2.5
Total	709	11.7	226,666,728	319,699	49.8	781	12.8	112,678,598	144,275	24.7	940	15.5	67,645,815	71,963	14.8
1910.															
Bituminous	618	10.6	191,518,675	309,901	46.0	763	13.1	107,052,053	140,304	25.7	960	16.5	68,858,273	71,727	16.5
Pennsylvania anthracite	157	51.0	65,788,484	419,035	82.5	64	20.8	10,664,819	166,638	13.4	26	8.4	2,281,971	87,768	2.9
Total	775	12.7	257,307,159	332,009	51.9	827	13.5	117,716,872	142,342	23.7	986	16.1	71,140,244	72,150	14.3
1911.															
Bituminous	568	9.6	178,956,538	315,064	44.2	797	13.5	115,072,711	144,382	28.4	853	14.5	60,747,508	71,216	15.0
Pennsylvania anthracite	168	57.5	74,709,145	444,697	87.2	50	17.1	8,514,667	170,293	9.9	21	7.2	1,607,527	76,549	1.9
Total	736	11.9	253,665,683	344,654	51.7	847	13.7	123,587,378	145,912	25.2	874	14.2	62,355,035	71,344	12.8
1912.															
Bituminous	677	11.8	221,017,125	326,465	49.2	790	13.7	112,471,613	142,369	25.0	921	16.0	66,672,953	72,392	14.8
Pennsylvania anthracite	170	61.8	70,000,585	411,768	87.9	46	16.7	7,556,053	164,262	9.4	15	5.6	1,284,301	85,620	1.6
Total	847	14.0	291,017,710	343,586	55.0	836	13.9	120,027,666	143,574	22.6	936	15.5	67,957,254	72,604	12.9
1913.															
Bituminous	694	12.0	241,463,241	347,930	50.5	837	14.5	118,475,544	141,548	24.8	960	16.6	69,073,329	71,951	14.5
Pennsylvania anthracite	174	62.6	78,949,046	453,730	89.5	39	14.0	6,611,711	169,531	7.5	21	7.6	1,832,621	87,268	2.1
Total	868	14.3	320,412,287	369,139	56.6	876	14.5	125,087,255	142,794	22.1	981	16.2	70,905,950	72,279	12.6

	Fourth class. (Mines producing 10,000 to 50,000 tons.)					Fifth class. (Mines producing less than 10,000 tons.)					Total.		
	Mines.		Production.			Mines.		Production.					
	Number.	Percentage.	Total.	Average per mine.	Percentage.	Number.	Percentage.	Total.	Average per mine.	Percentage.	Mines.	Quantity.	Average per mine.
1909.													
Bituminous	1,536	26.6	40,529,922	26,387	10.7	2,054	35.6	7,113,649	3,463	1.9	5,775	378,715,077	65.578
Pennsylvania anthracite	29	9.5	774,172	26,695	1.0	30	10.0	119,755	3,992	.2	304	76,813,562	252,676
Total	1,565	25.7	41,304,094	26,392	9.1	2,084	34.3	7,233,404	3,471	1.6	6,079	455,528,639	74,918
1910.													
Bituminous	1,568	27.0	42,282,021	26,966	10.2	1,909	32.8	6,561,235	3,437	1.6	5,818	416,272,257	71,549
Pennsylvania anthracite	28	9.1	812,517	29,018	1.0	33	10.7	147,808	4,479	.2	308	79,695,599	258,752
Total	1,596	26.0	43,094,538	27,002	8.7	1,942	21.7	6,709,043	3,458	1.4	6,126	495,967,856	80,961
1911.													
Bituminous	1,592	27.1	43,128,432	27,091	10.7	2,077	35.3	6,970,435	3,356	1.7	5,887	404,875,624	68,775
Pennsylvania anthracite	27	9.3	782,856	28,995	.9	26	8.9	111,498	4,288	.1	292	85,725,693	293,581
Total	1,619	26.2	43,911,288	27,122	9.0	2,103	34.0	7,081,933	3,368	1.4	6,179	490,601,317	79,398
1912.													
Bituminous	1,589	27.7	42,839,782	26,960	9.5	1,770	30.8	6,323,650	3,573	1.5	5,747	449,325,123	78,184
Pennsylvania anthracite	24	8.7	668,853	27,869	1.0	20	7.2	90,674	4,534	.1	275	79,600,466	289,456
Total	1,613	26.8	43,508,635	26,974	8.2	1,790	29.8	6,414,324	3,583	1.2	6.022	528.925.589	87,832
1913.													
Bituminous	1,559	27.0	42,335,652	27,156	8.9	1,726	29.9	6,275,111	3,636	1.3	5,776	477,622,877	82.691
Pennsylvania anthracite	21	7.6	683,956	32,569	.8	23	8.2	94,300	4,100	.1	278	88,171,634	317,164
Total	1,580	26.1	43,019,608	27,228	7.6	1,749	28.9	6,369,411	3,642	1.1	6,054	565,794,511	93,458

In the following tables the statistics of production by classes of mines are given for 1912 and 1913, by States. It will be observed that 84.2 per cent of the anthracite mines are included in the first three classes, that is, those producing 50,000 tons or over, and that less than 1 per cent of the total anthracite product is from mines of the other two classes. Of the bituminous mines, 43 per cent in 1913 were included in the first three classes and they produced 90 per cent of the total output, whereas 57 per cent of the total number was mines of the third and fourth classes, which produced only 10 per cent of the total output.

There were seven States in 1913 in which more than 50 per cent of the total production of bituminous coal was from mines of the first class, but in one of these, Georgia, only two mines were in operation, one of which produced 235,892 tons, or more than 92 per cent of the total for the State. Of the States whose total production exceeded 3,000,000 tons, Utah, a Rocky Mountain State, led with 82 per cent of its total production from mines of the first class, and Montana, another Rocky Mountain State, held the record in both 1912 and 1913 for high average production per mine, three mines in that State having an average output of 555,720 tons in 1912 and 581,597 tons in 1913. Virginia came next to Utah in its percentage of output (71.8) from mines of the first class in 1913 and next to Montana in its high average per mine—453,004 tons. Pennsylvania had 66.7 per cent of its bituminous production in 1913 from mines of the first class, Illinois had 66 per cent, New Mexico 62.6 per cent, and Montana 54 per cent. Three of these States, it will be noted, are in the Rocky Mountain region—public-land States; two are in the Appalachian region, and one in the Central. West Virginia, the second State in the Union in the production of coal, had only 37.6 per cent of its total output from mines of the first class, with 28.9 per cent from those of the second class, and 21.8 per cent from mines of the third class. The tendency toward operation in larger units is exemplified in West Virginia, however, by the increase in the percentage of output from mines of the first class from 23.5 in 1909 to 37.6 in 1913. In 1909 there were 48 first-class mines in West Virginia, and in 1913 there were 89. The total percentage of production of bituminous coal from first-class mines increased from 49.2 in 1912 to 50.5 in 1913. The differences in the percentages from the second-class and third-class mines in the two years were less than one-half of 1 per cent, and the actual total production from each of the fourth-class and fifth-class mines in 1913 was less than in 1912.

Production of coal in the United States in 1912 and 1913 according to classes of mines, in short tons.

1912.

State.	First class. (Mines producing over 200,000 tons.)					Second class. (Mines producing from 100,000 to 200,000 tons.)					Third class. (Mines producing from 50,000 to 100,000 tons.)				
	Mines.		Production.			Mines.		Production.			Mines.		Production.		
	Number.	Percentage.	Total.	Average per mine.	Percentage.	Number.	Percentage.	Total.	Average per mine.	Percentage.	Number.	Percentage.	Total.	Average per mine.	Percentage.
Alabama	13	6.0	3,734,754	287,289	23.2	50	23.0	7,364,764	147,295	45.7	41	18.9	2,967,102	72,368	18.4
Alaska															
Arkansas	1	1.8	279,707	279,707	13.3	6	10.9	784,865	130,811	37.4	7	12.7	506,977	72,425	24.1
California															
Colorado	13	8.2	3,847,332	295,949	35.0	19	12.0	2,610,818	137,411	23.8	39	24.5	2,817,912	72,254	25.7
Georgia						1	50.0	199,219	199,219	87.6					
Idaho															
Illinois	115	20.8	39,027,660	339,371	65.2	88	15.9	12,675,772	144,043	21.2	66	12.0	4,757,036	72,076	7.9
Indiana	18	7.6	4,687,606	260,423	30.6	42	17.6	6,072,590	144,585	39.7	37	15.5	2,839,683	76,748	18.6
Iowa	2	1.0	409,297	204,649	5.6	20	9.1	2,979,099	148,955	40.9	25	11.4	1,823,970	72,959	25.0
Kansas						27	17.6	3,509,287	129,974	50.2	29	19.0	2,168,807	74,786	31.0
Kentucky	8	2.3	2,088,287	261,036	12.8	45	12.8	6,356,977	141,288	38.8	63	17.9	4,207,400	66,784	25.7
Maryland	3	4.0	1,797,599	599,200	36.3	10	13.5	1,393,874	139,387	28.2	10	13.5	810,817	81,082	16.4
Michigan						1	4.5	106,631	106,631	8.8	13	59.1	919,364	70,720	76.2
Missouri	1	.5	228,097	228,097	5.4	11	5.0	1,405,683	127,789	33.1	14	6.5	1,041,607	74,401	24.6
Montana	3	6.1	1,667,159	555,720	54.7	5	10.2	693,870	138,774	22.8	3	6.1	245,918	81,973	8.1
New Mexico	7	20.0	2,546,861	363,837	72.0	4	11.4	631,250	157,813	17.9	2	5.7	149,750	74,875	4.2
North Dakota						1	2.0	181,918	181,918	38.8					
Ohio	58	9.0	16,357,508	282,026	47.8	56	8.7	8,197,305	146,389	23.9	61	9.4	4,584,730	75,160	13.4
Oklahoma						9	8.9	1,130,545	125,616	30.8	17	16.8	1,151,824	67,754	31.4
Oregon															
Pennsylvania bituminous	309	20.9	105,837,953	342,518	65.5	194	13.1	27,871,850	143,669	17.3	221	15.0	16,243,055	73,498	10.0
Tennessee	4	3.4	1,407,606	351,902	21.8	16	13.4	2,159,948	134,997	33.4	21	17.7	1,385,498	65,976	21.4
Texas	1	2.2	230,578	230,578	10.5	7	15.6	737,988	105,427	33.7	10	22.2	664,225	66,423	30.4
Utah	6	26.0	2,385,187	397,531	79.2	3	13.0	420,243	140,081	14.0	2	8.8	133,603	66,802	4.4
Virginia	13	21.3	5,507,875	423,683	70.2	4	6.6	619,211	154,803	7.9	15	24.6	1,103,248	73,950	14.0
Washington	4	8.3	961,210	240,303	28.6	11	22.9	1.516,430	137,857	45.1	6	12.5	417,288	69,548	12.4
West Virginia	84	11.3	24,540,193	292,145	36.8	143	19.3	20,226,111	141,441	30.3	205	27.6	14,603,428	71,236	21.9
Wyoming	14	19.5	3,474,656	248,190	47.2	17	23.6	2,625,365	154,433	35.7	14	19.5	1,129,711	80,694	15.3
Total bituminous	677	11.8	221,017,125	326,465	49.2	790	13.7	112,471,613	142,369	25.0	921	16.0	66,672,953	72,392	14.8
Pennsylvania anthracite	170	61.8	70,000,585	411,768	87.9	46	16.7	7,556,053	164,262	9.4	15	5.6	1,284,301	85,620	1.6
Grand total	847	14.0	291,017,710	343,586	55.0	836	13.9	120,027,666	143,574	22.6	936	15.5	67,957,254	72,604	12.9

Production of coal in the United States in 1912 and 1913 according to classes of mines, in short tons—Continued.

1912—Continued.

State.	Fourth class. (Mines producing from 10,000 to 50,000 tons.)					Fifth class. (Mines producing less than 10,000 tons.)					Total.		
	Mines.		Production.			Mines.		Production.					
	Number.	Percentage.	Total.	Average per mine.	Percentage.	Number.	Percentage.	Total.	Average per mine.	Percentage.	Mines.	Quantity.	Average per mine.
Alabama	75	34.6	1,843,623	24,582	11.5	38	17.5	190,357	5,009	1.2	217	16,100,600	74,196
Alaska						1	100.0	355	355	100.0	1	355	355
Arkansas	20	36.4	453,242	22,662	21.6	21	38.2	76,028	3,620	3.6	55	2,100,819	38,197
California						4	100.0	10,978	2,744	100.0	4	10,978	2,744
Colorado	53	33.3	1,562,581	29,483	14.2	35	22.0	139,181	3,977	1.3	159	10,977,824	69,043
Georgia	1	50.0	28,284	28,284	12.4						2	227,503	113,752
Idaho						3	100.0	2,319	773	100.0	3	2,319	773
Illinois	112	20.3	2,755,551	24,603	4.6	171	31.0	669,207	3,913	1.1	552	59,885,226	108,488
Indiana	48	20.2	1,311,307	27,319	8.6	93	39.1	374,532	4,027	2.5	238	15,285,718	64,226
Iowa	62	28.3	1,641,956	26,483	22.5	110	50.2	435,207	3,956	6.0	219	7,289,529	33,286
Kansas	42	27.5	1,049,202	24,981	15.0	55	35.9	258,886	4,707	3.8	153	6,986,182	45,661
Kentucky	124	35.2	3,341,547	26,948	20.4	112	31.8	377,444	3,370	2.3	352	16,371,655	46,510
Maryland	26	35.2	858,433	23,017	17.4	25	33.8	86,406	3,456	1.7	74	4,947,129	66,853
Michigan	4	18.2	167,169	41,792	13.9	4	18.2	12,855	3,214	1.1	22	1,206,019	54,819
Missouri	46	21.1	1,115,883	24,258	26.3	145	66.9	449,771	3,102	10.6	217	4,241,041	19,544
Montana	11	22.5	361,966	32,906	11.9	27	55.1	76,775	2,844	2.5	49	3,045,688	62,157
New Mexico	7	20.0	169,994	24,285	4.8	15	42.9	38,032	2,535	1.1	35	3,535,887	101,025
North Dakota	10	19.6	176,526	17,653	37.6	40	78.4	110,610	2,765	23.6	51	469,054	9,197
Ohio	160	24.7	4,108,676	25,679	12.0	312	48.2	1,003,909	3,218	2.9	647	34,252,128	52,940
Oklahoma	50	49.5	1,293,069	25,861	35.3	25	24.8	93,069	3,723	2.5	101	3,668,507	36,322
Oregon	2	22.2	25,554	12,777	61.5	7	77.8	16,001	2,286	38.5	9	41,555	4,617
Pennsylvania, bituminous	380	25.7	10,415,567	27,409	6.4	373	25.3	1,347,979	3,614	.8	1,477	161,716,404	109,490
Tennessee	55	46.2	1,422,580	25,865	21.9	23	19.3	95,893	4,169	1.5	119	6,471,525	54,383
Texas	25	55.6	550,661	22,026	25.2	2	4.4	5,160	2,580	2.3	45	2,138,612	48,636
Utah	2	8.8	48,387	24,194	1.6	10	43.4	24,786	2,479	.8	23	3,012,206	130,965
Virginia	23	37.7	603,616	26,244	7.7	6	9.8	11,908	1,984	.2	61	7,845,858	128,621
Washington	12	25.0	389,947	32,496	11.6	15	31.3	76,057	5,070	2.3	48	3,360,932	70,019
West Virginia	235	31.7	7,077,673	30,118	10.6	75	10.1	274,654	3,662	.4	742	66,722,059	89,922
Wyoming	4	5.5	66,788	16,697	.9	23	31.9	65,291	2,839	.9	72	7,361,811	102,247
Total bituminous	1,589	27.7	42,839,782	26,960	9.5	1,770	30.8	6,323,650	3,573	1.5	5,747	449,325,123	78,184
Pennsylvania, anthracite	24	8.7	668,853	27,869	1.0	20	7.2	90,674	4,534	.1	275	79,600,466	289,456
Grand total	1,613	26.8	43,508,635	26,974	8.2	1,790	29.8	6,414,324	3,583	1.2	6,022	528,925,589	87,832

1913.

State	First class. (Mines producing over 200,000 tons.)					Second class. (Mines producing from 100,000 to 200,000 tons.)					Third class. (Mines producing from 50,000 to 100,000 tons.)				
	Mines.		Production.			Mines.		Production.			Mines.		Production.		
	Number.	Percentage.	Total.	Average per mine.	Percentage.	Number.	Percentage.	Total.	Average per mine.	Percentage.	Number.	Percentage.	Total.	Average per mine.	Percentage.
Alabama	19	8.5	6,112,051	321,687	34.6	42	18.7	5,862,478	139,583	33.2	44	19.6	3,121,545	70,944	17.6
Alaska															
Arkansas	1	1.9	242,134	242,134	10.8	3	5.7	392,314	130,771	17.6	15	28.3	1,073,798	71,587	48.1
California															
Colorado	7	4.1	2,097,317	299,617	22.7	21	12.3	2,941,436	140,068	31.9	33	19.3	2,422,162	73,399	26.3
Georgia	1	50.0	235,892	235,892	92.3										
Idaho and Nevada															
Illinois	107	20.3	40,655,172	379,955	66.0	93	17.7	13,411,198	144,206	21.8	62	11.8	4,462,182	71,971	7.3
Indiana	28	12.1	8,078,659	288,524	47.2	38	16.5	5,445,416	143,300	31.9	28	12.1	1,902,734	67,955	11.1
Iowa	6	3.0	1,498,626	249,771	20.0	18	8.9	2,556,474	142,026	34.1	23	11.3	1,614,686	70,203	21.5
Kansas						29	19.1	3,693,794	127,372	51.4	42	27.6	2,439,049	58,073	34.0
Kentucky	10	3.0	3,488,229	348,823	17.9	51	15.4	7,244,988	142,059	37.2	80	24.2	5,596,564	69,957	28.7
Maryland	5	7.5	2,165,695	433,139	45.4	5	7.5	752,000	150,400	15.8	14	20.9	1,130,068	80,719	23.7
Michigan						2	7.7	213,625	106,813	17.3	12	46.1	807,028	67,252	65.6
Missouri						12	5.8	1,531,063	127,588	36.2	15	7.2	1,132,721	75,515	26.8
Montana	3	7.0	1,744,790	581,597	54.0	7	16.3	983,401	140,486	30.4	3	7.0	187,580	62,527	5.8
New Mexico	6	16.7	2,322,024	387,004	62.6	6	16.7	1,044,073	174,012	28.2	1	2.7	96,392	96,392	2.6
North Dakota						1	1.8	188,691	188,691	39.5					
Ohio	56	8.4	16,294,149	290,967	45.3	70	10.5	10,523,196	150,331	29.3	63	9.4	4,727,287	75,036	13.1
Oklahoma	1	1.1	202,404	202,404	4.9	9	9.5	1,204,629	133,848	28.9	22	23.1	1,586,964	72,135	38.1
Oregon															
Pennsylvania, bituminous	316	21.0	115,861,271	366,650	66.7	209	13.9	29,297,912	140,181	16.9	225	15.0	16,809,008	74,707	9.7
Tennessee	5	3.7	1,305,260	261,052	18.9	14	10.5	1,911,575	136,541	27.7	29	21.6	1,824,108	62,900	26.5
Texas	1	2.1	222,430	222,430	9.2	9	19.2	950,675	105,631	39.1	8	17.0	541,021	67,628	22.3
Utah	7	25.9	2,667,421	381,060	82.0	2	7.4	317,823	158,912	9.8	3	11.1	207,831	69,277	6.4
Virginia	14	23.3	6,342,058	453,004	71.8	7	11.7	945,216	135,031	10.7	10	16.7	808,086	80,809	9.2
Washington	4	7.6	1,059,956	264,989	27.3	13	24.5	1,803,775	138,752	46.5	9	17.0	596,115	66,235	15.4
West Virginia	89	11.3	26,770,693	300,794	37.6	147	18.7	20,610,855	140,210	28.9	213	27.0	15,505,422	72,795	21.8
Wyoming	8	13.1	2,097,010	262,126	28.4	29	47.5	4,648,937	160,308	62.9	6	9.8	480,978	80,163	6.5
Total bituminous	694	12.0	241,463,241	347,930	50.5	837	14.5	118,475,544	141,548	24.8	960	16.6	69,073,329	71,951	14.5
Pennsylvania, anthracite	174	62.6	78,949,046	453,730	89.5	39	14.0	6,611,711	169,531	7.5	21	7.6	1,832,621	87,268	2.1
Grand total	868	14.3	320,412,287	369,139	56.6	876	14.5	125,087,255	142,794	22.1	981	16.2	70,905,950	72,279	12.6

Production of coal in the United States in 1912 and 1913 according to classes of mines, in short tons—Continued.

1913—Continued.

State.	Fourth class. (Mines producing from 10,000 to 50,000 tons.)					Fifth class. (Mines producing less than 10,000 tons.)					Total.		
	Mines.		Production.			Mines.		Production.					
	Number.	Percentage.	Total.	Average per mine.	Percentage.	Number.	Percentage.	Total.	Average per mine.	Percentage.	Mines.	Quantity.	Average per mine.
Alabama	94	42.0	2,448,122	26,044	13.8	25	11.2	133,496	5,340	0.8	224	17,677,692	78,918
Alaska						1	100.0	2,072	2,072	100.0	1	2,072	2,072
Arkansas	19	35.8	474,753	24,987	21.2	15	28.3	50,406	3,360	2.2	53	2,233,405	42,140
California	1	50.0	18,209	18,209	73.3	1	50.0	6,630	6,630	26.7	2	24,839	12,420
Colorado	54	31.6	1,559,566	28,881	16.9	56	32.7	203,680	3,637	2.2	171	9,224,161	53,942
Georgia	1	50.0	19,734	19,734	7.7						2	255,626	127,813
Idaho and Nevada						3	100.0	2,177	726	100.0	3	2,177	726
Illinois	99	18.8	2,467,368	24,923	4.0	165	31.4	551,727	3,344	.9	526	61,547,647	117,011
Indiana	51	22.1	1,390,194	27,259	8.1	86	37.2	287,753	3,346	1.7	231	17,104,756	74,047
Iowa	54	26.6	1,505,924	27,887	20.1	102	50.2	323,034	3,167	4.3	203	7,498,744	36,940
Kansas	29	19.1	800,754	27,612	11.2	52	34.2	243,626	4,685	3.4	152	7,177,223	47,219
Kentucky	103	31.1	2,827,836	27,455	14.5	87	26.3	338,757	3,894	1.7	331	19,496,374	58,901
Maryland	19	28.3	615,900	32,416	12.9	24	35.8	105,687	4,404	2.2	67	4,769,350	71,184
Michigan	6	23.1	191,541	31,924	15.6	6	23.1	18,432	3,072	1.5	26	1,230,626	47,332
Missouri	47	22.6	1,141,065	24,278	26.9	134	64.4	426,299	3,181	10.1	208	4,231,148	20,342
Montana	11	25.5	259,278	23,571	8.0	19	44.2	58,726	3,091	1.8	43	3,233,775	75,204
New Mexico	8	22.2	200,511	25,064	5.4	15	41.7	42,806	2,854	1.2	36	3,705,806	102,939
North Dakota	9	16.4	158,940	17,660	33.2	45	81.8	130,322	2,896	27.3	55	477,953	8,690
Ohio	142	21.3	3,309,223	23,304	9.2	336	50.4	1,108,970	3,300	3.1	667	35,962,825	53,917
Oklahoma	42	44.2	1,104,914	26,307	26.5	21	22.1	64,296	3,061	1.6	95	4,163,207	43,823
Oregon	1	14.3	16,462	16,462	36.2	6	85.7	29,026	4,838	63.8	7	45,488	6,498
Pennsylvania, bituminous	377	25.1	10,126,045	26,860	5.8	376	25.0	1,540,295	4,096	.9	1,503	173,634,531	115,525
Tennessee	63	47.0	1,747,618	27,740	25.3	23	17.2	111,587	4,852	1.6	134	6,900,148	51,494
Texas	24	51.1	683,218	28,467	28.1	5	10.6	31,800	6,360	1.3	47	2,429,144	51,684
Utah	2	7.4	38,757	19,379	1.2	13	48.2	21,212	684	.6	27	3,253,044	120,483
Virginia	22	36.6	694,315	31,560	7.9	7	11.7	36,906	5,272	.4	60	8,826,581	147,110
Washington	13	24.5	364,747	28,057	9.4	14	26.4	53,298	3,807	1.4	53	3,877,891	73,168
West Virginia	264	33.5	8,041,456	30,460	11.3	75	9.5	317,904	4,239	.4	788	71,246,330	90,414
Wyoming	4	6.6	129,202	32,301	1.7	14	23.0	34,187	2,442	.5	61	7,390,314	121,153
Total bituminous	1,559	27.0	42,335,652	27,156	8.9	1,726	29.9	6,275,111	3,636	1.3	5,776	477,622,877	82,691
Pennsylvania, anthracite	21	7.6	683,956	32,569	0.8	23	8.2	94,300	4,100	.1	278	88,171,634	317,164
Grand total	1,580	26.1	43,019,608	27,228	7.6	1,749	28.9	6,369,411	3,642	1.1	6,054	565,794,511	93,458

KINDS OF COAL PRODUCED IN THE UNITED STATES.

Under the general head of bituminous coal in this series of reports all coal except the anthracite product of Pennsylvania is considered. Strictly speaking, the anthracite production should include small quantities of that grade mined in Colorado and New Mexico. This factor is so relatively insignificant, however, never having amounted to as much as 100,000 tons in one year, that it has seemed best and has been the invariable custom to give Pennsylvania anthracite separate treatment, and the small Rocky Mountain product has been included in the bituminous production. The latter includes also those grades of coal classed as semianthracite, semibituminous, cannel, block, splint, and lignite. In the following tables the production of these varieties of coal in 1912 and 1913 have been compiled according to the replies made by the operators to the inquiries as to the character of the coal produced. Technical exactness is, therefore, not claimed, but it is believed that the quantities stated approximate quite closely the actual production of each variety in each State, and that they are sufficiently correct for practical purposes.

The table for 1913 shows that in addition to the 81,718,680 long tons (91,524,922 short tons) of anthracite produced in Pennsylvania, 35,416 short tons of this grade of coal were mined in Colorado and 34,345 tons in New Mexico. The principal production of semianthracite is from Arkansas, with smaller quantities from Oklahoma, Colorado, and Virginia. The production of Sullivan County, Pa., is included with the anthracite production of that State, though its classification as anthracite is a matter of some contention. This item amounts to about 600,000 short tons annually. West Virginia leads in the production of semibituminous coal, with Pennsylvania second, Maryland third, and Colorado fourth. West Virginia also leads in the production of splint coal, and Kentucky is the only other State credited with any of this product in 1913. Cannel coal was reported from seven States in 1913, Kentucky contributing nearly two-thirds of the total. Kentucky also took first place in the production of block coal in 1913, displacing Indiana. These two States yielded over 90 per cent of the total production of block coal. Wyoming is the principal producer of subbituminous coal ("black lignite"), 60 per cent of the State's total being of that grade, and Colorado ranks second, with Montana third and New Mexico fourth. All of the output of North Dakota and nearly half of that for Texas is lignite or brown coal. Bituminous coal is produced in every State having a production of 100,000 tons or more, with the exception of North Dakota.

Classification of the coal product of the United States in 1912, by States, in short tons.

State.	Bituminous.	Anthracite.	Semibituminous.	Lignite and subbituminous.	Semianthracite.	Block.	Splint.	Cannel.	Total.
Pennsylvania	158,364,023	84,361,598	3,433,374					68,091	246,227,086
West Virginia	56,627,727		5,050,993			37,750	a 4,834,784	b 235,433	66,786,687
Illinois	59,861,735					23,491			59,885,226
Ohio	34,456,137		2,497			66,054		4,039	34,528,727
Kentucky	14,889,478		160,293		3,736	41,050	1,221,295	c 174,669	16,490,521
Alabama	16,100,600								16,100,600
Indiana	14,817,006					d 461,339		7,373	15,285,718
Colorado	6,601,744	52,165	2,128,847	2,195,068					10,977,824
Virginia	7,800,804				45,834				7,846,638
Wyoming	1,024,395		2,821,069	3,522,660					7,368,124
Iowa	7,220,235					60,950		8,344	7,289,529
Kansas	6,975,862				10,320				6,986,182
Tennessee	6,458,028						2,700	12,500	6,473,228
Maryland	1,363,216		3,600,822						4,964,038
Missouri	4,322,116					14,157		3,583	4,339,856
Oklahoma	3,327,632		73,564		274,222				3,675,418
New Mexico	2,768,869	32,411	100,673	634,871					3,536,824
Washington	2,538,694		215,411	606,827					3,360,932
Montana	656,565		1,405,735	986,195					3,048,495
Utah	2,967,762			48,387					3,016,149
Texas	1,141,667		56,240	990,705					2,188,612
Arkansas	1,049,898		8,319		1,042,602				2,100,819
Michigan	1,206,230								1,206,230
North Dakota				499,480					499,480
Georgia, Oregon, California, Idaho, Nevada, Alaska, North Carolina	240,577		15,153	27,907					283,637
Total	412,781,000	84,446,174	19,072,990	9,512,100	1,376,714	704,791	6,058,779	514,032	534,466,580

a Includes 157,537 tons of semisplint coal.
b Includes 206,585 tons of semicannel coal.
c Includes 86,377 tons of semicannel coal.
d Includes 32,842 tons of semiblock coal.

Classification of the coal product of the United States in 1913, by States, in short tons.

State.	Bituminous.	Anthracite.	Semibituminous.	Lignite and subbituminous.	Semianthracite.	Block.	Splint.	Cannel.	Total.
Pennsylvania	169,351,803	91,524,922	4,371,240					58,174	265,306,139
West Virginia	59,252,804		6,888,239				a 5,157,636	10,303	71,308,982
Illinois	61,618,744								61,618,744
Ohio	35,320,706		814,833			58,994		5,994	36,200,527
Kentucky	17,937,086		302,623			538,090	662,414	b 176,387	19,616,600
Alabama	17,678,522								17,678,522
Indiana	16,716,226					c 449,445			17,165,671
Colorado	5,560,571	35,416	1,546,758	1,995,222	94,543				9,232,510
Virginia	8,774,784				53,284				8,828,068
Iowa	7,506,608					13,700		5,628	7,525,936
Wyoming	1,820,556		894,592	4,677,918					7,393,066
Kansas	7,202,210								7,202,210
Tennessee	6,760,154		136,927					6,703	6,903,784
Maryland	1,230,100		3,549,739						4,779,839
Missouri	4,305,611					8,583		3,931	4,318,125
Oklahoma	3,994,881		25,000		145,889				4,165,770
Washington	2,884,408		236,872	756,611					3,877,891
New Mexico	2,849,499	34,345	23,750	801,212					3,708,806
Utah	3,157,011			97,817					3,254,828
Montana	852,635		1,408,094	980,244					3,240,973
Texas	1,247,988			1,181,156					2,429,144
Arkansas	839,547		23,039		1,371,521				2,234,107
Michigan	1,231,786								1,231,786
North Dakota				495,320					495,320
Georgia Oregon California Idaho Alaska Nevada	269,052		35,171	26,554					330,777
Total	438,363,292	91,594,683	20,256,877	11,012,054	1,665,237	1,068,812	5,820,050	267,120	570,048,125

a Includes 64,500 tons semisplint coal. b Includes 86,263 tons of semicannel coal. c Includes 63,329 tons of semiblock coal.

LABOR STATISTICS.

The coal mines of the United States gave employment in 1913 to nearly 750,000 men (747,644), of whom 571,899, or 76.5 per cent, were employed in the bituminous mines and 175,745, or 23.5 per cent, in the anthracite mines of Pennsylvania. The average working time (257 days) made by the anthracite workers and by the whole number of employees (238 days) in 1913 was the largest on record, and the average time made by the bituminous mine workers (232 days) was exceeded in three years only since 1890, namely, in 1899, 1900, and 1907. The bituminous mine workers also established a new record for the average production per man for one year, 837 tons, and the average tonnage per man in the anthracite region, 520 tons, in 1913 was larger than in any preceding year with the exception of 1911. The average tonnage per man per day in the anthracite mines has shown a declining tendency since 1899 and has decreased each year since 1908, this average in 1913 (2.02 tons) being the lowest made since 1892. The average production per man per day in the bituminous fields, on the other hand, has shown an increasing tendency during the 23 years that these statistics have been compiled, though in 1913 there was a slight change in the other direction from 3.68 tons per man in 1912 to 3.61 tons in 1913. The apparent increase in the efficiency of the employees in the bituminous mines has been due, as shown elsewhere in this report, to the steady increase in the use of mining machines and to the increased ratio that machine-mined coal bears to the total bituminous production.

The following table shows the number of men employed in the coal mines of the United States in 1908, 1910, 1911, 1912, and 1913, with the average number of days worked, by States. The statistics of labor in 1909 were collected by the Bureau of the Census, and the inquiries were in such form that the compilations did not give results comparable with the statistics presented in these reports:

Statistics of labor employed in coal mines of the United States, 1908–1913, by States.

State.	1908		1910		1911		1912		1913	
	Number of days active.	Average number employed.	Number of days active.	Average number employed.	Number of days active.	Average number employed.	Number of days active.	Average number employed.	Number of days active.	Average number employed.
Alabama	222	19,197	249	22,210	227	22,707	245	22,613	255	24,552
Arkansas	145	5,337	128	5,568	133	5,657	157	4,536	174	4,652
California	a 220	a 49	189	19	a 265	a 60	a 184	a 52	a 302	40
Colorado	212	14,523	236	15,864	207	14,316	227	13,000	229	11,990
Georgia	261	670	265	386	b 277	b 514	b 254	b 450	261	500
Idaho	160	24	200	14	c 228	c 13	c 253	c 20	c 183	12
Illinois	185	68,035	160	72,645	188	76,600	194	78,098	189	79,529
Indiana	174	18,380	229	21,878	182	21,182	182	21,651	190	22,235
Iowa	214	16,021	218	16,666	203	16,599	188	16,370	195	15,757
Kansas	181	13,916	148	12,870	190	11,357	202	11,646	197	12,479
Kentucky	186	16,996	221	20,316	201	21,921	201	24,304	212	26,332
Maryland	220	6,079	270	5,809	243	5,881	259	6,162	248	5,645
Michigan	207	4,247	211	3,575	218	3,323	183	3,113	188	3,305
Missouri	169	8,988	154	9,691	182	10,259	206	9,704	187	10,418
Montana	224	3,146	239	3,837	220	3,866	220	3,440	228	3,630
New Mexico	197	3,448	283	3,585	230	4,007	274	3,928	289	4,329
North Dakota	181	631	207	534	229	640	232	622	221	641
Ohio	161	47,407	203	46,641	179	46,035	201	45,527	206	45,815
Oklahoma	172	8,651	144	8,657	156	8,790	174	8,785	197	9,044
Oregon	249	214	257	153	179	189	239	222	283	203
Pennsylvania bituminous	201	165,961	238	175,403	233	168,199	252	165,144	267	172,196
Tennessee	209	11,812	225	11,930	232	10,703	234	10,309	241	11,263
Texas	254	4,400	234	4,197	226	5,353	230	5,127	253	5,101
Utah	227	2,664	260	3,053	236	3,060	285	3,328	273	4,158
Virginia	200	6,208	241	7,264	261	7,392	251	8,678	280	9,162
Washington	202	5,484	256	6,314	225	6,498	226	5,519	260	5,794
West Virginia	185	56,861	228	68,663	221	66,730	266	68,248	234	74,786
Wyoming	217	6,915	218	7,771	230	7,924	238	8,036	232	8,331
Total bituminous	193	516,264	217	555,533	211	549,775	223	548,632	232	571,899
Pennsylvania anthracite	200	174,174	229	169,497	246	172,585	231	174,030	257	175,745
Grand total	195	690,438	220	725,030	220	722,360	225	722,662	238	747,644

a Includes Alaska. b Includes North Carolina. c Includes Nevada.

An interesting comparison of the productive efficiency of the employees in the anthracite and bituminous mines during a period of 24 years is presented in the following table. It will be observed that in the anthracite mines during the last decade of the nineteenth century there was a notably decreasing tendency in the number of days the workers in the anthracite mines were able to work, until in 1897 and 1898 they barely averaged 50 per cent of the possible working days in the year, excluding Sundays and legal holidays. These figures substantiate the claim made about that time that the anthracite miners were unable to earn a total living wage. The consumption of the prepared sizes of anthracite being almost exclusively for domestic purposes, the production was at a "peak load" during the fall and winter months, with long periods of idleness during the summer. In order to meet the demands of the "peak loads" it was necessary to keep on the rolls a much larger number of men than if steady employment could be given the year round. In 1901 in order to remedy this unsatisfactory condition the operators adopted the plan of allowing discounts from the circular prices for coal bought during the spring and summer, the purpose being to induce consumers to purchase their supplies at that time and to make the cellars of housekeepers the storage places for the next winter's supply of fuel. No more beneficent action has ever had place in the anthracite region of Pennsylvania and its influence was almost immediately effective, though it did not prevent the great strike of the following year, 1902. Beginning with 1903, however, a marked improvement is shown in the working time made by the anthracite miners. From 1892 to 1902, inclusive, the anthracite mine workers did not average as much as 200 days in any one year and the general average for the period was 173 days. Since 1903, on the other hand, the anthracite miners have averaged less than 200 days in only one year, 1906, when there was an extended suspension pending a renewal of the anthracite strike commission's awards, and the general average for the period has been 220 days, 47 days, or 27 per cent, more than the general average for the earlier period. Coincidentally with this presentation should also be considered, however, the average tonnages made by the anthracite workers. It will be noted that as the working time decreased after 1892 the average production per man per day increased, showing a greater intensity of labor on the days the men were able to work, and that the average tonnage per man per year did not vary between wide extremes, 351 tons for a minimum and 433 tons for a maximum, with a general average of 390 tons. In 1901, the year the spring reductions went into effect, the average production per man rose to 464 tons and since 1903 the general average has been 489 tons with a minimum of 439 tons (49 tons more than the general average for the earlier period) and a maximum of 524 tons. Coincidentally again, it will be noted that with the opportunity for working more days in the year the average tonnage per day per man has shown a decided decrease, the low record of 2.02 tons in 1913 being the smallest in 20 years.

The average working time in the bituminous mines has not shown the same rate of increase in the yearly tonnage per employee, but there has been some improvement in the 13 years of the present century over the last decade of the preceding one. From 1891 to 1900 the workers in the bituminous mines averaged 208 days a year, and since 1901 they have averaged 218 days, a gain of 5 per cent. There has, however, been a marked increase in the average production per man both per year and per day. In the closing decade of the last century the average daily production for each employee ranged from 2.57 tons to 3.09 tons with a mean average of 2.89 tons, and the average per year ranged from 486 tons to 713 tons with a mean average of 600 tons. The first of the 13 years of the present century is the only one in which the average production per man per day has fallen below 3 tons. It has ranged from 2.94 tons in that year to 3.68 tons in 1912 and has had a mean average of 3.30 tons, and the average per year has ranged from 637 tons to 837 tons, with a mean average of 720 tons. In other words, since 1901 the average production per man has shown an increase of 0.37 ton per day and of 120 tons per year over the equivalent averages for the 10 years from 1891 to 1900. The highest average production per man per year in the history of bituminous mining and the lowest average per day in the anthracite mines in 20 years were made in 1913. The increased efficiency of the bituminous workers has not been due to any greater intensity of labor, but to the use of machines in undercutting and shearing the coal. In 1891 a little more than 5 per cent of the total bituminous product was machine mined, in 1901 more than 25 per cent, and in 1913 more than 50 per cent.

Production of coal according to number of persons employed, 1890–1913.

Year.	Anthracite.				Bituminous.			
	Men employed.	Days worked.	Average tonnage per man per day.	Average tonnage per man per year.	Men employed.	Days worked.	Average tonnage per man per day.	Average tonnage per man per year.
1890	126,000	200	1.85	369	192,204	226	2.56	579
1891	126,350	203	1.98	401	205,803	223	2.57	573
1892	129,050	198	2.06	407	212,893	219	2.72	596
1893	132,944	197	2.06	406	230,365	204	2.73	557
1894	131,603	190	2.08	395	244,603	171	2.84	486
1895	142,917	196	2.07	406	239,962	194	2.90	563
1896	148,991	174	2.10	365	244,171	192	2.94	564
1897	149,884	150	2.34	351	247,817	196	3.04	596
1898	145,504	152	2.41	367	255,717	211	3.09	651
1899	139,608	173	2.50	433	271,027	234	3.05	713
1900	144,206	166	2.40	398	304,375	234	2.98	697
1901	145,309	196	2.37	464	340,235	225	2.94	664
1902	148,141	116	2.40	279	370,056	230	3.06	703
1903	150,483	206	2.41	496	415,777	225	3.02	680
1904	155,861	200	2.35	469	437,832	202	3.15	637
1905	165,406	215	2.18	470	460,629	211	3.24	684
1906	162,355	195	2.25	439	478,425	213	3.36	717
1907	167,234	220	2.33	512	513,258	234	3.29	769
1908	174,174	200	2.39	478	516,264	193	3.34	644
1910	169,497	229	2.17	498	555,533	217	3.46	751
1911	172,585	246	2.13	524	549,775	211	3.50	738
1912	174,030	231	2.10	485	548,632	223	3.68	820
1913	175,745	257	2.02	520	571,899	232	3.61	837

In most of the bituminous coal mines of the United States the length of the working day is 8 hours. In 1913 out of a total of 5,324 mines for which the number of hours worked per day were reported, 3,292, or 62 per cent, worked 8 hours; 946, or 18 per cent of the total, worked 9 hours, and 1,086, or 20 per cent of the total, worked 10 hours. The 8-hour mines employed a total of 347,043 men, the 9-hour mines employed a total of 85,267 men, and the 10-hour mines employed 127,887 men. When these figures are compared with those for 1912 it will be observed that there was a decided decrease in the number of mines that worked 10 hours and in the number of men employed therein, whereas there was a decided increase in the number of mines and in the number of men that worked 8 and 9 hours. The decrease in the 10-hour days and the increase in the 9-hour days were due chiefly to changes in West Virginia in which State in 1912 there were 119 mines employing 10,815 men that worked 9 hours and 535 mines employing 50,944 men that worked 10 hours. In 1913 the number of 9-hour mines was increased to 369 with an aggregate of 35,123 men, while the 10-hour mines were reduced to 365 and the number of 10-hour men to 37,094. In Alabama there was a decrease in 9-hour mines and men and an increase in those working 10-hours, and in Kentucky there was a decrease in the 8-hour mines and men and increases in those working 9 and 10 hours. The States in which the 9-hour and 10-hour days prevail are the States of the southern Appalachian region, Maryland, Virginia, West Virginia, Alabama, Kentucky and Tennessee, which are for the most part "open shop" or nonunion, and the 8-hour day prevails in the States where the men are well organized.

It should be remembered, however, that when the length of the working day is stated, reference is made to the number of hours the mines are supposed to have been in operation, and not to the number of hours worked by the miners. In both the anthracite and bituminous fields practically all the coal is mined by contract at an agreed rate per ton or other basis of payment. The miner is an independent contractor and is not obliged to put in a certain number of hours at his working place. The figures in the following table really indicate the number of hours the men were given opportunity to work, and do not mean that all the employees worked 8, 9, or 10 hours, as the case might be.

Since the settlement of the anthracite strike of 1902 the mines in that region have been operated on a 9-hour basis, with the exception of engineers and pumpmen, who work 8 hours, and of the miners, who work by contract.

In the following table is presented a statement of the number of mines and men working 8, 9, and 10 hours in the important bituminous coal-producing States in 1912 and 1913:

Number of hours to the working day in 1912 and 1913, by States.

1912.

State.	8 hours.		9 hours.		10 hours.		All others.
	Mines.	Men.	Mines.	Men.	Mines.	Men.	Men.
Alabama	11	338	46	4,145	107	13,938	4,192
Arkansas	46	4,196					340
Colorado	61	2,923	5	173	50	4,631	5,273
Illinois	480	75,411	10	67			2,620
Indiana	211	21,220	1	6	5	109	316
Iowa	194	15,806	1	9	1	4	551
Kansas	132	11,186	7	380			80
Kentucky	69	6,037	58	4,901	149	11,815	1,551
Maryland	2	53	4	41	57	6,000	68
Michigan	20	3,107					6
Missouri	172	9,139	5	72	3	17	476
Montana	39	3,435			1	5	
New Mexico	2	4	6	140	23	3,777	7
North Dakota	12	59	4	51	23	415	97
Ohio	581	44,180	11	474	1	10	863
Oklahoma	82	8,105			3	120	560
Oregon	5	170					52
Pennsylvania	774	91,928	316	32,935	214	35,322	4,959
Tennessee	5	317	77	5,720	29	3,980	292
Texas	20	2,908	1	40	19	1,789	390
Utah	22	3,326	1	2			
Virginia	2	24	3	41	49	8,181	432
Washington	42	5,344			2	50	125
West Virginia	47	4,959	119	10,815	535	50,944	1,530
Wyoming	60	7,807	1	3			226
Total	3,091	321,982	676	60,015	1,271	141,107	25,006

1913.

State.	8 hours.		9 hours.		10 hours.		All others.
	Mines.	Men.	Mines.	Men.	Mines.	Men.	Men.
Alabama	13	420	36	2,496	135	18,185	3,451
Arkansas	53	4,652					
Colorado	146	11,175	3	75	5	128	612
Illinois	482	78,137	7	41	1	5	1,346
Indiana	199	21,637	3	42	6	121	435
Iowa	185	15,248	2	16	1	12	481
Kansas	138	12,240	1	5			234
Kentucky	68	5,754	84	7,389	147	12,390	799
Maryland	3	15	5	203	49	5,105	322
Michigan	24	3,305					
Missouri	179	10,200	4	79			139
Montana	40	3,416	1	4			210
New Mexico	16	2,335	8	401	10	1,590	3
North Dakota	13	61	5	51	24	472	57
Ohio	604	45,487	8	187	3	32	109
Oklahoma	87	8,725			2	109	210
Oregon	4	157					46
Pennsylvania	849	100,568	312	32,064	242	38,671	893
Tennessee	9	710	78	6,163	35	3,927	463
Texas	19	2,727	8	525	11	1,299	550
Utah	23	4,063	2	95			
Virginia	1	32	8	302	49	8,743	85
Washington	52	5,794					
West Virginia	29	1,864	369	35,123	365	37,094	705
Wyoming	56	8,321	2	6	1	4	
Total	3,2[illegible]2	347,013	[illegible]6	85,267	1,086	127,887	11,150

There are so many influences affecting the mining of bituminous coal that it is difficult, if not impossible, to draw any reliable conclusions in regard to the effect which the length of the working day has upon the productive efficiency of the labor employed. Chief among these influences is the independent character of the miner himself, who being a contractor working "by the job" rarely works the number of hours the mine itself is in operation. The thickness of the bed and the physical character of the coal itself are potential influences upon the capacity of the miner and these vary over such wide ranges, even in one State, that any deductions drawn from the statistics presented herewith may be misleading. The following table shows the prevailing number of hours to the working day in the more important coal-producing States, the number of days worked in each, and the average tonnage made by each employee per day for the years 1912 and 1913. The largest average yearly tonnage per man during 1913 was made in the bituminous mines of Pennsylvania, most of which were operated 8 hours a day. The bituminous mines of Pennsylvania in 1913 established a new record for the average quantity of coal produced per employee which exceeded for the first time in history 1,000 tons per man. The next largest average made in 1913 was in Virginia where the average number of tons per man for the year was 964, followed closely by West Virginia with an average of 954 tons per man. Most of the mines of importance in Virginia are operated 10 hours a day and in West Virginia they are about equally divided between 9 and 10 hours. From the States of the Appalachian region in which were located the three leading States in average tonnage per man per year, the record for the next three States shifts to the Rocky Mountain region where Montana, at 8 hours a day, shows an average tonnage per man of 893 tons; Wyoming, at 8 hours a day, has an average tonnage of 887; and New Mexico, in which the number of men working 8 hours exceeded the number working 10 hours by about 50 per cent, has an average output per man for the year of 857 tons. The smallest average production per man, 373 tons, in 1913, as in 1912, was made in Michigan, an 8-hour State, and in Missouri, also an 8-hour State, the second smallest production per man, 414 tons, was made. The best average daily production per man, 4.1 tons, in 1913 was in Illinois, and 8-hour State; West Virginia came second, with an average of 4.08 tons; Indiana third, with 4.06 tons; and the smallest average daily production per man, 1.88 tons, was made in Texas, Michigan being next to foot with an average of 1.98 tons per man per day.

In 1913 the mean average number of days worked in the mines operating 8 hours a day was 214, and in the States where the 9 and 10 hour day prevailed the average number of days worked was 245, indicating that in the States where the longer days prevailed the men also worked more days in the year. In 1912, when operations in the organized States wese interrupted by suspensions pending the renewal of the wage contracts, mine workers in the 8-hour States averaged 208 working days and in the other States 245 days.

Average production per man compared with hours worked per day, and average number of days per year in 1912 and 1913.

State.	1912				1913			
	Number of hours per day.	Days worked.	Average tonnage.		Number of hours per day.	Days worked.	Average tonnage.	
			Per year.	Per day.			Per year.	Per day.
Alabama	9 and 10	245	712	2.91	9 and 10	255	720	2.82
Arkansas	8	157	463	2.95	8	174	480	2.76
Colorado	8 and 10	227	844	3.72	8	229	770	3.36
Illinois	8	194	767	3.95	8	189	775	4.10
Indiana	8	182	706	3.88	8	190	772	4.06
Iowa	8	188	445	2.37	8	195	478	2.45
Kansas	8	202	600	2.97	8	197	577	2.93
Kentucky	8, 9, and 10	201	679	3.38	8, 9, and 10	212	745	3.51
Maryland	10	259	806	3.11	10	248	847	3.42
Michigan	8	183	387	2.11	8	188	373	1.98
Missouri	8	206	447	2.17	8	187	414	2.21
Montana	8	220	886	4.03	8	228	893	3.92
New Mexico	10	274	900	3.28	8 and 10	289	857	2.97
North Dakota	10	232	803	3.46	10	221	773	2.90
Ohio	8	201	758	3.77	8	206	790	3.83
Oklahoma	8	174	418	2.4	8	197	461	2.34
Pennsylvania:								
Anthracite	9	231	485	2.1	9	257	520	2.02
Bituminous	a 8	252	980	3.89	a 8	267	1,009	3.78
Tennessee	9 and 10	234	628	2.68	9 and 10	241	613	2.54
Texas	8 and 10	230	424	1.84	8 and 10	253	476	1.88
Utah	8	285	906	3.18	8	273	783	2.87
Virginia	10	251	904	3.6	10	280	964	3.44
Washington	8	226	609	2.69	8	260	669	2.57
West Virginia	8, 9, and 10	266	979	3.68	9 and 10	234	954	4.08
Wyoming	8	238	917	3.85	8	232	887	3.82

a Represents 60 per cent of employees; the other 40 per cent about evenly divided between 9 and 10 hours.

STRIKES AND SUSPENSIONS.

On account of the fact that the wage agreements in the organized bituminous coal-producing regions were signed in 1912 for a period of two years and in the anthracite region for four years, from April 1 of that year, there was no general shutdown or suspension in 1913, but there were the usual number of local disturbances, most of which were settled without much loss of time. In two States, however, West Virginia and Colorado, there were bitterly contested struggles for the recognition of the union, both of them accompanied by bloodshed and both resulting in the declaration of martial law. In Colorado the warfare got beyond the control of the State, and upon the request of the governor, Federal troops were sent to the scene to restore law and order. The trouble in West Virginia began in August, 1912, in the Paint and Cabin Creek districts of Kanawha County, and was carried well forward into the summer of 1913. The trouble in Colorado began in the latter part of September, 1913, and was carried as far into the current year as the struggle in West Virginia was into 1913. The difficulty in West Virginia was confined to a relatively small area in the State, and although the production of Kanawha County was reduced the deficiency was made up by increased production in other parts of the State. In Colorado the most important producing districts of the State were affected and a decided decrease in the total production resulted. The number of men affected by the strike in Colorado was 7,324 (61 per cent of the total number employed) and they were idle for an average of 75 days, or for the entire remainder of the year. In West Virginia 8,800 men (12 per cent of the total number of coal miners in the State) were idle for an average of 43 days. In neither West Virginia nor Colorado, however, were as many men on strike in 1913 as there were from local disturbances in Pennsylvania, Ohio, and Illinois. In the anthracite mines of Pennsylvania petty strikes affected a total of 64,086 (within 10 per cent of all the men on strike in all the bituminous mines of the country), but the average time lost by each man was only 8 days. In the bituminous mines of Pennsylvania 17,244 men were on strike for an average of 16 days; in Illinois 11,861 men were idle for an average of 55 days, the total time lost being over 100,000 working days more than the time lost in Colorado; and in Ohio 10,029 men were idle for an average of 26 days. The total number of men idle in the bituminous mines in 1913 was 71,309 for an average of 36 days, compared with 159,098 men for an average of 35 days in 1912. In the anthracite mines, 151,958 men were idle in 1912 for an average of 45 days. Ten States in 1913 reported no strikes, lockouts, or suspensions. These were Alaska, California, Georgia, Idaho, Nevada, North Dakota, Oregon, Texas, Virginia, and Wyoming.

The statistics of labor troubles in the coal fields of the United States in 1912 and 1913 are presented in the following table. In computing the number of days lost, Sundays have not been included, possible working days only having been considered.

Statistics of labor strikes in the coal mines of the United States in 1912 and 1913.

State.	1912			1913		
	Number of men on strike.	Total days lost.	Average number of days lost per man.	Number of men on strike.	Total days lost.	Average number of days lost per man.
Alabama	384	12,323	32	1,048	27,041	26
Arkansas	403	37,685	94	1,221	32,481	27
Colorado				7,324	552,082	75
Illinois	60,505	2,026,526	33	11,861	655,622	55
Indiana	15,400	795,887	52	2,657	44,143	17
Iowa	8,455	370,449	44	721	13,538	19
Kansas	2,088	13,487	65	3,178	28,936	9
Kentucky	2,759	79,685	29	1,029	18,638	18
Maryland	347	3,228	9	200	400	2
Michigan	2,028	101,424	50	180	1,260	7
Missouri	952	55,022	58	918	31,251	34
Montana	869	8,445	10	1,094	6,682	6
New Mexico				8	1,040	130
North Dakota	10	20	2			
Ohio	27,200	895,777	32	10,029	263,234	26
Oklahoma	860	12,109	14	1,696	135,274	80
Oregon	60	420	7			
Pennsylvania	22,538	538,248	24	17,244	274,296	16
Tennessee	670	20,011	30	857	42,966	50
Texas	238	1,724	7			
Utah				5	1,300	260
Washington	807	31,347	39	1,239	60,145	49
West Virginia	12,165	606,588	50	8,800	377,405	43
Wyoming	360	3,425	10			
Total bituminous	159,098	5,613,830	35	71,309	2,567,734	36
Pennsylvania anthracite	151,958	6,913,475	45	64,086	481,678	8

A summary of the statistics of strikes in the coal mines of the United States since 1899 is given in the following table:

Summary of labor strikes in the coal mines of the United States, 1899–1913.

Years.	Number of men on strike.	Total working days lost.	Average number of days lost per man.
1899	45,981	2,124,154	46
1900	131,973	4,878,102	37
1901 [a]	20,593	733,802	35
1902	200,452	16,672,217	83
1903 [a]	47,481	1,341,031	28
1904	77,661	3,382,830	44
1905	37,542	796,735	21
1906	372,343	19,201,348	51.5
1907 [a]	32,540	462,392	14
1908 [a]	145,145	5,449,938	38
1909 [a]	24,763	723,634	29
1910	218,493	19,250,524	88
1911	41,413	983,737	24
1912	311,056	12,527,305	40
1913	135,395	3,049,412	22.5

[a] Bituminous mines only.

COAL MINED BY MACHINES.

The substitution of mechanical methods for hand labor in the bituminous coal mines of the United States during the last quarter of a century has been one of the most interesting features connected with that branch of the coal-mining industry. It would have been a physical impossibility to have attained the present enormous production of bituminous coal (nearly half a billion tons in 1913) if it had been necessary to depend upon hand labor alone. The results accomplished by the use of mining machines are threefold: (1) The exacting character of the miners' employment is much ameliorated; (2) the percentage of lump coal is increased, which means a better average price for the total product; and (3) the cost of production is reduced. The first is of a humanitarian character, but the two last which are purely economic have been the chief incentives in the change of mining methods which has made the mining of bituminous coal in the United States during the last 25 years an epoch in the history of the industry. In many cases the installation of mining machinery has been forced upon the operators by the constantly advancing cost of labor and the necessity for keeping mining expenses within the lowest possible limits because of the keen competition and the low selling prices which have existed for many years in the principal coal-producing States. In 1890, the first year that the statistics of labor employed in the coal mines of the United States were collected and when the use of mining machines was just beginning, the average production of bituminous coal per man employed was 579 tons and the total production was 111,302,322 short tons. In 1913 the mine employees averaged only 6 more days in the year, the average production per man was 837 tons and the total production was 478,523,203 short tons, about 4.3 times that of 1890. But in 1913, 242,476,559 tons, or a little more than 50 per cent of the total, were machine-mined, whereas in 1890 probably less than 5,000,000 tons (not 5 per cent of the total) were machine mined. At the same rate of production per man as in 1890, the total output of bituminous coal in the United States for 1913 would have been about 331,000,000 tons or about two-thirds of the product actually won. If the bituminous mines had worked full 300 days in 1913 the production would have amounted to over 618,000,000 tons.

The total production of bituminous coal in the United States increased from 450,104,982 short tons in 1912 to 478,523,203 tons in 1913. The quantity of coal undercut or otherwise mined by the use of machines increased from 210,538,822 tons to 242,476,559 tons. The increase in the total production was 28,418,221 tons, or 6.3 per cent, and the increase in the output by the use of machines was 31,937,737 tons, or more than 15 per cent. The increase in the production of machine-mined coal exceeded the increase in the total production by 3,519,516 tons. The percentage of machine-mined coal to the total output has increased each year since the first successful mining machines were installed. In 1903, 10 years prior to the period covered by the present report, the quantity of bituminous coal mined by machinery in the United States represented 27.6 per cent of the total; in 1910 it was 41.7 per cent; in 1911, 43.9 per cent; in 1912, 46.8 per cent; and in 1913, 50.7 per cent.

During the last few years there has been a general complaint of shortage of labor in the bituminous fields, a condition favorable to further advances in mining wages and to the more extended use of mining machinery to offset them. It is to be expected, therefore, that the production of coal by mechanical methods will continue to show proportionate increase until a relatively small quantity will be mined by hand. In addition to the economic and humanitarian results accomplished by the use of machines, another important end is attained. The larger the proportion of coal mined by machines the smaller will be the proportion of coal shot off the solid without having been previously mined or sheared. Any step which mitigates that evil in the mining of bituminous coal is a step in advance, and as shown in the section on mining methods in this report, there was a reduction in the percentage of coal mined by powder. Recent developments in the construction of mining machinery have provided machines which are adapted to beds of any inclination., so that there are now practically no insurmountable physical obstacles to the substitution of machines for hand labor.

The methods of attacking the coal by machinery are of two distinct types. One is that of sawing; the other, of chopping. Three types of machines represent the former method—the chain-breast, the long-wall, and the short-wall. In these machines the coal is attacked by bits attached to an endless chain or to the periphery of a disk, and, as can be readily seen, the action is very similar to that of sawing wood. In the second type of machine the coal is attacked by bits attached to arms actuated reciprocally, as in the action of drilling, except that the work of the drill is not confined to one hole, but is freely changed at the will of the operator. These machines are designated as the pick or puncher, in which the drill is mounted on two wheels and operated on a platform in front of the face of the coal, and as the radialaxe or post-puncher, in which the piston is attached to a post and the drill is radiated in one plane. This latter machine has been developed for use in the steep-pitching beds. A new machine, brought out in 1912, combines the sawing and the chopping actions of the other two types. In this machine bits are inserted in the manner of a screw around an arm projecting from the machine. This arm is given both a reciprocating and a revolving motion, so that the coal is attacked by both a chopping and a sawing action. This machine was not actually placed on the market until 1913.

The total number of machines reported in use in the bituminous coal mines of the United States in 1913 was 16,381, an increase of 1,083 over 1912, when the number of machines reported was 15,298. The average number of tons mined by each machine in 1913 was 14,802, against 13,763 in 1912, the average for 1913 being the largest tonnage per machine reported. The best record prior to 1913 was in 1899, when the average production per machine was 14,068 tons. The most popular types of machines now in use are the pick or puncher and the chain-breast, the latter being in somewhat more general use in 1913; in 1912 the larger number of machines used were punchers. Out of the total of 16,381 machines in use in 1913, 6,936, or 42.3 per cent, were chain-breast; 6,327 were punchers; 2,210 were short wall; 791 were long wall; and 117 were of the radialaxe or post-puncher type. The rapid gain of the short-wall machine in popularity is referred to in the report for 1912, and it continued in 1913, the number of this type of machine having increased from 1,371 to 2,210, a gain of 839, or 60 per cent. Pennsylvania, the largest producer of bituminous coal, is also first in the total tonnage mined by machines and in the total number of machines in use. West Virginia, the second State in coal-producing importance, ranks also second in the number of machines in use and in the tonnage won by them; but the credit for the largest percentage of machine-mined coal to the total output belongs indisputably to Ohio, whose output of coal mined by machines in 1913 was 90.2 per cent of the total production. In 1912, 87 per cent of Ohio's production was machine mined. Kentucky ranks second in the percentage of the total product mined by machines with 73.2 per cent in 1913, against 66.4 per cent in 1912. Michigan's percentage of machine-mined coal increased from 52.7 per cent in 1912 to 70 per cent in 1913. West Virginia, Pennsylvania, and Indiana were each credited with more than half of their total production mined by machines in both years, and Illinois had 53 per cent in 1913, compared with 45 in 1912. In 1913 Pennsylvania's production of machine-mined coal was 92,487,438 short tons out of a total of 173,781,217 tons. West Virginia, with a total production of 71,308,982 tons, reported 39,410,264 tons mined by machines; Ohio, with a total production of 36,200,527 tons, reported 32,642,848 tons as mined by machines. Illinois's production of machine-mined coal was 32,630,555 out of a total of 61,618,744 tons; Indiana reported 9,737,425 tons as machine-mined out of a total production of 17,165,671.

The statistics in regard to the coal mined by machines during 1912 and 1913 are shown in the following table, together with the number of machines used in each State, the number of tons mined by machines, the total production of the States in which machines were used, and the percentage of the machine-mined product to the total of those States.

Bituminous coal mined by machines in the United States, 1912 and 1913, by States.

State.	Number of machines in use.		Number of tons mined by machines.	
	1912	1913	1912	1913
Alabama	353	377	3,742,549	4,124,301
Arkansas	9	27	76,611	251,105
California	1	2	200	1,200
Colorado	304	300	2,552,168	2,311,493
Illinois	1,654	1,845	26,878,049	32,630,555
Indiana	687	732	8,363,759	9,737,425
Iowa	24	28	95,342	120,716
Kansas	11	9	75,816	22,120
Kentucky	1,168	1,263	10,954,648	14,353,583
Maryland	53	13	125,625	82,989
Michigan	126	130	635,560	862,700
Missouri	86	104	898,852	863,946
Montana	69	97	984,905	1,076,641
New Mexico	25	44	285,362	497,070
North Dakota	11	13	168,904	222,227
Ohio	1,547	1,681	30,048,831	32,642,848
Oklahoma	60	103	259,719	670,629
Pennsylvania	6,176	6,301	82,192,042	92,487,438
Tennessee	227	252	1,201,895	1,842,658
Texas	21	24	105,400	100,889
Utah	13	50	114,716	625,475
Virginia	185	187	3,205,504	4,206,988
Washington	56	63	258,089	280,515
West Virginia	2,253	2,541	34,946,394	39,410,264
Wyoming	179	195	2,367,882	3,050,784
Total	15,298	16,381	210,538,822	242,476,559

State.	Total tonnage of States using mining machinery.		Percentage of total product mined by machines.	
	1912	1913	1912	1913
Alabama	16,100,600	17,678,522	23.2	23.3
Arkansas	2,100,819	2,234,107	3.7	11.2
California	10,978	24,839	1.8	4.8
Colorado	10,977,824	9,232,510	23.2	25.0
Illinois	59,885,226	61,618,744	44.9	53.0
Indiana	15,285,718	17,165,671	54.7	56.7
Iowa	7,289,529	7,525,936	1.3	1.6
Kansas	6,986,182	7,202,210	1.1	0.3
Kentucky	16,490,521	19,616,600	66.4	73.2
Maryland	4,964,038	4,779,839	2.5	1.7
Michigan	1,206,230	1,231,786	52.7	70.0
Missouri	4,339,856	4,318,125	20.7	20.0
Montana	3,048,495	3,240,973	32.3	33.2
New Mexico	3,536,824	3,708,806	8.1	13.4
North Dakota	499,480	495,320	33.8	44.9
Ohio	34,528,727	36,200,527	87.0	90.2
Oklahoma	3,675,418	4,165,770	7.1	16.1
Pennsylvania	161,865,488	173,781,217	50.8	53.2
Tennessee	6,473,228	6,903,784	18.6	26.7
Texas	2,188,612	2,429,144	4.8	4.2
Utah	3,016,149	3,254,828	3.8	19.2
Virginia	7,846,638	8,828,068	40.8	47.6
Washington	3,360,932	3,877,891	7.7	7.2
West Virginia	66,786,687	71,308,982	52.3	55.3
Wyoming	7,368,124	7,393,066	32.1	41.3
Total	449,832,323	478,217,265	[a] 46.8	[a] 50.7

[a] Average.

One of the determining factors in the choice of machines for undercutting the coal is the character of the roof, it being impracticable to operate chain-breast machines when the roof is tender and the timbering has to be kept up close to the face. This limitation does not apply to the short-wall or continuous-cutter machines, which can be operated in mines where the timbering is within 3 feet, or even less, of the face. Neither of these machines is so well adapted as the punchers for use in mines where "sulphur balls" (nodules of iron pyrites) are prevalent, as the sulphur balls will break or quickly dull the cutting bits, whereas the operator of the puncher can cut around them. The limitations of the chain type of machine (including the continuous cutters) are compensated for, however, by the higher efficiency in the mines where they can be used and by the greater ease with which the wires can be carried through the mines as compared with the air pipes for the punchers. It will be observed in the following table that in Ohio where the machine-mined production represents all but about 10 per cent of the total output, chain-breast machines are largely in the ascendency, there being 1,421 of this type of machines out of the total of 1,681 machines in use in the State during 1913. In Pennsylvania the pick machines far outnumber all others and represent more than 50 per cent of the total number of machines in use. In 1913 out of 6,301 machines in Pennsylvania 3,341 were punchers and 2,086 were chain-breast; and of the other important coal-producing States, punchers have exceeded the other types of machines in Alabama, Colorado, Kentucky, and Tennessee, and chain-breast machines outnumber punchers in Illinois, Indiana, Virginia, and West Virginia. Long-wall machines are most numerous in Missouri, and the radialaxe or post-puncher held almost the entire field in the State of Washington. In the following table are shown the number and kind of machines in use in each State, so far as they were reported to the Survey in 1912 and 1913:

Number and kinds of machines in use in 1912 and 1913, by States.

State.	1912						1913					
	Pick.	Chain breast.	Long wall.	Short wall.	Radial axe or post.	Total.	Pick.	Chain breast.	Long wall.	Short wall.	Radial axe or post.	Total.
Alabama	222	60	12	59	......	353	249	42	20	66	......	377
Arkansas	......	......	......	6	3	9	......	23	......	4	......	27
California	......	......	......	......	1	1	......	......	......	......	2	2
Colorado	187	33	16	57	11	304	168	35	12	80	5	300
Illinois	847	701	22	81	3	1,654	802	906	55	82	......	1,845
Indiana	198	348	99	42	......	687	166	365	105	96	......	732
Iowa	16	3	3	1	1	24	3	7	8	8	2	28
Kansas	9	......	2	......	......	11	5	1	3	......	......	9
Kentucky	611	361	54	136	6	1,168	574	377	98	213	1	1,263
Maryland	41	......	5	7	......	53	6	1	5	1	......	13
Michigan	48	37	......	41	......	126	26	38	......	66	......	130
Missouri	2	2	78	4	......	86	7	7	80	10	......	104
Montana	38	21	......	8	2	69	53	22	......	19	3	97
New Mexico	7	4	......	13	1	25	7	6	1	30	......	44
North Dakota	......	11	......	......	......	11	......	4	......	9	......	13
Ohio	77	1,362	2	106	......	1,547	56	1,421	17	187	......	1,681
Oklahoma	16	14	4	15	11	60	35	13	......	45	10	103
Pennsylvania	3,660	2,023	52	439	2	6,176	3,341	2,086	137	736	1	6,301
Tennessee	154	17	15	39	2	227	176	21	4	50	1	252
Texas	18	......	3	......	......	21	20	......	3	1	......	24
Utah	5	6	......	2	......	13	5	7	......	38	......	50
Virginia	5	128	1	51	......	185	4	106	1	76	......	187
Washington	......	......	......	......	56	56	1	......	......	1	61	63
West Virginia	604	1,217	175	245	12	2,253	562	1,364	231	365	19	2,541
Wyoming	68	77	2	19	13	179	61	84	11	27	12	195
Total	6,833	6,425	545	1,371	124	15,298	6,327	6,936	791	2,210	117	16,381

The statistics relating to the use of mining machines were first collected by the Survey for the year 1896. The inquiries at that time covered the number of machines in use and the quantity of coal won by them in 1891, five years before. From the returns to the Survey since 1896, the results of which have been published in detail in the preceding volumes of Mineral Resources of the United States, the following table has been prepared, showing the development in the mechanical mining of bituminous coal since 1891:

Production of coal by machines in the United States since 1891, in short tons.

Year.	Number of machines in use.	Total tonnage won by machines.	Average production for each machine.
1891	545	6,211,732	11,398
1896	1,446	16,424,932	11,373
1897	1,956	22,649,220	11,579
1898	2,622	32,413,144	12,362
1899	3,125	43,963,933	14,068
1900	3,907	52,784,523	13,510
1901	4,341	57,843,335	13,325
1902	5,418	69,611,582	12,848
1903	6,658	77,974,894	11,712
1904	7,663	78,606,997	10,258
1905	9,184	103,396,452	11,258
1906	10,212	118,847,527	11,638
1907	11,144	137,973,701	12,381
1908	11,569	123,183,334	10,648
1909	13,049	142,496,878	10,920
1910	13,254	174,012,293	13,127
1911	13,829	178,158,236	12,854
1912	15,298	210,538,822	13,763
1913	16,381	242,476,559	14,802

It has already been shown in the discussion of the statistics of the labor employed in the coal mines of the United States that there has been in the last 25 years a marked increase in the average production per man in the bituminous coal mines which may be attributed directly to the increase in the use of mining machines. In the following table the quantity and percentage of machine-mined coal in 1912 and 1913 are compared with similar statistics for the year 1900. It will be observed that in practically every State in which the machine-mined tonnage has increased the daily and yearly production per man have also increased, but as shown from the figures for 1912 and 1913 this advance is not exhibited in every State when the figures for those two years only are compared. In Alabama, for instance, the quantity of coal mined by machines increased from 3,742,549 tons in 1912 to 4,124,301 tons in 1913, but the average production per man per day decreased from 2.91 to 2.82 tons. Similarly, in Arkansas the production from machine-mined coal increased from 76,611 to 251,105 tons, but the daily output per man decreased from 2.95 to 2.76. The same condition is noted in Michigan, Montana, New Mexico, North Dakota, Pennsylvania (bituminous coal), Tennessee, Utah, Virginia, Washington, and Wyoming. In fact, in the majority of the States in 1913 the average tonnage per day per man was less than it was in 1912.

In the following table the quantity and percentage of machine-mined production in 1900, 1912, and 1913, by States, are compared with the daily and yearly average production by each employee in the States where mining machines are used:

Average production per man compared with production by machines in 1900, 1912, and 1913, by States, in short tons.

State.	Average tonnage.						Production by machines.					
	Per year.			Per day.			Total tonnage by machines.			Percentage of machine coal to State total.		
	1900	1912	1913	1900	1912	1913	1900	1912	1913	1900	1912	1913
Alabama	601	712	720	2.34	2.91	2.82	370,150	3,742,549	4,124,301	4.4	23.2	23.3
Arkansas	517	463	480	2.36	2.95	2.76	219,085	76,611	251,105	14.8	3.7	11.2
California	454	211	710	1.47	1.14	2.14	....	200	1,200	.....	1.8	4.8
Colorado	703	844	770	2.66	3.72	3.36	756,025	2,552,168	2,311,493	14.4	23.2	25.0
Illinois	659	767	775	2.92	3.95	4.10	5,083,594	26,878,049	32,630,555	19.7	44.9	53.0
Indiana	553	706	772	2.78	3.88	4.06	1,774,045	8,363,759	9,737,425	27.4	54.7	56.7
Iowa	448	445	478	1.96	2.37	2.45	132,757	95,342	120,716	2.6	1.3	1.6
Kansas	528	600	577	2.28	2.97	2.93	46,164	75,816	22,120	1.0	1.1	.3
Kentucky	551	679	745	2.43	3.38	3.51	2,339 944	10,954,648	14,353,583	43.9	66.4	73.2
Maryland	757	806	847	3.73	3.11	3.42	138,014	125,625	82,989	3.4	2.5	1.7
Michigan	499	387	373	1.91	2.11	1.98	191,577	635,560	862,700	22.6	52.7	70.0
Missouri	433	447	414	2.02	2.17	2.21	110,036	898,852	863,946	3.1	20.7	20.0
Montana	699	886	893	2.77	4.03	3.92	1,045,115	984,905	1,076,641	62.9	32.3	33.2
New Mexico	638	900	857	2.44	3.28	2.97	112,000	285,362	497,070	8.6	8.1	13.4
North Dakota	398	803	773	2.80	3.46	2.90	33,965	168,904	222,227	26.2	33.8	44.9
Ohio	687	758	790	3.20	3.77	3.83	8,835,743	30,048,831	32,642,848	46.5	87.0	90.2
Oklahoma (Indian Territory)	425	418	461	1.86	2.40	2.34	239,424	259,719	670,629	12.5	7.1	16.1
Pennsylvania, bituminous	861	980	1,009	3.56	3.89	3.78	26,867,053	82,192,042	92,487,438	33.7	50.8	53.2
Tennessee	459	628	613	1.90	2.68	2.54	176,872	1,201,895	1,842,658	4.8	18.6	26.7
Texas	340	424	476	1.38	1.84	1.88	....	105,400	100,889	.....	4.8	4.2
Utah	877	906	783	3.54	3.18	2.87	....	114,716	625,475	.....	3.8	19.2
Virginia	659	904	964	2.76	3.60	3.44	231,269	3,205,504	4,206,988	9.7	40.8	47.6
Washington	674	609	669	2.33	2.69	2.57	10,000	258,089	280,515	.4	7.7	7.2
West Virginia	777	979	954	3.36	3.68	4.08	3,418,377	34,946,394	39,410,264	15.1	52.3	55.3
Wyoming	753	917	887	2.83	3.85	3.82	653,314	2,367,882	3,050,784	16.3	32.1	41.3

MINING METHODS.

In the report for 1911 the first attempt was made to present statistics of the quantity of bituminous coal properly mined, either by hand or by machine, and of the quantity and percentage that was shot or blasted without having been previously undercut or sheared. The method practiced in the latter case is characterized as "shooting off the solid," the only preparation for which consists in drilling the holes necessary for the explosive charge. So much has been said by speakers and writers in condemnation of this practice, dangerous as it is to life and property and injurious to the quality of the product, that it would hardly seem necessary to do more than repeat the plea for its prohibition by law or by the inspection authorities of the State, and yet in a few States it has been indirectly encouraged by legislation which compels the payment for mining on the mine-run instead of the screened-coal basis. The latest State to enact this kind of a law is Ohio, but fortunately in that State the danger of increasing the quantity of coal shot off the solid is somewhat lessened by the high percentage of coal mined by machines, more than 90 per cent of the total product in 1913 being machine mined and less than 4 per cent shot off the solid. It will be interesting to note if operations under the new law, made effective in 1914, show any appreciable changes in these proportions.

Shooting off the solid increases the liability to accident in a vocation already extra hazardous by accentuating the danger from explosions of gas and dust and from mine fires; it is injurious to the mining property in that the inordinate charges of powder weaken the roofs and pillars and this increases the liability to falls of roof and coal, the most prolific cause of fatal accidents in coal mines; and it is wickedly wasteful in that it materially reduces the quality of the product. The heavy charges of powder necessary to blow down the coal when it has not been previously undercut or sheared result in the production of a much larger proportion of fine coal and render the lump coal so friable that it disintegrates badly in handling and in transportation. This naturally creates dissatisfaction on the part of the consumer who buys lump coal and gets, at best, mine-run.

The principal offenders in the practice of shooting off the solid are those States in which for more reasons than one the contrary condition should prevail, and that is in the States of the Middle West in what is designated as the interior province. In these States the product is a dry, noncoking bituminous coal, of which the slack or fine coal is not available in the manufacture of coke; nor is the fine coal or slack as satisfactory a steam fuel as the screened coal, and like the small sizes of anthracite it is sold at below the cost of production. There is absolutely no excuse or logical argument in favor of a continuance of the practice. Of the total quantity of coal shot off the solid (75,155,707 short tons), 38,253,166 tons, or 50.9 per cent, were produced in 1913 in the States of Arkansas, Illinois, Indiana, Iowa, Missouri, and Oklahoma. An improvement in this respect was recorded in 1913 as compared with 1912, and it is to be hoped that this improvement will continue until the shooting of the coal off the solid shall be reduced to a minimum. Arkansas, which in 1912 was the leader in wrong doing, with 92. 2 per cent of its output shot off the solid, reported 79.5 per cent so mined in 1913, and Oklahoma, which was only a little behind Arkansas with 86.4 per cent in 1912, reduced its percentage in 1913 to 80.9 per cent. In Illinois the percentage of coal shot off the solid was reduced from 40.3 in 1912 to 33.2 in 1913, and in Kansas from 83.9 to 80.5. Indiana showed about the same percentage in both years—30.2 in 1912 and 30.1 in 1913. Missouri decreased from 48 in 1912 to 46.8 in 1913. Iowa's percentage of coal shot off the solid has increased in both of the last two years, from 68.4 in 1911 to 69.1 in 1912 and to 72.3 in 1913. The entire production of Georgia in 1913, 96.5 per cent of the production of Idaho, and all of the production in Nevada, were reported as shot off the solid, but in Georgia the fine coal is usable and is used in the manufacture of coke, and in the other two States the combined production is only a little over 2,000 tons. West Virginia stood at the head of the honor roll in both years, with less than 1 per cent out of a total production of over 71,000,000 tons in 1913 shot off the solid. Pennsylvania is a good second to West Virginia, with 2.6 per cent of its bituminous product shot off the solid; Ohio came third, with 3.7 per cent; and Utah fourth, with 4.6 per cent. Three of these it will be noted were the three leading States in the Appalachian region, and two of them, Pennsylvania and West Virginia, held the first and second place in coal-producing importance in the United States. The quantity of machine-mined coal increased from 210,538,822 tons, or 46.8 per cent of the total, in 1912 to 242,476,559 tons, or 50.7 per cent, in 1913. The hand-mined coal increased from 136,650,635 tons in 1912 to 141,555,532 tons in 1913, but the percentage decreased from 30.4 to 29.6. The powder-mined coal decreased from 76,241,575 tons to 75,155,707 tons, a decrease in percentage from 16.9 to 15.7.

The following table shows the quantity and percentage of bituminous coal in the several States mined by hand and by machines, shot off the solid, and mined by unreported methods in 1912 and 1913:

Quantity and percentage of bituminous coal mined by different methods, by States, in short tons.

1912.

State.	Mined by hand.	Percentage.	Shot off the solid.	Percentage.	Mined by machines.	Percentage.	Not reported.	Percentage.	Total production.
Alabama	6,658,732	41.4	5,658,457	35.1	3,742,549	23.2	40,862	0.3	16,100,600
Arkansas	73,556	3.5	1,937,817	92.2	76,611	3.7	12,835	.6	2,100,819
California	7,778	70.9	2,500	22.8	200	1.8	500	4.5	10,978
Colorado	7,076,131	64.5	1,309,544	11.9	2,552,168	23.2	39,981	.4	10,977,824
Georgia	147,815	65	79,688	35	....	......	....	......	227,503
Illinois	7,675,805	12.8	24,136,940	40.3	26,878,049	44.9	1,194,432	2	59,885,226
Indiana	2,094,397	13.7	4,615,580	30.2	8,363,759	54.7	211,982	1.4	15,285,718
Iowa	1,451,673	19.9	5,034,729	69.1	95,342	1.3	707,785	9.7	7,289,529
Kansas	408,835	5.9	5,864,226	83.9	75,816	1.1	637,305	9.1	6,986,182
Kentucky	2,306,222	14	2,727,399	16.5	10,954,648	66.4	502,252	3.1	16,490,521
Maryland	4,668,104	94	121,130	2.5	125,625	2.5	49,179	1	4,964,038
Michigan	120,637	10	443,222	36.7	635,560	52.7	6,811	.6	1,206,230
Missouri	1,036,994	23.9	2,083,656	48	898,852	20.7	320,354	7.4	4,339,856
Montana	923,698	30.3	1,123,571	36.9	984,905	32.3	16,321	.5	3,048,495
New Mexico	2,642,137	74.7	599,463	16.9	285,362	8.1	9,862	.3	3,536,824
North Dakota	71,103	14.2	181,798	36.4	168,904	33.8	77,675	15.6	499,480
Ohio	2,332,767	6.8	1,341,823	3.9	30,048,831	87	805,306	2.3	34,528,727
Oklahoma	49,212	1.3	3,175,455	86.4	259,719	7.1	191,032	5.2	3,675,418
Pennsylvania	54,545,218	33.7	4,801,784	3	82,192,042	50.8	20,326,444	12.5	161,865,488
Tennessee	2,708,650	41.8	2,127,917	32.9	1,201,895	18.6	434,766	6.7	6,473,228
Texas	1,028,025	47	280,105	12.8	105,400	4.8	775,082	35.4	2,188,612
Utah	2,805,498	93	91,992	3.1	114,716	3.8	3,943	.1	3,016,149
Virginia	898,821	11.5	3,741,533	47.7	3,205,504	40.8	780	......	7,846,638
Washington	1,991,549	59.3	1,102,993	32.8	258,089	7.7	8,301	.2	3,360,932
West Virginia	31,101,454	46.6	453,215	.7	34,946,394	52.3	285,624	.4	66,786,687
Wyoming	1,810,559	24.6	3,180,067	43.2	2,367,882	32.1	9,616	.1	7,368,124
Other States	15,265	33.8	24,971	55.3	....	......	4,920	10.9	45,156
Total	136,650,635	30.4	76,241,575	16.9	210,538,822	46.8	26,673,950	5.9	450,104,982

1913.

State.	Mined by hand.	Percentage.	Shot off the solid.	Percentage.	Mined by machines.	Percentage.	Not reported.	Percentage.	Total production.
Alabama	6,315,787	35.7	7,052,234	39.9	4,124,301	23.3	186,200	1.1	17,678,522
Arkansas	205,112	9.2	1,775,851	79.5	251,105	11.2	2,039	.1	2,234,107
California	....	......	23,639	95.2	1,200	4.8	....	......	24,839
Colorado	5,592,638	60.6	1,286,293	13.9	2,311,493	25	42,086	.5	9,232,510
Georgia	....	......	255,626	100	....	......	....	......	255,626
Illinois	8,069,361	13.1	20,469,139	33.2	32,630,555	53	449,689	.7	61,618,744
Indiana	1,862,729	10.9	5,175,229	30.1	9,737,425	56.7	390,288	2.3	17,165,671
Iowa	1,523,655	20.2	5,440,437	72.3	120,716	1.6	441,128	5.9	7,525,936
Kansas	1,068,039	14.8	5,796,689	80.5	22,120	.3	315,362	4.4	7,202,210
Kentucky	1,755,461	9	3,092,985	15.7	14,353,583	73.2	414,571	2.1	19,616,600
Maryland	4,373,920	91.5	293,950	6.2	82,989	1.7	28,980	.6	4,779,839
Michigan	2,370	.2	363,856	29.5	862,700	70	2,860	.3	1,231,786
Missouri	1,018,588	23.6	2,021,292	46.8	863,946	20	414,299	9.6	4,318,125
Montana	1,003,726	31	1,143,364	35.3	1,076,641	33.2	17,242	.5	3,240,973
New Mexico	2,548,243	68.7	652,969	17.6	497,070	13.4	10,524	.3	3,708,806
North Dakota	54,931	11.1	130,341	26.3	222,227	44.9	87,821	17.7	495,320
Ohio	1,600,605	4.4	1,323,793	3.7	32,642,848	90.2	633,281	1.7	36,200,527
Oklahoma	92,183	2.2	3,371,218	80.9	670,629	16.1	31,740	.8	4,165,770
Pennsylvania	61,509,942	35.4	4,481,956	2.6	92,487,438	53.2	15,301,881	8.8	173,781,217
Tennessee	2,464,970	35.7	2,555,482	37	1,842,658	26.7	40,674	.6	6,903,784
Texas	1,494,996	61.5	612,132	25.2	100,889	4.2	221,127	9.1	2,429,144
Utah	2,416,647	74.2	150,172	4.6	625,475	19.2	62,534	2	3,254,828
Virginia	1,740,485	19.7	2,879,108	32.6	4,206,988	47.6	1,487	.1	8,828,068
Washington	2,120,257	54.7	1,465,248	37.8	280,515	7.2	11,871	.3	3,877,891
West Virginia	31,079,190	43.6	596,184	.8	39,410,264	55.3	223,344	.3	71,308,982
Wyoming	1,618,696	21.9	2,719,884	36.7	3,050,784	41.3	3,702	.1	7,393,066
Other States	23,001	45.7	26,636	53	....	......	675	1.3	50,312
Total	141,555,532	29.6	75,155,707	15.7	242,476,559	50.7	19,335,405	4	478,523,203

COAL-WASHING OPERATIONS.

Since 1908 the schedules requesting information regarding the production of bituminous coal in the United States have included inquiries regarding the quantity of coal washed at the mines. This is done in order to reduce the impurities, ash and sulphur, and to improve the quality of the product either for the market or for coke making. The larger part of the product so treated is slack used in the manufacture of coke, but in some States, notably in Illinois where the coal is noncoking, the washed product is principally nut coal for domestic use. In 1913 the quantity of bituminous coal sent to the washeries operated in connection with the mines was 25,051,801 short tons, which yielded 22,069,691 tons of cleaned coal and 2,982,-110 tons of refuse. In 1912 there were 19,844,517 tons sent to the washeries, and the cleaned product obtained was 17,538,572 tons, with 2,305,945 tons of refuse. In the statement of the total production of coal in the United States the refuse is deducted and only the cleaned coal considered as the marketed product. Alabama leads in the quantity of coal washed, nearly one-half of the total quantity so treated in 1913 being from that State. The total quantity of cleaned coal from the Alabama washeries in 1913 was 7,210,588 short tons, of which 60 per cent was used in the manufacture of coke. Pennsylvania was second in the quantity of coal sent to the washeries, with 5,400,444 tons of cleaned coal obtained in 1913. Practically all of it was used in the manufacture of coke, the reports from the coke operators showing that 5,375,000 tons of washed coal were used in the manufacture of coke. In Illinois 4,190,960 tons were sent to the washeries, and the quantity of washed coal obtained was 3,664,928 short tons. A very small portion of this was used in the retort ovens, mixed with West Virginia coal, but over 99 per cent was sized coal, used principally for household fuel. In the State of Washington 1,643,282 tons were sent to the washeries, and the cleaned coal obtained was 1,343,120 tons, of which about 10 per cent was used in the manufacture of coke and the remainder went into the regular market. The three States of Alabama, Pennsylvania, and Illinois reported about 75 per cent of the total quantity of coal washed at the mines.

In the anthracite region of Pennsylvania considerable quantities of usable coal have for a number of years been recovered from the washeries of old culm banks. This item amounted in 1913 to 2,860,-021 long tons, or 3,203,224 short tons, as compared with 4,165,288 long tons, or 4,665,123 short tons in 1912. The quantity of coal recovered by the anthracite washeries is not included in the following table, which shows the quantity of bituminous coal washed at the mines in 1912 and 1913:

Bituminous coal washed at the mines in 1912 and 1913, with quantity of washed coal and of refuse obtained from it, by States, in short tons.

State.	1912			1913		
	Quantity of coal washed.	Quantity of cleaned coal.	Quantity of refuse.	Quantity of coal washed.	Quantity of cleaned coal.	Quantity of refuse.
Alabama	7,187,211	6,325,946	861,265	8,149,082	7,210,588	938,494
Arkansas	72,753	50,563	22,190	46,346	32,985	13,361
Colorado	116,950	107,174	9,776	328,016	266,281	61,735
Georgia	111,923	87,300	24,623	124,306	82,943	41,363
Illinois	3,522,760	3,070,523	452,237	4,190,960	3,664,928	526,032
Indiana	18,784	17,077	1,707	76,132	65,499	10,633
Iowa	....	....	....	31,711	22,080	9,631
Kansas	....	....	....	48,423	39,343	9,080
Kentucky	164,496	150,626	13,870	183,396	162,880	20,516
Maryland	53,842	53,191	651	....	....	....
Michigan	128,738	113,623	15,115	166,709	145,840	20,869
Missouri	140,582	101,953	38,629	160,487	118,681	41,806
Montana	666,713	599,104	67,609	601,176	547,674	53,502
New Mexico	....	....	....	587,853	487,473	100,380
Ohio	336,639	305,629	31,010	306,713	269,178	37,535
Oklahoma	143,537	117,018	26,519	17,850	14,307	3,543
Oregon	12,501	10,501	2,000	12,958	9,719	3,239
Pennsylvania	4,819,330	4,326,162	493,168	6,011,172	5,400,444	610,728
Tennessee	449,847	390,994	58,853	707,773	624,426	83,347
Texas	25,599	20,639	4,960	28,701	21,761	6,940
Virginia	60,640	56,925	3,715	47,936	45,638	2,298
Washington	863,643	731,521	132,122	1,643,282	1,343,120	300,162
West Virginia	948,029	902,103	45,926	1,580,819	1,493,903	86,916
Total	19,844,517	17,538,572	2,305,945	25,051,801	22,069,691	2,982,110

VALUES PER TON.

Following the advances in wages granted in both the anthracite and bituminous fields by the agreements of 1912 there was a general advance in prices of coal in the important producing States in 1913, a notable exception being shown in Illinois, where, because of peculiar conditions, values declined. Singularly enough, the number of States in which prices advanced and of those in which they declined were exactly the same—13 each; but as the declines were for the most part in the less important States, the general average for bituminous coal showed an advance in 1913 over 1912 of 3 cents a ton. There were only two years in a period of more than three decades in which the average value per ton for bituminous coal exceeded that of 1913. These were 1880, when the statement of values was largely a matter of estimate, and 1903, when, because of the prolonged strike in the anthracite region in 1902 and of long periods of idleness from the same cause in the organized bituminous States, a practical fuel famine existed and prices were abnormally inflated. The average value per ton for anthracite in 1913 was the highest in the period of 34 years for which statistics are available.

The following tables show the average value per ton, by States, for the last five years, with the advances and declines in 1913, as compared with 1912, and the general averages for anthracite and bituminous values for 34 years:

Average value per short ton for coal at the mines since 1908, by States and Territories.

State.	1908	1909	1910	1911	1912	1913	Advance (+) or decline (−) in 1913.
Alabama	$1.26	$1.19	$1.26	$1.27	$1.29	$1.31	+$0.02
Arkansas	1.68	1.48	1.56	1.61	1.71	1.76	+ .05
California	[a]3.19	2.21	[a]2.74	[a]2.00	[a]2.33	[a]3.54	+ 1.21
Colorado	1.41	1.33	1.42	1.45	1.49	1.52	+ .03
Georgia	1.38	1.41	1.46	[b]1.49	[b]1.49	1.41	− .08
Idaho	4.02	4.27	3.92	[c]2.68	[c]3.14	[c]2.43	− .71
Illinois	1.05	1.05	1.14	1.11	1.17	1.14	− .03
Indiana	1.06	1.02	1.13	1.08	1.14	1.11	− .03
Iowa	1.63	1.65	1.75	1.73	1.80	1.79	− .01
Kansas	1.49	1.44	1.61	1.53	1.62	1.67	+ .05
Kentucky	1.01	.94	.99	.99	1.02	1.05	+ .03
Maryland	1.17	1.11	1.12	1.11	1.18	1.24	+ .06
Michigan	1.81	1.79	1.91	1.78	1.99	1.99	....
Missouri	1.64	1.65	1.79	1.72	1.76	1.73	− .03
Montana	1.96	1.97	1.82	1.79	1.82	1.74	− .08
New Mexico	1.37	1.29	1.39	1.44	1.42	1.46	+ .04
North Dakota	1.63	1.56	1.49	1.43	1.53	1.52	− .01
Ohio	1.06	.99	1.05	1.03	1.07	1.10	+ .03
Oklahoma	2.03	2.00	2.22	2.05	2.14	2.05	− .09
Oregon	2.74	2.69	3.48	2.32	2.60	2.53	− .07
Pennsylvania bituminous	1.01	.94	1.02	1.01	1.05	1.11	+ .06
Tennessee	1.15	1.09	1.11	1.12	1.14	1.14	....
Texas	1.80	1.72	1.67	1.66	1.67	1.77	+ .10
Utah	1.69	1.66	1.68	1.69	1.67	1.65	− .02
Virginia	.91	.89	.90	.91	.96	1.01	+ .05
Washington	2.21	2.54	2.50	2.29	2.39	2.38	− .01
West Virginia	.95	.86	.92	.90	.94	1.01	+ .07
Wyoming	1.62	1.55	1.55	1.56	1.58	1.56	− .02
Total bituminous	1.12	1.07	1.12	1.11	1.15	1.18	+ .03
Pennsylvania anthracite	1.90	1.84	1.90	1.94	2.11	2.13	+ .02
General average	1.28	1.20	1.25	1.26	1.30	1.33	+ .03

[a] Includes Alaska.
[b] Includes North Carolina.
[c] Includes Nevada.

Average value per short ton of coal in the United States for 34 years.

Year.	Anthracite.	Bituminous.	Year.	Anthracite.	Bituminous.
1880	$1.47	$1.25	1897	$1.51	$0.81
1881	2.01	1.12	1898	1.41	.80
1882	2.01	1.12	1899	1.46	.87
1883	2.01	1.07	1900	1.49	1.04
1884	1.79	.94	1901	1.67	1.05
1885	2.00	1.13	1902	1.84	1.12
1886	1.95	1.05	1903	2.04	1.24
1887	2.01	1.11	1904	1.90	1.10
1888	1.91	1.00	1905	1.83	1.06
1889	1.44	.99	1906	1.85	1.11
1890	1.43	.99	1907	1.91	1.14
1891	1.46	.99	1908	1.90	1.12
1892	1.57	.99	1909	1.84	1.07
1893	1.59	.96	1910	1.90	1.12
1894	1.51	.91	1911	1.94	1.11
1895	1.41	.86	1912	2.11	1.15
1896	1.50	.83	1913	2.13	1.18

SHIPMENTS BY RAILROADS.

Since 1910 schedules asking for the statements of the production of bituminous coal have included inquiries regarding the names of the railroads carrying the product and the quantity of coal shipped over each route. From the replies received to these inquiries the following tables have been prepared showing the initial shipments over each transportation route during 1912 and 1913. Corresponding statements were contained in the reports for 1911 and 1912. The tables show not only the initial shipments taken by each railroad, but the State in which the coal originated. The quantities reported in these tables do not include the coal delivered from one road to another, and consequently do not represent the total quantity of coal carried by the various transportation routes. They do, however, represent quite accurately the total quantity of coal transported. For instance, the total shipments of bituminous coal in 1913 shown in these tables amounted to 403,161,603 short tons, whereas the total quantity reported as loaded at the mines for shipment was 403,530,711 tons, the difference in the two statements being less than one-tenth of 1 per cent. In 1912 the total quantity of bituminous coal loaded for shipment was 377,000,066 short tons, of which 373,897,332 tons were distributed according to the originating railroad or waterway over which the product was shipped. When the originating line is simply a side line of a few miles in length, operated for the purpose of delivering the coal to a regular carrier and not engaged in regular passenger and transportation business, the shipments are considered as originating on the railroad to which the coal is delivered. These tables having been compiled from the reports of the coal producers as to the railways or waterways over which the product was shipped and not from the transportation companies, some difference might be found in the tables presented in this report and those compiled by the railroad companies, but it is believed that such difference would not be material. All of the shipments over any particular railroad system are grouped together. For instance, the Pennsylvania Railroad includes the Pennsylvania lines west of Pittsburgh, such as the Pittsburgh, Fort Wayne & Chicago, the Pittsburgh, Cincinnati, Chicago & St. Louis, the Terre Haute & Indianapolis, the Vandalia, and other subsidiary lines; the New York Central system includes the Lake Shore & Michigan Southern, the Cleveland, Cincinnati, Chicago & St. Louis (Big Four), the Pittsburgh & Lake Erie, the Chicago, Indiana & Southern, the Cincinnati Northern, and other subsidiary lines; the Baltimore & Ohio system includes the Baltimore & Ohio Southwestern, the Cleveland, Lorain & Wheeling, and the Cincinnati, Hamilton & Dayton; the Chesapeake & Ohio system includes the Chesapeake & Ohio Railroad of Indiana, and the Hocking Valley Railway. The Frisco system in 1912 and previous years included the Chicago & Eastern Illinois Railroad, which originated the larger part of the tonnage of the system. These systems have been separated, however; the Chicago & Eastern Illinois is in the hands of a receiver, and the shipments for 1913 were divided between the Chicago & Eastern Illinois and the Frisco system.

Fifty per cent of the total railroad shipments is taken by the five transportation systems penetrating the Appalachian coal field. These are the Pennsylvania, the Baltimore & Ohio, the New York Central, the Norfolk & Western, and the Chesapeake & Ohio, although the first three also receive a considerable tonnage (more than 17,000,000 tons in the aggregate in 1913) from the central coal field. All of the shipments of the Norfolk & Western and the Chesapeake & Ohio Railroads are from the Appalachian region. A little more than 20 per cent of the total shipments by railroad originates on the Pennsylvania system and chiefly from the Pennsylvania mines. The total quantity of coal reported as shipped over the Pennsylvania Railroad in 1913 was 79,005,844 short tons out of a total of rail shipments of 392,470,769 tons. In 1912 the total shipments originating on the Pennsylvania Railroad were 72,536,245 short tons. The Baltimore & Ohio system is the second coal-carrying route in importance, with total original shipments in 1913 amounting to 37,288,046 short tons, about 2,500,000 tons less than half the shipments over the Pennsylvania system. West Virginia is the most important State contributing to the Baltimore & Ohio tonnage, the shipments from West Virginia mines over the system in 1913 amounting to 14,533,628 short tons; Pennsylvania mines shipped approximately 11,000,000 tons, and Ohio mines a little over 9,000,000 tons. The New York Central system, third in importance as a coal carrier, originated shipments amounting to 35,666,594 short tons, of which considerably more than one-half, or 19,663,538 tons, were from Pennsylvania mines; Illinois mines shipped about 8,000,000 tons over the New York Central lines in 1913, and the Ohio mines contributed practically 6,000,000 tons. The Norfolk & Western and the Chesapeake & Ohio—fourth and fifth, respectively, in importance as coal carriers—received about 80 per cent of their tonnage from the coal fields in the southern part of West Virginia. The former carried approximately 24,000,000 tons in 1913, of which nearly 20,000,000 tons were from the West Virginia mines, and the Chesapeake & Ohio system transported a little over 22,000,000 tons, of which 16,250,000 tons were from West Virginia territory. In 1911 and 1912 the Frisco system, including the Chicago & Eastern Illinois Railroad, ranked sixth among the coal-carrying roads, but on account of the separation in 1913 the Frisco system dropped to thirteenth place and its former position was taken by the Louisville & Nashville Railroad, whose originating shipments in 1913 amounted to 14,600,000, of which 8,000,000 tons were from Kentucky mines and a little more than 4,000,000 tons from Alabama mines. The Illinois Central system originated approximately 14,000,000 tons, nearly 70 per cent of which was from Illinois mines and the remainder practically from Kentucky. The Burlington route handled 12,700,000 tons, of which 8,500,000 tons were from Illinois mines; and the Chicago & Eastern Illinois handled 11,250,000 tons, of which 6,420,000 tons were from Illinois mines and 4,830,000 tons from Indiana mines. The Southern Railway received 10,400,000 tons, chiefly from Alabama and Tennessee mines. Other systems carrying coal in excess of 5,000,000 tons during 1913 were the Buffalo, Rochester & Pittsburgh, the Wheeling & Lake Erie, the Frisco lines, the Union Pacific, and the Missouri Pacific.

Shipments of bituminous coal in the United States, by railroads and waterways, in 1912.

Railroad.	State.	Quantity.	Total.
		Short tons.	
Pennsylvania Railroad system	Pennsylvania	57,379,312	72,536,245
	Ohio	8,865,812	
	Indiana	4,135,996	
	Illinois	1,388,752	
	West Virginia	751,007	
	Maryland	15,366	
Baltimore & Ohio system	West Virginia	13,540,289	34,376,015
	Pennsylvania	11,018,685	
	Ohio	7,858,167	
	Illinois	1,627,325	
	Maryland	176,315	
	Indiana	155,234	
New York Central lines	Pennsylvania	18,434,865	30,836,347
	Illinois	5,639,307	
	Ohio	5,123,821	
	Indiana	1,089,733	
	Michigan	548,621	
Chesapeake & Ohio lines	West Virginia	16,280,095	22,353,644
	Ohio	4,218,428	
	Kentucky	1,832,121	
	Virginia	23,000	
Norfolk & Western	West Virginia	18,863,182	21,994,109
	Virginia	2,173,323	
	Kentucky	957,604	
Frisco lines	Illinois	5,796,145	14,494,079
	Indiana	4,062,949	
	Kansas	1,971,885	
	Alabama	1,534,915	
	Arkansas	586,651	
	Oklahoma	288,850	
	Missouri	252,255	
	Colorado	429	
Louisville & Nashville	Kentucky	7,033,623	13,916,894
	Alabama	4,252,556	
	Tennessee	1,547,354	
	Illinois	705,010	
	Virginia	378,351	
Illinois Central	Illinois	8,437,621	12,169,144
	Kentucky	3,252,808	
	Indiana	415,437	
	Alabama	63,278	
Burlington	Illinois	7,597,693	11,737,397
	Wyoming	1,593,023	
	Iowa	1,316,035	
	Missouri	771,370	
	Colorado	440,647	
	Kansas	18,629	
Wabash	Ohio	4,757,856	11,477,818
	Illinois	3,657,373	
	Pennsylvania	2,647,668	
	Missouri	324,360	
	Iowa	90,561	
Southern	Alabama	3,959,228	9,585,748
	Tennessee	1,941,536	
	Virginia	1,260,115	
	Illinois	1,063,558	
	Indiana	788,664	
	Kentucky	572,647	
Buffalo, Rochester & Pittsburgh	Pennsylvania	7,666,759	7,666,759
Union Pacific-Southern Pacific lines	Wyoming	5,262,765	6,067,537
	Colorado	362,972	
	Texas	148,688	
	Washington	136,376	
	Utah	94,276	
	Kansas	31,937	
	Oregon	14,361	
	Missouri	12,414	
	California	3,748	
Missouri Pacific	Illinois	2,633,672	5,673,695
	Kansas	1,362,148	
	Arkansas	868,287	
	Missouri	809,288	
	Colorado	300	
Santa Fe	New Mexico	1,893,712	5,032,994
	Kansas	1,346,481	
	Colorado	960,797	
	Illinois	418,228	
	Missouri	398,813	
	Oklahoma	14,963	
Denver & Rio Grande	Utah	2,434,237	4,786,472
	Colorado	2,352,235	

Shipments of bituminous coal in the United States, by railroads and waterways, in 1912—Continued.

Railroad.	State.	Quantity.	Total.
		Short tons.	
Western Maryland	West Virginia	2,566,512	3,767,387
	Maryland	1,194,066	
	Pennsylvania	6,809	
Chicago, Milwaukee & St. Paul	Illinois	1,500,851	3,621,235
	Iowa	1,182,735	
	Montana	878,802	
	Washington	48,756	
	North Dakota	10,091	
Cumberland & Pennsylvania	Maryland	3,450,644	3,451,028
	Pennsylvania	384	
Virginian	West Virginia	3,382,375	3,382,375
Northern Pacific	Washington	2,109,818	3,380,163
	Montana	1,112,196	
	North Dakota	158,149	
Missouri, Kansas & Texas	Oklahoma	1,420,444	3,211,491
	Kansas	1,264,123	
	Texas	360,279	
	Missouri	166,645	
Chicago & Alton	Illinois	2,983,874	3,131,073
	Missouri	147,199	
Colorado & Southern Railway lines	Colorado	2,913,777	2,941,277
	Texas	27,500	
Kanawha & Michigan	West Virginia	2,624,269	2,799,886
	Ohio	175,617	
Rock Island lines	Oklahoma	1,025,559	2,732,784
	Iowa	925,990	
	Illinois	344,308	
	Arkansas	217,148	
	Missouri	115,690	
	Texas	48,959	
	Colorado	36,500	
	Kansas	18,630	
Chicago & North Western line	Iowa	1,559,075	2,656,509
	Illinois	959,959	
	Wyoming	137,475	
Bessemer & Lake Erie	Pennsylvania	2,617,053	2,617,053
Chicago, Terre Haute & Southeastern	Indiana	2,364,396	2,364,396
Macoupin County	Illinois	2,284,038	2,284,038
Pittsburgh, Shawmut & Northern	Pennsylvania	2,062,599	2,062,599
Erie	Pennsylvania	1,664,753	1,861,029
	Illinois	106,132	
	Ohio	90,144	
Buffalo & Susquehanna	Pennsylvania	1,529,007	1,529,007
Birmingham Southern	Alabama	1,527,974	1,527,974
Carolina, Clinchfield & Ohio	Virginia	1,385,132	1,385,132
Nashville, Chattanooga & St. Louis	Tennessee	1,320,440	1,339,683
	Alabama	19,243	
Mobile & Ohio	Illinois	802,255	1,311,842
	Alabama	509,587	
Minneapolis & St. Louis	Iowa	617,165	1,212,711
	Illinois	595,546	
Queen & Crescent	Tennessee	756,614	1,130,886
	Kentucky	322,052	
	Alabama	52,220	
Texas & Pacific	Texas	998,886	1,003,947
	Arkansas	5,061	
St. Louis, Troy & Eastern	Illinois	963,823	963,823
Monon	Indiana	924,476	924,476
Great Northern Railway lines	Montana	827,255	873,024
	North Dakota	42,529	
	Washington	3,240	
Colorado & Wyoming	Colorado	865,477	865,477
Litchfield & Madison	Illinois	863,975	863,975
St. Louis & O'Fallon	do	819,569	819,569
Pittsburgh, Chartiers & Youghiogheny	Pennsylvania	815,511	815,511
Interstate	Virginia	797,059	797,059
Central of Georgia	Alabama	637,663	745,798
	Georgia	108,135	
Colorado & Southeastern	Colorado	743,932	743,932
El Paso & Southwestern	New Mexico	726,560	726,560
Huntingdon & Broad Top Mountain	Pennsylvania	707,180	707,180
Kansas City Southern	Kansas	591,931	652,258
	Missouri	60,327	
Columbia & Puget Sound	Washington	610,155	610,155
Coal & Coke	West Virginia	610,092	610,092
Toledo, St. Louis & Western	Illinois	588,048	589,491
	Indiana	1,443	
East St. Louis & Suburban	Illinois	589,202	589,202
Chicago, Peoria & St. Louis Railway of Illinois	do	573,529	573,529
East Broad Top Railroad & Coal Co	Pennsylvania	515,504	515,504
Denver, Northwestern & Pacific	Colorado	512,375	512,375

Shipments of bituminous coal in the United States, by railroads and waterways, in 1912—Continued.

Railroad.	State.	Quantity.	Total.
		Short tons.	
Missouri & Louisiana	Missouri	510,742	510,742
Elgin, Joliet & Eastern	Illinois	509,104	509,104
Ligonier Valley	Pennsylvania	482,996	482,996
Pere Marquette	Michigan	452,218	452,218
Morgantown & Kingwood	West Virginia	431,188	431,188
International & Great Northern	Texas	426,014	426,014
Chicago Great Northern	Iowa	405,875	425,735
	Missouri	13,517	
	Kansas	6,343	
Midland Valley	Arkansas	310,753	423,218
	Oklahoma	112,465	
Illinois Traction System	Illinois	412,927	412,927
Monongahela	Pennsylvania	384,272	384,272
Union	do	372,696	372,696
Missouri, Oklahoma & Gulf	Oklahoma	339,266	339,266
St. Paul & Kansas City Short Line	Iowa	307,774	307,774
Colorado Midland	Colorado	286,225	286,225
Detroit, Toledo & Ironton	Ohio	285,614	285,614
St. Louis & Belleville Electric	Illinois	266,335	266,335
Rock Island Southern	do	265,814	265,814
Peoria & Pekin Union	do	263,677	263,677
Illinois Southern	do	238,946	238,946
Tennessee Central	Tennessee	226,835	226,835
Kentucky & Tennessee	Kentucky	210,196	210,196
Atlanta, Birmingham & Atlantic	Alabama	204,350	204,350
Quincy, Omaha & Kansas City	Missouri	191,379	191,379
Buffalo Creek & Gauley	West Virginia	154,532	154,532
Minneapolis, St. Paul & Sault Ste. Marie	North Dakota	141,697	141,697
Fort Smith & Western	Oklahoma	138,021	138,021
Marietta, Columbus & Cleveland	Ohio	137,959	137,959
Kanawha & West Virginia	West Virginia	128,269	128,269
Evansville, Suburban & Newburgh	Indiana	105,492	105,492
Louisville, Henderson & St. Louis	Kentucky	101,287	102,709
	Arkansas	1,422	
Pittsburgh & Susquehanna	Pennsylvania	95,467	95,467
Seaboard Air Line	Alabama	81,461	81,461
Western Allegheny	Pennsylvania	76,352	76,352
Oklahoma Central	Oklahoma	73,524	73,524
Fort Dodge, Des Moines & Southern	Iowa	69,895	69,895
Ashland Coal & Iron	Kentucky	65,297	65,297
Puget Sound Electric	Washington	64,551	64,551
Wichita Falls & Southern	Texas	63,928	63,928
Philadelphia & Reading	Pennsylvania	40,537	61,023
	Ohio	20,486	
Central Indiana	Indiana	35,794	35,794
Toledo, Peoria & Western	Illinois	30,000	30,000
Miscellaneous	Alabama	461,281	1,412,052
	Kentucky	403,823	
	Illinois	162,168	
	Michigan	79,480	
	Washington	68,381	
	Colorado	48,649	
	Iowa	39,899	
	Ohio	35,038	
	Indiana	28,705	
	West Virginia	27,560	
	Missouri	20,784	
	Kansas	12,686	
	Virginia	10,732	
	Texas	10,000	
	Oklahoma	2,866	
Total railroad shipments		366,864,936	366,864,936
Monongahela River	Pennsylvania	4,988,074	5,037,656
	West Virginia	49,582	
Kanawha River	do	868,542	868,542
Ohio River	Kentucky	331,340	820,812
	West Virginia	271,391	
	Pennsylvania	164,036	
	Ohio	54,045	
Allegheny River	Pennsylvania	164,036	164,036
Illinois River	Illinois	36,017	36,017
Warrior River	Alabama	10,000	10,000
Various waterways	Illinois	66,598	95,333
	Kentucky	28,735	
Total waterway shipments		7,032,396	7,032,396
Grand total		373,897,332	373,897,332

Shipments of bituminous coal in the United States, by railroads and waterways, in 1913.

Railroad.	State.	Quantity.	Total.
		Short tons.	
Pennsylvania Railroad system	Pennsylvania	63,000,671	79,005,844
	Ohio	9,405,673	
	Indiana	4,614,203	
	Illinois	1,248,735	
	West Virginia	714,316	
	Maryland	22,246	
Baltimore & Ohio system	West Virginia	14,533,628	37,288,046
	Pennsylvania	10,964,609	
	Ohio	9,108,399	
	Illinois	1,416,393	
	Kentucky	857,093	
	Maryland	224,749	
	Indiana	183,175	
New York Central lines	Pennsylvania	19,663,538	35,666,594
	Illinois	8,054,996	
	Ohio	5,920,608	
	Indiana	1,371,830	
	Michigan	655,622	
Norfolk & Western	West Virginia	19,897,245	23,929,001
	Virginia	2,526,629	
	Kentucky	1,505,127	
Chesapeake & Ohio lines	West Virginia	16,261,479	22,101,495
	Ohio	3,980,034	
	Kentucky	1,859,982	
Louisville & Nashville	do	8,003,626	14,596,873
	Alabama	4,165,452	
	Tennessee	1,533,175	
	Illinois	608,722	
	Virginia	244,597	
	Indiana	41,301	
Illinois Central	Illinois	9,369,083	13,928,062
	Kentucky	3,857,623	
	Indiana	591,310	
	Alabama	110,046	
Burlington	Illinois	8,513,708	12,693,706
	Wyoming	1,757,640	
	Iowa	1,268,384	
	Missouri	802,702	
	Colorado	346,361	
	Kansas	4,851	
Chicago & Eastern Illinois	Illinois	6,419,637	11,247,352
	Indiana	4,827,715	
Southern	Alabama	4,464,297	10,387,624
	Tennessee	2,284,261	
	Virginia	1,259,651	
	Illinois	1,113,299	
	Indiana	943,505	
	Kentucky	322,611	
Buffalo, Rochester & Pittsburgh	Pennsylvania	8,662,836	8,662,836
Wheeling & Lake Erie	Ohio	4,199,972	7,402,798
	Pennsylvania	3,202,826	
Frisco lines	Kansas	2,442,819	5,856,856
	Alabama	2,037,729	
	Arkansas	736,330	
	Oklahoma	377,218	
	Missouri	262,230	
	Colorado	500	
Union Pacific-Southern Pacific lines	Wyoming	4,736,707	5,666,477
	Colorado	320,803	
	Texas	294,985	
	Washington	165,321	
	Utah	91,447	
	Oregon	23,821	
	Kansas	15,982	
	California	14,864	
	Missouri	2,547	
Missouri Pacific	Illinois	2,775,998	5,574,884
	Kansas	1,182,705	
	Missouri	913,260	
	Arkansas	702,335	
	Colorado	586	
Santa Fe	New Mexico	1,638,802	4,627,137
	Kansas	1,452,546	
	Colorado	693,772	
	Illinois	437,009	
	Missouri	368,138	
	Oklahoma	36,870	
Denver & Rio Grande	Utah	2,435,663	4,460,332
	Colorado	1,905,772	
	Wyoming	112,237	
	New Mexico	6,660	

Shipments of bituminous coal in the United States, by railroads and waterways, in 1913—Continued.

Railroad.	State.	Quantity.	Total.
		Short tons.	
Western Maryland	West Virginia	2,839,356	3,914,683
	Maryland	1,053,002	
	Pennsylvania	22,325	
Rock Island lines	Iowa	1,410,235	3,896,778
	Oklahoma	1,197,226	
	Illinois	666,829	
	Arkansas	296,826	
	Missouri	185,281	
	Colorado	73,931	
	Texas	61,599	
	Kansas	4,851	
Chicago, Milwaukee & St. Paul	Illinois	1,551,666	3,890,030
	Iowa	1,334,907	
	Montana	928,295	
	Washington	72,710	
	North Dakota	2,452	
Northern Pacific	Washington	2,421,608	3,882,851
	Montana	1,194,245	
	North Dakota	154,761	
	Wyoming	112,237	
Wabash	Illinois	3,255,200	3,708,541
	Missouri	308,081	
	Iowa	126,060	
	Ohio	19,200	
Virginian	West Virginia	3,626,016	3,626,016
Cumberland & Pennsylvania	Maryland	3,366,521	3,366,521
Kanawha & Michigan	West Virginia	3,106,949	3,274,927
	Ohio	167,978	
Bessemer & Lake Erie	Pennsylvania	3,228,287	3,228,287
Missouri, Kansas & Texas	Oklahoma	1,398,868	2,865,353
	Kansas	997,467	
	Texas	314,384	
	Missouri	154,634	
Pittsburg, Shawmut & Northern	Pennsylvania	2,837,196	2,837,196
Colorado & Southern Railway lines	Colorado	2,612,040	2,780,576
	Wyoming	112,236	
	Texas	56,300	
Chicago & North Western line	Iowa	1,402,509	2,692,555
	Illinois	1,151,037	
	Wyoming	139,009	
Chicago & Alton	Illinois	2,554,444	2,663,875
	Missouri	109,431	
Chicago, Terre Haute & Southeastern	Indiana	2,492,248	2,492,248
Birmingham Southern	Alabama	2,185,750	2,185,750
Buffalo & Susquehanna	Pennsylvania	1,785,088	1,785,088
Carolina, Clinchfield & Ohio	Virginia	1,609,429	1,609,429
Erie	Pennsylvania	1,495,400	1,565,547
	Ohio	70,147	
Nashville, Chattanooga & St. Louis	Tennessee	1,289,906	1,302,406
	Alabama	12,500	
Mobile & Ohio	Illinois	838,414	1,295,795
	Alabama	457,381	
Minneapolis & St. Louis	Iowa	629,000	1,131,949
	Illinois	502,949	
Texas & Pacific	Texas	1,023,633	1,023,633
Great Northern Railway lines	Montana	898,508	959,828
	North Dakota	42,424	
	Washington	18,896	
Interstate	Virginia	933,290	933,290
Queen & Crescent	Tennessee	733,343	929,757
	Kentucky	104,836	
	Alabama	91,578	
Kansas City Southern	Kansas	785,691	902,235
	Missouri	70,905	
	Oklahoma	45,639	
Central of Georgia	Alabama	771,111	893,610
	Georgia	122,499	
Huntingdon & Broad Top Mountain	Pennsylvania	877,822	877,822
Pittsburgh, Chartiers & Youghiogheny	do	852,452	852,452
Monon	Indiana	839,282	839,282
Toledo, St. Louis & Western	Illinois	736,775	791,775
	Indiana	55,000	
St. Louis & O'Fallon	Illinois	790,563	790,563
Litchfield & Madison	do	785,517	785,517
Coal & Coke	West Virginia	776,898	776,898
St. Louis, Troy & Eastern	Illinois	773,493	773,493
Columbia & Puget Sound	Washington	744,002	744,002
El Paso & Southwestern	New Mexico	724,754	724,754
Chicago & Illinois Midland	Illinois	669,557	669,557
Kanawha, Glen Jean & Eastern	West Virginia	641,876	641,876

Shipments of bituminous coal in the United States, by railroads and waterways, in 1913—Continued.

Railroad.	State.	Quantity.	Total.
		Short tons.	
Cambria & Indiana	Pennsylvania	641,456	641,456
Ligonier Valley	do	622,084	622,084
Morgantown & Kingwood	West Virginia	551,413	551,413
East St. Louis & Suburban	Illinois	541,477	541,477
Missouri & Louisiana	Missouri	523,571	523,571
Chicago, Peoria & St. Louis Railway of Illinois	Illinois	522,556	522,556
Kentucky & Tennessee	Kentucky	512,088	512,088
Chicago Great Western	Iowa	455,733	470,771
	Missouri	10,187	
	Kansas	4,851	
Missouri, Oklahoma & Gulf	Oklahoma	432,175	432,175
Elgin, Joliet & Eastern	Illinois	431,890	431,890
Pere Marquette	Michigan	410,835	410,835
Midland Valley	Arkansas	300,560	390,984
	Oklahoma	90,424	
Peoria & Pekin Union	Illinois	387,812	387,812
International & Great Northern	Texas	368,112	368,112
Denver & Salt Lake	Colorado	315,235	315,235
East Broad Top Railroad & Coal Co	Pennsylvania	313,471	313,471
St. Louis, Rocky Mountain & Pacific	New Mexico	309,065	309,065
Illinois Traction system	Illinois	290,089	290,089
Union	Pennsylvania	284,447	284,447
Tennessee Central	Tennessee	277,136	277,136
St. Louis & Belleville Electric	Illinois	273,298	273,298
Colorado Midland	Colorado	273,279	273,279
Buffalo Creek & Gauley	West Virginia	271,916	271,916
Detroit, Toledo & Ironton	Ohio	269,325	269,325
Monongahela	Pennsylvania	251,288	251,288
Toledo, Peoria & Western	Illinois	234,315	234,315
Colorado & Wyoming	Colorado	211,666	211,666
Oklahoma Central	Oklahoma	205,719	205,719
Atlanta, Birmingham & Atlantic	Alabama	205,373	205,373
Cumberland	Kentucky	195,452	195,452
Marietta, Columbia & Cleveland	Ohio	193,700	193,700
Peoria Railway Terminal	Illinois	162,220	162,220
Kanawha & West Virginia	West Virginia	158,598	158,598
Pittsburgh & Susquehanna	Pennsylvania	156,851	156,851
Illinois Southern	Illinois	146,374	146,374
Denver and Intermountain	Colorado	142,953	142,953
Minneapolis, St. Paul & Sault Ste. Marie	North Dakota	136,603	136,603
West Virginia Northern	West Virginia	115,558	115,558
Evansville, Suburban & Newburgh	Indiana	108,296	108,296
Rio Grande Southern	Colorado	95,200	95,200
Seaboard Air Line	Alabama	90,468	90,468
St. Louis Southwestern	Texas	89,373	89,373
Fort Dodge, Des Moines & Southern	Iowa	87,438	87,438
Louisville, Henderson & St. Louis	Kentucky	82,476	82,476
Ashland Coal & Iron Co	do	81,704	81,704
Puget Sound Electric	Washington	78,036	78,036
Colorado & Southeastern	Colorado	77,308	77,308
St. Louis, Iron Mountain & Southern	Arkansas	76,689	76,689
Wichita Falls & Southern	Texas	76,223	76,223
Laramie, Hahn's Peak & Pacific	Colorado	61,355	61,355
San Antonio & Aransas Pass	Texas	41,985	41,985
Central Indiana	Indiana	31,644	31,644
Grand Trunk	Michigan	15,792	15,792
San Antonio, Uvalde & Gulf	Texas	14,984	14,984
Miscellaneous	Alabama	432,182	1,157,981
	Pennsylvania	244,808	
	Kentucky	85,842	
	Illinois	72,100	
	Ohio	63,315	
	Oklahoma	55,638	
	West Virginia	48,296	
	Virginia	41,885	
	Michigan	29,741	
	Missouri	26,118	
	Iowa	25,570	
	Washington	19,434	
	Kansas	4,851	
	Arkansas	4,618	
	Texas	2,000	
	Alaska	1,568	
	Nevada	15	
Total railroad shipments		392,470,769	392,470,769
Monongahela River	Pennsylvania	8,528,547	8,592,418
	West Virginia	63,871	

Shipments of bituminous coal in the United States, by railroads and waterways, in 1913—Continued.

Railroad.	State.	Quantity.	Total.
		Short tons.	
Kanawha River	West Virginia	1,018,019	1,018,019
Ohio River	Kentucky	398,155	803,773
	West Virginia	151,323	
	Pennsylvania	133,081	
	Ohio	96,012	
	Indiana	25,202	
Allegheny River	Pennsylvania	133,081	133,081
Kentucky River	West Virginia	50,291	50,291
Warrior River	Alabama	47,729	47,729
Illinois River	Illinois	27,791	27,791
Various waterways	Kentucky	9,424	17,732
	Oregon	7,761	
	Washington	547	
Total waterway shipments		10,690,834	10,690,834
Grand total		403,161,603	403,161,603

IMPORTS AND EXPORTS.

The following tables have been compiled from official returns to the Bureau of Foreign and Domestic Commerce of the Department of Commerce and show the imports and exports of coal from 1907 to 1912, inclusive. The values given in both cases are considerably higher than the average "spot" rates by which the values of the domestic production have been computed.

The exports consist of anthracite and bituminous coal, the quantity of bituminous being the greater in the last few years. They are made principally by rail over the international bridges and by lake and sea to the Canadian Provinces. Exports are also made by sea to the West Indies, to Central and South America, and elsewhere.

The imports are principally from Australia and British Columbia to San Francisco, from Great Britain to the Atlantic and Pacific coasts, and from Nova Scotia to Atlantic coast points.

The total exports of coal from the United States during 1913 were 22,141,143 long tons (equivalent to 24,798,080 short tons), valued at $67,209,514, compared with 18,148,767 long tons (equivalent to 20,326,619 short tons), valued at $56,242,896 in 1912. Of the exports in 1913, 4,154,386 long tons (4,652,912 short tons), valued at $21,759,850, were anthracite, and 17,986,757 long tons (20,145,168 short tons), valued at $45,449,664, were bituminous coal.

In 1912 the exports of anthracite were 3,688,789 long tons (4,131,443 short tons), and the quantity of bituminous coal exported was 14,459,978 long tons (16,195,175 short tons). The total exports in 1913 exceeded those of 1912 by 3,992,376 long tons (equivalent to 4,471,461 short tons) in quantity, and by $10,966,618 in value. The anthracite exports increased 465,597 long tons (521,469 short tons) in quantity, and $2,334,587 in value. The bituminous exports increased 3,526,779 long tons (3,949,992 short tons) in quantity, and $8,632,031 in value.

The imports of anthracite are unimportant, amounting to only 896 long tons in 1913 and averaging less than 4,000 tons for the last four years. The imports of bituminous coal and shale amounted to 1,412,997 long tons (equivalent to 1,582,557 short tons), valued at $3,853,930, against 1,605,873 long tons (1,798,578 short tons), valued at $4,509,066, in 1912. The imports in 1913 included 352,007 long tons (394,248 short tons) of slack or culm passing through a ½-inch screen, having a value of $689,864. This is used for making coke at Everett, near Boston, Mass. Most of the anthracite imported into the United States is to San Francisco and other points on the Pacific coast, and is brought in principally as ballast in vessels coming for outgoing cargoes. Compared with the domestic production, the total quantity of coal imported into the United States is of little consequence. The imports during the last three years have been less than 0.3 per cent of the production.

Coal of domestic production exported from the United States, 1909–1913, in long tons.

Year.	Anthracite.		Bituminous and shale.	
	Quantity.	Value.	Quantity.	Value.
1909	2,842,714	$14,141,468	9,693,843	$24,300,050
1910	3,021,627	14,785,387	10,784,239	26,685,405
1911	3,553,999	18,093,285	13,878,754	34,499,989
1912	3,688,789	19,425,263	14,459,978	36,817,633
1913	4,154,386	21,759,850	17,986,757	45,449,664

Coal imported and entered for consumption in the United States, 1909–1913, in long tons.

Year.	Anthracite.		Bituminous and shale.	
	Quantity.	Value.	Quantity.	Value.
1909	3,191	$12,918	1,274,903	$3,628,533
1910	8,196	42,244	1,986,258	4,761,223
1911	2,463	12,550	1,234,998	3,604,797
1912	1,670	8,329	[a] 1,605,873	4,509,066
1913	896	5,620	[a] 1,412,997	3,853,930

[a] Includes 455,587 long tons of slack or culm (value, $901,051) passing ½-inch screen in 1912 and 352,007 tons (value $689,864) in 1913.

Tariff.—The tariff from 1824 to 1843 was 6 cents per bushel, or $1.68 per long ton; from 1843 to 1846, $1.75 per ton; 1846 to 1857, 30 per cent ad valorem; 1857 to 1861, 24 per cent ad valorem; 1861, bituminous and shale, $1 per ton; all other, 50 cents per ton; 1862 to 1864, bituminous and shale, $1.10 per ton; all other, 60 cents per ton; 1864 to 1872, bituminous and shale, $1.25 per ton; all other, 40 cents per ton. By the act of 1872 the tariff on bituminous coal and shale was made 75 cents per ton, and so continued until the act of August, 1894, changed it to 40 cents per ton. On slack or culm the tariff was made 40 cents per ton by the act of 1872, was changed to 30 cents per ton by the act of March, 1883, and so continued until the act of August, 1894, changed it to 15 cents per ton. The tariff act of 1897 provided that all coals which contain less than 92 per cent fixed carbon and which will pass over a half-inch screen shall pay a duty of 67 cents per ton. Slack or culm was not changed by the act of 1897. Tons are all 2,240 pounds. Anthracite coal has been free of duty since 1870. During the period from June, 1854, to March, 1866, the reciprocity treaty was in force, and coal from the British possessions in North America was admitted into the United States duty free. A special act of Congress placed all the coal on the free list for one year from January 1, 1903, in order to relieve the shortage caused by the anthracite strike of 1902. Under the tariff act approved August 5, 1909, anthracite is practically excluded. It remained on the free list, but only as coal stores for American vessels, and could not be unloaded. The rate on bituminous coal was placed at 45 cents per long ton, and the rate on slack or culm was fixed at 15 cents per ton. Under the tariff act of October 3, 1913, all kinds of coal—anthracite, bituminous, culm, slack, and shale, coke and manufactured fuel in the form of briquets—were placed on the free list.

WORLD'S PRODUCTION OF COAL.

Since 1899, when the United States supplanted Great Britain as the leading coal-producing country of the world, this country's relative importance in that respect has steadily advanced. In the 14 years from 1899 to 1913 the coal production of the United States has increased from 253,741,192 short tons to 570,048,125 short tons, a gain of 316,306,933 tons, or nearly 125 per cent. The production in Great Britain during the same period has increased a little over 30 per cent, from 246,506,155 tons to 321,922,130 tons; Germany, which ranks third among the coal-producing countries of the world, has increased its production by a ratio (88 per cent) nearly three times that of Great Britain, from 149,719,766 tons in 1899 to 281,979,467 tons in 1912.[1] The combined production of Great Britain in 1913 and Germany in 1912 was 603,901,597 short tons, which exceeded that of the United States alone by less than 6 per cent. In 1913 the United States in the production of coal exceeded Great Britain by 248,125,995 short tons, or nearly 80 per cent, and Germany's production in 1912 by 288,068,658 tons, or more than 100 per cent.

The total production of all the European countries in 1913 (latest figures available used when statistics for 1913 are not at hand) amounted to about 772,000,000 tons, or about 35 per cent more than that of the United States alone. The total world's production was approximately 1,443,400,000 short tons, of which the United States contributed 39.5 per cent, Great Britain 22 per cent, and Germany 20 per cent. The United States in 1913 increased its production by over 35,000,000 tons, and Great Britain by 30,000,000 tons. In 1912 Germany came within 10,000,000 tons, or 3 per cent, of equaling Great Britain, but in 1913 Great Britain exceeded Germany's production in 1912 by nearly 40,000,000 tons.

The writer is indebted for the figures covering the production of coal in foreign countries, as shown in the following table, to Mr. William G. Gray, statistician of the American Iron and Steel Institute. Where the statistics for 1913 are not available, those for the year nearest 1913 for which they could be obtained are given. For the sake of convenience the quantities are expressed in the measurement customary in each country and are reduced for purposes of comparison to the short ton of 2,000 pounds.

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[1] The statistics of Germany's production in 1913 are not available as this report goes to press.

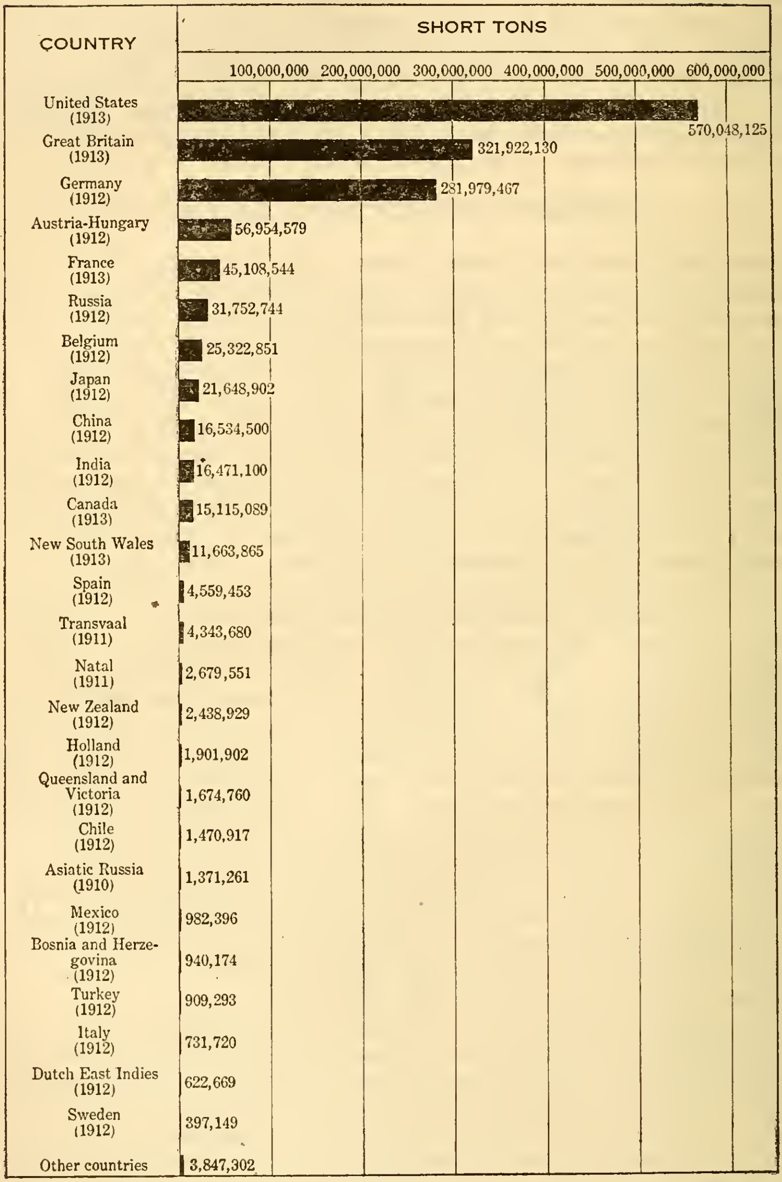

FIGURE 20.—World's production of coal.

The world's production of coal.

Countries.		Usual unit in producing country.	Equivalent in short tons.
United States (1913)	long tons	508,971,540	570,048,125
Great Britain (1913)	do	287,430,473	321,922,130
Germany (1912)	metric tons	235,810,094	281,979,467
Austria-Hungary (1912)	do	51,668,855	56,954,579
France (1913)	do	40,922,203	45,108,544
Russia (1912)	do	28,805,900	31,752,744
Belgium (1912)	do	22,972,740	25,322,851
Japan (1912)	do	19,639,755	21,648,902
China (1912)	do	15,000,000	16,534,500
India (1912)	long tons	14,706,339	16,471,100
Canada (1913)	short tons	15,115,089	15,115,089
New South Wales (1913)	long tons	10,414,165	11,663,865
Spain (1912)	metric tons	4,136,309	4,559,453
Transvaal (1911)	long tons	3,878,286	4,343,680
Natal (1911)	do	2,392,456	2,679,551
New Zealand (1912)	do	2,177,615	2,438,929
Holland (1912)	metric tons	1,725,394	1,901,902
Asiatic Russia (1910)	do	1,244,000	1,371,261
Chile (1912)	do	1,334,407	1,470,917
Queensland (1912)	long tons	902,166	1,010,426
Mexico (1912)	metric tons	891,224	982,396
Bosnia and Herzegovina (1912)	do	852,920	940,174
Turkey (1912)	do	824,905	909,293
Italy (1912)	do	663,812	731,720
Victoria (1912)	long tons	593,155	664,334
Dutch East Indies (1912)	metric tons	564,882	622,669
Orange Free State (Orange River Colony) (1911)	long tons	430,973	482,690
Indo-China (1912)	metric tons	427,523	471,259
Peru (1912)	do	278,927	307,461
Servia (1911)	do	304,359	335,495
Sweden (1912)	do	360,291	397,149
Western Australia (1912)	long tons	295,079	330,488
Formosa (1912)	metric tons	278,455	306,941
Bulgaria (1911)	do	245,314	270,410
Rhodesia (1911)	long tons	189,758	212,529
Roumania (1911)	metric tons	242,025	266,784
British Borneo (1910)	long tons	171,366	191,930
Korea (1911)	metric tons	123,668	136,319
Cape Colony (Cape of Good Hope) (1911)	long tons	79,485	89,023
Tasmania (1912)	do	53,560	59,987
Spitzbergen (1911)	metric tons	40,000	44,092
Brazil (1911)	do	15,000	16,535
Portugal (1912)	do	15,366	16,938
Venezuela (1908)	do	14,064	15,503
Switzerland (1911)	do	7,500	8,267
Philippine Islands (1912)	do	2,720	2,998
Greece (1910)	do	1,500	1,653
Unspecified	long tons	250,000	280,000
Total			1,443,393,052
Percentage of the United States			39.5

As a matter of historical interest the following table, giving the statistics of the production of coal in the more important countries of the world since 1870, is presented. In the 44 years covered by this table the percentage of the total contributed by the United States increased from less than 15 to nearly 40. The largest percentage credited to the United States was in 1913, when this country produced 39.49 per cent of the world's total.

World's production of coal, by countries, 1870–1913.

Year.	United States.		Great Britain.		Germany.	
	Long tons.	Short tons.	Long tons.	Short tons.	Metric tons.	Short tons.
1870	29,496,054	33,035,580	110,431,192	123,682,935	34,003,004	37,488,312
1880	63,822,830	71,481,570	146,969,409	164,605,738	59,118,035	65,177,634
1890	140,866,931	157,770,963	181,614,288	203,408,003	89,290,834	98,398,500
1900	240,789,310	269,684,027	225,181,300	252,203,056	149,551,000	164,805,202
1910	447,853,909	501,596,378	264,433,028	296,164,991	222,301,660	245,043,120
1911	443,188,505	496,371,126	271,891,899	304,518,927	234,259,061	258,223,763
1912	477,202,303	534,466,580	260,416,338	291,666,299	255,810,094	281,979,467
1913	508,971,540	570,048,125	287,430,473	321,922,130	....	....

Year.	Austria-Hungary.		France.		Belgium.	
	Metric tons.	Short tons.	Metric tons.	Short tons.	Metric tons.	Short tons.
1870	8,355,945	9,212,429	13,179,788	14,530,716	13,697,118	15,101,073
1880	14,800,000	16,317,000	19,361,564	21,346,124	16,886,698	18,617,585
1890	27,504,032	30,323,195	26,083,118	28,756,638	20,365,960	22,453,471
1900	39,029,729	43,010,761	33,404,298	36,811,536	23,462,817	25,856,024
1910	48,649,768	53,626,639	38,570,473	42,516,232	23,927,230	26,374,986
1911	49,859,655	54,960,298	39,229,591	43,242,778	23,053,540	25,411,917
1912	51,668,855	56,954,579	....	....	22,972,740	25,322,851
1913	51,668,855	56,954,579	40,922,203	45,108,544	22,972,740	25,322,851

Year.	Russia.		Japan.		Other countries.	Total.	Percentage of United States.
	Metric tons.	Short tons.	Metric tons.	Short tons.	Short tons.	Short tons.	
1870	667,806	735,922	....	....	1,063,121	234,850,088	14.07
1880	3,238,470	3,570,413	....	....	3,621,342	364,737,406	19.60
1890	6,016,525	6,633,219	2,653,000	2,923,606	13,025,637	563,693,232	27.99
1900	16,151,557	17,799,016	7,429,457	8,187,262	27,684,964	846,041,848	31.88
1910	22,650,000	24,967,095	15,681,324	17,285,523	71,445,828	1,279,020,792	39.22
1911	26,636,818	29,361,764	17,632,710	19,436,536	79,436,191	1,310,973,300	37.86
1912	28,805,900	31,752,744	19,639,755	21,648,902	[a] 82,934,740	[b] 1,369,968,940	39.00
1913	28,805,900	31,752,744	19,639,755	21,648,902	[a] 88,655,710	[b] 1,443,393,052	39.49

[a] For detailed statement see table on preceding page.
[b] Latest available figures are used in making up totals for 1913.

COAL-TRADE REVIEW.

It has been the practice in the preparation of the annual report on the production of coal to include reviews of the coal trade in some of the principal cities, and this custom has been followed in the present chapter. These reviews have been contributed chiefly by secretaries of chambers of commerce or other local authorities familiar with the coal trade of their respective communities. They will be found interesting, in that they reflect the conditions which have influenced the markets and the bearing they have had upon production. Acknowledgments of the services rendered is gratefully made and recognition by name is given for each contribution.

NEW YORK CITY.

By Frederick Hobart, associate editor of the Engineering and Mining Journal.

GENERAL CONDITIONS.

It can not be said that there were any marked changes apparent in the coal trade of New York City and vicinity during the year 1913. In the early part of the year business was active and demand reasonably good. Later on, especially in the last quarter of the year, there was a decided falling off, which was principally evident in bituminous coal and was due to a decreased demand from the manufacturing industries. There was also some falling off in the anthracite demand, due to the very mild weather which prevailed in November and December. It may be added that the latter decrease was more than made up during the very severe weather which marked the opening months of 1914. With regard to this weather demand, however, the difference between a mild and a cold month is not so great as might be supposed. So large a proportion of the so-called domestic coal supply in the city is consumed in the large buildings and apartment houses where fires are maintained and have to be maintained without much regard to the weather, that the difference in consumption is comparatively small. In fact, experts estimate that the actual change in consumption is not over 5 per cent, and certainly does not reach 10 per cent.

No material change can be reported in the methods of handling coal supply and deliveries in the city. As has before been noted in these reviews, rail coal coming to New York is delivered at the docks on the New Jersey side of the Hudson and is conveyed to the city mainly by barges and car floats. The facilities for handling at the railroad terminals are mainly good, but in the city, with the exception of a few large plants on the river front, they are rather slow and wasteful. The coal supply of New York costs its consumers more than it should, though it is difficult to see the way to any improvement. Complaint is made from time to time of the high cost of coal, but the expenses of unloading and delivering coal which are necessarily incurred by the distributers are so high that the profit in the trade is small. Even the large consumers, whose receipts amount to many tons daily, are unable to effect any considerable economies in this respect. Certainly no changes of any importance were made during the year under review.

All allowances for the causes of diminished consumption being made, it is estimated that the quantity of coal delivered in the New York district, which includes the city of New York and the immediate vicinity, was about 16,000,000 long tons, or rather less than in 1912. Of this quantity, 11,500,000 tons were anthracite[1] and 4,500,000 tons were bituminous coal. The quantity of bituminous consumed in the city is greater than is popularly supposed, for the reason that many large plants used a certain quantity of bituminous mixed with the small sizes of anthracite. The city ordinances forbid smoke, but this mixture can, with proper firing, usually be burned without any emission of black smoke. In addition to the coal consumed in the city, there is handled over the New York wharves yearly about 4,500,000 tons of bunker coal, or coal supplied to steamships, making a total of between 20,000,000 and 21,000,000 tons which comes to New York harbor yearly.

Although no exact statistics for the water movement are available, some 20 per cent of the total receipts are brought to New York Harbor

[1] According to confidential reports furnished the Geological Survey by courtesy of officials of the railroads entering New York harbor ports, the total receipts of anthracite at New York harbor in 1913 amounted to 13,935,347 tons, but no exact separation can be made of the quantities destined for local consumption and those forwarded to New England and elsewhere. After deducting Mr. Hobart's estimate of 11,500,000 tons as the consumption of New York and vicinity, it appears that the quantity transshipped was approximetely 2,500,000 long tons.

by barges and sailing vessels. The main sources of bituminous supply are the Clearfield, Irwin, and Somerset districts in Pennsylvania, the Cumberland in Maryland, and the Fairmont in West Virginia. The Pittsburgh district in Pennsylvania also furnishes some coal, which is mainly bunker coal. The supplies arriving by water are chiefly from the Pocahontas and New River districts of West Virginia.

New York is not a coal-exporting port, most of the foreign coal going from Hampton Roads, Baltimore, or Philadelphia. Nevertheless, there were shipped from New York Harbor for foreign ports in 1913 about 175,000 tons of anthracite, 25,000 tons of bituminous, and 30,000 tons of coke. That coke shipments should come to this port is rather remarkable, but it is so recorded in the returns to the Department of Commerce.

The trade of New York divides itself naturally into anthracite and bituminous, and can be best treated under those separate heads.

ANTHRACITE TRADE.

The year opened with trade in a somewhat disturbed condition owing to a heavy snowstorm which had fallen a few days before, and had seriously interrupted the movement of cars. The storm itself had caused an increased activity, whereas the supply was sharply curtailed and dealers were anxiously searching for coal. The flurry was only temporary, however, and the market quickly quieted down. The list prices on January 1, which continued generally in force during the first quarter of the year, were for domestic sizes f. o. b. New York Harbor ports, $5 per ton for broken, $5.25 for egg and stove, and $5.50 for nut. Steam sizes were quoted on the same basis at $3.50 for pea, $2.75 for buckwheat, $2.25 for No. 2 buckwheat or rice, and $1.75 for barley. During most of the rest of the month the market showed a fair degree of activity. A little shortage of nut coal developed toward the end of the month, but this was soon made up as a fair supply came forward. Some coal was sold at a small discount by speculators who had bought supplies earlier in anticipation of a shortage, but this had only a passing effect on the market.

During February colder weather produced a little better demand for domestic sizes; steam sizes were also in good demand, and the first of the month a little shortage of buckwheat was in evidence, and some premiums were paid for that size. This did not affect regular trade so much however, as the "independent" and washery steam coal, which generally brings from 10 cents to 15 cents a ton below the list prices. During all February weather conditions continued good for the trade, and a fair business was reported.

During March the anthracite trade was quiet and rather slow, dealers naturally buying no coal, except what was necessary to fill their current demands, in view of the near approach of April. Steam coal eased off a little, and quotations on the 1st of March were $3.50 a ton for pea, $2.50 to $2.75 for buckwheat, $2 to $2.25 for rice, and $1.60 to $2 for barley. The lower quotations were generally for independent coal. Buying continued slow all through the month, and there was some slacking down in work at the collieries.

On April 1 the general reduction of 50 cents a ton for the summer discounts was announced, and there was naturally a rush to buy, although this rush was not quite so great as usual, for the reason that many retailers had fair stocks on hand which they were anxious to dispose of before filling up their yards. Under the reduced schedule, broken coal was quoted at $4.50 a ton f. o. b. New York Harbor ports, egg and stove $4.75, and nut $5. The summer discounts do not apply to steam sizes, which remained about the same, with prices if anything a little firmer. Throughout the month of April the trade continued to improve, and the total for the month figured up quite satisfactorily; in fact, toward the end of the month it was difficult to fill orders promptly.

On May 1, according to custom, 10 cents was taken off the summer discounts, as usual, making list prices 10 cents a ton higher for the month. This did not much affect the demand, which continued steady for the greater part of the month, with no special incident to mark its course. There was a little spurt about the close of the month.

On June 1 another 10 cents was taken off the summer discounts. The trade continued fairly active, however, and was considered good for a summer month. The companies were a little slow in making deliveries, as the Lake trade had set in actively, and there was considerable shipment of anthracite to Lake ports. The trade continued through the month with very little change, and there was no special rush at its close to save the further advance to be made on July 1.

In July the main incident was the passage by the Pennsylvania legislature imposing a tax of 2½ per cent on all anthracite mined in the State. The companies, of course, demurred to this tax, and proposed to test its constitutionality. Meantime they made it evident that it was their intention to pass it on to the consumers; an addition of 25 cents a ton on all domestic sizes was made, the list price being unchanged while the tax was billed as a separate item, and this practice was continued. The announcement of the additional price caused a little excitement, but for the most part it was accepted as inevitable. Trade was rather quiet during August, after another 10 cents had been taken off the discount, but perhaps not more so than is usual at this season.

On September 1 the remaining 10 cents was removed from the discount and quotations returned to the former list prices per ton—$5 for broken, $5.25 for stove and egg, and $5.50 for chestnut, with, of course, the addition of the tax, which made the rate really 25 cents above the figures given. Steam sizes continued steady at $3.50 a ton for pea, $2.75 for buckwheat, $2.25 for rice, and $1.75 for barley, with a range of 10 to 15 cents below those prices for individual coal. The quantity of washery coal coming forward, has diminished so much that that class of coal does not affect the market. The market continued irregular and uncertain through the month, principally owing to the rather slack demand for steam sizes.

The same conditions continued well on into October, and in fact during the greater part of that month. Retailers had generally all the stocks they could carry and domestic demand was not heavy.

November opened with mild, almost summer weather, and domestic requirements continued small. By way of stimulating the market, a slight scarcity of stove and nut sizes developed about the middle of the month, but that soon passed over, and trade resumed its moderate course. The demand for steam coal was still rather light. Late in the month there was a short spell of cold weather, but it did not last long enough to stimulate the demand.

For the month of December, the story is soon told. The weather continued mild, no special demand developed, supplies continued abundant, and sales were on a moderate basis. There had been an absence of snow, so that transportation and car supply were good, and the year closed with an exceedingly quiet trade, although, as the event proved, cold weather and storms were soon to develop a considerable activity. Domestic sales were probably up to the average during the year, but sales of steam sizes were light, on the whole; that is, so far as the current market was concerned. So large a proportion of those sizes, however, are sold under contract, with the prices fixed early in the year, that current demand has only minor effect.

BITUMINOUS COAL MARKET.

In January the market opened actively with a good demand. Supplies were temporarily rather small, owing to the recent storm, and the consequent disturbance in car supply and the movement of trains to tidewater. West Virginia coal was, perhaps, in largest quantity on the market for the time being. The current quotations f. o. b. New York harbor ports were $3.15 to $3.25 a ton for West Virginia, $3.10 to $3.25 for ordinary Clearfield, and $3.30 to $3.40 for best Miller vein Pennsylvania steam coal. Gas coal was in rather light demand. The market continued fairly strong through January, although supplies improved. At the close of the month, West Virginia coal seemed to be in rather oversupply, and there was a slight break, concessions of 5 and 10 cents being made to close sales.

At the beginning of February the market was weaker, West Virginia being quoted at $2.90 to $2.95, ordinary Clearfield at the same figure, and Miller vein at $3 to $3.05. About the middle of the month the market seemed to be suffering from a surplus of coal, and there was a sharp fall in prices, West Virginia coal being quoted at $2.65 to $2.75, Clearfield at $2.75 to $2.85, and Miller vein at $3.05 to $3.15.

This weakness continued into March, and the market for the greater part of that month was reported easier at current prices, with a tendency to make small discounts to secure trade. During March the usual dickering over yearly contracts began with the advantage, apparently, on the side of consumers, who held out for low prices. Sellers were not inclined to concede these, and the closing of contracts proceeded very slowly. Perhaps the only notable point in the month's trade was the larger offering of West Virginia coal.

In April the trade was better as far as volume was concerned, but prices were low, West Virginia coal being offered at $2.55 to $2.60 and Clearfield at $2.65 to $2.70, whereas good Miller vein held better than other sorts, being still quoted at $3.05 to $3.15. Contracting was on a somewhat better scale, although sellers refused to make lower prices for the year. Some large firms seemed to be keeping out of the market altogether, preferring to trust to the risks of the open market rather than to keep themselves tied up by long contracts. As usual, there was later a difference of opinion as to the judiciousness of this course. Toward the end of the month there were reports of offering of low-grade coal at very cheap prices, but these seem to have been exaggerated, and they were not on a scale large enough to cause any serious disturbance.

In May the market opened a little heavy, but speedily stiffened up under a stronger demand. There was some call for spot lots, and when this was supplied business quieted down a little, but prices remained steady, and there was very little change from those quoted above. At the end of the month some demurrage coal, the first which made its appearance in any quantity during the year, was offered, at rather low prices, but this was soon disposed of.

In June, during the first half of the month, business was fairly good. Yearly contracts were out of the way for the most part, and the demand was sufficient to dispose of the current arrivals at tide-water. Prices at the opening of the month were $2.50 to $2.60 for West Virginia, $2.60 to $2.70 for ordinary Clearfield, and $3 to $3.10 for best Miller vein. For most of the month demand continued strong, and in some cases premiums of 5 cents a ton were paid for prompt deliveries. A feature of the month, or at any rate for the first half, was a heavy call for gas coal, which was temporarily rather scarce. Good arrivals, however, supplied this demand, and business resumed its usual course. Toward the end of the month the market grew firmer, partly on account of the West Virginia strikes and partly because of the diversion of coal to the West for the Lake trade, which set in well at this time.

The month of July opened with a good demand, and supplies were rather lighter on account of a shortage of labor and the disturbances in West Virginia. Some trouble also developed about car supply, and it was toward the middle of the month before this difficulty was adjusted. Trade continued good all through the month, and the market closed firm, with West Virginia quoted at $2.65 to $2.70, good Clearfield at $2.75 to $2.80, and best Miller vein at $3.10 to $3.20.

The market continued firm well into August, and prices were generally held, although a little irregularity was noted at one time. The tone of the market was, generally speaking, rather easier.

September marked the continuance of this easier tone, although sellers managed to hold prices fairly well. Demand, however, showed some falling off, which was not promising for the future. This was balanced by slow arrivals, due to a scarcity of cars in the mining region and consequent delay in shipments. A little improvement in this respect brought about an easier condition toward the end of the month.

In October supplies continued rather scarce, and gave an appearance of firmness, in spite of some moderation in the demand. It is noticeable that the rush to buy coal for the shoal-water ports before those ports are closed by ice was rather less than usual; in fact, it made no serious impression on the trade. Apparently those ports had laid in stocks which were considered sufficient in the regular course of trade, and did not feel the necessity of any special provision late in the season.

In November, slow movement, due to railroad congestion and labor troubles, made the market still firmer, this condition being helped by the unusual number of firms not under yearly contract. The first week in the month there was an advance in prices, West Virginia being quoted at $2.75 to $2.85, ordinary Clearfield at $2.85 to $2.95, and Miller vein at $3.15 to $3.25. During the rest of the month the market was much quieter, and some shading of prices was reported, the particulars of which were difficult to obtain.

In December the current demand was reported still slow. A strong effort was made to hold prices, but about the middle of the month a decline of at least 5 cents was noted, West Virginia being quoted at $2.65 to $2.75, good Clearfield at $2.70 to $2.80, and Miller vein at $3.05 to $3.20. A little later there was a still further decline, coal being offered to good buyers at fully 10 cents below quoted prices. Some demurrage coal also made its appearance at a discount of 15 cents to 20 cents a ton from the list prices. The market for the year closed upon the whole dull and weak, with not a very good prospect for the opening year. Supplies arriving were moderate only, but apparently sufficient for the demand.

COASTWISE TRADE.

The coastwise trade in 1913 was remarkably free from incident, and there were comparatively few changes in rates. An increasing share of the bituminous business was taken by the barges, which are either operated by the large companies or are under contract, and which already held most of the anthracite traffic. Chartering was slow and most of the sailing vessel business appeared to be done from Philadelphia, Baltimore, and Hampton Roads, New York taking only a moderate share of it. The vessel business, in fact, can not be made the subject of an extended review from this port, so much of it being done by barges or from other ports.

There was, as usual, a good deal of complaint of delays at the sound ports, the rail shipments from which are controlled by the New Haven road, which still seems to be firm in its policy of diverting as much as possible of the coal going to central and western New England to the all-rail lines and is not inclined to help out the water business. Otherwise, the trade has been without incidents of importance.

There is some speculation as to whether the opening of the Cape Cod Canal next year will have much influence on the trade. It is not likely that much difference will result; at least, that is the view of many coasting captains. The canal tolls will be higher than can be counterbalanced by the extra time necessary for the outside trip, and probably few coal-laden boats will take the canal, except in cases of emergency or of long continued stormy weather.

PHILADELPHIA, PA.

[From FREDERICK E. SAWARD's annual volume, The Coal Trade.]

The year 1913 was a time of contradictions in the Philadelphia coal trade. Weather conditions were remarkable, in that when business should have been brisk the thermometer stubbornly refused to lend its aid. Prices, despite this fact, held up very well, so much so that in both branches of the industry quotations were maintained on an extraordinary level, and not until the close of the year was there any appreciable decline.

In the anthracite trade the year opened with warm weather. The result was that both wholesale and retail business was rather dull. Premiums, which had been in vogue in the fall months of 1912, went out of fashion.

The first real day of winter came early in February, and throughout the rest of that month seasonal weather prevailed, resulting in the ready absorption and consumption of a normal production. The next month thrifty retailers began to look for bargains at April prices. The merchants were not disappointed, for wholesale prices broke badly in the early part of March and the general curtailment of winter production had to be resorted to to prevent the market from being flooded. The retail trade held its prices to the consumer fairly well, but began to anticipate spring orders in the latter part of the month at the April discount quotations.

The opening prices for April were: Wholesale at mines, broken, \$3; egg, \$3.25; stove, \$3.50; chestnut, \$3.65; pea, \$2.50. Retail, broken, \$6.50; egg, \$6.50; stove, \$6.75; nut, \$7; pea, \$5.50. Less 25 cents for cash.

Ten cents were added to the prices, except on that for pea, on the first of each succeeding month until the winter schedule was in force again.

Trade continued normal throughout the spring months. The wholesaler kept to the fore the bogie of the 1912 scarcity and so managed to turn out a fair production, slightly better, indeed, than would have been seen under ordinary conditions.

The fall was exceptionally mild, and until Christmas there was no evidence of real winter weather. Suspensions were necessary, therefore, in December. The retailer, early in December, advanced prices 25 cents a ton, making them: Egg, \$7; stove, \$7.25; chestnut, \$7.50; pea, \$5.50; with no discount for cash.

In the bituminous trade the year opened with prices at high tide. A boom had begun in November of 1912, and the quotations at the beginning of 1913 stood at \$1.75 to \$2.

The open winter was unusually favorable for production and freight movement. The consumer felt very comfortable and, even though there was a show of winter in February, prices fell gradually to \$1.40 to \$1.50 for good grades.

There was no wage scale to upset business, so conditions continued normal throughout the spring. In April contracts were closed at slightly higher prices than in 1912. The demand was good, with quotations at \$1.25 to \$1.35, for good grades; South Fork and other higher grades, \$1.50; cheap grades, \$1.10 to \$1.15.

As summer drew on, there was an acute need of getting men for the mines. July, August, and September saw an unusual demand, the mines working as full as possible, being hampered, however, by scarcity of labor and occasional car shortage. Labor troubles in the southern field stimulated the demand for Pennsylvania coal in New England. Prices for good grades were \$1.40 to \$1.50, and for cheaper grades, \$1.15 to \$1.25.

In the fall months the region obtained more men; cars were more plentiful, and the output greater than in the summer. Still, the trade absorbed the increased tonnage with very little easing off in prices.

Despite the summery December, conditions were fairly satisfactory in the last months of the year. Very little coal was sacrificed. The year closed with prices probably as low as at any time in 1913 for the cheaper grades—95 cents to \$1.05. It should be noted that throughout the year the better grades of coal held firm in price, which showed a profit over cost of production, while in 1912 the very best coal was sacrificed at times.

Mr. Frank L. Neall, manager Consolidated News, Statistics and Transportation Bureau, Philadelphia, reports that the coastwise shipments from Philadelphia in 1913 consisted of 1,396,271 long tons of anthracite and 1,901,109 tons of bituminous coal. The local consumption of anthracite in 1913, as reported by Mr. Neall, was 3,775,701 long tons, as compared with 3,774,987 tons in 1912. The exports amounted to 63,481 long tons of anthracite, valued at $292,922, and 915,145 tons of bituminous coal, valued at $2,603,915. The bulk of both the anthracite and the bituminous coal was exported to Cuba, that country taking 40,269 tons of anthracite, valued at $176,400, and 525,756 tons of bituminous coal, valued at $1,486,656.

The following table shows the freight rates from the mines to Philadelphia:

Freight rates per long ton on anthracite from coal regions to Philadelphia, Pa.

Region.	Prepared sizes.	Pea.	Buckwheat.
Schuylkill	$1.70	$1.40	$1.25
Lehigh	1.75	1.45	1.30
Wyoming	1.80	1.50	1.35

The average range of retail prices for anthracite and bituminous coal during the last two years, by months, has been as follows:

Average prices for anthracite and bituminous coal at Philadelphia in 1912 and 1913, by months, per long ton.

Month.	Chestnut.	Prepared sizes.	Pea.	Buckwheat.	Rice.	Bituminous.
January	$6.75–$7.00	$6.50–$7.00	$4.75	$3.35–$3.75	$2.75–$3.10	$3.75–$4.00
February	6.75– 7.00	6.50– 7.00	4.75	3.35– 3.75	2.75– 3.10	3.75– 4.00
March	7.00– 7.50	6.50– 7.00	$4.75– 5.00	3.50– 3.80	2.75– 3.25	3.75– 4.50
April	7.00– 7.50	6.75– 7.25	4.75– 5.00	3.50– 4.00	2.75– 3.25	3.75– 4.50
May	6.75– 7.00	6.50– 6.75	4.75– 5.00	3.30– 3.75	2.75– 3.10	3.50– 4.75
June	6.50– 6.75	6.50– 6.75	4.50– 4.75	3.25– 3.50	2.50– 3.00	3.00– 4.00
July	6.75– 6.85	6.50– 6.85	4.50– 4.75	3.25– 3.50	2.50– 3.00	3.00– 4.00
August	6.75– 6.95	6.50– 6.85	4.50– 4.75	3.20– 3.75	2.50– 3.10	3.00– 4.00
September	7.00– 7.25	6.25– 6.75	4.50– 4.75	3.35– 3.75	2.50– 3.10	3.25– 4.00
October	7.00– 7.25	6.50– 7.00	4.50– 4.85	3.35– 3.75	2.50– 3.10	3.25– 4.00
November	7.00– 7.25	6.50– 7.00	4.50– 4.85	3.35– 3.75	2.50– 3.10	3.40– 4.00
December	7.00– 7.25	6.50– 7.00	4.50– 4.85	3.35– 3.75	2.50– 3.10	3.50– 4.00

The price circular of the Philadelphia & Reading Coal & Iron Co., which is the same as that of other companies, and is for coal delivered on board vessels at Port Richmond, Philadelphia, for shipment beyond the capes of the Delaware, was as follows, subject to the usual discount of 50 cents a ton in April; 40 cents in May; 30 cents in June; 20 cents in July; and 10 cents in August:

Circular prices for anthracite delivered at Port Richmond, Philadelphia, in 1913, per long ton.

	Broken.	Egg.	Stove.	Chestnut.
Free white ash	$4.75	$5.00	$5.00	$5.25
Hard white ash	4.85	5.00	5.00	5.25
Shamokin	....	5.25	5.25	5.25
Schuylkill red ash	....	5.50	5.50	5.50
Lorberry	....	5.50	5.50	5.50
Lykens Valley	5.75	6.00	6.00	6.00

BOSTON, MASS.

By Robert S. Coffin, secretary of the committee on fuel supply, Boston Chamber of Commerce.

Receipts and shipments.—The receipts of coal at Boston during the year 1913 were the largest in the history of the port. There was an increase of more than half a million tons over the previous year. The aggregate receipts of anthracite and bituminous amounted to 7,115,-993 long tons, as against 6,578,017 long tons in 1912, an increase of 537,976 long tons. Of the receipts for 1913, 1,854,450 tons were anthracite, 4,991,884 tons were domestic bituminous coal, and 269,659 tons were foreign bituminous. This was an increase of 135,318 tons of anthracite and of 442,125 tons of domestic bituminous, but a decrease of 39,467 tons of foreign bituminous.

There was a good demand for all kinds of coal in the early part of the year, owing in part to activity in many lines of industry; on the other hand, there was an adequate supply of coal to fill the demand, a condition in strong contrast to the distressing shortage of 1912.

A considerable tonnage of the coal received at Boston is forwarded over the railroads to interior New England points. In 1913, 98,244 tons, or about 5 per cent, of the anthracite receipts and 1,073,832 tons, or about 20 per cent, of the bituminous coal received at Boston were reshipped to interior points. The net receipts, for local consumption, amounted to 1,756,206 tons of anthracite and 4,187,711 tons of bituminous coal.

The following table shows the receipts of both anthracite and bituminous coal at Boston, by months, for 1913, the quantity forwarded to interior points, the net receipts for local consumption, and the total for 1913 as compared with the totals for the three preceding years:

Receipts and shipments of coal at and from Boston in 1913, by months, in long tons.

1913	Receipts from all points.		Amount forwarded to New England points.		Net receipts (for local consumption).	
	Anthracite.	Bituminous.	Anthracite.	Bituminous.	Anthracite.	Bituminous.
	Tons.	*Tons.*	*Tons.*	*Tons.*	*Tons.*	*Tons.*
January	187,148	382,653	3,280	84,543	183,868	298,110
February	121,783	419,825	4,532	82,998	117,251	336,827
March	104,427	458,191	2,438	105,265	101,989	352,926
April	143,016	463,409	17,192	82,288	125,824	381,121
May	173,069	430,950	8,771	76,786	164,298	354,164
June	164,759	445,598	8,347	71,549	156,412	374,049
July	166,802	431,854	13,332	82,462	153,470	349,392
August	168,506	486,483	7,938	97,826	160,568	388,657
September	169,924	447,871	15,046	99,237	154,878	348,634
October	126,968	394,479	6,230	94,471	120,738	300,008
November	153,185	410,851	3,101	99,759	150,084	311,092
December	174,863	489,379	8,037	96,648	166,826	392,731
Total, 1913	1,854,450	5,261,543	98,244	1,073,832	1,756,206	4,187,711
1912	1,719,132	4,858,885	142,407	1,179,491	1,576,725	3,679,394
1911	1,982,940	4,435,091	246,610	1,235,228	1,736,330	3,199,863
1910	1,826,164	4,403,858	241,641	743,635	1,584,523	3,660,223

The following table shows the receipts of domestic and foreign coal at the port of Boston for a period of 10 years, in long tons.

The only receipts of foreign coal, as usual, were from the bituminous mines of the Dominion Coal Co., Cape Breton, practically the entire tonnage of which was consigned to the by-product coking plant at Everett, a suburb of Boston.

Receipts of coal at Boston, Mass., in 1904–1913, in long tons.

Year.	Domestic.				Foreign.	Total.
	By water.		By rail.			
	Anthracite.	Bituminous.	Anthracite.	Bituminous.	Bituminous.	
1904	1,961,785	2,397,885	40,994	117,605	550,383	5,068,652
1905	1,941,478	2,757,186	35,920	41,104	608,471	5,384,159
1906	1,630,674	2,772,593	29,005	87,251	658,072	5,177,595
1907	2,016,252	3,196,057	37,036	89,927	545,652	5,884,924
1908	1,733,112	3,240,562	43,289	62,367	370,709	5,450,039
1909	1,668,126	3,393,423	38,533	101,588	228,297	5,429,967
1910	1,760,883	3,954,251	65,281	153,043	296,564	6,230,022
1911	1,881,767	4,101,745	101,173	69,485	263,861	6,418,031
1912	1,554,156	4,475,520	164,976	74,239	309,126	6,578,017
1913	1,676,311	4,944,687	178,139	47,197	269,659	7,115,993

Anthracite.—The retail prices of anthracite in 1913 were lower than in 1912, but somewhat higher than normal. The increased cost of labor in the handling and distribution of coal makes it unlikely that the lower prices of a few years ago will again be reached. Within the last two years local coal companies have made advances in wages to their employees amounting to approximately $2 a week, and other expenses have increased in like proportion.

The first reduction from the abnormally high winter prices was made February 1, when a reduction of 25 cents a ton was made on all sizes. The summer prices went into effect on the usual date, April 1, when all sizes were reduced 75 cents a ton, with the exception of nut coal, which was reduced 50 cents a ton. This was 25 cents a ton lower than the summer prices of 1912. On July 1 the prices on all sizes were advanced 25 cents a ton, and two further advances of 25 cents each were made on August 2 and October 2.

Retail prices, per short ton, of anthracite at Boston in 1913, by kinds.

Kind.	Feb. 1.	Apr. 1.	July 1.	Aug. 2.	Oct. 2.
Furnace	$7.25	$6.50	$6.75	$7.00	$7.25
Egg	7.75	7.00	7.25	7.50	7.75
Stove	8.00	7.25	7.50	7.75	8.00
Nut	8.00	7.50	7.75	8.00	8.25
Pea	6.25	5.50	5.75	6.00	6.25
Shamokin	8.25	7.50	7.75	8.00	8.25
Franklin	9.25	8.50	8.75	9.00	9.25

Coastwise freight rates.—The coastwise freight rates in 1913 were slightly higher than normal. There was decidedly less fluctuation in 1913 than for several years. The volume of coal carried to Boston in sailing vessels has steadily decreased, while the tonnage carried in steam colliers has steadily increased. Coal steamers almost exclusively are on Government form, which calls for a per diem charge rather than a rate per ton, and it is, therefore, difficult to make comparisons in rates. On the other hand, most sailing vessels in the trade are taken on season charters at a reasonable rate through several months, if not for the entire year. All this tends to make rates steadier. Most of the coal shipped to New England came in steamers and other vessels under contract, and the current demand was light throughout the year.

From Hampton Roads the minimum rate in 1913 was 70 cents a ton and the maximum rate was $1 a ton, as compared with rates ranging from 60 cents to $1.50 a ton in 1912; the rates from Philadelphia in 1913 ranged from 70 cents to $1.25, as compared with rates ranging from 75 cents to $1.25 in 1912; from Baltimore the rates in 1913 ranged from 75 cents to $1.10 a ton, as against 75 cents to $1.25 a ton in 1912. In general, freights were on a basis of 70 cents to 75 cents a ton to Boston. A number of season charters were closed at these rates, and it was the exception when a schooner or barge got a higher freight after March 1. During the latter part of the year there was a surplus of steam, sail, and barge transportation.

Coal freights to Boston during 1912 and 1913.

From—	Minimum.		Maximum.	
	Rate.	Date.	Rate.	Date.
1912.				
New York	[a] $0.50-$0.55		$1.25	Mar. 15-Apr. 15.
Philadelphia	.65	May 20-June 15	1.30	Feb. 26.
Baltimore	.75	June 25	1.25	Feb. 13.
Norfolk and Newport News	.60	June 20	1.50	Mar. 16.
1913.				
New York	[a] $0.50-$0.55		$1.25	Jan. 30.
Philadelphia	[b] .70- .80	Mar. 15-Nov. 1	1.25	Jan. 15-Jan. 30.
Baltimore	[b] .75	June 1-Aug. 1	1.10	Jan. 15.
Norfolk and Newport News	[b] .70- .75	June 15-Sept. 1	1.00	Jan. 1-Mar. 1.

[a] 50 to 55 cents was season rate on anthracite coal-carrying railroad transportation from New York and 75 cents from Philadelphia. 70 cents was the minimum rate on sail (sailing vessels) tonnage from New York to Boston.

[b] These rates apply to sail tonnage. Large number of season charters—that is, for 8 to 10 to 12 trips at 70 to 75 cents, most of the sail transportation being closed on that basis rather than from trip to trip as in former years.

BALTIMORE, MD.

By Samuel G. Wilmer, financial editor of the Manufacturers' Record.

There was a considerable increase in the coal trade at the port of Baltimore during the year 1913 as compared with 1912. Business once more took an upward turn and the combined gross receipts of bituminous coal and anthracite displayed an advance of about 6½ per cent in volume. There were no serious labor conditions to affect business as there were in 1912, when, owing to troubles in the mining regions, receipts were restricted and trading was generally unsatisfactory notwithstanding good prices. In 1913 prices continued fair for bituminous and the local business was large, being, according to the expressed opinion of an authority, the greatest in the history of the coal trade. Prices declined in the latter part of the year in spite of some strikes at mines, the drop being due to pressing coal for sale upon purchasers already supplied, shipments being pushed forward from stock of fuel previously accumulated.

Receipts of bituminous coal amounted to 5,842,437 long tons, or 220,172 tons (nearly 4 per cent) more than in 1912. Receipts of anthracite were 1,039,965 long tons, or 198,360 tons (over 22 per cent) more than in 1912. Receipts of coke also went up, and heavily, their increase being 207,103 short tons in a total of 345,898 tons, or nearly 150 per cent over the previous year. This gain was in the main due to enlarged purchases of coke by the Maryland Steel Co., which also makes much of the coke it uses in by-product ovens at its steel plant. Alterations in the coking plant which were begun in the latter part of the year made larger purchases necessary.

In fact, all the statistics of Baltimore's coal trade for 1913 are marked by increases, except in the single matter of anthracite exports, which were almost nothing, for not a pound of anthracite was exported in the last half of 1913, and little was sent out in the first half. Coastwise shipments of bituminous coal amounted to 3,655,796 tons, an increase of 38,514 tons, and similar shipments of anthracite were 261,316 tons, or 44,174 tons more than in 1912. Hence the coastwise shipments of both aggregated 3,917,112 tons, or 82,688 tons more than the total of 1912. Exports of bituminous coal were 870,651 tons, an increase of 242,129 tons, and exports of anthracite were only 2,662 tons. Coke exports were 63,377 tons, an increase of 8,763 tons.

Of anthracite it may be said that prices are always firm. This fuel is used in Baltimore almost exclusively for domestic purposes, and, owing to the warm winter of 1912–13, the consumption was smaller than usual; the mild temperature during January broke the record for many years. The quantity of anthracite consumed at industrial plants is practically nothing. There has, however, been a little increase in the use of very small hard coal for heating in apartment houses and, in one or two instances, in private dwellings. Furnaces with grates adapted to burning the buckwheat size of anthracite have been installed and, it is understood, with satisfactory results, but there is small probability of any large increase in its use. In this market bituminous coal, by reason of its lower price, as well as on account of its better steaming quality, commonly takes precedence over the very small hard coal for heating apartment houses, office buildings, and other large edifices. Generally the anthracite trade was without particular feature, and receipts were normal.

In the accompanying tables the receipts and shipments of both bituminous and anthracite coal are shown and included are the coal and coke used at the extensive works of the Maryland Steel Co. at Sparrows Point, and at the plant of the Central Foundry Co. at Dundalk, both plants being near Baltimore and always included in any estimate of the local coal business, as their purchases are practically part of it.

Receipts and shipments of coal and coke at Baltimore, Md., 1912–13, in long tons.

Kind.	1912			1913		
	Receipts.	Tidewater shipments.		Receipts.	Tidewater shipments.	
		Coastwise.	Exports.		Coastwise.	Exports.
Bituminous	5,622,265	[a] 3,617,282	628,522	5,842,437	[a] 3,655,796	870,651
Anthracite	841,605	217,142	3,876	1,039,965	[a] 261,316	2,662
Total	6,463,870	3,834,424	632,398	6,882,402	3,917,112	873,313
Coke (short tons)	138,795	....	54,614	345,898	....	63,377

[a] Includes shipments to points on Chesapeake Bay and in Baltimore Harbor.

Coastwise shipments of coal from Baltimore, 1903–1913, in long tons.

Year.	Anthracite.	Bituminous.	Total.
1903			1,731,896
1904	238,728	2,064,060	2,302,788
1905	252,568	2,832,321	3,084,889
1906	238,162	3,176,710	3,414,872
1907	266,062	3,804,066	4,070,128
1908	251,739	3,704,851	3,956,590
1909	235,233	3,344,225	3,579,458
1910	272,695	3,891,018	4,163,713
1911	276,766	4,135,893	4,412,659
1912	217,142	3,617,282	3,834,424
1913	261,316	3,655,796	3,917,112

It will be observed that the increase in export of bituminous coal was again large as compared with that of 1912, and there was also an increase in coke export, although it was comparatively small. The following table displays the exports of these fuels month by month during 1913 and also for the entire year, together with the total for each twelvemonth during the preceding eight years.

Exports of bituminous coal and coke from Baltimore in 1913, by months, in long tons.

Month.	Coal.	Coke.
January	82,194	458
February	66,106	3,116
March	69,799	558
April	90,630	10,396
May	88,138	9,144
June	110,091	3,978
July	82,869	2,919
August	38,385	11,590
September	45,403	10,326
October	60,465	3,592
November	60,873	6,934
December	75,798	366
Total, 1913	870,651	63,377
1912	628,522	54,614
1911	479,096	98,285
1910	493,416	46,847
1909	332,016	50,446
1908	347,489	105,317
1907	559,880	77,822
1906	458,203	69,230
1905	341,107	32,954

The following statements exhibit the receipts of bituminous coal and coke at the respective plants of the two large industries previously named herein:

Maryland Steel Co.—Bituminous coal consumed at the plant of the Maryland Steel Co. in 1913 amounted to 518,130 long tons. In its own ovens the company manufactured 206,582 short tons of coke and it also bought 191,740 tons, all of which was used in its manufacturing processes. In 1912 it used 558,985 tons of bituminous coal and made in its ovens 262,832 tons of coke, besides buying 47,720 tons of the latter.

Central Foundry Co.—At the plant of the Central Foundry Co. during 1913 there were consumed 2,836 long tons of bituminous coal and 3,185 short tons of coke. In 1912 the consumption of these fuels was 2,890 tons of bituminous coal and 2,647 tons of coke.

In the preparation of the figures used in this article these two manufacturing companies and the Baltimore & Ohio, the Pennsylvania, and the Western Maryland railroad companies furnished hearty and courteous assistance, which is hereby acknowledged.

NORFOLK AND NEWPORT NEWS, VA.

The well-known steam and "smokeless" coals mined in the southern part of West Virginia and in the southwestern counties of Virginia reach tidewater at the mouth of Chesapeake Bay over the Chesapeake & Ohio Railway to Newport News, the Norfolk & Western Railway to Lambert Point, and the Virginian Railway to Sewall Point, the last two being on the south side of Hampton Roads, near Norfolk, and the Chesapeake & Ohio terminals being on the north side of "The Roads." The three terminals make this harbor second only to New York as a coal-handling port.

The quantity of coal, entirely bituminous, handled at the Hampton Roads ports in 1913 was about 150,000 long tons less than in 1912, when the high record of 11,850,706 long tons was made. All of the decrease was in bunker coal, which fell off from 1,659,603 tons in 1912 to 1,391,088 tons in 1913. This trade had been abnormally large in 1912, with an increase of nearly 538,000 tons over 1911. The bunker trade in 1913 showed a normal increase over two years before. Shipments over the Norfolk & Western Railway to Lambert Point increased from 4,980,984 long tons in 1912 to 5,410,060 tons in 1913, and those over the Virginian Railway to Sewall Point from 2,474,052 tons to 3,283,926 tons. Shipments over the Chesapeake & Ohio Railway to Newport News decreased, probably on account of the labor troubles in the Kanawha field, from 4,395,670 tons to 3,012,356 tons.

For the figures included in the following table the writer is indebted to the following officials, namely: Messrs. Joseph W. Coxe, comptroller, Norfolk & Western Railway, at Roanoke, Va.; W. A. Young, superintendent coal terminals, Virginian Railway, at Sewall Point, Norfolk, Va., and E. D. Hotchkiss, general freight agent, Chesapeake & Ohio Railway, at Richmond, Va.

The coal receipts at Hampton Roads in 1912 and 1913 are shown in the following table:

Coal receipts at Hampton Roads in 1912 and 1913, in long tons.

Destination.	Norfolk & Western Ry.	Chesapeake & Ohio Ry.	Virginian Ry.	Total.
1912.				
Coastwise	3,186,956	2,637,000	1,842,490	7,666,446
Export	1,193,711	917,514	254,476	2,365,701
Bunker	600,317	682,200	377,086	1,659,603
Local		158,956		158,956
Total	4,980,984	4,395,670	2,474,052	11,850,706
1913.				
Coastwise and local	3,407,592	1,714,691	2,683,271	7,811,554
Export	1,362,639	911,368	235,873	2,503,880
Bunker	639,829	386,477	364,782	1,391,088
Total	5,410,060	3,012,536	3,283,926	11,706,522

The monthly shipments over the Virginian Railway in 1913, as reported by Mr. Young, were as follows:

Statement of coal dumped over Sewall Point Pier, 1913, by months, in long tons.

Month.	Coastwise.	Export.	Bunker.	Total.
January	180,345	48,339	31,859	260,543
February	202,945	26,673	28,565	258,183
March	215,860	17,413	28,190	261,463
April	209,828	15,713	23,684	249,225
May	215,078	29,796	36,663	281,537
June	182,816	34,831	37,111	254,758
July	183,410	12,618	25,036	221,064
August	247,100	10,557	25,728	283,385
September	265,935	7,909	26,744	300,588
October	254,740	9,887	40,152	304,779
November	298,445	9,366	32,958	340,769
December	226,769	12,771	28,092	267,632
Total	2,683,271	235,873	364,782	3,283,926

The shipments over the Norfolk & Western Railway to Lambert Point piers, as reported by Mr. Coxe, were as follows:

Statement of coal dumped over Lambert Point piers, 1913, by months, in long tons.

Month.	Coastwise.	Export.	Bunker.	Total.
January	276,804	128,627	63,980	469,411
February	303,274	108,337	50,590	462,201
March	294,994	106,585	51,870	453,449
April	293,880	131,936	50,895	476,711
May	306,041	130,043	54,212	490,296
June	235,110	158,480	51,971	445,561
July	287,290	139,074	59,461	485,825
August	329,565	89,729	47,727	467,021
September	264,173	96,307	41,825	402,305
October	278,706	94,022	59,360	432,088
November	240,735	44,780	47,229	332,744
December	297,020	134,719	60,709	492,448
Total	3,407,592	1,362,639	639,829	5,410,060

The monthly shipments of coal over the Chesapeake & Ohio Railway in 1913, at Newport News, as reported by Mr. Hotchkiss, were as follows:

Shipments of coal to Newport News, 1913, by months, in long tons.

Month.	Coastwise and export.	Bunker.	Total.
January	181,972	38,018	219,990
February	237,138	35,976	273,114
March	246,262	25,303	271,565
April	260,603	36,476	297,079
May	255,132	31,968	287,100
June	212,785	36,775	249,560
July	162,601	35,460	198,061
August	251,281	26,386	277,667
September	223,790	31,754	255,544
October	194,981	27,827	222,808
November	168,504	29,328	197,832
December	231,010	31,206	262,216
Total	2,626,059	386,477	3,012,536

The total shipments from Virginia and southern West Virginia coal mines to Hampton Roads during the last five years have been as follows:

Shipments of coal to Hampton Roads, 1909–1913, in long tons.

Year.	Norfolk & Western Ry. to Lambert Point.	Chesapeake & Ohio Ry. to Newport News.	Virginian Ry. to Sewall Point.
1909	3,228,854	4,985,426	241,644
1910	4,040,649	4,409,848	1,147,077
1911	3,923,098	4,390,554	2,012,483
1912	4,980,984	4,395,670	2,474,052
1913	5,410,060	3,012,536	3,283,926

PITTSBURGH, PA.

The city of Pittsburgh, with a population in 1913 estimated at less than 550,000 persons, consumes nearly as much coal as Greater New York, with a population of approximately 5,000,000. If to the coal is added the coke, without including the natural gas used, Pittsburgh's consumption of fuel largely exceeds that of the great metropolis. No accurate data regarding the annual consumption of coal in New York are available, but it is estimated that the consumption, including the boroughs of Richmond, Queens, and The Bronx, is between 18,000,000 and 20,000,000 short tons of coal annually. From statistics compiled by the Geological Survey the consumption of coal alone in the city of Pittsburgh in 1913 was 18,538,676 short tons. If to this is added 5,000,000 tons of coke consumed in the Pittsburgh district, the total consumption of the solid mineral fuel was about 23,500,000 short tons, or 10 per cent more than all the boroughs of Greater New York together. The total coal business of Pittsburgh in 1913, local consumption and the shipments to points east and west included, was almost exactly 64,300,000 short tons. The coke used and handled in the district was approximately 15,000,000 tons, making a total of about 79,000,000 tons of solid fuel. The total quantity of coal sent to New York Harbor ports for local consumption, for bunker trade, and for transshipment is between 35,000,000 and 40,000,000 short tons, from which it appears that the total quantity of coal handled in Pittsburgh is about twice as much as that sent to New York Harbor ports. The quantity of coal shipped to the Pittsburgh district in 1913 was 18,538,676 short tons, an increase of 816,893 tons over 1912. The shipments from the Pittsburgh district to points west of Pittsburgh was 28,633,569 short tons, an increase of 2,554,218 tons. The total quantity of coal shipped by rail and water to the Pittsburgh district and through Pittsburgh to points west in 1913 was 47,172,245 short tons against 43,801,134 tons in 1912. The shipments to Pittsburgh by rail in 1913 were 8,203,091 short tons and by slack-water navigation 10,335,585 tons. The shipments to points west of Pittsburgh by rail were 26,044,234 short tons and by water 2,589,335 tons. The shipments from the Pittsburgh district to eastern points, which go all rail and do not pass through the city, amounted in 1913 to 17,127,692 short tons, against 15,349,045 tons in 1912.

The shipments of coke to Pittsburgh in 1913 were 5,071,509 short tons (against 4,962,207 tons in 1912); to points west of Pittsburgh, 5,422,164 short tons (against 5,684,566 tons in 1912); and from the Pittsburgh district to eastern points, 3,304,980 short tons (against 3,294,656 tons in 1912).

The author is indebted to Lieut. Col. Francis R. Shunk, Corps of Engineers, U. S. Army, for the statement of the movement of coal through the locks of Monongahela River and at Davis Island Dam, and to the following railroad officials for the rail shipments from which the foregoing figures and the following table have been compiled: Messrs. R. H. Large, general coal freight agent, Pennsylvania Railroad Co., Philadelphia; W. L. Cromlish, coal and coke agent, Baltimore & Ohio Railroad, Pittsburgh; J. C. Venning, general ore and coal agent, Pennsylvania lines west of Pittsburgh; J. B. Nessle, general freight agent, Pittsburgh & Lake Erie Railroad, Pittsburgh; J. B. Safford, superintendent, Pittsburgh, Chartiers & Youghiogheny Railway, Pittsburgh; S. B. Woodside, general freight agent, Wabash-Pittsburgh Terminal & Westside Belt Railway, Pittsburgh.

The rail and water shipments to and from the Pittsburgh district during the last six years have been as follows:

Movement of coal to and through Pittsburgh, 1908–1913, in short tons, showing totals by rail and water.

Destination.	1908	1909	1910	1911	1912	1913
By rail:						
To Pittsburgh district	3,494,905	4,654,249	6,139,959	5,142,412	7,778,450	8,203,091
To west of Pittsburgh	18,970,848	18,981,995	[a]22,683,276	[a]22,474,289	24,086,001	26,044,234
Total by rail	22,465,753	23,636,244	28,823,235	27,616,701	31,864,451	34,247,325
By Monongahela River locks:						
To Pittsburgh district	6,435,851	9,737,505	9,460,695	9,207,232	9,943,333	10,335,585
To west of Pittsburgh	1,742,339	2,463,385	1,770,305	2,816,975	1,993,350	2,589,335
Total by water	8,178,190	12,200,890	11,231,000	12,024,207	11,936,683	12,924,920
Total shipments	30,643,943	35,837,134	40,054,235	39,640,908	43,801,134	47,142,245

[a] Includes a small quantity of coal sent to Lake Erie points.

Movement of coal to and through Pittsburgh, 1908–1913, in short tons, showing totals to Pittsburgh district and west of Pittsburgh.

Destination.	1908	1909	1910	1911	1912	1913
To Pittsburgh district:						
By rail	3,494,905	4,654,249	6,139,959	5,142,412	7,778,450	8,203,091
By water	6,435,851	9,737,505	9,460,695	9,207,232	9,943,333	10,335,585
Total to Pittsburgh district	9,930,756	14,391,754	15,600,654	14,349,644	17,721,783	18,538,676
To west of Pittsburgh:						
By rail	18,970,848	18,981,995	22,683,276	22,474,289	24,086,001	26,044,234
By water	1,742,339	2,463,385	1,770,305	2,816,975	1,993,350	2,589,335
Total to west of Pittsburgh	20,713,187	21,445,380	24,453,581	25,291,264	26,079,351	28,633,569
Total shipments to Pittsburgh and points west	30,643,943	35,837,134	40,054,235	39,640,908	43,801,134	47,172,245
Shipments, all rail, to points east of Pittsburgh	11,666,160	11,300,162	10,781,544	13,169,866	15,349,045	17,127,692

BUFFALO, N. Y.

By JOHN W. CHAMBERLIN, trade journal correspondent.

There was a decided increase in practically all branches of the Buffalo coal trade during the first part of 1913, though as the close of the year approached it was seen that the movement was in great part artificial. The spectacle of heavy shipments of both anthracite and bituminous during the hot months, when the movement is commonly light, so inspired the operators, jobbers, and shipping agents that they called for cars between the mines and the city often far beyond the capacity of the railroads to supply them.

The consumer appeared to enter fully into the craze and readily paid the full circular prices for bituminous coal and coke as well as for anthracite. There was often a dollar or more premium paid for "independent" anthracite, which trade was and still is more active than formerly. As the fall season came on, when the trade should increase, it declined and continued to do so until the end of the year, leaving every member of the trade wondering at the odd reversal.

The increase of anthracite shipments by Lake from this port, from 3,665,717 long tons in 1912 to 4,657,331 tons in 1913, is a fair indication of the movement. These are the only figures to be had that are strictly dependable, those furnished by the customhouse being mostly cargo estimates. On this basis it is safe to estimate that the anthracite movement to the city increased 1,000,000 tons over 1912, and that of bituminous coal, 500,000 tons, which makes, speaking moderately, a total of 8,500,000 tons of bituminous and 8,000,000 tons of anthracite. City consumption does not exceed 450,000 tons of anthracite and something like half of the bituminous coal received, the rest going east, north, and west (bituminous) by rail, and north and west (anthracite) by Lake and rail.

It is easy to predict that the movement of both anthracite and bituminous coal in this direction in 1914 will be considerably less than it was in 1913. In fact, there has since the opening of 1914 been every evidence of a heavy overstock of both in practically every locality that depends on this market for its coal, besides which the local consumption, at least of bituminous coal, has fallen off pretty generally and is not likely to recover within the current year.

At the same time the importance of Buffalo as a sales and reshipping center continues in spite of dull trade, though the territory covered has not materially enlarged. The enlargement of the Welland Canal, on which work has already begun, will modify sales somewhat, but in what direction or amount is not to be stated now.

Though not in a mining State, Buffalo has 10 firms engaged in mining bituminous coal, which last year produced 6,525,000 tons of coal, 9 of the operations being in the Allegheny Valley and vicinity, in Pennsylvania, and 1 in Iowa. There is a general effort to increase this output from year to year, but only the Shawmut company gives promise of material progress, it having outlined an extensive new district adjacent to one opened a short time ago.

Transportation and handling facilities remain unchanged, with the exception of a second car ferry across Lake Ontario from Charlotte, to be built this year. Other new car-ferry projects on Lakes Erie and Ontario have not materialized.

The increase in exports to Canada continues, as shown by the following table, though the Canadian trade at the close of 1913 and since has been exceedingly dull.

Export of coal and coke from Buffalo to Canada, 1907–1913, in long tons.

Year.	Anthracite.	Bituminous.	Coke.	Total.
1907	809,192	2,036,914	204,821	3,050,947
1908	786,063	1,726,332	213,712	2,726,107
1909	800,741	1,748,759	350,085	2,899,585
1910	931,378	2,014,762	420,805	3,366,945
1911	1,695,035	2,620,727	416,069	4,231,831
1912	1,234,564	2,609,702	423,524	4,267,790
1913	1,615,176	2,906,682	475,417	4,997,275

There was no change in rail freights during the year, and the trade is somewhat unsettled on account of it, as the idea prevails that the general changes contemplated are not to include coal rates. The rates to Buffalo for 1913 were $2 from the anthracite mines, $1.25 for bituminous coal from the Pittsburgh district, $1.10 from the Allegheny Valley, $1.85 for Connellsville coke, and $1.75 by rail from Buffalo to Chicago. The Lake rate, for a long time 40 cents to leading Lake Michigan ports and 30 cents to Lake Superior, has in 1914 been made 30 cents generally, except to minor ports.

CINCINNATI, OHIO.

[From the annual report of W. C. Culkins, executive secretary and superintendent of the Cincinnati Chamber of Commerce.]

The coal trade of Cincinnati in 1913 presented a number of unusual features. It opened with an abundance of coal arriving from the mines by rail and river. Contract prices by operators and sales agencies went on smoothly up to the first of April, the usual contracting time. One of the unique occurrences of the first of April was that contract prices were advanced sharply over those in any years in the history of the trade, and so promising were the prospects that there were no murmurs on the part of buyers. The railroads were taxed to their utmost to move the big consignments of coal in addition to other merchandise transportation demanded.

The floods of March and April changed the aspect of the case to a greater stringency of cars and greater difficulties of transportation. Prices were advanced monthly throughout the year, largely because of the shortage in transportation, and in August the highest prices were reached for every grade and for every division of the production of the mines. Demand was strong up to the latter part of November, when it began to recede, as far as domestic consumption was concerned, solely on account of the weather. The demand for manufacturing purposes continued strong up to the holidays, when it fell off, and the close of the year saw a practically demoralized market with an overproduction of coal and a disposition on the part of some of the trade to force the product into an already more than abundant supply.

The records of the Chamber of Commerce show that notwithstanding flood, fire, and the exceptionally warm weather, the business of 1913 was somewhat in excess of that of 1912, and as prices were much better, the year was more profitable than usual to all interested in the trade.

The annual receipts of coal, in short tons, at Cincinnati, according to reports of gagers, private returns, and records of the Chamber of Commerce, for the last five years, have been as follows:

Receipts of coal at Cincinnati, 1909–1913, in short tons.

Year.	By river.			By rail.	
	Pittsburgh.	Kanawha.	Other kinds.	Receipts.	Anthracite.
1909	839,952	1,000,336	1,952	3,053,760	18,840
1910	514,140	949,160	1,460	4,384,240	13,480
1911	729,748	1,536,551	....	5,212,701	6,280
1912	501,640	1,313,981	....	6,017,893	8,640
1913	428,737	1,507,257	....	6,210,832	13,689

Total annual receipts, by river and by rail, and aggregate receipts, with total annual shipments, by river and by rail, and aggregate shipments, for five years:

Movements of coal at Cincinnati, 1909–1913, in short tons.

Year.	Receipts.			Shipments.		
	By river.	By rail.	Aggregate.	By river.	By rail.	Aggregate.
1909	1,842,240	3,053,760	4,896,000	269,080	2,528,440	2,797,520
1910	1,464,760	4,384,240	5,849,000	170,240	4,036,800	4,207,040
1911	2,266,299	5,212,701	7,479,000	246,076	4,077,342	4,323,418
1912	1,815,621	6,026,533	7,842,154	279,842	4,396,859	4,676,701
1913	1,935,994	6,224,521	8,160,515	357,313	4,341,462	4,698,775

CLEVELAND, OHIO.

The total coal and coke receipts at Cleveland, as reported by Mr. Munson A. Havens, secretary of the Cleveland Chamber of Commerce, increased nearly 1,240,000 short tons over 1912, which held the record up to the close of that year. Three-fourths of this increased business was in the local consumption and about one-fourth represented the increase in the shipments through Cleveland by Lake and rail to other points. The total receipts in 1913 were 9,817,157 short tons, against 8,577,834 tons in 1912. All of the increase was in the receipts of bituminous coal which showed a gain of nearly 2,150,000 tons, from 6,673,940 tons in 1912 to 8,822,355 tons in 1913. Anthracite receipts fell off slightly, from 150,647 tons to 140,227 tons. The coke receipts were more than cut in half, from 1,753,247 short tons to 854,575 tons. The shipments of coke to other points in 1913 were 200,000 tons less than in 1912, these figures being respectively 288,238 tons and 85,303 tons. The quantity of coal manufactured in Cleveland in 1913 was slightly less than in the preceding year so that the total consumption of coke in that city was about 700,000 tons less than in 1912. The consumption of bituminous coal on the other hand shows an increase of about 1,660,000 short tons and indicates that the manufacturing enterprises using bituminous coal for fuel were more active than those dependent upon coke.

The total receipts of anthracite and bituminous coal and coke were 9,817,157 short tons, the shipments were 4,986,302 tons, and the local consumption 4,830,855 tons. The last figure compared with the local consumption of 1912, which was 3,921,307 short tons, shows a considerable gain.

The coal and coke receipts and shipments at Cleveland, Ohio, for the last five years are shown in the following tables:

Coal and coke receipts and shipments at Cleveland, Ohio, 1909–1913, in short tons.

RECEIPTS.

Kind.	1909	1910	1911	1912	1913
Bituminous	6,264,998	7,097,170	6,242,910	6,673,940	8,822,355
Anthracite	363,162	400,425	168,208	150,647	140,227
Coke	1,034,649	937,714	911,477	1,753,247	854,575
Total	7,662,809	8,435,309	7,322,595	8,577,834	9,817,157

SHIPMENTS.

Kind.	1909	1910	1911	1912	1913
Anthracite by rail	25,383	18,020	....	....	46,409
Bituminous by rail	122,814	383,408	....	118,623	176,665
Bituminous by lake	4,602,275	5,023,368	3,108,741	4,249,666	4,677,925
Coke by rail	102,375	197,784	273,313	288,238	85,303
Total	4,852,847	5,622,580	3,382,054	4,656,527	4,986,302

Total coal and coke receipts and shipments, with local consumption, at Cleveland, Ohio, 1909–1913, in short tons.

Year.	Receipts.	Shipments.	Local consumption.
1909	7,662,809	4,852,847	2,809,962
1910	8,435,309	5,622,508	2,812,801
1911	7,322,595	3,382,054	3,940,541
1912	8,577,834	4,656,527	3,921,307
1913	9,817,157	4,986,302	4,830,855

MILWAUKEE, WIS.

[From the annual report of H. A. Plumb, secretary of the Milwaukee Chamber of Commerce.]

A new record was established in the receipts of coal at Milwaukee in 1913, the quantity arriving having reached a total of 5,860,263 short tons. These receipts include arrivals both by Lake and rail, the Lake receipts amounting to 5,228,770 tons and the rail receipts to 631,493 tons. Both of these figures exceeded any others in the history of the city. It should be remembered that the receipts by rail include the coal reaching Milwaukee over the car-ferry routes. This item in 1913 amounted to 322,708 short tons, which was practically identical with the figures for 1912, when the car-ferry receipt were 323,705 tons. There were altogether 809 cargoes of coal so arriving at the port of Milwaukee during the open season of navigation in 1913. The average cargoes were 6,462 tons, of which the bituminous cargoes averaged 6,826 tons and the anthracite 5,441 tons. As indicative of the larger bunker capacity employed in 1913 in carrying coal to Milwaukee, these averages compare with 6,647 tons as the average cargo of bituminous coal and with 5,077 tons as the average of anthracite in 1912. In 1913 there were 129 cargoes of over 10,000 tons each, compared with 73 equivalent cargoes in 1912, and the number of cargoes in excess of 11,000 tons increased from 13 in 1912 to 28 in 1913.

Coal is received at Milwaukee by 28 plants, 4 of which are private firms not in the retail trade. The 28 plants have an unloading capacity of 100,000 tons in 10 hours. The freight rates to Milwaukee during 1913 were 5 cents higher than in 1912, except in December. The rates to Milwaukee were from 5 to 10 cents less than to Chicago and 5 cents more than to Duluth and Superior.

The receipts of coal at and shipments from Milwaukee during the last five years, and the total receipts for a series of years since 1865, are shown in the following tables:

Receipts of coal at Milwaukee, Wis., 1909–1913, in short tons.

Source.	1909	1910	1911	1912	1913
By lake from—					
Buffalo	778,392	810,409	909,080	834,131	1,028,491
Erie	80,980	82,072	90,342	367,527	153,602
Oswego	56,588	68,983	65,166	64,213	79,150
Cleveland	382,828	436,057	219,852	357,232	570,599
Ashtabula	212,314	520,376	446,330	242,297	486,739
Lorain	610,444	671,656	848,687	766,897	722,098
Sandusky	393,869	388,467	369,601	532,065	599,752
Toledo	1,057,076	1,311,786	1,453,631	1,180,596	1,228,153
Fairport	108,210	61,737	107,803	48,037	27,853
Huron, Ohio	26,015	86,046	64,780	144,966	129,068
Other ports	115,358	173,743	30,150	44,727	203,265
Total Lake	3,822,074	4,611,332	4,605,422	4,582,688	5,228,770
By railroad	[a] 353,948	[b] 449,869	[c] 409,489	589,569	631,493
Total receipts	4,176,022	5,061,201	5,014,911	5,172,257	5,860,263

[a] Including 205,669 tons by car ferry.
[b] Including 327,415 tons by car ferry.
[c] Including 265,572 tons by car ferry.

Shipments of coal from Milwaukee, Wis., 1909–1913, in short tons.

Shipped by—	1909	1910	1911	1912	1913
Chicago, Milwaukee & St. Paul Ry	776,010	1,019,330	765,980	248,768	394,734
Chicago & North Western Ry	483,250	530,010	543,840	577,225	495,100
Wisconsin Central Ry.[a]	123,500	139,435	119,135	129,607	104,003
Lake	....	360	60	178	6,762
Total	1,382,760	1,689,135	1,429,015	955,778	1,000,599

[a] The Wisconsin Central Railway is now part of the "Soo line."

Receipts of coal by lake at Milwaukee, Wis., 1909–1913, by kinds, in short tons.

Kind.	1909	1910	1911	1912	1913
Anthracite	834,980	930,472	1,013,907	973,388	1,153,406
Bituminous	2,987,094	3,680,860	3,591,515	3,609,300	4,075,364
Total	3,822,074	4,611,332	4,605,422	4,582,688	5,228,770

Receipts of coal at Milwaukee, Wis., by lake and rail, in 1865, 1870, 1880, 1890, 1900, 1905, and annually from 1910 to 1913, in short tons.

1865	36,369	1905	3,157,464
1870	122,865	1910	5,061,201
1880	368,568	1911	5,014,911
1890	999,657	1912	5,172,257
1900	1,808,593	1913	5,860,263

Lake freights on coal from Buffalo to principal upper Lake ports during the season of 1913, as compared with those of 1912, were as follows:

Freight rates per ton on coal from Buffalo to principal upper lake ports, 1912 and 1913, by months.

Month.	To Milwaukee.		To Chicago.				To Duluth.	
			North Branch.		South Branch.			
	1912	1913	1912	1913	1912	1913	1912	1913
March	$0.30	$0.35	$0.35	$0.40	$0.40	$0.45	$0.30	$0.30
April	.30	.35	.35	.40	.40	45	.30	.30
May	.30	.35	.35	.40	.40	.45	.30	.30
June	.30	.35	.35	.40	.40	.45	.30	.30
July	.30	.35	.35	.40	.40	.45	.30	.30
August	.30	.35	.35	.40	40	.45	.30	.30
September	.30	.35	.35	.40	.40	.45	.30	.30
October	.30	.35	.35	.40	.40	.45	.30	.30
November	.30	.75	.35	.40	.40	.45	.30	.30
December	1.00	....	1.00	.75	1.00	.75	1.00	1.00

ST. LOUIS, MO.

According to statistics furnished by Mr. William F. Saunders, secretary and general manager of the Business Men's League of St. Louis, there was a decrease of a little more than 3 per cent in the consumption of bituminous coal in 1913, as compared with the high record of the city in 1912; the statistics of anthracite and coke were practically the same in both years. The receipts of bituminous coal decreased from 8,942,872 short tons in 1912 to 8,651,156 tons, the difference being 291,716 tons. The anthracite receipts were 274,423 tons in 1913, as compared with 277,683 tons, a decrease of 3,260 tons. The receipts of coke in each of the last four years have varied barely 2,000 tons, ranging from 190,370 tons in 1912 to 192,425 tons in 1911. In 1913 they amounted to 190,857 tons. In the coal trade of St. Louis receipts and local consumption are practically synonymous terms, as all of the coal entering the city is consumed there or in the immediate suburbs.

St. Louis is favorably situated for securing cheap fuel, being within a short distance of the coal fields of southwestern Illinois.

The receipts of coal and coke at St. Louis during the last six years, and the high, low, and closing prices in 1912 and 1913, are shown in the following tables.

Coal and coke receipts at St. Louis, Mo., 1908–1913, in short tons.

Year.	Bituminous.	Anthracite.	Coke.	Year.	Bituminous.	Anthracite.	Coke.
1908	7,129,055	236,036	357,016	1911	7,798,309	487,030	192,425
1909	7,418,268	236,040	171,570	1912	8,942,872	277,683	190,370
1910	7,945,680	289,463	191,190	1913	8,651,156	274,423	190,857

Coal prices at St. Louis, Mo., during 1912 and 1913, in short tons.

Kind.	1912			1913		
	Highest.	Lowest.	Closing.	Highest.	Lowest.	Closing.
Standard Illinois lump coal	$2.02	$1.27	$1.62	$1.82	$1.32	$1.62
High-grade Illinois lump coal	2.92	1.67	2.22	2.67	1.67	2.32
Anthracite, large	6.95	6.45	6.95	6.95	6.45	6.95
Anthracite, small	7.20	6.70	7.20	7.20	6.70	7.20
Connellsville coke	6.80	5.30	6.80	5.40	5.25	5.25
New River coke	6.80	5.30	6.80	5.40	5.25	5 25
Kentucky coke	4.75	3.25	4.75	4.00	3.60	3.60
Gas coke	5.00	4.25	5.00	4.85	4.30	4.75

SAN FRANCISCO, CAL.

In San Francisco, as in other cities of the Pacific coast, the use of petroleum for steam purposes by railroads and manufacturers has largely supplanted coal, which is at the present time confined almost entirely to domestic consumption. The total quantity of coal consumed in San Francisco and the neighboring cities on the eastern shore of San Francisco Bay in 1913 was apparently about 525,000 short tons. The three railroads entering California—the Southern Pacific, the Western Pacific, and the Atchison, Topeka & Santa Fe—carried into the State in 1913 (including the coal used by themselves) a total of 363,123 tons, chiefly from New Mexico, Utah, and Wyoming, and 75,743 tons of it went to San Francisco. The receipts of domestic coal by water at San Francisco amounted to 193,962 long tons (207,236 short tons), of which 126,668 long tons (141,868 short tons) were from eastern States for use chiefly in United States naval vessels in Pacific waters. The imports, principally from Australia, Japan, and British Columbia, amounted in 1913 to 217,070 long tons (243,148 short tons). Labor troubles in the British Columbian mines were responsible for a heavy decrease in receipts from that region, which were partly made up by larger imports from Japan. The total imports, however, showed considerable decrease in 1913 as in 1912, owing to the larger use of petroleum fuel in the city and State. Receipts of coal from Australia and Japan depend principally upon the exports of wheat from California, vessels carrying wheat bringing return cargoes of coal for ballast.

The statistics showing the shipments of coal by rail into San Francisco and other cities in California in 1913 have been furnished through the courtesy of Messrs. W. G. Barnwell, assistant freight traffic manager, Atchison, Topeka & Santa Fe Railway at San Francisco; G. W. Luce, freight traffic manager, Southern Pacific Co., at San Francisco; and J. T. Hendricks, freight traffic manager, Western Pacific Railway, at San Francisco. The statistics of receipts of coal by water from Washington and Oregon have been furnished by Mr. L. M. King, secretary, San Francisco Chamber of Commerce; and the imports of foreign coals, by the Bureau of Foreign and Domestic Commerce, Department of Commerce.

It is estimated that the total consumption of California oil for fuel, including that used in the manufacture of gas, was 63,000,000 barrels in 1913, equivalent, approximately, to 18,000,000 tons of coal, or about 22 times as much as the coal consumed within the State. The total consumption in 1913, estimated from the rail and water receipts, was about 813,500 tons. The receipts of coke, chiefly from Great Britain and Germany, amounted in 1913 to 31,222 short tons, a decrease from 39,116 tons in 1912.

Sources of coal consumed in California, 1907–1913, in long tons.

[Includes arrivals by water only at port of San Francisco.]

Sources.	1907	1908	1909	1910	1911	1912	1913
British Columbia	243,677	165,204	188,125	157,489	207,203	181,138	43,017
Australia	142,924	452,819	68,086	115,179	198,730	92,033	82,694
Great Britain	31,359	21,805	3,105	....	2,639	1,429	420
China	....	....	....	....	6,170	822	801
Japan	33,598	58,170	546	38,817	279	1,638	89,888
Panama	....	....	....	....	....	....	250
Oregon	32,645	22,205	24,125	23,293	7,439	1,200	
Washington	85,738	69,947	16,940	50,342	57,298	49,829	193,962
Eastern	34,333	188,110	69,696	101,265	80,338	122,090	
Total	604,274	978,260	370,623	486,385	560,096	450,179	411,032

PRODUCTION OF COAL BY STATES.

ALABAMA.

Total production in 1913, 17,678,522 short tons; spot value. $23,083,724.

The increase in coal production in Alabama in 1913 as compared with 1912 was 1,577,922 short tons, or 9.8 per cent, in quantity and $2,254,472, or 10.8 per cent, in value. The average value per ton advanced from $1.29 to $1.31. The increased production in 1913 was due to several causes. During a part of 1912 some of the larger companies were in the hands of receivers and this condition cut down the possible output for that year. The production was further restricted by the burning of the tipple at one of the large mines. The tipple was not rebuilt until the early part of 1913. Several new mines were opened in 1913 and these have been furnishing a gradually increasing output. Some of the older mines have added improvements and extended their workings to provide for an increased tonnage. Labor conditions were much better in 1913 than in either 1912 or 1911, for, although in some districts there was a scarcity rather than a surplus, other districts reported a better labor supply, miners having been recruited from other lines of employment. Car shortage was less acute than in recent years prior to 1913, as some of the large coal-carrying roads have added materially to their facilities for handling the output. The increased tonnage went principally to points outside the State, as the demand for manufacturing, transportation, and domestic consumption within the State was not above normal. The most notable feature in the trade was the increased bunker requirements on the Gulf coast and larger shipments of coke to western points. The relations between operators and mine workers were generally harmonious and increased wages were put in force in February. Earnings by miners and mine laborers in 1913 are said to have been higher than ever before in the history of coal mining in Alabama. Improved sanitary and living conditions put into effect by many companies added to the general betterment.

The average tonnage per man for 1913 showed an increase over 1912 from 712 to 720, but there was a slight falling off in the average output per man per day from 2.91 to 2.82. The former was due to the larger number of days worked—255 in 1913 against 245 in 1912, and the latter partly to the amount of development work in progress during 1913 and partly to the larger number of new recruits. The number of men employed in 1913 was 24,552, against 22,613 in 1912.

The production by the use of machines increased from 3,742,549 short tons in 1912 to 4,124,301 tons in 1913, the percentage to the total output being about the same in both years, 23.2 per cent in 1912 and 23.3 per cent in 1913. The number of machines increased from 353 to 377. Of the latter 249 were punchers, 42 chain breast, 20 long wall, and 66 short wall. It is unfortunate to be obliged to record a marked increase in the quantity and percentage of coal shot off the solid. In 1912 the quantity of powder-mined coal reported was 5,658,457, or 35.1 per cent of the total; in 1913 it was 7,052,234 tons, or 39.9 per cent. The hand-mined coal decreased from 6,658,732 tons, or 41.4 per cent, in 1912. to 6,315,787 tons, or 35.7 per cent, in 1913.

The statistics of fatal accidents compiled by the Bureau of Mines show that there were 124 men killed in the coal-mining operations of Alabama in 1913, all but 1 underground. More than half of the deaths, 68 in all, were due to falls of roof and coal, 27 to gas and dust explosions (including suffocations by mine gases), and 19 to mine cars and locomotives. In 1912 there were 121 fatal accidents in Alabama coal mines. The death rate per thousand in 1913 was 5 against 5.4 in 1912, and the number of tons mined for each life lost was 142,569 against 133,063.

The total time lost by strikes in 1913 was 27,041 days, 1,048 men being idle for an average of 26 days.

Nearly one-half of the coal mined in Alabama in 1913 was washed before being marketed or used in the manufacture of coke. The quantity washed was 8,149,082 tons, yielding 7,210,588 tons of cleaned coal and 938,494 tons of refuse. The difference of 1.3 per cent between the production as reported to the Geological Survey and to the State mine inspector is probably due to the inclusion in the reports to the latter of some of the refuse, and its omission in the reports to the Survey. The quantity of refuse actually reported to the Survey as removed at the mines and deducted from the gross tonnage was more than twice the difference between the Federal and State figures.

The statistics of production of coal in Alabama in 1912 and 1913, with the distribution of the product for consumption, are shown in the following table:

Coal production of Alabama in 1912 and 1913, by counties, in short tons.

1912.

County.	Loaded at mines for shipment.	Sold to local trade and used by employees.	Used at mines for steam and heat.	Made into coke.	Total quantity.	Total value.	Average price per ton.	Average number of days active.	Average number of employees.
Bibb	1,662,198	9,823	109,314		1,781,335	$2,621,682	$1.47	272	2,948
Blount	143,603	1,139	1,600		146,342	181,036	1.24	211	282
Etowah	166,366	3,067	1,875		171,308	249,749	1.46	265	260
Jefferson	6,168,715	81,368	339,211	1,585,555	8,174,849	10,433,728	1.28	251	10,922
St. Clair	722,276	2,456	25,021		749,753	959,219	1.28	291	725
Shelby	463,788	3,501	29,660		496,949	872,501	1.76	250	878
Tuscaloosa	631,114	12,038	48,863	188,952	880,967	1,091,882	1.24	239	1,220
Walker	3,271,284	32,030	102,681	141,967	3,547,962	4,158,094	1.17	211	5,079
Winston	18,550	105	75		18,730	27,793	1.48	220	57
Other counties [a] and small mines.	124,627	2,059	5,719		132,405	233,568	1.76	229	242
Total	13,372,521	147,586	664,019	1,916,474	16,100,600	20,829,252	1.29	245	22,613

1913.

County.	Loaded at mines for shipment.	Sold to local trade and used by employees.	Used at mines for steam and heat.	Made into coke.	Total quantity.	Total value.	Average price per ton.	Average number of days active.	Average number of employees.
Bibb	1,802,243	9,214	99,569		1,911,026	$2,979,240	$1.56	274	3,158
Blount	174,580	2,758	1,620		178,958	236,448	1.32	203	354
Etowah	135,815	725	1,252		137,792	171,600	1.25	256	209
Jefferson	7,149,844	83,353	412,891	1,382,746	9,028,834	11,790,737	1.31	266	11,643
St. Clair	861,579	2,909	25,891		890,379	1,150,457	1.29	277	798
Shelby	457,313	4,469	35,787		497,569	862,783	1.73	257	850
Tuscaloosa	699,690	13,891	68,836	134,888	917,305	1,172,227	1.28	271	1,183
Walker	3,671,708	42,809	101,760	150,986	3,967,263	4,481,373	1.13	223	6,031
Winston	24,841	60	50		24,951	36,724	1.47	228	67
Other counties [a]	116,423	2,162	5,030		123,615	200,059	1.62	233	259
Small mines		830			830	2,076	2.50		
Total	15,094,036	163,180	752,686	1,668,620	17,678,522	23,083,724	1.31	255	24,552

[a] Cullman, Jackson, and Marion.

In the following table is presented a statement of the production of coal in Alabama, by counties, during the last five years, with increase and decrease in 1913 as compared with 1912:

Coal production of Alabama, 1909–1913, by counties, in short tons.

County.	1909	1910	1911	1912	1913	Increase (+) or decrease (−), 1913.
Bibb	1,338,243	1,580,564	1,633,197	1,781,335	1,911,026	+ 129,691
Blount, Cullman	[a] 186,261	[a] 235,456	[a] 210,070	[a] 276,429	[a] 300,092	+ 23,663
Etowah	46,194	172,465	255,860	171,308	137,792	− 33,516
Jefferson	7,176,922	8,298,702	7,776,390	8,174,849	9,028,834	+ 853,985
St. Clair	354,005	428,409	529,211	749,753	890,379	+ 140,626
Shelby	524,925	488,141	463,089	496,949	497,569	+ 620
Tuscaloosa	1,006,989	1,081,219	1,031,658	880,967	917,305	+ 36,338
Walker	2,973,776	3,788,479	3,103,595	3,547,962	3,967,263	+ 419,301
Winston	32,278	16,442	16,424	18,730	24,951	+ 6,221
Other counties and small mines	63,857	21,585	1,927	2,318	3,311	+ 993
Total	13,703,450	16,111,462	15,021,421	16,100,600	17,678,522	+ 1,577,922
Total value	$16,306,236	$20,236,853	$19,079,949	$20,829,252	$23,083,724	+$2,254,472

[a] Includes production of Marion County.

The great Appalachian coal region which furnishes over two-thirds of the coal production of the United States and which extends from Ohio and Pennsylvania on the north in a gradually narrowing belt through eastern Kentucky and Tennessee has its southern terminus in a considerably broadened area that occupies a large part of the northern half of Alabama. The coal-bearing formations of Alabama underlie about 8,400 square miles and are divided into four distinct basins, the Coosa, the Cahaba, and the Warrior, named from the rivers which drain them, and the Plateau, which includes Blount, Lookout, and Sand or Raccoon Mountains. By far the most important basin in area and in production is the Warrior, which includes all of Walker County, most of Jefferson, Tuscaloosa, and Fayette counties, and smaller parts of Blount, Cullman, Winston, and Marion counties. The area known to contain coal is approximately 4,000 square miles, or one-half the total coal area of the State, and contributes about 80 per cent of the total production.

There are several distinct coal groups in the basin, the most important of which are the Brookwood, the Pratt, and the Mary Lee, designated by the names of their principal beds. The Mary Lee group includes the Blue Creek, the Jagger, and the Newcastle beds, most of which are mined in places. The Brookwood, the Pratt, and the Mary Lee produce most of the coking coal mined in the State, and more than half of all of the coal mined in the district.

The Cahaba Basin, second in importance, is a long narrow syncline, 68 miles long and about 6 miles wide, southeast of the Warrior, and occupies parts of St. Clair, Jefferson, Shelby, and Bibb counties. There are many workable beds, and the total quantity of coal in the basin is large. The production is something over 10 per cent of the total for the State.

The Coosa Basin is a deep syncline east of the Cahaba and parallel with it, extending across Shelby and St. Clair counties. It is also long and narrow, 60 miles long by 6 miles wide. It has not been thoroughly explored, but in different parts of the area from two to twelve beds, 3 or more feet in thickness, have been reported.

The Plateau field embraces parts of Blount, Etowah, Dekalb, Cherokee, Marshall, and Jackson counties, and although it has an area underlain by coal four times that of the Cahaba and the Coosa combined, the resources in Alabama are comparatively small. There are four to six beds locally workable.

So far as known, the earliest record of the existence of coal in Alabama was made in 1834. The first statement of production in the State is contained in the United States census report for 1840, in which year the production is given as 946 tons. The census report for 1850 does not mention any coal production for the State, and the next authentic record is contained in the census statistics of 1860, when Alabama is credited with an output of 10,200 short tons. The mines of Alabama were probably worked to a considerable extent during the Civil War, but there are no records of the actual production until 1870, for which year the United States census reports a production of 11,000 tons. Ten years later the production had increased to 323,972 short tons, but the development of the present great industry really began in 1881 and 1882, when attention was directed to the large iron deposits near the city of Birmingham, and thus the great "boom" of that city and vicinity was inaugurated. By 1885 the coal production of the State had increased to nearly 2,500,000 tons. Then followed a period of relapse and liquidation, which lasted two years, after which business settled down to a conservative and rational basis and has since developed steadily. In 1902 the coal production of the State reached a total of more than 10,000,000 tons, and reached the maximum of 17,678,522 tons in 1913.

The statistics of production in Alabama from 1840 to the close of 1913 are shown in the following table:

Production of coal in Alabama from 1840 to 1913, in short tons.

Year.	Quantity.	Year.	Quantity.	Year.	Quantity.	Year.	Quantity.
1840	946	1859	9,000	1878	224,000	1897	5,893,770
1841	1,000	1860	10,200	1879	280,000	1898	6,535,283
1842	1,000	1861	10,000	1880	323,972	1899	7,593,416
1843	1,200	1862	12,500	1881	420,000	1900	8,394,275
1844	1,200	1863	15,000	1882	896,000	1901	9,099,052
1845	1,500	1864	15,000	1883	1,568,000	1902	10,354,570
1846	1,500	1865	12,000	1884	2,240,000	1903	11,654,324
1847	2,000	1866	12,000	1885	2,492,000	1904	11,262,046
1848	2,000	1867	10,000	1886	1,800,000	1905	11,866,069
1849	2,500	1868	10,000	1887	1,950,000	1906	13,107,963
1850	2,500	1869	10,000	1888	2,900,000	1907	14,250,454
1851	3,000	1870	11,000	1889	3,572,983	1908	11,604,593
1852	3,000	1871	15,000	1890	4,090,409	1909	13,703,450
1853	4,000	1872	16,800	1891	4,759,781	1910	16,111,462
1854	4,500	1873	44,800	1892	5,529,312	1911	15,021,421
1855	6,000	1874	50,400	1893	5,136,935	1912	16,100,600
1856	6,800	1875	67,200	1894	4,397,178	1913	17,678,522
1857	8,000	1876	112,000	1895	5,693,775		
1858	8,500	1877	196,000	1896	5,748,697	Total	254,954,358

ALASKA.

The total production of coal in Alaska in 1913 was 2,300 tons, valued at $13,800. This does not include about 1,000 tons of coal taken from the Matanuska field for official test by the Navy Department. This coal was mined during the summer under the supervision of the Bureau of Mines and was sledded to Knik during the winter. In the previous year, 1912, about 600 tons were mined from one of the Cunningham claims in the Bering River field and tested on a warship at Annapolis, but the coal was found unsuited for naval vessels. This coal was not included in the production for that year. Most of the small production of commercial coal in 1913 was from the Whorf mine at Port Graham, patented in 1913, and the only coal mine in Alaska to which patent has been issued. The mine has been opened on about 65 acres and supplies a local market with a lignitic product. All of the other coal mined was lignite for individual use.

The following table shows the annual coal production of Alaska since 1897, and an estimate of the output between 1888 and 1896. A little coal was mined prior to 1884 by the crews of vessels that ran short of fuel, but it probably did not aggregate more than a few hundred tons. The total output of coal prior to 1889, including that mined by the Russians, was probably less than 10,000 tons.

Production of coal in Alaska, 1888–1913, in short tons.

Year.	Quantity.	Value.
1888–1896	6,000	$84,000
1897	2,000	28,000
1898	1,000	14,000
1899	1,200	16,800
1900	1,200	16,800
1901	1,300	15,600
1902	2,212	19,048
1903	1,447	9,782
1904	1,694	7,225
1905	3,774	13,250
1906	5,541	$17,974
1907	10,139	53,600
1908	3,107	14,810
1909	2,800	12,300
1910	1,000	15,000
1911	900	7,200
1912	355	2,840
1913	2,300	13,800
Total	47,969	362,029

NOTE.—The production for 1888–1896 is estimated on the best data obtainable. The figures for 1897 to 1913 are based for the most part on data supplied by operators.

The consumption of coal in Alaska since 1899 has been as follows:

Coal consumption of Alaska, by sources, 1899 to 1913, in short tons.

Year.	Imported from States, chiefly from Washington.		Produced in Alaska, chiefly subbituminous and lignite.[b]	Total domestic.[b]	Total foreign coal, chiefly bituminous from British Columbia.[c]	Total coal consumed.
	Bituminous.	Anthracite.				
1899	[a] 10,000	....	1,200	11,200	50,120	61,320
1900	15,048	....	1,200	16,248	56,623	72,871
1901	[a] 24,000	....	1,300	25,300	77,674	102,974
1902	[a] 40,000	....	2,212	42,212	68,363	110,575
1903	64,625	1	1,447	66,073	60,605	126,678
1904	36,689	....	1,694	38,383	76,815	115,198
1905	67,707	6	3,774	71,487	72,567	144,054
1906	68,960	533	5,541	75,034	47,590	122,624
1907	45,130	1,116	10,139	56,385	88,596	144,981
1908	23,402	491	3,107	27,000	72,831	99,831
1909	33,112	....	2,800	35,912	74,316	110,228
1910	32,138	....	1,000	33,138	73,904	107,042
1911	32,255	....	900	33,155	88,573	121,728
1912	27,767	....	355	28,122	59,804	87,926
1913	61,666	....	2,300	63,966	60,600	124,566
Total	582,499	2,147	38,969	623,615	1,028,981	1,652,596

[a] Estimated. [b] By calendar years. [c] By fiscal years ending June 30.

While the coal consumption in Alaska remained nearly stationary, the use of fuel oil has very much increased. The Treadwell group of mines now uses California oil, as do many of the dredges at Nome, steamers running to Alaska and boats on Yukon River. The Copper River Railway is now partly equipped with oil-burning locomotives, and the Alaska Northern Railroad, when operated at all, uses a gasoline car. The Tanana Valley Railroad also runs a gasoline passenger coach. The following table indicates the increased use of oil-burning and gasoline engines in Alaska. This, of course, does not include the fuel oil used by coastwise steamers, which is estimated at 541,000 barrels, in 1913.

Shipments of petroleum products to Alaska from other parts of the United States, 1905–1913, in gallons.

Year.	Crude.		Naphtha.		Illuminating.		Lubricating.		Total value.
	Quantity.	Value.	Quantity.	Value.	Quantity.	Value.	Quantity.	Value.	
1905	2,715,386	$91,068	713,496	$109,921	627,391	$113,921	83,319	$31,660	$346,570
1906	2,688,100	38,409	580,978	100,694	568,033	109,964	83,992	32,854	281,921
1907	9,104,300	143,506	636,881	119,345	510,145	99,342	100,145	37,929	400,122
1908	11,891,375	176,483	939,424	147,104	566,598	102,567	94,542	36,423	462,577
1909	14,034,900	334,258	746,930	118,810	531,727	98,786	85,687	35,882	587,736
1910	18,835,670	477,673	788,154	136,569	626,972	95,483	104,512	38,625	748,350
1911	18,142,364	406,400	1,238,865	167,915	423,750	57,896	100,141	34,048	666,259
1912	15,523,555	309,804	2,736,739	344,739	672,176	100,722	154,565	60,949	816,214
1913	15,682,412	453,756	1,735,658	272,661	661,656	106,603	150,918	61,966	894,986

ARKANSAS.

Total production in 1913, 2,234,107 short tons; spot value, $3,923,701.

The coal production of Arkansas increased from 2,100,819 short tons, valued at $3,582,789 in 1912, to 2,234,107 tons, valued at $3,923,701 in 1913, a gain of 133,288 tons, or 6.34 per cent in quantity and of $340,912, or 9.52 per cent in value. The average value per ton advanced from $1.71 to $1.76. The increased production in 1913 is attributed chiefly to a larger railroad consumption caused by a decrease in the supply of fuel oil, but partly also to increased business. This was offset to some extent by decreased domestic consumption, particularly in Texas, due to an increased use of natural gas in that State. The prolonged drought in August and September also had an adverse influence upon coal production, as it cut down the wheat crop in Kansas and the cotton crop in Oklahoma and Texas. Transportation facilities were improved over those of previous years and a reduction in freight rates, put into effect in the latter part of the year, is expected to have a beneficial effect upon the industry by enabling larger quantities of coal to be shipped to the northwest, where Arkansas semianthracite has established a market and has already, to some extent, replaced West Virginia smokeless coal. The conditions at the close of 1913 presented a more hopeful outlook for the future than has obtained in Arkansas for several years. Complaint is still made of a short and unsatisfactory supply of labor. Operations at Hartford were interrupted for some time in 1913 by a controversy over the machine-mining scale, and a number of small strikes due to various causes occurred at Jenny Lind and Denning. The controversy over the machine-mining rate arose as the result of the introduction of a number of machines into a district for which no scale existed at the time. The effect of their use is exhibited in the production by an increase from 76,611 short tons of machine-mined coal in 1912 to 251,105 tons in 1913. It is also shown in a gratifying decrease in the quantity of coal shot off the solid—from 1,937,817 tons to 1,775,851 tons. In 1912 the coal shot off the solid represented a little more than 92 per cent of the total product; in 1913 it was 79.5 per cent. The number of machines in use in 1913 was 27, three times the number in use in

1912. Four of the machines operated in 1913 were short wall and 23 were chain breast.

The number of men on strike for one cause or another in 1913 was 1,221, a little more than one-fourth of the total number employed, and the average number of working days lost by each man on strike was 27. The total number of employees increased from 4,536 in 1912 to 4,652 in 1913, and the average working time increased from 157 to 174 days. The average quantity of coal produced by each man employed was 2.76 tons per day and 480 tons during the year in 1913 against 2.95 and 463 tons, respectively, in 1912.

According to the Bureau of Mines, there were 12 fatal accidents in 1913—just double the number in 1912. Half of the fatalities in 1913 were due to falls of roof and coal and 2 to an explosion of dust. The death rate per thousand in 1913 was 2.58, and there were 186,176 tons of coal mined for each life lost. In 1912 the death rate was 1.3, and the quantity of coal mined for each life lost was 350,137 tons.

The statistics of production, by counties, for 1912 and 1913, with the distribution of the product for consumption, are shown in the following table:

Coal production of Arkansas in 1912 and 1913, by counties, in short tons.

County.	Loaded at mines for shipment.	Sold to local trade and used by employees.	Used at mines for steam and heat.	Total quantity.	Total value.	Average price per ton.	Average number of days active.	Average number of employees.
1912.								
Franklin	355,637	2,390	15,287	373,314	$609,453	$1.63	172	750
Johnson	184,110	3,391	4,825	192,326	441,226	2.29	105	698
Logan	12,622	2,500	150	15,272	40,203	2.63	156	44
Sebastian	1,388,037	5,467	60,624	1,454,128	2,301,904	1.58	164	2,869
Other counties [a] and small mines	56,416	1,363	8,000	65,779	190,003	2.89	200	175
Total	1,996,822	15,111	88,886	2,100,819	3,582,789	1.71	157	4,536
1913.								
Franklin	331,539	1,730	13,413	346,682	$591,766	$1.71	178	657
Johnson	156,517	2,095	7,596	166,208	397,198	2.39	111	711
Sebastian	1,547,695	2,980	84,704	1,635,379	2,681,657	1.64	185	2,930
Other counties [b] and small mines	81,607	1,182	3,049	85,838	253,080	2.95	198	354
Total	2,117,358	7,987	108,762	2,234,107	3,923,701	1.76	174	4,652

[a] Pope and Washington.
[b] Logan, Pope, and Washington.

A statement of the production of coal in Arkansas, by counties, for the last five years, with increase and decrease in 1913 as compared with 1912, is shown in the following table:

Coal production of Arkansas, 1909–1913, by counties, in short tons.

County.	1909	1910	1911	1912	1913	Increase(+) or decrease (−), 1913.
Franklin	281,399	296,725	421,591	373,314	346,682	− 26,632
Johnson	171,102	133,365	137,081	192,326	166,208	− 26,118
Logan	25,169	15,492	11,974	15,272	5,028	− 10,244
Pope	56,344	13,240	45,935	64,216	79,608	+ 15,392
Sebastian	1,818,781	1,425,347	1,484,532	1,454,128	1,635,379	+ 181,251
Other counties and small mines	24,362	21,789	5,676	1,563	1,202	− 361
Total	2,377,157	1,905,958	2,106,789	2,100,819	2,234,107	+ 133,288
Total value	$3,523,139	$2,979,213	$3,396,849	$3,582,789	$3,923,701	+$340,912

Arkansas contains two coal fields—one of high-grade fuel, in the western part of the State, and the other of lignite, in the lowlands southeast of Hot Springs and Little Rock. The latter has never been adequately developed, because lignite has had little or no commercial value, and it is probable that this field will not be an important factor in the fuel production of the State for some time to come.

The field of high-grade fuel lies along Arkansas River, extending from the Oklahoma State line on the west to Russellville on the east, a distance of about 75 miles. In the north-south direction its width, though differing much in different localities, probably averages about 20 miles. It includes in whole or in part the counties of Sebastian, Franklin, Johnson, Pope, Logan, Scott, and Crawford, but nearly all of the coal at present mined comes from the four counties standing at the head of the list.

Only a few coal beds occur in this field. The most important, from which probably 99 per cent of the coal mined in the State is derived, corresponds with the Hartshorne coal of Oklahoma, and, in fact, is the direct eastward extension of that bed. This coal is mined extensively at Huntington, Hartford, Midland, Bonanza, Jenny Lind, Greenwood, and other places in Sebastian County; at Denning and Altus, in Franklin County; at Clarksville, in Johnson County; and in the vicinity of Russellville, in Pope County.

The Charleston coal bed, about 700 feet higher than the Hartshorne bed, is mined in a small way about Charleston, Franklin County, and the Paris bed, about 300 feet higher than the Charleston, is mined locally in the vicinity of Paris, Logan County. Another small coal bed lies about 500 feet below the Hartshorne, but it is irregular and of little value, and at the present time is not mined on a commercial scale at any place in the State.

In quality the coal increases from west to east. The fuel ratio (fixed carbon divided by volatile matter) ranges from about 3.5 in the vicinity of the State line on the west to 5 at Denning and Coal Hill, 6.5 at Spadra, and about 8 at Russellville. In other words, the coal in the western part of the field belongs to the class called semibituminous, and that of the east to the class called semianthracite. The semibituminous coal of the western half of the field is exceedingly tender and friable and, as delivered at the mine mouth, consists of from 30 to 40 per cent fine coal. This fine coal is of excellent quality, but does not find a ready market, and frequently can not be disposed of at any price. This condition makes mining expensive and unsatisfactory.

According to the United States census for 1840 a small quantity of coal (220 short tons) was mined in Arkansas during that year. With the exception of 9,972 short tons mined in Missouri and 400 tons from Iowa mines, this was the only coal produced west of Mississippi River in that year, and for the next 20 years they were the only States west of the Mississippi from which any coal production was reported. The industry in Arkansas did not develop rapidly during the earlier years, as the census of 1860 shows a production of only 200 tons and that of 1880 a total of 14,778 tons. From 1881 to 1902 production increased quite regularly, but for the last 12 years has remained practically stationary. The production of 2,234,107 tons in 1913 was only 112,847 tons more than the average annual production from 1902 to 1913, inclusive. The maximum of 2,670,438 short tons was attained in 1907.

The annual production of coal in Arkansas from 1840 to the close of 1913 will be found in the following table:

Production of coal in Arkansas from 1840 to 1913, in short tons.

Year.	Quantity.	Year.	Quantity.	Year.	Quantity.	Year.	Quantity.
1840	220	1888	276,871	1898	1,205,479	1908	2,078,357
1860	200	1889	279,584	1899	843,554	1909	2,377,157
1880	14,778	1890	399,888	1900	1,447,945	1910	1,905,958
1881	20,000	1891	542,379	1901	1,816,136	1911	2,106,789
1882	25,000	1892	535,558	1902	1,943,932	1912	2,100,819
1883	50,000	1893	574,763	1903	2,229,172	1913	2,234,107
1884	75,000	1894	512,626	1904	2,009,451		
1885	100,000	1895	598,322	1905	1,934,673	Total	36,559,588
1886	125,000	1896	675,374	1906	1,864,268		
1887	129,600	1897	856,190	1907	2,670,438		

CALIFORNIA.

Total production in 1913, 24,839 short tons; spot value, $84,073.

Coal mining and the coal trade generally in California lay little claim to importance among the industries of the State, particularly since the beginning of the present century, when the production of petroleum began to exert such a powerful influence on the fuel consumption of the Pacific coast. From 1910 to 1912, inclusive, the coal production of California was only a little more than 10,000 tons in each year, but in 1913 work was resumed on the Stone Canyon properties in Monterey County, and the production increased to 24,839 short tons, valued at $84,073, from 10,978 tons, valued at $23,601, in 1912. The only other production in 1913 was from the Ione mines in Amador County, whose output was slightly less than in 1912.

The production of petroleum in California in 1913 amounted to 97,788,525 barrels, and it is estimated by David T. Day,[1] of the United States Geological Survey, that 63,000,000 barrels were used directly for fuel. It is also estimated that 3½ barrels of petroleum are equivalent to 1 short ton of ordinary bituminous coal, from which it appears that about 18,000,000 tons of coal would be required to

[1] See current report on production of petroleum: U. S. Geol. Survey Mineral Resources, 1913, 1914.

perform the service rendered by California petroleum in the production of heat and power and in the manufacture of gas. California oil is the principal fuel for locomotives as far north as Washington and across the Sierras and the Cascades, its freedom from sparks serving as a great protection against forest fires as compared with coal or wood fuel. It is used almost exclusively on inland and coastwise steamers and, to an increasing extent, by the trans-Pacific steamers. It has even displaced coal on Puget Sound, many of the steamers of the Canadian Pacific fleet plying between Vancouver, Victoria, and other points having been equipped for burning oil. There is still, however, some demand for coal in California, particularly for domestic use and for bunker trade at San Francisco; but it is almost exclusively supplied by coals from other States—Washington, Utah, Wyoming, and New Mexico—and from foreign countries, chiefly British Columbia, with small quantities of anthracite and high-grade bituminous coals from the Eastern States. The railroads entering California brought from the Rocky Mountain States in 1913 a total of 363,123 short tons of coal; the receipts by water at San Francisco from Oregon, Washington, and Eastern States were 193,962 long tons, or 207,236 short tons; and the imports into San Francisco, Los Angeles, and San Diego reported by the Bureau of Foreign and Domestic Commerce of the Department of Commerce were 217,070 long tons (243,148 short tons)—a total of 813,507 short tons. The total consumption of coal in California, including that supplied to the bunker trade, which, with the United States naval vessels, probably takes the larger part of the coal received by water, was only 4.5 per cent of the quantity of coal displaced by the use of California petroleum.

The statistics of coal production in California during the last five years, with the distribution of the product for consumption, are shown in the following table:

Distribution of the coal product of California, 1909–1912, in short tons.

Year.	Loaded at mines for shipment.	Sold to local trade and used by employees.	Used at mines for steam and heat.	Total quantity.	Total value.	Average price per ton.	Average number of days active.	Average number of employees.
1909	34,888	3,297	7,651	45,836	95,042	2.07	....	14
1910	6,679	3,985	500	11,164	18,336	1.64	192	14
1911	4,981	5,266	500	10,747	16,097	1.50	254	45
1912	3,748	3,630	3,600	10,978	23,601	2.15	184	52
1913	14,864	1,808	8,167	24,839	84,073	3.38	332	35

There are in California a number of small, widely separated coal fields, chief among them the Mount Diablo field of Contra Costa County, the Corral Hollow field of Alameda County, a small area in Amador County, the Priest Valley and Trafton fields of San Benito County, and the Stone Canyon field of Monterey County. The first two, which are on the eastern border of San Francisco Bay, and consequently in the west-central part of the State, produce black lignite or subbituminous coal. The areas in Monterey County are more to the south and in or near a region which has been considerably distorted. The coals are of the same geologic age as those farther north, but they have been altered into true bituminous coals. The alteration in the San Benito County area has not progressed so far as in the case of the Monterey County coals, but they closely approach the bituminous grade. None of them possess coking qualities.

The records of the State Mining Bureau of California show a production of coal in that State as early as 1861. It was at that time one of the 16 coal-producing States and, relatively, of some importance as a coal producer. During the latter part of that decade and throughout the following decade the coal production of California exceeded 100,000 tons annually and reached a maximum of 236,950 tons in 1880. Since 1881 the production has been irregular, having been influenced chiefly, up to the beginning of the present century, by the imports of Australian and British Columbian coals, the receipts of Australian coals depending principally upon the wheat production and shipments from the Pacific coast. Since 1900, with the great increase in the production and use of petroleum which began in that year, coal production in California has fallen to an insignificant quantity.

The production of coal in California from 1861 to the close of 1913 is shown in the following table:

Production of coal in California from 1861 to 1913, in short tons.

Year.	Quantity.	Year.	Quantity.	Year.	Quantity.	Year.	Quantity.
1861	6,620	1875	166,638	1889	119,820	1903	104,673
1862	23,400	1876	128,049	1890	110,711	1904	78,888
1863	43,200	1877	107,789	1891	93,301	1905	77,050
1864	50,700	1878	134,237	1892	85,178	1906	25,290
1865	60,530	1879	147,879	1893	72,603	1907	13,950
1866	84,020	1880	236,950	1894	67,247	1908	18,755
1867	124,690	1881	140,000	1895	75,453	1909	45,836
1868	143,676	1882	112,592	1896	78,544	1910	11,164
1869	157,234	1883	76,162	1897	87,992	1911	10,747
1870	141,890	1884	77,485	1898	145,888	1912	10,978
1871	152,493	1885	71,615	1899	160,915	1913	24,839
1872	190,859	1886	100,000	1900	171,708		
1873	186,611	1887	50,000	1901	151,079	Total	5,153,264
1874	215,352	1888	95,000	1902	84,984		

COLORADO.

Total production in 1913, 9,232,510 short tons; spot value, $14,035,090.

Compared with 1912, when the production of coal in Colorado amounted to 10,977,824 short tons valued at $16,345,336, the returns for 1913 show a decrease of 1,745,314 tons, or 15.9 per cent, in quantity and of $2,310,246, or 14.13 per cent, in value. The smaller production in 1913 was due entirely to the inauguration of a strike, called on September 16 and put into effect a week later, which reduced the output in the southern part of the State for the rest of the year to about 40 per cent of the normal. The production in 1913 was the smallest since 1905. As has been the case in numerous other instances of labor disaffection, the trouble in Colorado arose from a demand for the recognition of the union and eventuated in a contest which for bitterness, violence, and bloodshed has exceeded any similar conflict in recent history, necessitating first the State militia, and finally the presence of Federal troops to restore and maintain order. At the time of writing this report (June, 1914), a condition of warfare still exists, although mining has been resumed with nearly a full complement of men under the protection of the Federal authorities. Few of the mines were rendered entirely idle at any time during the strike, and although 7,324 men (more than 60 per cent of the average number employed during the year) were idle for an average of 75 days each, the average number of days the mines worked was 229, or 2 days more than in 1912, when a production of practically 11,000,000 tons was mined without a single instance of strike or suspension being reported. The total time lost was equal to 20 per cent of the time made, from which it appears that except for the strike the production for the year would have amounted to about 11,500,000 tons, or within half a million tons of the maximum record of 1910. It is doubtful, however, if with no interruption by strikes, the output would have reached the possible tonnage, or even the record of 1912, for owing to crop shortage in adjoining States, there was a reduced demand for coal for both railroad and commercial purposes. Up to the time the strike was inaugurated the production was about 100,000 tons less than for the corresponding period in 1912. There was no complaint of car shortage or other inadequate transportation facilities in 1913.

The average number of men employed in the coal mines of Colorado in 1913 was 11,990, working an average of 229 days, against 13,000 men for 227 days in 1912. The miners of Colorado have a good record for efficiency. In 1912 the average production by each man employed was 844 tons, and in 1913 it was 770 tons; the average daily production per man was 3.7 tons in 1912 and 3.36 tons in 1913. Of the total output of 9,232,510 short tons in 1913, 5,592,638 tons, or 60.6 per cent, were mined by hand; 2,311,493 tons, or 25 per cent, by machines; and 1,286,293 tons, or 13.9 per cent, were shot off the solid. The last method shows a decrease in quantity but an increase in percentage as compared with 1912, when 1,309,544 tons, or 11.9 per cent, were "powder-mined." There was a decrease in the number of machines in use, from 304 in 1912 to 300 in 1913. More than half of the machines in use are of the pick or puncher type, 168 in 1913 being of that type. Of the remainder, 35 were chain breast, 12 were long wall, 80 were short wall, or continuous cutters, and 5 were radial-ax or post punchers. The quantity of coal washed, most of which is slack used for coke-making, was 328,016 tons, the cleaned coal amounting to 266,281 tons and the refuse to 61,735 tons.

Reports to the Bureau of Mines show that there were 108 fatal accidents in the coal mines of Colorado in 1913, an increase of 13 over 1912. Of the total deaths 47 were due to falls of roof and coal, 37 to gas and dust explosions, 7 to mine cars and locomotives, and 17 (3 of which were on the surface), were due to other causes.

The statistics of production in Colorado in 1912 and 1913, with the distribution of the product for consumption, are shown in the following table:

Coal production of Colorado in 1912 and 1913, by counties, in short tons.

1912.

County.	Loaded at mines for shipment.	Sold to local trade and used by employees.	Used at mines for steam and heat.	Made into coke.	Total quantity.	Total value.	Average price per ton.	Average number of days active.	Average number of employees.
Boulder	981,784	18,618	54,523		1,054,925	$1,707,385	$1.62	190	1,316
Delta	57,329	16,030	1,684		75,043	138,784	1.85	163	83
El Paso	206,341	118,873	9,690		334,904	479,053	1.43	262	412
Fremont	689,860	23,918	25,055		738,833	1,603,259	2.17	198	1,340
Garfield	175,619	2,520	7,313		185,452	254,687	1.37	250	178
Gunnison	501,147	2,080	20,594	33,864	557,685	831,733	1.49	201	661
Huerfano	1,804,837	13,102	81,599		1,899,538	3,226,064	1.70	213	2,443
La Plata	108,612	15,442	912	7,521	132,487	231,631	1.75	217	164
Las Animas	3,844,200	41,687	97,642	725,169	4,708,698	5,864,060	1.25	262	4,895
Mesa	80,826	30,167	3,500		114,493	159,544	1.39	196	135
Routt	429,359	3,675	15,227		448,261	783,499	1.75	200	480
Weld	445,479	26,491	19,067		491,037	726,002	1.48	206	536
Other counties [a]	201,756	4,785	15,745		222,286	313,325	1.41	169	357
Small mines		14,182			14,182	26,310	1.86		
Total	9,527,149	331,570	352,551	766,554	10,977,824	16,345,336	1.49	227	13,000

1913.

County.	Loaded at mines for shipment.	Sold to local trade and used by employees.	Used at mines for steam and heat.	Made into coke.	Total quantity.	Total value.	Average price per ton.	Average number of days active.	Average number of employees.
Boulder	846,402	12,778	43,738		902,918	$1,539,062	$1.70	242	1,178
Delta	71,235	14,019	1,210		86,464	130,631	1.51	176	102
El Paso	169,660	141,128	16,111		326,899	487,419	1.49	240	415
Fremont	487,617	28,161	20,000		535,778	1,097,320	2.05	170	1,291
Garfield	148,545	2,523	7,594		158,662	211,664	1.33	220	179
Gunnison	412,263	2,380	22,730	35,380	472,753	726,846	1.54	195	622
Huerfano	1,626,739	10,599	67,902		1,705,240	2,822,242	1.66	208	2,351
La Plata	102,580	23,651	1,121	12,703	140,055	238,354	1.70	241	187
Las Animas	2,236,957	57,028	91,253	1,354,119	3,739,357	4,915,606	1.31	269	4,293
Mesa	101,527	28,346	4,565		134,438	197,182	1.47	232	127
Routt	315,325	5,183	14,453		334,961	578,195	1.73	160	431
Weld	363,392	26,667	19,072		409,131	667,622	1.63	224	468
Other counties [b]	254,391	4,404	18,500	210	277,505	406,716	1.47	218	346
Small mines		8,349			8,349	16,231	1.94		
Total	7,136,633	365,216	328,249	1,402,412	9,232,510	14,035,090	1.52	229	11,990

[a] Archuleta, Jackson, Jefferson, Montezuma, and Pitkin.
[b] Archuleta, Jackson, Jefferson, Pitkin, and Rio Blanco.

As the scene of the greater part of the labor struggle in 1913 was in Las Animas County, that county sustained the heaviest loss in tonnage, as compared with 1912. The decrease in Las Animas County was 969,341 tons, or more than 20 per cent, and was more than half the total decrease in the State. Fremont County's production decreased 203,055 tons; Huerfano's, 194,298 tons; Boulder's, 152,007 tons; and Routt's, 113,300 tons. Only 3 of the 14 counties included in the following table showed increased production in 1913, and they were relatively small producers.

The statistics of production, by counties, during the last five years, with increase and decrease in 1913 as compared with 1912, are given in the following table:

Coal production in Colorado, 1909–1913, by counties, in short tons.

County.	1909	1910	1911	1912	1913	Increase(+) or decrease (−), 1913.
Boulder	1,332,322	802,769	954,752	1,054,925	902,918	− 152,007
Delta	55,031	63,590	71,399	75,043	86,464	+ 11,421
El Paso	312,233	336,780	332,155	334,904	326,899	− 8,005
Fremont	611,980	722,142	661,240	738,833	535,778	− 203,055
Garfield	257,796	189,755	165,908	185,452	158,662	− 26,790
Gunnison	598,463	640,982	575,648	557,685	472,753	− 84,932
Huerfano	1,915,910	2,387,090	1,786,654	1,899,538	1,705,240	− 194,298
Jefferson	195,809	227,744	1,187	94,534	155,928	+ 61,394
La Plata	139,858	147,755	96,749	132,487	140,055	+ 7,568
Las Animas	4,592,964	5,548,085	4,458,753	4,708,698	3,739,357	− 969,341
Mesa	98,241	129,530	92,881	114,493	134,438	+ 19,945
Pitkin	159,753	183,068	101,773	74,683	53,317	− 21,366
Routt	92,439	258,452	317,791	448,261	334,961	− 113,300
Weld	327,545	322,896	520,396	491,037	409,131	− 81,906
Other counties [a]	26,592	13,098	20,097	67,251	76,609	+ 9,358
Total	10,716,936	11,973,736	10,157,383	10,977,824	9,232,510	− 1,745,314
Total value	$14,296,012	$17,026,934	$14,747,764	$16,345,336	$14,035,090	−$2,310,246

[a] Includes small mines.

The coal fields of Colorado are divided by the major ranges of the Rocky Mountains into three general groups designated as the eastern, the park, and the western. The eastern group, the most highly developed of the three, comprises the Denver region and the Canon City and Trinidad fields. The park group includes the little known and almost undeveloped fields of the South, Middle, and North parks. The western group, the largest in area, which contains the greatest amount of coal, includes the Yampa field on the north, the Danforth Hills, White River, and Grand Hogback fields north of Grand River, the Glenwood Springs, Crested Butte, and Grand Mesa fields south of Grand River, the Book Cliffs field west of Grand Junction, and the Durango field in the southwestern part of the State. All of these fields of the western group, with the exception of the Yampa field, in the extreme north, and the Durango field, in the south, belong to the great Uinta region, or basin, which extends from Gunnison County, Colo., on the east, to Carbon and Emery counties, in the central part of Utah, on the west.

In quality the coals of Colorado range from subbituminous ("black lignite"), in the Denver region, through various grades of bituminous, including the high-grade coking coal of the Trinidad and Glenwood Springs fields, to true anthracite, in the Crested Butte and Yampa fields. Some of the coal beds of Colorado attain enormous thickness. This is especially true in the Glenwood Springs field, and some of the beds in the North Park field are also said to be of great thickness. The total area underlain by coal in Colorado is estimated at 17,130 square miles, and about 60 per cent of that entire area is believed to contain coal workable under present conditions. There is an extent of territory embracing over 4,000 square miles about which little is known, but which may contain workable coal, and nearly 3,000 square miles of territory in which the coal lies under heavy cover and is not workable on that account at the present time.

Coal mining as an industry in Colorado began in 1864, a production of 500 short tons being recorded in that year. In 1876 the production reached for the first time a total exceeding 100,000 tons, and six years later, in 1882, it had reached the million-ton mark. Since that date the increase has been almost uninterrupted, there being only five times prior to 1911 (in 1884, 1892, 1894, 1904, and 1908) when the production showed a decrease of any importance, and only six times altogether in 38 years. The largest decrease was in the "hard-times" year, 1894. The coal production of the State exceeded 3,000,000 tons in 1890; 10 years later it had grown to over 5,000,000 tons; in 1910 it exceeded 11,000,000 tons; but in 1911, 1912, and 1913 it fell below the 11,000,000-ton mark.

The record, by years, since 1864 is shown in the following table:

Production of coal in Colorado from 1864 to 1913, in short tons.

Year.	Quantity.	Year.	Quantity.	Year.	Quantity.	Year.	Quantity.
1864	500	1877	160,000	1890	3,077,003	1903	7,423,602
1865	1,200	1878	200,630	1891	3,512,632	1904	6,658,355
1866	6,400	1879	322,732	1892	3,510,830	1905	8,826,429
1867	17,000	1880	462,747	1893	4,102,389	1906	10,111,218
1868	10,500	1881	706,744	1894	2,831,409	1907	10,790,236
1869	8,000	1882	1,061,479	1895	3,082,982	1908	9,634,973
1870	4,500	1883	1,229,593	1896	3,112,402	1909	10,716,936
1871	15,600	1884	1,130,024	1897	3,361,703	1910	11,973,736
1872	68,540	1885	1,356,062	1898	4,076,347	1911	10,157,383
1873	69,997	1886	1,368,338	1899	4,776,224	1912	10,977,824
1874	77,372	1887	1,791,735	1900	5,244,364	1913	9,232,510
1875	98,838	1888	2,185,477	1901	5,700,015		
1876	117,666	1889	2,597,181	1902	7,401,343	Total	175,361,698

GEORGIA.

Total production in 1913, 255,626 short tons; spot value, $361,319.

The coal production of Georgia in 1913 was the largest in five years, or since 1908. Compared with 1912, when the output amounted to 227,503 short tons, valued at $338,426, the production in 1913 shows an increase of 28,123 short tons, or 12.36 per cent, in quantity and of $22,893, or 6.76 per cent, in value. The average price per ton declined from $1.49 to $1.41. The maximum production of coal in Georgia was 416,951 short tons, obtained in 1903, just 10 years before the year under review. For the next eight years, with the exception of 1907, the output steadily declined until a minimum of 165,210 tons was reached in 1911. A revival of activity is indicated in the returns for 1912 and 1913. The decrease in production from 1903 to 1911 and the increased output in the last two years were due entirely to peculiar labor conditions and not to the state of the trade and market requirements. Prior to 1904 the principal labor employed in the coal mines of Georgia consisted of convicts leased from the State government. An act of legislature prohibiting further leasing of convicts to industrial enterprises caused the gradual withdrawal from the coal mines of this labor as contracts expired, and operators in the somewhat isolated region where the mines are located were unable to supply the deficiency by free labor.

The influence of free labor on the efficiency record is shown by the fact that in 1907, when the principal labor was performed by convicts, it required 808 men, working an average of 262 days, to produce 362,401 tons, an average of 449 tons per man for the year and of 1.71 tons for each working day. In 1908 under similar conditions, 670 men, working 261 days, produced 264,822 tons, the corresponding averages being, respectively, 395 tons and 1.51 tons. In 1912, 450 men, working 254 days, produced 227,503 tons, and in 1913, 500 men, working 261 days, produced 255,626 tons, the averages per man being 506 tons for the year and 2 tons a day in 1912, and 511 tons for the year and 1.96 tons a day in 1913.

No mining machines are used in the coal mines of Georgia. The reports to the Survey show that all of the output in 1913 was shot off the solid. About one-third the entire production (82,943 tons in 1913) was washed coal. The total quantity of coal sent to the washeries in 1913 was 124,306 tons, of which 41,363 tons was discarded as refuse. Georgia "washed nut" has a high reputation as a steam and domestic fuel. All of the coal reported as washed in 1913 was slack used in the manufacture of coke.

The Bureau of Mines reports that 3 men were killed in the coal mines of Georgia in 1913, all of them by falls of roof. The death rate per thousand was 6 and the production for each life lost was 42,604 short tons.

The statistics of production during the last five years, with the distribution of the product for consumption, are shown in the following table:

Coal production of Georgia, 1909–1913, in short tons.

Year.	Loaded at mines for shipment.	Sold to local trade and used by employees.	Used at mines for steam and heat.	Made into coke.	Total quantity.	Total value.	Average price per ton.	Average number of days active.	Average number of employees.
1909	119,806	1,000	4,100	86,290	211,196	$298,792	$1.41	....	460
1910	94,330	776	2,760	79,379	177,245	259,122	1.46	265	386
1911	86,141	957	5,435	72,677	165,210	246,208	1.49	278	510
1912	108,135	1,304	6,141	111,923	227,503	338,426	1.49	254	450
1913	122,499	1,303	7,518	124,306	255,626	361,319	1.41	261	500

The coal-productive area of Georgia underlies portions of two counties in the extreme northwestern corner of the State. The Walden Basin of Tennessee crosses Dade County in Georgia, and extending southwesterly becomes the Blount Mountain and Warrior basins in Alabama. The Lookout Basin, a narrow outlying area, extends from Etowah County, in Alabama, in a northeasterly direction into Walker County, Ga. The total area of the coal fields in Georgia is estimated at 167 square miles, the smallest coal area of any Appalachian State. Not all of the field is workable. Extensive operations have been carried on in both counties, however, but all of the production in 1913 was by two companies operating in Walker County. On account of its high percentage (80 per cent) of fixed carbon and its low sulphur content, the Lookout Mountain coal (Walker County) gives a large product of excellent coke which is sold to the furnaces of Chattanooga and of other points in Tennessee and in Georgia.

The Eighth United States Census contains the first authentic statement of the production of coal in Georgia. This report, which is for 1860, gives the production in that year as 1,900 short tons. The census for 1870 does not mention any production in Georgia for that year. The Tenth Census (1880) reports an output of coal for the State of

154,644 short tons, since which time the production has been reported in Mineral Resources of the United States.

The annual production since 1860 is shown in the following table:

Annual production of coal in Georgia, 1860–1913, in short tons.

Year.	Quantity.	Year.	Quantity.	Year.	Quantity.	Year.	Quantity.
1860	1,900	1874	60,000	1888	180,000	1902	414,083
1861	2,500	1875	80,000	1889	225,934	1903	416,951
1862	3,500	1876	110,000	1890	228,337	1904	383,191
1863	6,000	1877	120,000	1891	171,000	1905	351,991
1864	10,000	1878	128,000	1892	215,498	1906	332,107
1865	10,000	1879	140,000	1893	372,740	1907	362,401
1866	8,000	1880	154,644	1894	354,111	1908	264,822
1867	8,000	1881	168,000	1895	260,998	1909	211,196
1868	10,000	1882	160,000	1896	238,546	1910	177,245
1869	12,000	1883	155,000	1897	195,869	1911	165,210
1870	15,000	1884	150,000	1898	244,187	1912	227,503
1871	20,000	1885	150,000	1899	233,111	1913	255,626
1872	25,000	1886	223,000	1900	315,557		
1873	40,000	1887	313,715	1901	342,825	Total	9,425,298

IDAHO.

Total production in 1913, 2,143 short tons; spot value, $5,149.

The small output of coal in Idaho is from a few scattered lignite beds and is used locally.

The production in Idaho during the last six years has been as follows:

Coal production in Idaho, 1908–1913, in short tons.

Year.	Quantity.	Value.	Year.	Quantity.	Value.
1908	5,429	$21,832	1911	1,805	$4,808
1909	4,553	19,459	1912	2,319	6,603
1910	4,448	17,426	1913	2,143	5,149

ILLINOIS.

Total production in 1913, 61,618,744 short tons; spot value, $70,313,605.

The coal-mining industry of Illinois in 1913 presented some interesting and contradictory features. In the first place, the diminished supply of natural gas in Kansas caused an increased demand for Illinois coal in the territory naturally tributary to the Illinois coal fields but which for a few years had been supplied by gas, and during the last three months of the year the strike in the coal fields of Colorado caused a movement of Illinois coal to more western markets in order to supply the deficiency created by the strike. On the other hand, exceptionally mild weather in the early winter had a depressing influence on the domestic trade, and the water power developed by the Keokuk dam seriously affected the demand for and prices of steam coal within a radius of 250 miles from the power plant. It is estimated that the power furnished by the dam displaces about 3,000 tons of coal a day. The effect of these influences is shown by an increase in the quantity of coal produced from 59,885,226 short tons in 1912 to 61,618,744 tons in 1913, a gain of 1,733,518 tons, whereas the value showed scarcely any increase at all ($19,267), from

$70,294,338 to $70,313,605. The average value per ton declined from $1.17 in 1912 to $1.14 in 1913. The decline in value was distributed generally over the State, there being only a few counties where the average prices in 1913 were higher than in 1912. Labor conditions were more satisfactory in 1913 than in 1912; but that there was much to be desired in that respect is shown by the facts that 11,861 men were on strike during the year, that the average time lost by the men on strike was 55 days, and that the average time made by all the employees in 1913 was reduced by 5 days, as compared with 1912. Transportation facilities were generally adequate. As in other States in the Middle West, floods in March and April interrupted coal-mining operations in many parts of Illinois, and then the drought, which began in June and lasted into October, increased mining expenses somewhat, as it necessitated hauling water for the power plants in order to keep the mines in operation.

There are more coal-producing counties in Illinois than in any other State in the Union, half of the 102 counties in the State being, or having been, producers. The two most important producing counties are in the southern part of the State, where the coal beds attain a greater thickness than in the northern districts. Williamson County in 1913 had an output of 7,644,397 tons, and Franklin County, 6,072,102 tons. Sangamon and Macoupin counties, which form the more important part of the Springfield-Belleville belt, are third and fourth, respectively, in producing importance, Sangamon contributing 5,875,853 tons and Macoupin 5,097,619 tons in 1913. St. Clair County, which forms the southwestern extremity of the Springfield-Belleville belt, is fifth in importance, with a production of 4,383,459 tons, and Saline County, on the southern border of the Illinois field, produced 4,189,003 tons in 1913. Two other counties, Madison and Vermilion, exceeded 3,500,000 tons in production, and three, Fulton, Montgomery, and Perry, produced over 2,000,000 tons. Five other counties had outputs exceeding 1,000,000 tons. The principal increase in the coal production of Illinois in 1913 was in Franklin County, where a large amount of development has taken place during the last three years, advancing the county from eighth place in 1910 to second in importance in 1913. Franklin County's increase in 1913 over 1912 was 1,629,818 short tons, or 37 per cent. No other county showed a gain of as much as 600,000 tons. Perry County, whose output showed the second largest increase, gained 569,014 tons, and Montgomery County's output increased 506,879 tons. The principal decreases in production were in St. Clair (351,381 tons), Marion (322,060 tons), Madison (293,725 tons), and Saline counties (228,871 tons). Coal mining on a commercial scale was carried on in 48 counties in Illinois during 1913, the production showing an increase in 21 counties and a decrease in 28. No production was reported in 1913 from Calhoun County, in which a small output was made in 1912.

Until 1909 Illinois ranked second in importance among the coal-producing States, although in one previous year, 1906, West Virginia temporarily displaced Illinois. In 1909 Illinois again dropped behind West Virginia, and has remained and will probably continue to remain indefinitely the third State in coal-producing importance. In 1913 West Virginia exceeded Illinois by approximately 10,000,000 tons.

The increased efficiency in the labor employed in the coal mines of Illinois, as noted in the report of this series for 1912, continued in 1913, and was due chiefly to the larger production obtained through the use of mining machines. In 1913 the average production per man in the coal mines of Illinois was 775 tons for the year and 4.1 tons for each working day, against 767 tons for the year and 3.95 tons per day in 1912 and 701 tons for the year and 3.7 tons for each day in 1911. The quantity of coal mined by machines increased from 26,878,049 tons, or 44.9 per cent of the total, in 1912 to 32,630,555 tons, or 53 per cent in 1913. The increase in the quantity of machine-mined coal was 5,752,506 tons, or about 3⅓ times the total increase in the production of coal in the State. It is gratifying to note a corresponding decrease in the quantity of coal shot off the solid. In 1912 the quantity of coal mined by powder in the mines of Illinois was 24,136,940 tons, or 40 per cent of the total, and in 1913 that item amounted to 20,469,139 tons, or 33 per cent of the total. The quantity of coal mined by hand increased from 7,675,805 tons in 1912 to 8,069,361 tons in 1913, the percentages to the total being about the same in both years. The prevalence of solid shooting in the coal mines of Illinois has been little short of criminal, for it adds materially to the hazardous character of the miner's occupation and seriously impairs the quality of the product. The trade on which the mines of Illinois depend demands principally screened coal, with little sale for the slack or screenings except at greatly reduced price. Shooting off the solid adds largely to the percentage of the slack coal and increases the friability of the product which comes from the mines in lumps but breaks down rapidly in handling. With the increased use of coal-cutting machinery it is believed that within a few years little coal will be mined in Illinois without having been previously undercut or sheared. The flat-lying character of the Illinois coal beds is favorable to machine mining, and there appears to be no good reason for permitting solid shooting to continue. The number of machines in use increased from 1,654 in 1912 to 1,845 in 1913. The increase was entirely in the installation of chain-breast and long-wall machines. There were fewer punchers in use in 1913 than in 1912, the number of that type of machine having decreased from 847 in 1912 to 802 in 1913. The nunber of chain-breast machines, on the other hand, increased from 701 to 906. The number of long-wall machines increased from 22 to 55 and of short-wall machines from 81 to 82. Considerable quantities of Illinois coal are washed in preparation for the domestic trade, and washed Illinois egg and nut coals have a distinctive place in the markets. Many of the operators who cater to the domestic trade in Illinois coal carefully size their product by screens, sometimes as many as a half dozen sizes being prepared. Certain types of washers are much more effective when the coal has been screened before washing, and as a usual thing the washed coal has also been sized. In 1913 the quantity of Illinois coal washed was 4,190,960 tons, which yielded 3,664,928 tons of cleaned coal and 526,032 tons of refuse. The quantity of washed coal sold in Illinois in 1913 was nearly 600,000 tons greater than in 1912.

The casualty record of the coal mines of Illinois maintained by the Bureau of Mines shows that there were 164 fatal accidents in 1913, as compared with 159 in 1912 and 172 in 1911. All but 11 of the fatalities occurred under ground, and 80 of them (nearly 50 per cent) were due to falls of roof and coal. Haulage-way accidents were responsible for 38 deaths; explosions of gas killed 8; premature blasts and other accidents from explosives killed 11; and electric shocks and burns killed 8. Four men were killed in shafts and 7 on the surface. The death rate per thousand was 2.06 in 1913 against 2.04 in 1912 and 2.25 in 1911. The quantity of coal mined for each life lost was 375,724 short tons, against 376,637 in 1912 and 312,088 in 1911.

The statistics of production, by counties, in 1912 and 1913, with the distribution of the product for consumption, are shown in the following table:

Coal production of Illinois in 1912 and 1913, by counties, in short tons.

1912.

County.	Loaded at mines for shipment.	Sold to local trade and used by employees.	Used at mines for steam and heat.	Total quantity.	Total value.	Average price per ton.	Average number of days active.	Average number of employees.
Bureau	1,560,490	48,706	68,121	1,677,317	$2,736,737	$1.63	224	3,808
Christian	1,250,722	152,163	64,961	1,467,846	1,687,823	1.15	167	2,075
Clinton	978,791	12,947	48,741	1,040,479	1,073,188	1.03	171	1,336
Franklin	4,282,721	39,878	119,685	4,442,284	5,389,076	1.21	204	4,499
Fulton	2,337,698	54,323	61,403	2,453,424	3,193,202	1.30	201	3,578
Gallatin	48,977	14,399	868	64,244	72,295	1.13	147	164
Grundy	480,549	30,690	29,548	540,787	963,365	1.78	162	1,595
Henry	17,000	39,863	1,750	58,613	104,602	1.78	174	126
Jackson	629,550	29,806	48,834	703,190	968,303	1.38	160	1,068
Knox	....	21,417	876	22,293	39,765	1.78	163	60
La Salle	1,156,290	307,696	73,605	1,537,591	2,706,718	1.76	224	3,275
Livingston	24,918	39,219	1,637	65,774	130,847	1.99	216	127
Logan	392,374	56,638	17,516	466,528	574,713	1.23	186	678
McDonough	3,178	10,954	314	14,446	31,820	2.20	178	48
Macon	148,443	136,047	7,100	291,590	413,179	1.42	163	581
Macoupin	4,791,107	80,155	115,312	4,986,574	4,894,191	.98	206	5,061
Madison	3,804,878	124,515	96,485	4,025,878	4,386,620	1.09	184	4,466
Marion	1,221,716	48,313	40,995	1,311,024	1,406,346	1.07	224	1,401
Marshall	361,335	66,443	21,882	449,660	812,020	1.81	240	1,065
Menard	116,431	53,797	7,350	177,578	240,850	1.36	169	335
Mercer	364,886	15,635	12,497	393,018	594,171	1.51	209	479
Montgomery	2,092,984	43,122	46,717	2,182,823	2,348,084	1.08	192	2,665
Peoria	1,097,830	101,958	25,786	1,225,574	1,580,021	1.29	213	1,721
Perry	1,361,180	31,128	51,806	1,444,114	1,518,746	1.05	146	1,968
Randolph	752,609	30,924	14,630	798,163	814,922	1.02	138	1,116
Rock Island	15,456	47,477	3,884	66,817	107,377	1.61	180	122
St. Clair	4,437,137	182,573	115,130	4,734,840	4,656,454	.98	162	5,799
Saline	4,293,635	34,699	89,540	4,417,874	4,924,839	1.11	204	5,204
Sangamon	5,260,048	298,353	156,341	5,714,742	6,335,965	1.11	178	7,030
Shelby	153,045	24,210	8,246	185,501	252,865	1.36	142	339
Stark	10,881	21,845	1,450	34,176	57,128	1.67	188	43
Tazewell	192,423	71,224	7,674	271,321	348,063	1.28	225	376
Vermilion	3,179,572	201,243	54,108	3,434,923	3,940,780	1.15	234	4,149
Will	111,833	14,063	4,910	130,806	242,805	1.86	201	408
Williamson	6,982,822	69,188	302,497	7,354,507	8,214,769	1.12	187	8,602
Other counties [a] and small mines	1,391,021	238,250	69,636	1,698,907	2,531,689	1.49	229	2,731
Total	55,304,530	2,793,861	1,786,835	59,885,226	70,294,338	1.17	194	78,098

[a] Bond, Calhoun, Edgar, Greene, Jefferson, McLean, Morgan, Moultrie, Putnam, Schuyler, Scott, Warren, Washington, White, and Woodford.

Coal production of Illinois in 1912 and 1913, by counties, in short tons—Continued.

1913.

County.	Loaded at mines for shipment.	Sold to local trade and used by employees.	Used at mines for steam and heat.	Total quantity.	Total value.	Average price per ton.	Average number of days active.	Average number of employees.
Bureau	1,514,958	55,964	68,286	1,639,208	$2,614,561	$1.60	207	3,790
Christian	1,353,559	79,286	71,871	1,504,716	1,672,004	1.11	156	2,294
Clinton	1,001,903	11,601	36,071	1,049,575	1,021,262	.97	157	1,377
Franklin	5,872,038	42,254	157,810	6,072,102	7,007,904	1.15	220	5,662
Fulton	2,282,585	45,766	60,424	2,388,775	3,055,825	1.28	191	3,569
Gallatin	41,214	3,884	1,007	46,105	50,835	1.10	113	148
Grundy	361,221	23,598	16,708	401,527	663,649	1.65	153	1,148
Henry	320	41,388	1,675	43,383	79,015	1.82	180	113
Jackson	641,946	27,912	54,005	723,863	1,028,754	1.42	174	974
Knox	....	17,672	608	18,280	34,318	1.88	189	51
La Salle	1,125,740	364,790	73,929	1,564,459	2,738,704	1.75	237	2,893
Livingston	1,524	61,154	1,199	63,877	104,901	1.64	248	100
Logan	268,696	55,273	27,697	351,666	435,250	1.24	193	597
McDonough	1,682	10,921	....	12,603	27,656	2.19	161	35
Macoupin	4,908,004	71,020	118,595	5,097,619	5,057,710	.99	193	5,472
Madison	3,534,531	105,390	92,232	3,732,153	3,824,161	1.02	157	4,393
Marion	945,572	18,356	25,036	988,964	998,143	1.01	175	1,438
Marshall	340,639	62,174	23,677	426,490	776,171	1.82	217	1,078
Menard	77,673	35,577	6,924	120,174	151,633	1.26	148	281
Mercer	374,846	18,305	15,724	408,875	580,790	1.42	198	581
Montgomery	2,603,826	37,975	47,901	2,689,702	2,797,777	1.04	187	3,086
Peoria	1,048,737	91,910	22,426	1,163,073	1,432,687	1.23	206	1,519
Perry	1,918,763	30,146	64,219	2,013,128	2,055,441	1.02	190	2,267
Randolph	711,894	28,316	23,262	763,472	772,579	1.01	149	1,003
Rock Island	2,062	29,810	3,800	35,672	54,677	1.53	132	75
St. Clair	4,105,508	187,707	90,244	4,383,459	4,192,122	.96	175	4,785
Saline	4,065,766	33,728	89,509	4,189,003	4,739,217	1.13	200	4,911
Sangamon	5,457,986	255,273	162,594	5,875,853	6,277,960	1.07	164	7,775
Shelby	165,489	18,678	9,465	193,632	259,053	1.34	167	406
Stark	3,775	10,315	520	14,610	26,060	1.78	141	46
Tazewell	268,412	67,015	6,199	341,626	417,709	1.22	246	433
Vermilion	3,268,325	174,752	58,803	3,501,880	4,007,167	1.14	214	4,058
Wise	130,668	14,358	4,900	149,926	285,640	1.91	187	387
Williamson	7,379,489	67,203	197,705	7,644,397	8,263,104	1.08	180	9,472
Other counties and small mines *a*	1,549,728	369,486	85,683	2,004,897	2,809,166	1.40	214	3,312
Total	57,329,079	2,568,957	1,720,708	61,618,744	70,313,605	1.14	189	79,529

a Bond, Greene, Jefferson, McLean, Macon, Morgan, Moultrie, Putnam, Schuyler, Scott, Warren, Washington, White, and Woodford.

In the following table are shown the statistics of production of coal in Illinois, by counties, during the last five years, with increase and decrease in 1913 as compared with 1912:

Coal production of Illinois, 1909–1913, by counties, in short tons.

County.	1909	1910	1911	1912	1913	Increase(+) or decrease (—), 1913.
Bond	89,861	139,398	119,250	232,571	223,786	— 8,785
Bureau	1,612,452	973,346	1,628,688	1,677,317	1,639,208	— 38,109
Calhoun	....	....	1,400	1,156	....	— 1,156
Christian	1,395,158	1,223,295	1,222,259	1,467,846	1,504,716	+ 36,870
Clinton	970,709	950,243	921,225	1,040,479	1,049,575	+ 9,096
Franklin	2,316,509	1,778,768	3,555,586	4,442,284	6,072,102	+1,629,818
Fulton	2,388,617	1,721,527	2,133,029	2,453,424	2,388,775	— 64,649
Gallatin	64,713	70,091	63,008	64,244	46,105	— 18,139
Greene	7,318	9,082	6,207	7,841	5,009	— 2,832
Grundy	1,114,101	600,281	776,800	540,787	401,527	— 139,260
Hancock	1,085	640	230	....	....	
Henry	137,060	124,243	90,722	58,613	43,383	— 15,230
Jackson	652,280	584,240	687,753	703,190	723,863	+ 20,673
Jefferson	4,800	10,000	9,500	21,032	35,000	+ 13,968
Jersey	1,000	....	....	....	....	....
Kankakee	25,000	....	....	....	....	....
Knox	21,973	28,295	30,136	22,293	18,280	— 4,013
La Salle	1,686,391	1,178,885	1,610,470	1,537,591	1,564,459	+ 26,868
Livingston	246,031	162,898	89,423	65,774	63,877	— 1,897
Logan	395,888	409,244	334,860	466,528	351,666	— 114,862
McDonough	16,276	26,338	8,027	14,446	12,603	— 1,843
McLean	116,412	83,982	96,517	89,781	88,777	— 1,004
Macon	238,607	235,361	236,203	291,590	206,140	— 85,450
Macoupin	4,597,775	3,854,229	4,688,212	4,986,574	5,097,619	+ 111,045
Madison	3,373,798	4,102,773	3,152,705	4,025,878	3,732,153	— 293,725
Marion	1,171,950	812,873	1,224,326	1,311,024	988,964	— 322,060
Marshall	295,812	267,447	423,984	449,660	426,490	— 23,170
Menard	303,948	332,557	190,477	177,578	120,174	— 57,404
Mercer	369,762	229,024	297,552	393,018	408,875	+ 15,857
Montgomery	1,780,668	1,799,720	2,395,814	2,182,823	2,689,702	+ 506,879
Morgan	1,200	1,300	1,268	1,000	1,222	+ 222
Peoria	914,961	810,595	1,037,362	1,225,574	1,163,073	— 62,501
Perry	1,423,135	1,367,771	1,272,292	1,444,114	2,013,128	+ 569,014
Putnam	597,703	364,882	772,976	720,048	724,170	+ 4,122
Randolph	799,893	1,025,557	777,746	798,163	763,472	— 34,691
Rock Island	46,228	66,207	65,983	66,817	35,672	— 31,145
St. Clair	3,471,630	5,788,567	3,931,479	4,734,840	4,383,459	— 351,381
Saline	3,283,939	2,459,650	3,820,410	4,417,874	4,189,003	— 228,871
Sangamon	5,616,357	4,449,634	5,137,835	5,714,742	5,875,853	+ 161,111
Schuyler	4,573	2,427	6,138	4,573	1,855	— 2,718
Scott	2,056	2,400	464	460	600	+ 140
Shelby	124,087	135,672	81,615	185,501	193,632	+ 8,131
Stark	23,159	32,582	37,293	34,176	14,610	— 19,566
Tazewell	208,049	155,659	220,783	271,321	341,626	+ 70,305
Vermilion	1,919,955	2,515,250	3,385,200	3,434,923	3,501,880	+ 66,957
Warren	12,304	10,275	9,044	5,021	3,383	— 1,638
Washington	31,322	22,500	25,000	244,879	319,370	+ 74,491
White	22,133	23,722	35,681	27,052	22,304	— 4,748
Will	162,307	124,652	178,397	130,806	149,926	+ 19,120
Williamson	6,537,654	4,620,372	6,614,029	7,354,507	7,644,397	+ 289,890
Woodford	194,410	125,823	164,001	185,499	[a]302,184	+ 116,685
Small mines	111,981	85,969	109,759	157,994	71,097	— 86,897
Total	50,904,990	45,900,246	53,679,118	59,885,226	61,618,744	+1,733,518
Total value	$53,522,014	$52,405,897	$59,519,478	$70,294,338	$70,313,605	+ $19,267

[a] Includes production of Moultrie County.

There are 102 counties in Illinois, and coal has been mined in 51 of them. The coal formations underlie a number of other counties, the total productive territory occupying nearly three-fourths of the entire State. The total coal area is estimated at 35,600 square miles, the largest area in any State east of Mississippi River and exceeded only by those of Montana and North Dakota. The coal fields comprise the western part of a broad and relatively flat basin whose eastern border is in the western part of Indiana and whose southern extremity extends under Ohio River into Kentucky. The principal developments are in the northern, western, and southern borders from Grundy, La Salle, and Bureau counties on the north, to Williamson, and Saline counties on the south, with a somewhat isolated district in Vermilion County at the northeast. These developments are divided more into districts or regions from a commercial standpoint than into distinct fields determined by geologic conditions, though of course the accessibility of the beds at relatively shallow depths, or the thickness and quality of the coal, has influenced their exploitation. Among the principal mining districts are the Mazon Creek region of Grundy and Livingston counties; the Streator-Spring Vallay district of Bureau and La Salle counties; the Peoria district; the Springfield-Belleville belt, including Sangamon, Christian, Macoupin, Montgomery, Madison, and St. Clair counties; the Southwestern district, including Washington, Perry, Franklin, Jackson, and Williamson counties; the Harrisburg district of Saline County; and the Danville district in Vermilion County. Of these districts, the Springfield-Belleville belt is the most important, contributing nearly 40 per cent of the State's total output of coal.

The coal production of Illinois is from six different beds, Nos. 1, 2, 3, 5, 6, and 7, but in some cases doubt exists as to the exact correlation of the beds, Nos. 6 and 7 being especially confused locally. It has been demonstrated that what is generally designated as No. 7, in southeastern Illinois, is identical with No. 6 in the southwestern part of the State. Bed No. 6 is by far the most important one in the State. It averages 6 feet in thickness over a wide extent of territory, and is mined at depths varying from 50 to 800 feet. Nearly 60 per cent of the total output of the State is from this bed, and if to the coal reported as from No. 6 is added that reported as from No. 7 (which ought to be No. 6) the percentage from this bed would probably exceed 60. The mines operated on No. 6 coal, about 275 in number, average over 100,000 tons each in production.

Bed No. 5, which is the one chiefly worked in the Danville district, and in the north-central and southeastern parts of the State, is second in importance and produces something over 25 per cent of the total, and bed No. 2, or "Big Muddy," produces a little over 10 per cent.

The first mention of coal in the territory which afterward became the United States is contained in the Journal of Father Louis Hennepin,[1] published in 1698. This journal contains a map on which is marked "cole mine" on the banks of Illinois River near the site of the present city of Ottawa, Hennepin having passed through this region 30 years before, in 1668. After the discovery of coal in Illinois, however, nearly a century and a half elapsed before mining began. The Journal of the Franklin Institute for 1836 states that the first actual mining operations conducted by white men were at the Mount Carbon mines, near Brownsville, in Jackson County, on the banks of Big Muddy River, a short distance from its junction with the Mississippi. These mines were opened in 1810 and worked to a limited extent for many years.[2] Another region, said to have been

[1] Voyage de nouvelle découverte du très grand pays de l'Amérique. Amsterdam, 1698.
[2] Macfarlane, James, Coal regions of America, p. 421. New York, 1873.

opened about the same time, was near Belleville, in St. Clair County, opposite the present site of St. Louis. The outcrops of coal in the bluffs along the river banks first attracted attention, and naturally the first mining operations were started on these exposures. The earliest recorded production was in 1833, when an output of 6,000 tons is said to have been mined.

The production of coal in Illinois from 1833 to the close of 1913 is shown in the following table:

Production of coal in Illinois, 1833–1913, in short tons.

Year.	Quantity.	Year.	Quantity.	Year.	Quantity.	Year.	Quantity.
1833	6,000	1854	385,000	1875	4,453,178	1896	19,786,626
1834	7,500	1855	400,000	1876	5,000,000	1897	20,072,758
1835	8,000	1856	410,000	1877	5,350,000	1898	18,599,299
1836	10,000	1857	450,000	1878	5,700,000	1899	24,439,019
1837	12,500	1858	490,000	1879	5,000,000	1900	25,767,981
1838	14,000	1859	530,000	1880	6,115,377	1901	27,331,552
1839	15,038	1860	728,400	1881	6,720,000	1902	32,939,373
1840	16,967	1861	670,000	1882	9,115,653	1903	36,957,104
1841	35,000	1862	780,000	1883	12,123,456	1904	36,475,060
1842	58,000	1863	890,000	1884	12,208,075	1905	38,434,363
1843	75,000	1864	1,000,000	1885	11,834,459	1906	41,480,104
1844	120,000	1865	1,260,000	1886	11,175,241	1907	51,317,146
1845	150,000	1866	1,580,000	1887	12,423,066	1908	47,659,690
1846	165,000	1867	1,800,000	1888	14,328,181	1909	50,904,990
1847	180,000	1868	2,000,000	1889	12,104,272	1910	45,900,246
1848	200,000	1869	1,854,000	1890	15,292,420	1911	53,679,118
1849	260,000	1870	2,624,163	1891	15,660,698	1912	59,885,226
1850	300,000	1871	3,000,000	1892	17,862,276	1913	61,618,744
1851	320,000	1872	3,360,000	1893	19,949,564		
1852	340,000	1873	3,920,000	1894	17,113,576	Total	965,516,323
1853	375,000	1874	4,203,000	1895	17,735,864		

INDIANA.

Total production in 1913, 17,165,671 short tons; spot value, $19,001,881.

Although the coal production of Indiana in 1913 showed an increase of 1,879,953 short tons, or 12.3 per cent over 1912, it fell short of the record output of 1910 by more than 1,200,000 tons and was far from satisfactory to the producers. The year was ushered in with weather mild as spring and the remainder of the winter was so unseasonally warm that the consumption of coal for both domestic and steam purposes was considerably subnormal. The flood which swept over that part of the country in March and April caused a suspension of mining operations in some sections of the State lasting from 10 days to two weeks, and seriously handicapped operations at some mines for even a longer period. The flood was immediately followed by a drought during which the water supply in the mining districts all over the State was exhausted, necessitating the shipment of water to the mines, which caused boiler trouble and materially increased the operating expenses. In addition to all of this, there was a general decline in prices throughout the State, the average value per ton showing a decline from $1.14 in 1912 to $1.11 in 1913. The total value increased from $17,480,546 to $19,001,881, a gain of $1,521,335, or 8.7 per cent, as compared with the increase of 12.3 per cent in quantity.

Out of the 19 coal-producing counties in the State, 11 showed decreased production in 1913 and 8 increases. The decreases were generally in the less important counties, only one of the large producers, Sullivan County, having a smaller production in 1913 than in 1912, and in that county the decrease was less than 7,000 tons. The principal gains were in Vigo County, 673,228 tons; Knox County, 548,152 tons; and Vermilion County, 538,185 tons. Clay County, whose production has decreased annually since 1910, suffered the largest decrease in 1913—135,366 tons.

In spite of the adverse conditions which prevailed in 1913, labor was in better supply and the number of working days made by the employees was greater than in 1912. The total number of employees in the coal mines of Indiana increased from 21,651 in 1912 to 22,235 in 1913, and the average working time, from 182 to 190 days. The average annual production per man increased from 706 to 772 tons, and the average daily production by each man, from 3.88 to 4.06 tons.

The increased efficiency was due in part to the larger proportion of the product being mined by the use of machines, the increase in that item contributing two-thirds of the total increase, or 1,373,666 tons. The production of machine-mined coal in 1913 amounted to 9,737,425 short tons, or 57 per cent of the total, as compared with 8,363,759 tons, or 54.7 per cent, in 1912. There was not, however, any decrease in the proportion of the product shot off the solid, the figures being 4,615,580 tons in 1912 and 5,175,229 tons in 1913, and the percentage being the same in both years. The quantity of hand-mined coal decreased from 2,094,397 tons, or 13.7 per cent, in 1912 to 1,862,729 tons, or 11 per cent, in 1913. The method employed in mining 2 per cent of the production in 1913 was not reported. The number of mining machines in use increased from 687 in 1912 to 732 in 1913. Chain-breast machines are in the majority, 365, or something over half in 1913 being of that type. Of the remainder, 166 were punchers, 105 were long wall, and 96 were short wall or continuous cutters.

The number of fatal accidents reported to the Bureau of Mines for 1913 was 66, an increase from 40 in 1912. Of the 66 fatalities, 59 were underground, 5 in shafts, and 2 on the surface. Falls of roof and coal claimed 29 victims; gas and dust explosions, 15; and mine cars and locomotives, 8. The death rate per thousand was 2.97, against 1.85 in 1912, and the quantity of coal mined for each lost life was 260,086 tons, against 382,143 tons.

Strikes and suspensions were not of a serious character and resulted in the loss of an average of 17 days by the 2,657 men affected. The total time lost was only a little more than 1 per cent of the time made.

The statistics of coal production in 1913 and 1912, by counties, in Indiana, with the distribution of the product for consumption, are shown in the following table:

Coal production of Indiana in 1912 and 1913, by counties, in short tons.

1912.

County.	Loaded at mines for shipment.	Sold to local trade and used by employees.	Used at mines for steam and heat.	Total quantity.	Total value.	Average price per ton.	Average number of days active.	Average number of employees.
Clay	636,236	37,331	26,756	700,323	$949,270	$1.36	164	1,365
Daviess	83,395	19,056	2,628	105,079	150,931	1.44	205	215
Dubois and Martin		16,500		16,500	21,675	1.31	278	18
Fountain and Warren		5,066		5,066	10,480	2.07	195	19
Gibson	189,763	33,075	5,719	228,557	267,632	1.17	195	255
Greene	2,537,194	42,182	57,133	2,636,509	3,080,437	1.17	199	2,984
Knox	1,160,560	24,866	27,170	1,212,596	1,256,293	1.04	196	1,258
Owen	26,787	3,000	920	30,707	47,585	1.55	186	53
Parke	475,972	26,461	20,717	523,150	684,087	1.31	184	865
Perry		15,904		15,904	19,344	1.22	239	30
Pike	521,123	23,147	15,067	559,337	638,826	1.14	190	860
Spencer	2,597	7,703	6	10,306	15,152	1.47	210	20
Sullivan	2,968,371	43,233	79,764	3,091,368	3,428,248	1.11	179	4,419
Vanderburg	103,630	188,254	10,190	302,074	403,250	1.33	183	499
Vermilion	1,479,182	21,046	46,898	1,547,126	1,653,789	1.07	165	2,370
Vigo	3,363,229	106,053	94,764	3,564,046	4,055,879	1.14	183	5,511
Warrick	631,647	45,757	14,071	691,475	732,630	1.06	166	910
Small mines		45,595		45,595	65,038	1.43		
Total	14,179,686	704,229	401,803	15,285,718	17,480,546	1.14	182	21,651

1913.

County.	Loaded at mines for shipment.	Sold to local trade and used by employees.	Used at mines for steam and heat.	Total quantity.	Total value.	Average price per ton.	Average number of days active.	Average number of employees.
Clay	503,663	32,352	28,942	564,957	$746,940	$1.32	165	1,317
Daviess	71,411	6,634	5,985	84,030	108,826	1.30	207	160
Dubois and Martin	5,550	2,198	200	7,948	12,563	1.58	164	21
Fountain and Warren	55,000	7,202	2,700	64,902	83,930	1.29	156	90
Gibson	162,053	58,994	6,053	227,100	249,513	1.10	199	305
Greene	2,668,439	42,877	69,392	2,780,708	3,041,689	1.09	198	3,137
Knox	1,677,295	46,533	36,920	1,760,748	1,820,017	1.03	203	1,395
Owen	119,258	2,200	5,825	127,283	140,089	1.10	181	120
Parke	472,626	16,534	18,348	507,508	601,127	1.18	197	941
Perry		14,910		14,910	22,649	1.52	255	37
Pike	550,899	19,912	12,826	583,637	652,648	1.12	186	912
Spencer		8,429	50	8,479	12,037	1.42	225	22
Sullivan	2,955,243	42,751	86,425	3,084,419	3,390,549	1.10	159	4,376
Vanderburg	140,892	132,913	6,717	280,522	363,572	1.30	196	459
Vermilion	1,999,539	19,617	66,155	2,085,311	2,313,690	1.11	212	2,484
Vigo	4,023,703	109,951	103,620	4,237,274	4,653,657	1.10	203	5,556
Warrick	628,714	38,096	18,210	685,020	705,894	1.03	179	903
Small mines		60,915		60,915	82,491	1.35		
Total	16,034,285	663,018	468,368	17,165,671	19,001,881	1.11	190	22,235

In the following table are shown the statistics of the production of coal in Indiana, by counties, during the last five years, with increase and decrease in 1913 as compared with 1912:

Coal production of Indiana, 1909–1913, by counties, in short tons.

County.	1909	1910	1911	1912	1913	Increase(+) or decrease (−), 1913.
Clay	958,732	980,016	779,372	700,323	564,957	− 135,366
Daviess	73,877	87,374	79,466	105,079	84,030	− 21,049
Dubois	[a] 35,404	[a] 8,290	[a] 4,119	[a] 16,500	[a] 7,948	− 8,552
Fountain	5,520	3,300	1,700	1,100	60,200	+ 59,100
Gibson	232,599	296,753	247,128	228,557	227,100	− 1,457
Greene	2,612,686	3,439,002	2,563,366	2,636,509	2,780,708	+ 144,199
Knox	642,727	1,003,909	879,323	1,212,596	1,760,748	+ 548,152
Owen	15,904	10,690	22,693	30,707	127,283	+ 96,576
Parke	730,082	764,115	521,567	523,150	507,508	− 15,642
Perry	15,603	26,317	16,683	15,904	14,910	− 994
Pike	447,122	697,385	467,623	559,337	583,637	+ 24,300
Spencer	11,118	9,096	9,551	10,306	8,479	− 1,827
Sullivan	3,227,515	4,035,934	3,261,787	3,091,368	3,084,419	− 6,949
Vanderburg	271,644	398,293	279,109	302,074	280,522	− 21,552
Vermilion	1,443,099	1,635,623	1,673,621	1,547,126	2,085,311	+ 538,185
Vigo	3,562,534	4,181,799	2,793,352	3,564,046	4,237,274	+ 673,228
Warren	7,130	5,122	3,925	3,966	4,702	+ 736
Warrick	488,194	768,706	545,132	691,475	685,020	− 6,455
Small mines	52,769	38,091	51,838	45,595	60,915	+ 15,320
Total	14,834,259	18,389,815	14,201,355	15,285,718	17,165,671	+ 1,879,953
Total value	$15,154,681	$20,813,659	$15,326,808	$17,480,546	$19,001,881	+$1,521,335

[a] Includes Martin County.

All of the coal productive area of Indiana is in the southwestern part of the State, which constitutes the eastern edge of the eastern interior coal region. The total area embraces about 6,500 square miles and includes 26 counties, from 19 of which coal is being produced at the present time. Coal of workable thickness has been found at eight different horizons. All of the coal is classed as bituminous. Along the eastern edge of the field is a series of basins, some of which are but a few acres in area, which produce a variety of coal known as block or semiblock, from the almost perfectly rectangular blocks into which it fractures. This is a very pure, dry, noncoking coal, suitable for use in its raw state as a blast-furnace fuel, though usually mixed with coke when so used. The rest of the coals, designated locally as "bituminous" are excellent steam fuels. Some of them possess coking qualities but not sufficiently to compete with those of the Eastern States. Cannel coal is mined at several places. The "bituminous" coals are much more regular and persistent over large areas, some of them being traced with certainty over several thousand square miles of territory. The beds range from 3 to 10 feet in thickness and most of the mines are working on 5 feet or more of coal. Some of the mines, most of which are operated by shaft, are working on three different beds.

Some knowledge of the coal resources of Indiana was obtained as early as 1804, when the public-land surveys showed a number of outcrops. The report of the geological survey of Indiana, published in 1872, states that in 1811 coal was dug at Fulton, in Perry County, and taken by Robert Fulton aboard the steamer, *Orleans* on its first trip down Ohio River. There is good reason to believe that coal continued to be mined for local consumption between 1811 and 1837, when the first attempt at commercial mining was made; but there is no record of the quantity mined during that interim. The first commercial coal mining in Indiana was by the American Cannel Coal Co., at Cannelton, Perry County, in 1837. The coal was mined on the bluffs along Ohio and Wabash rivers, and for the first 10 years of the company's operations was loaded directly into boats for shipment down the Ohio.

In 1840 the United States Census reported that the production of coal in Indiana in that year was 9,682 tons. The industry developed slowly until 1865, when it was ascertained that the block coal mined in the Brazil and Terre Haute districts made a satisfactory blast-furnace fuel in its raw condition. At about that time the construction of railroads throughout the State gave an impetus to the coal-mining industry which has shown steady progress except when interrupted by periods of depression and labor disaffections.

The statistics of coal production in Indiana from 1840 to the close of 1913 are given in the following table, the years for which no official statistics are available having been estimated from the best information obtainable:

Production of coal in Indiana from 1840 to 1913, in short tons.

Year.	Quantity.	Year.	Quantity.	Year.	Quantity.	Year.	Quantity.
1840	9,682	1859	95,000	1878	1,000,000	1897	4,151,169
1841	10,000	1860	101,280	1879	1,196,490	1898	4,920,743
1842	18,000	1861	128,000	1880	1,454,327	1899	6,006,523
1843	25,000	1862	150,000	1881	1,984,120	1900	6,484,086
1844	30,000	1863	200,000	1882	1,976,470	1901	6,918,225
1845	35,000	1864	250,000	1883	2,560,000	1902	9,446,424
1846	40,000	1865	280,000	1884	2,260,000	1903	10,794,692
1847	45,000	1866	320,000	1885	2,375,000	1904	10,842,189
1848	50,000	1867	350,000	1886	3,000,000	1905	11,895,252
1849	56,000	1868	375,000	1887	3,217,711	1906	12,092,560
1850	60,000	1869	400,000	1888	3,140,979	1907	13,985,713
1851	60,000	1870	437,870	1889	2,845,057	1908	12,314,890
1852	75,000	1871	600,000	1890	3,305,737	1909	14,834,259
1853	75,000	1872	896,000	1891	2,973,474	1910	18,389,815
1854	80,000	1873	1,000,000	1892	3,345,174	1911	14,201,355
1855	80,000	1874	812,000	1893	3,791,851	1912	15,285,718
1856	85,000	1875	800,000	1894	3,423,921	1913	17,165,671
1857	85,000	1876	950,000	1895	3,995,892		
1858	87,000	1877	1,000,000	1896	3,905,779	Total..	251,632,098

IOWA.

Total production in 1913, 7,525,936 short tons; spot value, $13,496,710.

Compared with 1912, when the production of coal in Iowa amounted to 7,289,529 short tons, valued at $13,152,088, the record for 1913 showed an increase of 236,407 tons, or 3.24 per cent in quantity and of $344,622, or 2.62 per cent in value. Except for the drought, which began in June and did not end until September, conditions during the year were normal. The slight increase in production over 1912 was due to the disturbed labor situation in Colorado. Operators complain of the unsatisfactory character of the mine labor in the State, not so much on account of inefficiency as of exacting demands which they claim have increased the cost of mining beyond the prices they have been able to secure for their product and have discouraged the opening and development of new properties. Iowa is primarily an agricultural State and the markets for its coal, outside of that taken by the railroads, are chiefly in rural communities and cities of moderate size dependent upon agricultural trade. There are no extensive manufacturing interests requiring large supplies of fuel for power purposes. Some coal is shipped to Nebraska, Minnesota, and other States, but an equal quantity comes into Iowa from Illinois and eastern fields. The coal beds of the State are not thick, the thickest in the Des Moines district averaging about 5 feet, and they are somewhat irregular and faulted. The coal is of noncoking bituminous grade, somewhat high in sulphur, but is a fair steaming fuel. In the Centerville district the coal is regular and persistent, but thin, being not over 30 inches in thickness. It has, however, a strong roof that furnishes ideal conditions for long-wall mining. Mining operations are all on a moderate scale, there being only 6 mines producing over 200,000 tons, and 18 having an output of over 100,000 tons in 1913.

Coal was mined on a commercial scale in 21 counties in 1913, 1 less than in 1912—Scott County, which had a small production in 1912, not reporting any output in 1913. Of the 21 counties, 12 showed decreased production in 1913, and in 9 the production increased. The principal decrease in 1913 was in Mahaska County, whose output has declined each year since 1909. The decline in that county in 1913 was 223,106 tons, or nearly 40 per cent. The principal gains were in Dallas County, 137,980 tons; Monroe County, 177,865 tons; and Marion County, 116,484 tons. Marion County's production in 1913 was 64 per cent larger than in 1912. Dallas County continued an uninterrupted sequence of increases since 1906, reversing the conditions shown in Mahaska County.

The number of men employed in the coal mines of Iowa decreased from 16,370 in 1912 to 15,757 in 1913, but notwithstanding this shortage and the larger production of coal in 1913, the average number of working days showed only a slight increase from 188 to 195. There was, in consequence, an increase in the average yearly production per man from 445 tons to 478 tons, and in the average daily production from 2.37 to 2.45 tons.

Iowa is no exception to the other States of the interior province where shooting off coal from the solid is practised to a reprehensible degree, and the record in that respect for 1913 was worse than in 1912. The quantity of coal shot off the solid in 1913 was 5,440,437 short tons, or 72.3 per cent of the total; in 1912 69 per cent of the total was "powder-mined." There were 28 machines reported in use in 1913, but only 120,716 tons of coal were machine-mined. Of the machines in use, 3 were punchers, 7 were chain-breast, 8 were long-wall, 8 were short-wall, and 2 were radialaxe. The quantity of coal mined by hand was 1,523,655 tons, or 20.2 per cent of the total. The methods used in mining 441,128 tons, or nearly 6 per cent of the total, were not reported.

There were 7 instances of labor strikes during the year. The total number of men on strike was 721, and the average time lost by each was 19 days.

Little attempt is made in Iowa to improve the quality of the coal by washing. In 1913 the total quantity of coal washed was 31,711 tons, which yielded 22,080 tons of cleaned coal, and 9,631 tons of refuse.

According to reports of the Bureau of Mines, there were 26 fatal accidents in the coal mines of Iowa in 1913, an increase of 7 over 1912. All of the fatalities occurred underground, and 18 of them were due to falls of roof. Six deaths were due to haulage-way accidents. The death rate per thousand was 1.65 against 1.16 in 1912, and the quantity of coal mined for each life lost was 289,459 tons, as compared with 383,659 tons in 1912.

The statistics of coal production in Iowa in 1912 and 1913, by counties, with the distribution of the product for consumption, are shown in the following table:

Coal production of Iowa in 1912 and 1913, by counties, in short tons.

1912.

County.	Loaded at mines for shipment.	Sold to local trade and used by employees.	Used at mines for steam and heat.	Total quantity.	Total value.	Average price per ton.	Average number of days active.	Average number of employees.
Adams		9,868		9,868	$24,690	$2.50	124	55
Appanoose	1,168,776	65,969	17,921	1,252,666	2,506,844	2.00	161	4,166
Boone	172,585	35,683	3,900	212,168	454,731	2.14	161	776
Dallas	420,990	8,969	6,247	436,206	810,532	1.86	225	957
Greene	90	9,500		9,590	24,250	2.53	158	32
Guthrie		5,870		5,870	16,191	2.76	201	28
Jasper	237,221	19,530	14,550	271,301	669,936	2.47	212	584
Jefferson		4,248		4,248	9,170	2.16	170	16
Keokuk		14,240	50	14,290	26,733	1.87	153	31
Mahaska	546,100	20,669	12,074	578,843	944,156	1.63	211	983
Marion	161,655	16,434	3,979	182,068	315,260	1.73	191	428
Monroe	2,272,658	48,297	72,457	2,393,412	3,757,856	1.57	206	4,281
Polk	1,226,294	221,240	38,519	1,486,053	2,761,723	1.86	187	2,912
Taylor	2,600	2,520		5,120	12,700	2.48	155	31
Van Buren	5,600	3,529	25	9,154	18,785	2.05	221	14
Wapello	175,031	25,877	5,194	206,102	345,324	1.68	203	488
Wayne	87,387	10,631	1,150	99,168	205,182	2.47	159	377
Webster	42,320	3,054	2,700	48,074	107,088	2.23	196	151
Other counties[a] and small mines		64,078	1,250	65,328	140,937	2.16	180	60
Total	6,519,307	590,206	180,016	7,289,529	13,152,088	1.80	188	16,370

1913.

County.	Loaded at mines for shipment.	Sold to local trade and used by employees.	Used at mines for steam and heat.	Total quantity.	Total value.	Average price per ton.	Average number of days active.	Average number of employees.
Adams		6,971		6,971	$17,536	$2.52	182	48
Appanoose	1,130,383	64,104	12,900	1,207,387	2,436,279	2.02	170	4,186
Boone	216,189	35,243	4,780	256,212	522,929	2.04	179	754
Dallas	546,832	8,348	19,006	574,186	1,077,293	1.88	245	889
Guthrie		4,492		4,492	11,890	2.65	147	29
Jasper	255,200	8,867	3,500	267,567	567,211	2.12	156	800
Mahaska	327,655	21,748	6,334	355,737	568,314	1.60	199	698
Marion	276,064	16,249	6,239	298,552	487,151	1.63	193	581
Monroe	2,457,050	50,226	64,001	2,571,277	4,087,032	1.59	215	4,138
Polk	1,345,237	213,296	42,482	1,601,015	2,984,919	1.86	212	2,591
Van Buren	6,000	8,381		14,381	32,772	2.28	224	29
Wapello	124,845	25,969	2,891	153,705	259,099	1.69	240	309
Wayne	73,215	11,760	800	85,775	172,531	2.01	193	253
Webster	42,373	1,553	1,750	45,676	101,078	2.21	215	130
Other counties[b] and small mines.	23,890	57,963	1,150	83,003	170,676	2.06	81	322
Total	6,824,933	535,170	165,833	7,525,936	13,496,710	1.79	195	15,757

[a] Lucas, Page, Scott, and Warren.
[b] Greene, Jefferson, Keokuk, Lucas, Page, Taylor, and Warren.

The production, by counties, during the last five years, with increase and decrease in 1913 as compared with 1912, is shown in the following table:

Coal production of Iowa, 1909–1913, by counties, in short tons.

County.	1909	1910	1911	1912	1913	Increase (+) or decrease (−), 1913.
Adams	13,194	12,745	7,472	9,868	6,971	− 2,897
Appanoose	1,236,009	1,413,896	1,104,723	1,252,666	1,207,387	− 45,279
Boone	275,711	275,882	214,440	212,168	256,212	+ 44,044
Dallas	244,219	255,085	385,588	436,206	574,186	+ 137,980
Greene	9,700	10,150	11,800	9,590	9,600	+ 10
Guthrie	6,730	17,324	10,390	5,870	4,492	− 1,378
Jasper	323,092	349,063	292,427	271,301	267,567	− 3,734
Jefferson	6,255	7,530	5,129	4,248	3,000	− 1,248
Keokuk	14,430	13,141	12,512	14,290	4,404	− 9,886
Lucas	9,326	11,233	13,337	15,459	27,904	+ 12,445
Mahaska	925,438	848,199	777,189	578,843	355,737	− 223,106
Marion	329,353	215,281	171,329	182,068	298,552	+ 116,484
Monroe	2,025,559	2,184,030	2,259,239	2,393,412	2,571,277	+ 177,865
Page	16,134	10,550	12,396	5,050	1,250	− 3,800
Polk	1,788,129	1,778,264	1,532,010	1,486,053	1,601,015	+ 114,962
Scott	8,400	400	....	300	....	− 300
Taylor	13,536	9,749	9,950	5,120	6,223	+ 1,103
Van Buren	15,955	10,284	8,656	9,154	14,381	+ 5,227
Wapello	261,520	283,500	312,332	206,102	153,705	− 52,397
Warren	16,201	1,992	1,500	3,595	3,430	− 165
Wayne	128,004	135,439	116,382	99,168	85,775	− 13,393
Webster	66,584	49,973	46,026	48,074	45,676	− 2,398
Other counties and small mines	24,283	34,410	[a] 26,821	[a] 40,924	[a] 27,192	− 13,732
Total	7,757,762	7,928,120	7,331,648	7,289,529	7,525,936	+ 236,407
Total value	$12,793,628	$13,903,913	$12,663,507	$13,152,088	$13,496,710	+$344,622

[a] Small mines only.

The coal fields of Iowa constitute the northern limits of the western interior region and occupy the central and southern portions of the State. They have a total area of approximately 20,000 square miles, of which about 13,000 square miles are considered as workable under present conditions, and most of the remainder possess possibilities for the future.

The more important producing areas are: (1) The northern, including Webster, Boone, and neighboring counties, and yielding 4 per cent of the total output; (2) the north central, including Polk, Jasper, and Dallas counties, and producing 29 per cent of the output, chiefly from Polk County; (3) the south central, including Marion, Mahaska, Monroe, and adjacent counties, and producing 43 per cent of the total output; (4) the southeastern, including Wapello, Van Buren, and adjacent counties, and yielding 4 per cent of the total (in all of these areas practically all of the coal mined comes from the lower part of the Des Moines group); (5) the south central, including Appanoose and Wayne counties, produces 19 per cent of the State's total (the coal mined is from the Mystic or Centerville bed); (6) the southwestern, including Adams, Taylor, and Page counties, yields one-half of 1 per cent of the total. This product is from the Nodaway bed of the Missouri group.

Iowa probably ranks second among the States west of the Mississippi River in order of priority as a coal producer. At the time of taking the United States census for 1840 Iowa and Missouri were the only States west of the Mississippi in which any coal production was reported. Missouri, however, was credited with an output of nearly

10,000 tons, and Iowa's production was given at 400 tons. It is probable, therefore, that the first mine opened in Missouri antedated Iowa's initial production. The production of coal in Iowa since 1840 will be found in the following table, estimates being given for years for which no official figures are available:

Production of coal in Iowa, 1840 to 1913, in short tons.

Year.	Quantity.	Year.	Quantity.	Year.	Quantity.	Year.	Quantity.
1840	400	1859	42,000	1878	1,350,000	1897	4,611,865
1841	500	1860	41,920	1879	1,400,000	1898	4,618,842
1842	750	1861	50,000	1880	1,461,116	1899	5,177,479
1843	1,000	1862	53,000	1881	1,960,000	1900	5,202,939
1844	2,500	1863	57,000	1882	3,920,000	1901	5,617,499
1845	5,000	1864	63,000	1883	4,457,540	1902	5,904,766
1846	6,500	1865	69,574	1884	4,370,566	1903	6,419,811
1847	8,000	1866	99,320	1885	4,012,575	1904	6,519,933
1848	10,000	1867	150,000	1886	4,315,779	1905	6,798,609
1849	12,500	1868	241,453	1887	4,473,828	1906	7,266,224
1850	15,000	1869	295,105	1888	4,952,440	1907	7,574,322
1851	18,000	1870	263,487	1889	4,095,358	1908	7,161,310
1852	20,000	1871	300,000	1890	4,021,739	1909	7,757,762
1853	23,000	1872	336,000	1891	3,825,495	1910	7,928,120
1854	25,000	1873	392,000	1892	3,918,491	1911	7,331,648
1855	28,000	1874	799,936	1893	3,972,229	1912	7,289,529
1856	30,000	1875	1,231,547	1894	3,967,253	1913	7,525,936
1857	33,000	1876	1,250,000	1895	4,156,074		
1858	37,500	1877	1,300,000	1896	3,954,028	Total	186,603,097

KANSAS.

Total production in 1913, 7,202,210 short tons; spot value, $12,036,292.

Coal-mine operators in Kansas had little of which to complain in 1913. There was no serious trouble with labor, although there were some local strikes due to minor misunderstandings, but they were not of long duration. Railroad consumption increased somewhat on account of the strike in the Colorado mines, transportation facilities were satisfactory, and the demand for steam coal for manufacturing and for domestic fuel was generally well up to the supply. The only unfavorable instances were occasional shutdowns at the stripping operations and some inconvenience during the drought in the summer and early fall, when boiler water had to be hauled to the mines. Neither of these, however, caused serious interference with the mining operations. The output increased from 6,986,182 short tons, valued at $11,324,130, in 1912 to 7,202,210 tons, valued at $12,036,292 in 1913, the increase amounting to 216,028 tons, or 3.1 per cent in quantity, and $712,162, or 6.3 per cent in value. The average value per ton advanced from $1.62 to $1.67.

Shooting from the solid continues to be practiced in the coal mines of Kansas to a reprehensible extent, although there was a slight improvement in that regard in 1913. The coal mined by that method was 5,796,689 short tons, or 80.5 per cent of the total, compared with 5,864,226 tons, or 83.9 per cent of the total, in 1912. Machine mining has not made much progress in the State, the quantity so produced in 1913 being less than 25,000 tons. The coal reported as mined by hand was 1,068,039 tons, or 14.8 per cent of the total, and there were 315,362 tons for which the method of mining was not reported. A small percentage of the product, 48,423 tons, was washed, yielding 39,343 tons of cleaned coal and 9,080 tons of refuse.

The number of men employed in the coal mines of Kansas in 1913 was 12,479, and they worked an average of 197 days, against 11,646 men for an average of 202 days in 1912. The average production per man was 577 tons for the year and 2.93 tons for each working day in 1913, compared with 600 tons for the year and 2.97 tons per day in 1912.

The number of fatal accidents reported to the Bureau of Mines in 1913 was 28, the same as in 1912, but as the number of men employed and the quantity of coal produced were both larger in 1913 than in the preceding year, the death rate was slightly less (2.24 against 2.4), and the quantity of coal mined for each life loss slightly more (257,222 tons, against 249,507 tons).

The statistics of the production of coal in Kansas in 1912 and 1913, with the distribution of the product for consumption, are shown in the following table:

Coal production of Kansas in 1912 and 1913, by counties, in short tons.

1912.

County.	Loaded at mines for shipment.	Sold to local trade and used by employees.	Used at mines for steam and heat.	Made into coke.	Total quantity.	Total value.	Average price per ton.	Average number of days active.	Average number of employees.
Cherokee	2,256,917	23,635	52,392		2,332,944	$3,821,196	$1.64	207	3,436
Crawford	4,114,461	41,025	99,929		4,255,415	6,569,751	1.54	202	6,759
Leavenworth	145,442	19,145	39,161	775	204,523	445,597	2.18	221	682
Linn	23,978	8,760	850		33,588	65,205	1.94	198	94
Osage	121,476	14,062	258		135,796	367,176	2.70	171	660
Other counties [a] and small mines	560	23,351	5		23,916	55,205	2.31	129	15
Total	6,662,834	129,978	192,595	775	6,986,182	11,324,130	1.62	202	11,646

1913.

County.	Loaded at mines for shipment.	Sold to local trade and used by employees.	Used at mines for steam and heat.	Made into coke.	Total quantity.	Total value.	Average price per ton.	Average number of days active.	Average number of employees.
Cherokee	2,192,766	21,802	44,451		2,259,019	$3,740,324	$1.66	204	3,385
Crawford	4,464,565	46,020	103,672		4,614,257	7,513,732	1.63	197	7,656
Leavenworth	116,774	11,900	32,535		161,209	375,285	2.33	210	725
Linn	22,341	2,121	750		25,212	42,628	1.69	136	91
Franklin and Osage	106,841	10,473	212		117,526	309,939	2.64	153	622
Small mines		24,987			24,987	54,384	2.18		
Total	6,903,287	117,303	181,620		7,202,210	12,036,292	1.67	197	12,479

[a] Franklin and Neosho.

Crawford County, which produces about two-thirds of the total output, was the only county which showed any material increase in 1913. The gain in output was 358,842 tons. Cherokee County, the second in importance, with about 3 per cent of the total production, showed a decrease of 73,925 tons, and Leavenworth County's production decreased 43,314 tons.

The statistics of production, by counties, during the last five years, with increase and decrease in 1913 as compared with 1912, are shown in the following table:

Coal production of Kansas, 1909–1913, in short tons.

County.	1909	1910	1911	1912	1913	Increase(+) or decrease (−), 1913.
Cherokee	2,201,947	1,477,525	2,036,052	2,332,944	2,259,019	− 73,925
Cloud	800	800				
Crawford	4,328,012	2,986,411	3,778,242	4,255,415	4,614,257	+ 358,842
Franklin	3,160	2,000	2,400	725	1,716	+ 991
Leavenworth	321,132	275,377	206,049	204,523	161,209	− 43,314
Linn	8,514	24,298	27,366	33,588	25,212	− 8,376
Osage	100,197	116,769	104,479	135,796	115,810	− 19,986
Other counties and small mines	22,686	38,271	24,140	23,191	24,987	+ 1,796
Total	6,986,478	4,921,451	6,178,728	6,986,182	7,202,210	+ 216,028
Total value	$10,083,384	$7,914,709	$9,473,572	$11,324,130	$12,036,292	+$712,162

The coal-productive area of Kansas lies entirely in the eastern part of the State. The coal measures underlie approximately 20,000 square miles, of which about three-fourths may be considered as probably productive. Three fields or districts have been fairly well developed. The most important of them is the Cherokee and Crawford County field in the southeast corner of the State. Over 90 per cent of the total production of the Kansas mines is from these two counties. The principal coal bed in the district, the Cherokee, varies from 3 to 10 feet in thickness, though the average is only about 3½ feet. The coal is bituminous, of good quality, and roof and floor conditions are excellent. Some of the coal beds lie near the surface, and mining operations are carried on by removing the overburden and "stripping" the coal. Some of this coal, because of its absolute freedom from coking tendency, is known locally as "dead" coal and is used raw by the zinc smelters in and near Pittsburgh.

The second district in importance is that adjacent to Leavenworth and Atchison, in the northeast corner of the State, where at a depth of from 700 to 1,500 feet a thin bed is found and is mined "longwall." It is the only district in which deep mining is carried on in the Western Interior coal field. A considerable portion of the production from the shaft at Leavenworth is mined on the Missouri side of the river. In the earlier reports of this series it has been customary to credit all of the production to Kansas, as the opening is in that State, but for the last three years the tonnage taken from the Missouri side has been reported separately and has been credited to that State.

The third district is in the eastern central part of the State, chiefly in Osage County. The bed mined in this district is only 22 inches thick, but lies at comparatively shallow depth. There are more mines in Osage County than in the other two districts combined, but they are relatively small and are worked chiefly for comparatively local consumption.

The earliest record of coal production in Kansas shows that the State produced in 1869 a total of 36,891 tons. From 1870 to 1880 the production has been estimated from the best information obtainable, and since 1882 it has been collected by the statistical division of the United States Geological Survey, as shown in the following table, giving the annual production of coal in Kansas from 1869 to 1913, inclusive.

Production of coal in Kansas, 1869 to 1913, in short tons.

Year.	Quantity.	Year.	Quantity.	Year.	Quantity.	Year.	Quantity.
1869	36,891	1881	840,000	1893	2,652,546	1905	6,423,979
1870	32,938	1882	750,000	1894	3,388,251	1906	6,024,775
1871	41,000	1883	900,000	1895	2,926,870	1907	7,322,449
1872	44,800	1884	1,100,000	1896	2,884,801	1908	6,245,508
1873	56,000	1885	1,212,057	1897	3,054,012	1909	6,986,478
1874	85,000	1886	1,400,000	1898	3,406,555	1910	4,921,451
1875	150,000	1887	1,596,879	1899	3,852,267	1911	6,178,728
1876	225,000	1888	1,850,000	1900	4,467,870	1912	6,986,182
1877	300,000	1889	2,221,043	1901	4,900,528	1913	7,202,210
1878	375,000	1890	2,259,922	1902	5,266,065		
1879	460,000	1891	2,716,705	1903	5,839,976	Total	129,696,761
1880	771,442	1892	3,007,276	1904	6,333,307		

KENTUCKY.

Total production in 1913, 19,616,600 short tons; spot value, $20,516,749.

Kentucky is one of the 12 States that in 1913 established new records in the quantity and value of their coal production, and in one respect—the percentage of increase—Kentucky outclassed not only her 11 record-making sister States, but all of the States with the single exception of California, whose total production was less than 25,000 tons. The production of coal in Kentucky increased from 16,490,521 short tons, valued at $16,854,207 in 1912, to 19,616,600 tons, valued at $20,516,749 in 1913. The increase in quantity amounted to 3,126,079 short tons, or 19 per cent, and the value increased $3,662,542, or 21.7 per cent. The nearest approach to these rates of increase among the other States whose production exceeded 5,000,000 tons was in Virginia, whose output increased 12.5 per cent in quantity and 19 per cent in value. Nearly 80 per cent of the increase in Kentucky's production in 1913 was in the eastern counties. Letcher County led with an increase of over 900,000 tons; Pike County was a good second, with a gain of 717,579 tons; Harlan County was third in quantity of increase, showing a gain of 417,875 tons; and Bell County was fourth, with a addition of 288,461 tons. The total increase in the eastern part of the State was 2,481,767 tons, and the western counties showed a total gain of 644,312 tons. The principal increases in the western part of the State were in Muhlenberg County, 265,234 tons, and in Webster County, 222,179 tons. Until 1912 the larger portion of the production in Kentucky was from the western counties, but increases aggregating more than 4,200,000 tons in the eastern counties during the last two years have given the supremacy to that portion of the State. In 1913 the production of coal in the eastern counties exceeded that in the western district by more than 2,500,000 tons.

The average value per ton advanced from $1.02 in 1912 to $1.05 in 1913. The latter figure has been exceeded only twice in the last 25 years, in 1903 and in 1907, in both of which years the average value per ton was $1.06.

The number of men employed in the coal mines of Kentucky increased from 24,304 in 1912 to 26,332 in 1913, and the average working time from 201 to 212 days, the total working time showing an increase of 14 per cent, as compared with an increase of 19 per cent in production. This average production by each man employed was 745 tons in 1913 against 679 tons in 1912 and 640 tons in 1911. The average daily production per man increased from 3.18 tons in 1911 to 3.38 in 1912 and to 3.51 tons in 1913.

The increase in individual production was due in large part, if not entirely, to the more extended use of mining machines, Kentucky in the percentage of machine-mined tonnage to the total output ranking next to Ohio and second among all the States. The quantity of coal mined by the use of machines increased from 10,954,648 tons, or 66.4 per cent of the total, in 1912 to 14,353,583 tons, or 73.2 per cent of the total, in 1913. The increase in the output by machines was 3,398,935 tons, or 272,856 tons more than the total increase in the State. The number of machines in use increased from 1,168 in 1912 to 1,263 in 1913. Of the machines in use in 1913, 574 were punchers, 377 were chain-breast, 213 were short-wall, 98 were long-wall, and one was a radialaxe. The quantity of coal shot off the solid in 1913 was 3,092,985 tons, an increase from 2,727,399 tons in 1912, but a decrease in percentage of the total from 16.5 to 15.7 per cent. The quantity undercut by hand in 1913 was 1,755,461 tons, or 9 per cent of the total.

Labor troubles in the coal mines of Kentucky were insignificant, both in 1912 and 1913. Only 1,029 mine workers, less than 4 per cent of the total number of men employed ,were on strike in 1913, and the average time lost by them was 18 days. In 1912, 2,759 men were idle on account of strikes or suspensions for an average of 29 days. Notwithstanding the larger number of men employed and the more days worked in 1913 as compared with 1912, there were fewer fatalities reported to the Bureau of Mines, the accidental deaths being reduced by 3 from 51 in 1912 to 48 in 1913. There was no explosion of gas or dust which resulted fatally, and the chief causes of death were falls of roof, just half of the total number of fatalities being due to that type of accident. Five men were suffocated to death in an abandoned mine; 4 were killed by electricity; and 15 deaths were due to miscellaneous causes, one at a time. The death rate per thousand in 1913 was 1.8, and the quantity of coal mined for each life lost was 408,679, one of the best records of the year.

The statistics of production in 1912 and 1913, by counties, with the distribution of the product for consumption, are shown in the following table.

Coal production of Kentucky, 1912 and 1913, by counties, in short tons.

1912.

County.	Loaded at mines for shipment.	Sold to local trade and used by employees.	Used at mines for steam and heat.	Made into coke.	Total quantity.	Total value.	Average price per ton.	Average number of days active.	Average number of employees.
Bell	2,120,053	29,302	43,222	7,500	2,200,077	$2,382,862	$1.08	209	3,476
Boyd	92,874	6,909	975	....	100,758	90,829	.90	185	214
Carter	60,237	26,731	365	....	87,333	78,526	.90	198	189
Christian	54,749	2,225	3,165	....	60,139	50,517	.84	184	122
Daviess	14,286	73,522	2,217	....	90,025	101,309	1.13	253	132
Floyd	433,803	5,796	7,175	....	446,774	504,243	1.13	207	531
Hancock	....	3,800	....	....	3,800	5,700	1.50	134	15
Harlan	184,797	3,979	5,933	137,683	332,392	361,934	1.09	197	483
Henderson	164,296	63,336	8,527	....	236,159	259,754	1.10	164	438
Hopkins	2,264,891	77,750	126,302	80,170	2,549,113	2,130,462	.84	222	2,983
Johnson	901,977	9,295	20,958	....	932,230	1,299,033	1.39	217	1,045
Knox	815,463	7,809	17,600	....	840,872	892,180	1.06	219	1,520
Laurel	210,940	11,562	4,488	....	226,990	238,493	1.05	197	420
Lawrence	63,145	1,476	2,613	....	67,234	61,624	.92	171	202
Lee	46,485	679	580	....	47,744	62,366	1.31	193	124
McCreary	530,248	9,044	4,015	....	543,307	572,178	1.05	208	1,126
McLean	116,667	3,446	2,218	....	122,331	110,854	.91	137	251
Morgan	76,312	12,448	1,198	....	89,958	203,087	2.26	260	267
Muhlenberg	2,278,470	34,515	55,052	....	2,368,037	2,189,013	.92	160	3,627
Ohio	616,109	22,054	23,223	....	661,386	586,722	.89	165	1,122
Pike	1,330,815	13,918	27,614	34,115	1,406,462	1,355,596	.96	216	1,582
Union	472,908	48,067	28,915	531	550,421	541,603	.98	181	814
Webster	1,118,956	24,572	28,956	....	1,172,484	1,046,807	.89	229	1,189
Whitley	971,116	11,533	17,336	....	999,985	1,287,670	1.29	219	1,986
Other counties [a]	219,918	9,995	5,731	....	235,644	280,024	1.19	161	446
Small mines	....	118,866	....	....	118,866	160,821	1.35	....	....
Total	15,159,515	632,629	438,378	259,999	16,490,521	16,854,207	1.02	201	24,304

1913.

County.	Loaded at mines for shipment.	Sold to local trade and used by employees.	Used at mines for steam and heat.	Made into coke.	Total quantity.	Total value.	Average price per ton.	Average number of days active.	Average number of employees.
Bell	2,357,173	79,019	52,346	....	2,488,538	$2,790,939	$1.12	242	3,721
Boyd	119,178	10,392	1,638	....	131,208	118,612	.90	237	197
Carter	57,656	52,412	527	....	110,595	108,307	.98	220	184
Christian	67,160	725	1,640	....	69,525	68,068	.98	166	160
Daviess	....	48,398	145	....	48,543	47,770	.98	252	67
Floyd	437,141	3,313	5,495	....	445,949	515,472	1.16	217	555
Hancock	....	6,280	....	....	6,280	8,170	1.30	179	14
Harlan	532,235	9,211	8,759	200,062	750,267	922,837	1.23	189	1,014
Henderson	127,634	85,765	7,183	....	220,582	240,703	1.09	155	361
Hopkins	2,287,435	64,955	102,692	79,739	2,534,821	2,133,964	.84	199	3,008
Johnson	826,127	7,750	27,312	....	861,189	1,187,661	1.38	204	1,179
Knox	928,895	11,912	20,685	....	961,492	1,018,566	1.06	222	1,602
Laurel	173,454	16,100	7,015	....	196,569	251,417	1.28	198	410
Lee	27,761	2,195	196	....	30,152	46,395	1.54	172	69
Letcher	1,079,554	7,933	17,965	....	1,105,452	1,377,464	1.25	258	1,143
McCreary	616,924	5,593	2,584	....	625,101	642,160	1.03	264	1,053
McLean	75,867	5,937	1,525	....	83,329	70,090	.84	151	197
Morgan	76,230	12,851	1,265	....	90,346	173,410	1.92	282	225
Muhlenberg	2,553,979	28,050	51,242	....	2,633,271	2,380,949	.90	180	3,545
Ohio	719,714	27,485	28,346	....	775,545	683,033	.88	167	1,117
Perry	17,433	7,470	50	....	24,953	28,165	1.13	109	113
Pike	1,955,611	18,483	37,314	112,633	2,124,041	2,155,837	1.01	239	2,310
Union	583,393	77,174	30,401	....	690,968	703,530	1.02	195	758
Webster	1,347,016	16,870	30,777	....	1,394,663	1,211,846	.87	210	1,356
Whitley	990,208	9,747	15,415	....	1,015,370	1,391,934	1.37	207	1,761
Other counties [b]	72,048	3,376	2,201	....	77,625	78,806	1.02	168	213
Small mines	....	120,226	....	....	120,226	160,644	1.34	....	....
Total	18,029,826	739,622	454,718	392,434	19,616,600	20,516,749	1.05	212	26,332

[a] Breathitt, Clay, Greenup, Letcher, Magoffin, Perry, Pulaski, and Rockcastle.
[b] Breathitt, Clay, Greenup, Lawrence, Letcher, and Pulaski.

Kentucky is the only one of the coal-producing States which has within its borders areas belonging to any two of the great coal fields. The eastern counties of the State are underlain by the coal beds of the great Appalachian Mountain system, extending entirely across the State in a northeast-southwest direction, while the southern limits of the central or eastern interior field are found in the more northern counties of the western part of the State. The total area underlain by coal in the eastern counties of Kentucky is estimated at 10,270 square miles, and the coal-bearing areas in the western part of the State are estimated to contain 6,400 square miles, or somewhat more than one-half of that of the eastern part. Up to the close of 1911 the larger part of the production of the State had been from the western district, but as a result of extensive developments in Harlan, Johnson, Letcher, and Pike counties the larger part of the coal production in 1912 and 1913 was from the eastern part of the State. There is little probability of the western district again getting the ascendancy.

Generally speaking, the eastern coal field of Kentucky is a unit, unless the Middlesboro-Harlan portion of it, cut off by the Pine Mountain fault, be excepted. Until 1912 a large part of the field was without railroad facilities, but the construction of the Big Sandy & Elkhorn Railroad by the Baltimore & Ohio Railroad into Pike and Letcher counties, and of the Lexington & Eastern branch of the Louisville & Nashville system into Harlan and Letcher counties, has resulted in the development in eastern Kentucky during 1910, 1911, 1912, and 1913 of probably more absolutely new coal territory than has been opened in the same time in all the rest of the United States. Other railroad construction is in contemplation. Some impression of the effect of this development may be formed from the statement that in 1908 Pike County had a production of 560,000 tons of coal, and in 1913 it produced over 2,000,000 tons; Johnson County produced less than 160,000 tons in 1908 and over 860,000 tons in 1913; Harlan and Letcher counties produced no coal prior to 1910, except from country banks, and in 1913 they had a combined production of over 1,850,000 tons.

The coals of this field belong to the Allegheny formation ("Lower Productive Coal Measures") and to the Pottsville group. The Pottsville, which at Ohio River has a thickness of only a few hundred feet and carries five coals, is in the southeast corner of the State about 5,000 feet thick, and carries nearly 50 coals, of which a dozen or more are locally of workable thickness and quality. The eastern Kentucky coals are mostly high-grade "gas" or "coking" coals, with some cannel coal. In the Jellico coal field the Jellico and the Blue Gem beds are both thin, the latter being successfully mined where averaging only 22 inches. On the other hand, some of the beds show 8 and 9 feet or more of workable coal.

The workable coal of the western district of Kentucky is confined for the most part to two beds, designated as No. 9 and No. 11 by the Geological Survey of Kentucky. Of these, No. 9 (equivalent to No. 5 of the Illinois field) is the more persistent and furnishes probably 75 per cent or more of the total production of the western counties of the State. It underlies the whole or portions of eight counties, including all of the field except its eastern portion and the southern or southwestern edge and a few other places, where it has been cut out by irregularities in the structure, which near the west and south borders of the field is seriously affected by faults. The bed has an average thickness of about 5 feet and only rarely thickens out to more than 5 feet 6 inches or thins down to less than 4 feet 6 inches. Over a broad zone it lies within 300 feet below the surface, and the mining is done by shaft. Bed No. 11 lies from 40 to 100 feet above No. 9, and is the next important bed in western Kentucky. It is much more irregular than No. 9, but usually where worked has a thickness of 6 feet or over. Another bed lying about 25 feet above No. 11 is known as No. 12. It is mined in Webster, Hopkins, McLean, and Muhlenberg counties. In the central portion of this field this bed attains a thickness of from 3 to 6 feet. Other beds besides these three are mined at several localities in the district, notably what is supposed to be No. 6 and also No. 5.

In the following table is presented a statement of the production of coal in Kentucky for the last five years, by counties, with increase and decrease in each county in 1913 compared with 1912:

Coal production of Kentucky, 1909 to 1913, by counties, in short tons.

County.	1909	1910	1911	1912	1913	Increase(+) or decrease (−), 1913.
Bell	1,538,568	2,051,106	2,002,508	2,200,077	2,488,538	+ 288,461
Boyd	86,904	103,051	109,255	100,758	131,208	+ 30,450
Breathitt and Lee	105,091	92,125	57,102	84,180	36,152	− 48,028
Butler	7,228	1,756	1,580			
Carter	81,404	67,400	39,006	87,333	110,595	+ 23,262
Christian, Daviess, and Hancock	121,738	117,286	111,203	153,964	124,348	− 29,616
Floyd		137,330	250,883	446,774	445,949	− 825
Greenup		290	513			
Harlan		1,440	17,860	332,392	750,267	+ 417,875
Henderson	163,782	241,281	223,957	236,159	220,582	− 15,577
Hopkins	1,864,453	2,554,620	2,156,021	2,549,113	2,534,821	− 14,292
Johnson	222,746	468,609	801,464	932,230	861,189	− 71,041
Knox	610,705	654,478	764,601	840,872	961,492	+ 120,620
Laurel	214,251	275,224	242,728	226,990	196,569	− 30,421
Lawrence	96,440	100,895	52,146	67,234	69,157	+ 1,923
Letcher				193,298	1,105,452	+ 912,154
McCreary				543,307	625,101	+ 81,794
McLean	128,015	206,001	122,382	122,331	83,329	− 39,002
Morgan		70,061	75,581	89,958	90,346	+ 388
Muhlenberg	2,009,549	2,738,427	2,243,193	2,368,037	2,633,271	+ 265,234
Ohio	626,158	819,397	769,885	661,386	775,545	+ 114,159
Pike	684,450	953,605	1,136,997	1,406,462	2,124,041	+ 717,579
Pulaski	61,723	85,218	69,437	1,000	1,500	+ 500
Rockcastle		5,000		190		− 190
Union	444,457	590,378	462,683	550,421	690,968	+ 140,547
Webster	449,508	1,026,188	878,466	1,172,484	1,394,663	+ 222,179
Whitley	933,154	1,167,937	1,182,308	999,985	1,015,370	+ 15,385
Other counties and small mines	247,060	94,216	277,944	123,586	146,147	+ 22,561
Total	10,697,384	14,623,319	14,049,703	16,490,521	19,616,600	+ 3,126,079
Total value	$10,079,917	$14,405,887	$14,008,458	$16,854,207	$20,516,749	+$3,662,542

In the following table the statistics of Kentucky's coal production during the last five years are divided according to the counties in the eastern and the western parts of the State. The coal areas in the eastern part of Kentucky belong to the Appalachian region; those in the western district belong to the eastern interior region and form the southern extremity of the Illinois-Indiana field:

Coal production of the eastern district of Kentucky, 1909–1913, in short tons.

County.	1909	1910	1911	1912	1913	Increase(+) or decrease (−), 1913.
Bell	1,538,568	2,051,106	2,002,508	2,200,077	2,488,538	+ 288,461
Boyd	86,904	103,051	109,255	100,758	131,208	+ 30,450
Breathitt	20,982	24,432	11,245	36,436	6,000	− 30,436
Carter	81,404	67,400	39,006	87,333	110,595	+ 23,262
Floyd		137,330	250,883	446,774	445,949	− 825
Greenup		290	513			
Harlan		1,440	17,860	332,392	750,267	+ 417,875
Johnson	222,746	468,609	801,464	932,230	861,189	− 71,041
Knox	610,705	654,478	764,601	840,872	961,492	+ 120,620
Laurel	214,251	275,224	242,728	226,990	196,569	− 30,421
Lawrence	96,440	100,895	52,146	67,234	69,157	+ 1,923
Lee	84,109	67,693	45,857	47,744	30,152	− 17,592
Letcher				193,298	1,105,452	+ 912,154
McCreary				543,307	625,101	+ 81,794
Morgan		70,061	75,581	89,958	90,346	+ 388
Pike	684,450	953,605	1,136,997	1,406,462	2,124,041	+ 717,579
Pulaski	61,723	85,218	69,437	1,000	1,500	+ 500
Rockcastle		5,000		190		− 190
Whitley	933,154	1,167,937	1,182,308	999,985	1,015,370	+ 15,385
Other counties and small mines	190,663	45,255	86,773	64,153	86,034	+ 21,881
Total	4,826,099	6,279,024	6,889,162	8,617,193	11,098,960	+2,481,767

Coal production of the western district of Kentucky, 1909–1913, in short tons.

County.	1909	1910	1911	1912	1913	Increase(+) or decrease (−), 1913.
Butler	7,228	1,756	1,580			
Christian	45,453	37,136	32,418	60,139	69,525	+ 9,386
Daviess	61,175	73,786	78,135	90,025	48,543	− 41,482
Hancock	15,110	6,364	650	3,800	6,280	+ 2,480
Henderson	163,782	241,281	223,957	236,159	220,582	− 15,577
Hopkins	1,864,453	2,554,620	2,156,021	2,549,113	2,534,821	− 14,292
McLean	128,015	206,001	122,382	122,331	83,329	− 39,002
Muhlenberg	2,009,549	2,738,427	2,243,193	2,368,037	2,633,271	+ 265,234
Ohio	626,158	819,397	769,885	661,386	775,545	+ 114,159
Union	444,457	590,378	462,683	550,421	690,968	+ 140,547
Webster	449,508	1,026,188	878,466	1,172,484	1,394,663	+ 222,179
Other counties and small mines	56,397	48,961	191,171	[a] 59,433	[a] 60,113	+ 680
Total	5,871,285	8,344,295	7,160,541	7,873,328	8,517,640	+ 644,312

[a] Small mines only.

In 1912, for the first time in the history of coal mining in the State, the eastern district had the larger production. The lead will be maintained and widened by the continued increase of production in the recently developed virgin areas already referred to.

So far as the records of early coal production in the United States are to be accepted, Kentucky was the third State to enter the list of regular coal producers. According to one of the early reports of the Kentucky Geological Survey (published in 1838), the first coal produced in the State was mined in 1827 on "the right side of the (Cumberland) river below the mouth of Laurel." This was evidently from either Laurel or Pulaski County, but the exact location is not definitely stated. The same report says that in 1828 five boatloads of coal from these mines arrived at Nashville, and that from 1829 to 1834 probably from 25 to 35 boatloads were sent out each year. The boatloads averaged about 1,750 bushels, or 66 tons each. From 1834 to 1837 the shipments were from 75 to 100 boat-loads, or about 3,500 bushels annually. The coal was for the most part consumed in the salt works and iron furnaces convenient to the rivers, the only means of transportation.

From the best information obtainable it seems that the production of the State from 1829 to 1835 ranged from 2,000 to 6,000 tons a year. The United States census for 1840 gives the total production in the State as 23,527 short tons. By 1860, according to the census for that year, the production amounted to 285,760 short tons. Operations were necessarily somewhat interrupted during the Civil War, but since 1870, after the State had begun to recover from the effects of the war, the production increased rapidly, as shown in the following table, giving the annual and total production from 1828 to the close of 1913:

Production of coal in Kentucky from 1828 to 1913, in short tons.

Year.	Quantity.	Year.	Quantity.	Year.	Quantity.	Year.	Quantity.
1828	328	1850	150,000	1872	380,800	1894	3,111,192
1829	2,000	1851	160,000	1873	400,000	1895	3,357,770
1830	2,000	1852	175,000	1874	360,000	1896	3,333,478
1831	2,100	1853	180,000	1875	500,000	1897	3,602,097
1832	2,500	1854	190,000	1876	650,000	1898	3,887,908
1833	2,750	1855	200,000	1877	850,000	1899	4,607,255
1834	5,000	1856	215,000	1878	900,000	1900	5,328,964
1835	6,000	1857	240,000	1879	1,000,000	1901	5,469,986
1836	8,000	1858	250,000	1880	946,288	1902	6,766,984
1837	10,000	1859	275,000	1881	1,232,000	1903	7,538,032
1838	11,500	1860	285,760	1882	1,300,000	1904	7,576,482
1839	16,000	1861	280,000	1883	1,650,000	1905	8,432,523
1840	23,527	1862	275,000	1884	1,550,000	1906	9,653,647
1841	35,000	1863	250,000	1885	1,600,000	1907	10,753,124
1842	50,000	1864	250,000	1886	1,550,000	1908	10,246,553
1843	60,000	1865	200,000	1887	1,933,185	1909	10,697,384
1844	75,000	1866	180,000	1888	2,570,000	1910	14,623,319
1845	100,000	1867	175,000	1889	2,399,755	1911	14,049,703
1846	115,000	1868	160,000	1890	2,701,496	1912	16,490,521
1847	120,000	1869	160,000	1891	2,916,069	1913	19,616,600
1848	125,000	1870	150,582	1892	3,025,313		
1849	140,000	1871	250,000	1893	3,007,179	Total.	208,128,654

MARYLAND.

Total production in 1913, 4,779,839 short tons; spot value, $5,927,046.

The coal production of Maryland in 1913 was less than that of 1912 by 184,199 short tons, or 3.7 per cent, but the value showed a gain of $87,967, or 1.5 per cent, and exceeded that of any year since 1907. The annual production of coal in Maryland has been fairly constant for the last 16 years, the smallest production in that period being in 1909, when it amounted to 4,023,241 tons, and the largest production in 1907, when it reached as high as 5,532,628 tons. The output in 1913 was very close to the average of the 16 years. It is not to be expected that the production will show any material increase in the future, as the great bed, the "Maryland Big Vein," from which the greater part of the output has been obtained, is approaching exhaustion, and, although there is still a good supply remaining in the thinner and deeper beds, it is not at all probable that the future annual tonnage from them will exceed the records of the past, if indeed it maintains the same importance.

Although by far the greater part (more than 90 per cent) of Maryland's coal production is mined by hand, the record of individual efficiency by the miners is high. In 1913 there were 5,645 men employed in the coal mines of the State, and they worked an average of 248 days, as compared with 6,162 men for an average of 259 days in 1912. The average production by each man in 1913 was 847 tons for the year and 3.42 tons for each working day. In 1912 the average production per man for the year was 806 tons and the average daily production per man was 3.11 tons. These are exceptionally good averages, especially when it is considered that in 1913 4,373,920 tons, or 91.5 per cent of the total, were mined by hand, and that in 1912 nearly 95 per cent of the total product was hand mined. The machine-mined product in 1913 was only 82,989 short tons, or 1.7 per cent of the total. The quantity of coal shot off the solid was 293,950 tons.

There was only one instance of labor trouble in 1913 and that was insignificant, 200 men being idle for 2 days. In 1912 there were but three strikes reported, the longest of which lasted 12 days.

The Bureau of Mines reported 13 fatal accidents in 1913 in the coal mines of Maryland, the same number as in 1912; but as there were fewer men employed and fewer tons mined in 1913 the ratio of deaths was slightly increased and the tonnage per life lost was slightly less. The death rate per thousand in 1913 was 2.3 against 2.11 in 1912, and the quantity of coal mined for each life lost was 367,680 tons against 381,849 tons. The records for both years were better than the average and were improved upon by only a few States.

The statistics of the production of coal in Maryland in 1912 and 1913, with the distribution of the product for consumption, are shown in the following table:

Coal production of Maryland in 1912 and 1913, by counties, in short tons.

1912.

County.	Loaded at mines for shipment.	Sold to local trade and used by employees.	Used at mines for steam and heat.	Total quantity.	Total value.	Average price per ton.	Average number of days active.	Average number of employees.
Allegany	4,036,128	37,787	62,895	4,136,810	$5,129,153	$1.24	265	5,242
Garrett	800,263	6,811	3,245	810,319	690,566	.85	228	920
Small mines		16,909		16,909	19,360	1.14		
Total	4,836,391	61,507	66,140	4,964,038	5,839,079	1.18	259	6,162

1913.

County.	Loaded at mines for shipment.	Sold to local trade and used by employees.	Used at mines for steam and heat.	Total quantity.	Total value.	Average price per ton.	Average number of days active.	Average number of employees.
Allegany	3,943,759	32,605	61,897	4,038,261	$5,277,261	$1.31	246	4,771
Garrett	722,999	6,255	1,835	731,089	638,028	.87	261	874
Small mines		10,489		10,489	11,757	1.12		
Total	4,666,758	49,349	63,732	4,779,839	5,927,046	1.24	248	5,645

The statistics of production during the last five years, with the distribution of the product for consumption, are shown in the following table:

Distribution of the coal product of Maryland, 1909–1913, in short tons.

Year.	Loaded at mines for shipment.	Sold to local trade and used by employees.	Used at mines for steam and heat.	Total quantity.	Total value.	Average price per ton.	Average number of days active.	Average number of employees.
1909	3,917,803	55,882	49,556	4,023,241	$4,471,731	$1.11	....	8,004
1910	5,097,347	62,760	57,018	5,217,125	5,835,058	1.12	270	5,809
1911	4,547,600	72,050	66,145	4,685,795	5,197,066	1.11	248	5,881
1912	4,836,391	61,507	66,140	4,964,038	5,839,079	1.18	259	6,162
1913	4,666,758	49,349	63,732	4,779,839	5,927,046	1.24	248	5,645

Comparisons of the total production, by counties, in 1912 and 1913, are shown in the following table:

Coal production of Maryland, 1912 and 1913, by counties, in short tons.

County.	1912	1913	Increase(+) or decrease (−), 1913.
Allegany	4,136,810	4,038,261	− 98,549
Garrett	810,319	731,089	− 79,230
Small mines	16,909	10,489	− 6,420
Total	4,964,038	4,779,839	−184,199
Total value	$5,839,079	$5,927,046	+$87,967

The coal deposits of Maryland are confined to a limited area in the two western counties of the State, Allegany and Garrett. There are five basins known, respectively, as Georges Creek, Upper Potomac, Castleman, Lower Youghiogheny, and Upper Youghiogheny. Most of the production in the past has been in the Georges Creek basin, which, in Allegany County, contains a detached portion of the Pittsburgh bed known generally in this region as the "Maryland Big Vein." This bed has been worked for nearly a hundred years and is now approaching exhaustion. The greater prominence of the Georges Creek basin as the source of Maryland's coal production has given the name "Georges Creek" to most of the coal shipped from the State. Georges Creek coal has a high reputation as a steam and blacksmith fuel. It does not, however, possess strong coking qualities, and none of it is used for that purpose. The development of the upper Potomac basin in Garrett County began about 1895 and that area is now extensively worked. The other three basins are practically untouched. The gradual exhaustion of the "Big Vein" has led to the exploitation of some of the smaller beds in the Georges Creek basin, and many companies that formerly worked the "Big Vein" alone are now mining the thinner beds either independently or in conjunction with the big bed. The total amount of coal recoverable from the numerous small beds far exceeds the original contents of the "Big Vein," but they can not be so cheaply worked, and it appears doubtful if, in the annual production, they will do more than make up the deficiency caused by the exhaustion of the main bed.

Although coal was discovered in the Georges Creek basin as early as 1782, the first eastern shipments from the Maryland coal district were not made until 1830, when small quantities were transported by barges down the Potomac River. The first company was incorporated in 1836. After the construction of the Baltimore & Ohio Railroad, in 1842, and of the Chesapeake & Ohio Canal, in 1850, the output from the Maryland mines increased rapidly.

The attempt to ship coal from the Maryland mines by barges, prior to the advent of the Baltimore & Ohio Railroad, was not long continued. The method was too destructive of life and was the cause of so much loss in coal that it was soon abandoned, and it was not until 1842 that the industry really began to assume importance. The first shipments over the Chesapeake & Ohio Canal from Cumberland were made in 1850.

Maryland and the adjoining counties in West Virginia, which make up what is known as the Cumberland region, constitute the only districts outside of the anthracite region of Pennsylvania where records of coal production have been kept from the earliest years. These districts have been commonly known as the Georges Creek or Cumberland and the Piedmont regions. The Cumberland region was opened in 1842. The Piedmont region began shipping in 1853. The records of shipment have been carefully preserved and are published annually in the reports of the Cumberland coal trade.

The annual production from the coal mines of Maryland from 1820 to the close of 1913 has been as follows:

Production of coal in Maryland from 1820 to 1913, in short tons.

Year.	Quantity.	Year.	Quantity.	Year.	Quantity.	Year.	Quantity.
1820	3,000	1859	833,349	1878	2,068,925	1897	4,442,128
1832	12,000	1860	438,000	1879	2,132,233	1898	4,674,884
1840	8,880	1861	287,073	1880	2,228,917	1899	4,807,396
1842	2,104	1862	346,201	1881	2,533,348	1900	4,024,688
1843	12,421	1863	877,313	1882	1,555,445	1901	5,113,127
1844	18,345	1864	755,764	1883	2,476,075	1902	5,271,609
1845	30,372	1865	1,025,208	1884	2,765,617	1903	4,846,165
1846	36,707	1866	1,217,668	1885	2,833,337	1904	4,813,622
1847	65,222	1867	1,381,429	1886	2,517,577	1905	5,108,539
1848	98,032	1868	1,529,879	1887	3,278,023	1906	5,435,453
1849	175,497	1869	2,216,300	1888	3,479,470	1907	5,532,628
1850	242,517	1870	1,819,824	1889	2,939,715	1908	4,377,093
1851	317,460	1871	2,670,338	1890	3,357,813	1909	4,023,241
1852	411,707	1872	2,647,156	1891	3,820,239	1910	5,217,125
1853	657,862	1873	3,198,911	1892	3,419,962	1911	4,685,795
1854	812,727	1874	2,899,392	1893	3,716,041	1912	4,964,038
1855	735,137	1875	2,808,018	1894	3,501,428	1913	4,779,839
1856	817,659	1876	2,126,873	1895	3,915,585		
1857	654,017	1877	1,939,575	1896	4,143,936	Total	175,653,679
1858	722,686						

MICHIGAN.

Total production in 1913, 1,231,786 short tons; spot value, $2,455,227.

Michigan participated in the general increase in coal production in 1913, though the gain, both in quantity and value, was small, and the total was less than in any year from 1903 to 1911, inclusive. The increase as compared with 1912, when the production amounted to 1,206,230 short tons, valued at $2,399,451, was 25,556 tons, or 2.12 per cent in quantity, and $55,776, or 2.32 per cent in value. Michigan's coal production has exceeded 2,000,000 short tons in one year only, 1907, since when it decreased steadily until 1912, when it reached the minimum for the decade. The decrease is attributed to the competition of higher-grade coals from West Virginia and to the small demand for lump coal in the manufacturing plants of the State. Michigan is an important manufacturing State, particularly in furniture and in the evaporation of salt. The modern character of the State's manufacturing establishments is indicated by the fact that most of them are equipped with mechanical stokers, using slack coal obtained cheaply from West Virginia and of better quality than the Michigan product. Michigan slack thus becomes a drug on the market, and the coal mines are obliged to depend almost exclusively on the domestic trade which requires lump coal. In winter the demand for lump coal exceeds the capacity of the mines and in summer the production exceeds the demand.

The coal operators of the State keep pace with the manufacturing interests in modern methods and equipment, as is shown by the large number of machines installed for mining the coal and the large proportion of coal undercut by them. In 1913 862,700 short tons, or 70 per cent of the total, were machine mined. The total number of machines in use was 130, an increase of 4 over 1912. The 130 machines included 26 punchers, 38 chain-breast, and 66 short-wall or continuous cutters. Unfortunately the record for modern practice is somewhat marred by the quantity of coal shot off the solid, 363,856 tons, or 29.5 per cent of the total, being reported as "mined" in 1913 in this way. The quantity of coal sent to washeries in 1913 was 166,709 tons, which yielded 145,840 tons of cleaned coal and 20,869 tons of refuse.

In spite of the larger proportion of machine-mined coal in 1913 (that of 1912 being about 50 per cent) the tonnage per man was less in the later year. In 1912 3,113 men, working an average of 183 days, produced 1,206,230 tons, or an average of 387 tons per man for the year and of 2.11 tons per day. In 1913 3,305 men were employed for an average of 188 days and produced 1,231,786 tons, or an average for the year of 373 tons and for each day of 1.98 tons. The mines were practically free from labor troubles in 1913, one strike of 7 men for 180 days being the only exception reported.

The coal-mine fatalities as reported to the Bureau of Mines consisted of 2 deaths from falls of roof and 1 death from falling down a shaft, a total of 3, as compared with 8 in 1912 and 7 in 1911. The death rate in 1913 was a fraction less than 1, and there were 410,595 tons mined for each life lost.

The statistics of production of coal in Michigan, by counties, during 1912 and 1913, with the distribution of the product for consumption, are shown in the following tables:

Coal production of Michigan in 1912 and 1913, by counties, in short tons.

1912.

County.	Loaded at mines for shipment.	Sold to local trade and used by employees.	Used at mines for steam and heat.	Total quantity.	Total value.	Average price per ton.	Average number of days active.	Average number of employees.
Bay	584,005	7,828	39,098	630,931	$1,237,449	$1.96	173	1,664
Saginaw	440,032	46,838	17,742	504,612	1,025,959	2.03	193	1,302
Other counties [a] and small mines	56,282	7,745	6,660	70,687	136,043	1.92	203	147
Total	1,080,319	62,411	63,500	1,206,230	2,399,451	1.99	183	3,113

1913.

County.	Loaded at mines for shipment.	Sold to local trade and used by employees.	Used at mines for steam and heat.	Total quantity.	Total value.	Average price per ton.	Average number of days active.	Average number of employees.
Bay	558,170	5,513	28,035	591,718	$1,176,095	$1.99	202	1,465
Saginaw	524,079	44,874	27,240	596,193	1,194,553	2.00	176	1,750
Other counties [b] and small mines	29,741	7,864	6,270	43,875	84,579	1.93	208	90
Total	1,111,990	58,251	61,545	1,231,786	2,455,227	1.99	188	3,305

[a] Clinton, Ingham, and Tuscola. [b] Clinton, Ingham, Shiawassee, and Tuscola.

The statistics of production, by counties, during the last five years, with increase and decrease in 1913 as compared with 1912, are shown in the following table:

Coal production of Michigan, 1909–1913, by counties, in short tons.

County.	1909	1910	1911	1912	1913	Increase(+) or decrease (−), 1913.
Bay	822,577	766,470	717,084	630,931	591,718	− 39,213
Eaton	558	100	1,000			
Jackson	1,500					
Saginaw	859,434	667,282	667,954	504,612	596,193	+ 91,581
Shiawassee	[a] 100,623	[b] 101,115	[b] 90,036	[b] 70,687	[a] 43,875	− 26,812
Total	1,784,692	1,534,967	1,476,074	1,206,230	1,231,786	+ 25,556
Total value	$3,199,351	$2,930,771	$2,791,461	$2,399,451	$2,455,227	+$55,776

[a] Includes Clinton, Ingham, and Tuscola counties and small mines.
[b] Includes Clinton, Genesee, Ingham, and Tuscola counties and small mines.

The coal fields of Michigan occupy an isolated basin in the Lower Peninsula. They have an area of approximately 11,000 square miles in almost the exact center of the Peninsula. The fields are estimated to have originally contained 12,000,000,000 tons of coal, from which the exhaustion to the close of 1913 has amounted to about 34,400,000 tons. It is only within the last 12 years that the coal fields of Michigan have been worked to any considerable extent, and their development has followed in some degree the depletion of the forest resources. The lumber industry of Michigan has materially declined. Formerly the refuse from the lumber mills furnished fuel not only for their own operations but for salt-evaporating plants which were operated as a by-industry of the lumber mills. The exhaustion of the forests and the decline of the lumber industry have created a demand for coal to supply the salt works and other manufacturing establishments of the State. The decline in the lumber industry in Michigan is exhibited by the statistics compiled by the Twelfth and Thirteenth Censuses in cooperation with the United States Forest Service. In 1900 the lumber cut amounted to 3,462,152,000 board feet. The State was second in rank of quantity of lumber cut. In 1905 the lumber cut of Michigan had declined to 2,006,670,000 board feet and the State to third in rank. In 1910 Michigan's lumber cut had fallen to 1,681,081,000 board feet and the State to ninth in rank.

The principal coal-mining operations are in Bay and Saginaw counties, with a smaller production (chiefly from local mines) in Clinton, Ingham, Shiawassee, and Tuscola counties.

Coal was known to exist in Michigan early in the last century, and some mining is said to have been done in the Jackson field as early as 1835. Other mines were opened at Grand Ledge, in Clinton County, in 1838. It is known that some coal was produced at that place in those early years, but there is no record of the output prior to the census report of 1860, in which year Michigan was credited with a production of 2,320 tons. It was only in the closing decade of the last century that serious attention began to be paid to the coal resources of the State, and prior to 1896 the production had exceeded 100,000 tons in four years only. In 1897 it exceeded 200,000 tons, in 1899 it exceeded 600,000 tons, and in the first year of the present century it reached a total exceeding 1,200,000 tons. The maximum output of 2,035,858 tons was reached in 1907.

The record, by years, from 1860 to 1913, inclusive, is shown in the following table:

Production of coal in Michigan, 1860 to 1913, in short tons.

Year.	Quantity.	Year.	Quantity.	Year.	Quantity.	Year.	Quantity.
1860	2,320	1874	58,000	1888	81,407	1902	964,718
1861	3,000	1875	62,500	1889	67,431	1903	1,367,619
1862	5,000	1876	66,000	1890	74,977	1904	1,342,840
1863	8,000	1877	69,197	1891	80,307	1905	1,473,211
1864	12,000	1878	85,322	1892	77,990	1906	1,346,338
1865	15,000	1879	82,015	1893	45,979	1907	2,035,858
1866	20,000	1880	100,800	1894	70,022	1908	1,835,019
1867	25,000	1881	112,000	1895	112,322	1909	1,784,692
1868	28,000	1882	135,339	1896	92,882	1910	1,534,967
1869	29,980	1883	71,296	1897	223,592	1911	1,476,074
1870	28,150	1884	36,712	1898	315,722	1912	1,206,230
1871	32,000	1885	45,178	1899	624,708	1913	1,231,786
1872	33,600	1886	60,434	1900	849,475		
1873	56,000	1887	71,461	1901	1,241,241	Total	22,911,711

MISSOURI.

Total production in 1913, 4,318,125 short tons; spot value, $7,468,308.

Compared with 1912, when the coal production of Missouri amounted to 4,339,856 short tons, valued at $7,633,864, the returns for 1913 show a decrease of 21,731 tons, or 0.5 per cent, in quantity and of $165,556, or 2.2 per cent, in value. With the exception of 1912, however, the output in 1913 was the largest in the history of the State. The decreased production in 1913 was due, primarily, to the exceptionally mild weather in February and March, the output in those two months being nearly 135,000 tons less than in the corresponding period in 1912. The deficiency was made up in part by an increased demand by the railroads, a portion of whose supply had been cut off by the unsettled conditions in Colorado, and also by an improved demand for household consumption during the fall months. The demand for steam coal by the manufacturing interests was well maintained during the year. The coal-mining industry suffered somewhat from the drought during the summer months, and at times water for boiler use had to be hauled to the mines. Transportation facilities were ample and satisfactory, and there was little interruption to mining operations on account of labor troubles. There were occasional shutdowns, but no prolonged periods of idleness, the total time lost being less than 2 per cent of the time made. All told, there were 918 men on strike during the year, and the average number of idle days was 34.

The proportionately larger decrease in the value of the product in 1913, shown by the decline from $1.76 to $1.73 in the average value of coal per ton, was due to the warm weather and the slackened demand in February and March, when, as a usual thing, better prices prevail than in the summer months.

Notwithstanding the decreased production in 1913, the number of men employed increased from 9,704 to 10,418, but there was a decrease in the average number of working days—from 206 in 1912 to 187 in 1913. The average annual production per man was 414 tons and 2.21 tons for each working day in 1913, as compared with 447 tons and 2.17 tons, respectively, in 1912. Mining machines are used chiefly in the thin beds where long-wall mining is practiced. In consequence, the long-wall type of machine is in the majority, 80 out of a total of 104 machines employed in 1913 being of that type. Of the other 24, 10 were short-wall and 7 each chain-breast and punchers. In 1912 there were 86 machines reported. In spite of the increased number of machines in 1913 the quantity of machine-mined coal decreased from 898,852 tons to 863,946 tons, the item constituting 20 per cent of the total output in 1913. About one-half of Missouri's coal production is "powder-mined," 2,021,292 short tons, or 47 per cent of the total, being shot off the solid in 1913, against 2,083,656 tons, or 48 per cent of the total, in 1912. The hand-mined coal reported in 1913 amounted to 1,018,588 tons. The method employed in mining about 400,000 tons was not reported.

The number of fatal accidents in the coal mines of Missouri in 1913 was reduced to just one-half of the fatalities of the preceding year, or from 20 to 10, according to reports to the Bureau of Mines, and the death rate per thousand was reduced to a fraction less than 1, as compared with 2.06 in 1912. Of the 10 fatalities in 1913, 8 were due to falls of roof. The quantity of coal mined for each life lost in 1913 was 431,813 tons, against 216,993 tons in 1912.

The statistics of production, by counties, in 1912 and 1913, with the distribution of the product for consumption, are shown in the following table:

Coal production of Missouri in 1912 and 1913, by counties, in short tons.

1912.

County.	Loaded at mines for shipment.	Sold to local trade and used by employees.	Used at mines for steam and heat.	Total quantity.	Total value.	Average price per ton.	Average number of days active.	Average number of employees.
Adair	563,015	20,014	10,638	593,667	$965,880	$1.63	231	931
Audrain	6,356	16,752	2,404	25,512	56,683	2.22	234	103
Barton	361,606	8,689	11,787	382,082	598,399	1.57	194	619
Bates	140,303	14,805	4,121	159,229	277,225	1.74	190	282
Boone	....	19,556	140	19,696	39,016	1.98	148	78
Callaway	11,900	11,052	10	22,962	56,504	2.46	233	83
Dade	200	5,820	80	6,100	11,825	1.94	146	12
Henry	107,160	33,549	2,875	143,584	260,396	1.81	161	428
Lafayette	683,283	47,358	18,957	749,598	1,454,965	1.94	227	2,018
Linn	100,450	22,174	3,025	125,649	287,504	2.29	219	410
Macon	779,358	23,687	15,125	818,170	1,251,755	1.53	179	1,629
Putnam	25,198	5,737	775	31,710	54,828	1.73	118	163
Randolph	448,450	27,297	8,156	483,903	781,919	1.62	239	1,039
Ray	340,793	28,339	6,032	375,164	723,981	1.93	191	1,182
Other countries [a]	240,260	48,407	15,348	304,015	607,601	2.00	206	727
Small mines	....	98,815	....	98,815	205,383	2.08	....	....
Total	3,808,332	432,051	99,473	4,339,856	7,633,864	1.76	206	9,704

1913.

County.	Loaded at mines for shipment.	Sold to local trade and used by employees.	Used at mines for steam and heat.	Total quantity.	Total value.	Average price per ton.	Average number of days active.	Average number of employees.
Adair	407,358	21,475	11,158	439,991	$699,244	$1.59	139	1,031
Audrain	3,031	7,424	151	10,606	21,842	2.06	139	51
Barton	475,325	10,784	9,219	495,328	796,992	1.61	198	735
Bates	145,700	16,551	6,218	168,469	264,857	1.57	182	311
Boone	1,927	13,780	84	15,791	30,563	1.94	202	69
Callaway	729	31,860	300	32,889	69,907	2.13	185	166
Dade	120	5,630	....	5,750	9,762	1.70	122	19
Henry	182,900	76,176	2,120	261,196	437,194	1.67	226	474
Lafayette	666,343	45,441	17,822	729,606	1,347,090	1.85	201	2,073
Linn	97,100	17,699	2,826	117,625	276,455	2.35	199	369
Macon	743,783	21,745	12,736	778,264	1,255,417	1.61	172	1,681
Putnam	17,483	3,852	500	21,835	45,409	2.08	108	119
Randolph	443,099	29,778	9,005	481,882	769,802	1.60	220	1,074
Ray	312,123	22,389	8,773	343,285	651,227	1.90	152	1,261
Other countries [b]	268,513	45,553	14,565	328,631	613,528	1.87	224	985
Small mines	....	86,977	....	86,977	179,019	2.06	....	....
Total	3,765,534	457,114	95,477	4,318,125	7,468,308	1.73	187	10,418

[a] Caldwell, Cass, Clay, Cole, Grundy, Harrison, Howard, Johnsou, Livingston, Moniteau, Montgomery, Platte, Ralls, Schuyler, Sullivan, and Vernon.
[b] Caldwell, Clay, Cole, Cooper, Grundy, Harrison, Howard, Johnson, Moniteau, Montgomery, Platte, Ralls, Schuyler, Sullivan, and Vernon.

The statistics of production during the last five years, by counties, with increase and decrease in 1913 as compared with 1912, are shown in the following table:

Coal production in Missouri, 1909–1913, by counties, in short tons.

County.	1909	1910	1911	1912	1913	Increase(+) or decrease (–), 1913.
Adair	576,485	408,007	348,559	593,667	439,991	– 153,676
Audrain	41,207	40,662	29,673	25,512	10,606	– 14,906
Barton	259,766	222,595	295,236	382,082	495,328	+ 113,246
Bates	147,322	95,451	88,620	159,229	168,469	+ 9,240
Boone	18,000	19,885	22,031	19,696	15,791	– 3,905
Caldwell	7,815	7,300	3,181	2,015	4,200	+ 2,185
Callaway	25,179	28,954	36,411	22,962	32,889	+ 9,927
Grundy	9,818	9,640	8,000	10,000	10,000	....
Henry	263,352	145,644	240,571	143,584	261,196	+ 117,612
Johnson	8,128	2,532	1,500	3,411	3,690	+ 279
Lafayette	715,223	553,832	765,879	749,598	729,606	– 19,992
Linn	134,260	89,311	123,169	125,649	117,625	– 8,024
Livingston	400	200	....	500	....	– 500
Macon	790,083	613,949	675,933	818,170	778,264	– 39,906
Montgomery and Morgan	2,420	a 1,500	a 1,000	a 1,200	a 665	– 535
Putnam	48,120	61,968	30,276	31,710	21,835	– 9,875
Ralls	16,009	12,761	16,158	13,799	15,022	+ 1,223
Randolph	186,573	193,482	483,800	483,903	481,882	– 2,021
Ray	277,075	292,442	317,134	375,164	343,285	– 31,879
Vernon	20,278	7,208	2,658	2,340	10,073	+ 7,733
Other counties and small mines	209,017	175,110	346,318	375,665	377,708	+ 2,043
Total	3,756,530	2,982,433	3,836,107	4,339,856	4,318,125	– 21,731
Total value	$6,183,626	$5,328,285	$6,603,066	$7,633,864	$7,468,308	–$165,556

a Montgomery County only.

The coal fields of Missouri occupy the greater part of that portion of the State lying north and west of a line drawn from the northeast to the southwest corner. About 25,000 square miles contain coal-bearing formations of which about 60 per cent are potentially productive under present conditions and more will become available in the future. The supplies eventually recoverable are large and less than 1 per cent has been exhausted up to the present time. The coal is all of bituminous variety of medium quality, but is a fair steam producer. Developments have not kept pace with progress in some of the other States, largely because the markets that can be reached are restricted by the fuels, some of them of higher grade, from the States to the north, east, south, and west of Missouri. St. Louis secures its fuel from the more accessible fields of southwestern Illinois, and Kansas City depends to a large extent upon Arkansas, Kansas, and Oklahoma for coal. But a more potential factor in limiting the demand for Missouri coal in the last few years, or at least until 1912, has been the notable increase in the production of petroleum and natural gas in the Mid-Continent field of Kansas and Oklahoma. Natural gas from eastern Kansas is now piped to Kansas City, St. Joseph, and Joplin, Mo., and to Atchison, Leavenworth, and other cities in Kansas. Oil from the same district and from northern Oklahoma is being extensively used for fuel by manufacturers in Kansas City and other cities near the Missouri coal fields, and as long as these more desirable fuels are available the demand for Missouri coal is not likely to increase materially. Smaller supplies of gas and of fuel oil in 1912 and 1913 have caused an increase in the production of coal in the Southwestern States, an increase that was shared by Missouri. The interruptions to their regular supplies of fuel caused by the biyearly conflicts between coal operators and their miners has created a tendency on the part of manufacturers to substitute oil and gas for coal. The chief producing fields of the State are: (1) The Bevier, occupying parts of Macon, Randolph, Chariton, Howard, and Boone counties, and producing 27 per cent of the State's output from a bed that ranges from 3 to 6 feet in thickness. (2) The Lexington, including Lafayette, Ray, and Clay counties. The bed mined is only 14 to 26 inches thick and belongs in the Des Moines group. Because it is ideally adapted to the long-wall system of mining and is situated near large consuming centers, this bed, in spite of its thinness, produces 27 per cent of the total for the State. (3) The Southwestern, including various districts in Henry, Barton, Bates, and adjacent counties, where several beds are mined, chiefly in the lower part of the Des Moines group. About 20 per cent of the output comes from this part of the State. (4) The Novinger, in Adair County, which produces 15 per cent of the total output. The bed mined lies at the same stratigraphic horizon as the one in the Bevier field and averages 3½ feet in thickness. (5) The Marceline, in Linn County, where 4 per cent of the State's total production is taken from a bed 29 inches thick. (6) The Mendota, in Putnam, Schuyler, and northwestern Adair counties. The coal of this field lies stratigraphically about 100 feet above that in the Novinger field and probably at the same horizon as that of the Lexington field. It is the southern extension of the Mystic or Centerville bed of Iowa, but is not extensively mined in Missouri and produces only 2 per cent of the total for the State.

The occurrence of coal in Missouri appears to have been known as early as 1806, when, according to "An account of expeditions to the sources of the Mississippi," by Z. M. Pike, it was noted on the banks of Osage River. The coal attracted the attention of the early settlers, and numerous small local mines are reported to have been opened by them. No record is extant of the quantity of coal produced in those early days in Missouri, and the first statement regarding the quantity mined in the State is contained in the report of the United States Census for 1840, in which year a production of 9,972 tons is recorded. The annual output of coal in Missouri since 1840 is shown in the following table, the output from 1841 to 1869, inclusive, being estimates only:

Production of coal in Missouri from 1840 to 1913, in short tons.

Year.	Quantity.	Year.	Quantity.	Year.	Quantity.	Year.	Quantity.
1840	9,972	1859	260,000	1878	1,008,000	1897	2,665,626
1841	12,000	1860	280,000	1879	1,008,000	1898	2,688,321
1842	15,000	1861	300,000	1880	844,304	1899	3,025,814
1843	25,000	1862	320,000	1881	1,960,000	1900	3,540,103
1844	35,000	1863	360,000	1882	2,240,000	1901	3,802,088
1845	50,000	1864	375,000	1883	2,520,000	1902	3,890,154
1846	68,000	1865	420,000	1884	2,800,000	1903	4,238,586
1847	80,000	1866	450,000	1885	3,080,000	1904	4,168,308
1848	85,000	1867	500,000	1886	1,800,000	1905	3,983,378
1849	90,000	1868	541,000	1887	3,209,916	1906	3,758,008
1850	100,000	1869	550,000	1888	3,909,967	1907	3,997,936
1851	125,000	1870	621,930	1889	2,557,823	1908	3,317,315
1852	140,000	1871	725,000	1890	2,735,221	1909	3,756,530
1853	160,000	1872	784,000	1891	2,674,606	1910	2,982,433
1854	175,000	1873	784,000	1892	2,733,949	1911	3,836,107
1855	185,000	1874	789,680	1893	2,897,442	1912	4,339,856
1856	200,000	1875	840,000	1894	2,245,039	1913	4,318,125
1857	220,000	1876	1,008,000	1895	2,372,393		
1858	240,000	1877	1,008,000	1896	2,331,542	Total	120,168,472

MONTANA.

Total production in 1913, 3,240,973 short tons; spot value, $5,653,539.

The influences which affected the coal-mining industry in Montana in 1913 were three in number—(1) an influx of settlers into the State, which resulted in an increased demand for domestic coal; (2) a decreased consumption by the railroads because of the increasing use of oil; and (3) extensive hydroelectric developments to supply light and power to many cities and to mining and manufacturing establishments. The use of hydroelectric power has even extended to some of the coal-mining plants themselves. The two latter influences have naturally resulted in a decreased demand for steam coal; but the larger demand for domestic coal more than outweighed the two adverse influences combined, and the production in 1913 showed an increase over 1912 of 192, 478 short tons, or 6.3 per cent, in quantity and of $95,344, or 1.7 per cent, in value. The output in 1913 was the maximum attained, as had been the case in each of the four preceding years.

There were no serious interruptions to mining operations in 1913 because of labor troubles. The wage scale signed in 1912 was for two years, and consequently there was no controversy of a general character on that account. Operators claim, however, that notwithstanding increased wages and improved working conditions local disaffections have occurred, with short periods of idleness, and that leaders among the miners have had difficulty in making the rank and file live up to the spirit of the contracts into which they have entered. Altogether in 1913 there were six local strikes, which involved the idleness of 1,094 men for an average of six days each.

The curtailment of the steam-coal market, because of the reasons stated, has induced the larger operating companies to install cutting machines in order to reduce the quantity of small coal produced and to secure as great a percentage as possible of the larger coal required for the domestic trade. The installation of new coal-cutting machinery was particularly noticeable in the Bear Creek, Sand Coulee (Cottonwood), and Roundup fields. The total number of machines in use in the coal mines of Montana in 1913 was 97, as compared with 69 in 1912, and the quantity of machine-mined coal increased from 984,905 tons, or 32.3 per cent of the total product, in 1912 to 1,076,641 tons, or 33.2 per cent of the total, in 1913. The percentage of coal shot from the solid decreased from 37 (1,123,571 tons) in 1912 to 35 (1,143,364 tons) in 1913. The quantity of coal mined by hand in 1913 was 1,003,726 tons. Of the 97 machines in use, 53 were punchers, 22 chain-breast, 19 short-wall, and 3 radialaxe or post-punchers. The number of men employed in the coal mines of the State in 1913 was 3,630, and they worked an average of 228 days, against 3,440 men for an average of 220 days in 1912. The mine workers of Montana have a good efficiency record, and in 1912 the State showed the best average production per man per day among all the coal-producing States. In 1913 the average production per man for the year exceeded that of 1912 (893 tons against 886 tons), but the average daily output by each employee decrease from 4.03 tons to 3.92 tons.

The fatality record maintained by the Bureau of Mines shows an unfortunate increase from the low point of 7 in 1912 to 20 in 1913, with an increase in the rate per thousand from 2.03 to 5.5, whereas the quantity of coal mined for each life lost decreased from 435,499 tons to 162,049 tons.

The statistics of production, by counties, during 1912 and 1913, with the distribution of the product for consumption, are shown in the following table:

Coal production of Montana in 1912 and 1913, by counties, in short tons.

County.	Loaded at mines for shipment.	Sold to local trade and used by employees.	Used at mines for steam and heat.	Total quantity.	Total value.	Average price per ton.	Average number of days active.	Average number of employees.
1912.								
Carbon	1,095,207	20,439	71,624	1,187,270	$2,472,534	$2.08	221	1,527
Cascade	794,766	16,419	44,391	855,576	1,340,392	1.57	210	1,054
Chouteau	7,638	13,352	600	21,590	53,924	2.50	292	41
Fergus	....	6,251	....	6,251	15,881	2.54	150	9
Hill	....	9,674	325	9,999	16,352	1.64	242	19
Musselshell	878,452	7,745	27,707	913,904	1,532,629	1.68	232	656
Other counties [a]	42,440	5,365	3,293	51,098	119,572	2.34	203	134
Small mines	....	2,807	....	2,807	6,911	2.46	....	....
Total	2,818,503	82,052	147,940	3,048,495	5,558,195	1.82	220	3,440
1913.								
Carbon	1,208,363	30,986	65,175	1,304,524	$2,660,952	$2.04	228	1,561
Cascade	863,516	35,132	13,986	912,634	1,351,142	1.48	209	1,094
Fergus	....	5,348	....	5,348	16,044	3.00	252	8
Hill	3,000	6,335	70	9,405	20,743	2.21	138	29
Musselshell	928,295	8,569	27,104	963,968	1,481,956	1.54	270	806
Other counties [b]	19,124	17,562	1,210	37,896	102,811	2.71	148	132
Small mines	....	7,198	....	7,198	19,891	2.76	....	....
Total	3,022,298	111,130	107,545	3,240,973	5,653,539	1.74	228	3,630

[a] Gallatin, Missoula, Park, Rosebud, and Valley.
[b] Blaine, Custer, Missoula, Park, Rosebud, and Valley.

In the following table is presented a statement of the coal production of Montana, by counties, during the last five years, with increase and decrease in 1913 as compared with 1912:

Production of coal in Montana, 1909–1913, by counties, in short tons.

County.	1909	1910	1911	1912	1913	Increase(+) or decrease (−), 1913.
Carbon	989,664	1,211,028	1,185,189	1,187,270	1,304,524	+ 117,254
Cascade	954,657	928,306	994,043	855,576	912,634	+ 57,058
Chouteau	31,432	17,327	9,727	21,590	....	− 21,590
Fergus	221,663	287,614	16,711	6,251	5,348	− 903
Gallatin	16,771	22,465	8,515	1,406	....	− 1,406
Hill	....	....	....	9,999	9,405	− 594
Musselshell	....	....	706,364	913,904	963,968	+ 50,064
Park	139,464	98,434	46,333	44,626	21,126	− 23,500
Other counties and small mines	200,289	355,796	9,476	7,873	23,968	+ 16,095
Total	2,553,940	2,920,970	2,976,358	3,048,495	3,240,973	+ 192,478
Total value	$5,036,942	$5,329,322	$5,342,168	$5,558,195	$5,653,539	+ $95,344

The coal fields of Montana are widely scattered and range in the quality of their output from lignite to a fair grade of bituminous coal. Nearly all of the eastern third, or Great Plains, section of the State is underlain by lignite and low-grade subbituminous coal. As the mountainous district is approached the coals pass into high-grade subbituminous and true bituminous coals. These occur for the most part in relatively small and much scattered areas. In the valley region of the western part of the State the coals grade again into lignite, but, like those of the eastern part, they are also widely scattered and at present are not of economic importance. In point of production the most important field at the present time is what is known as the Red Lodge field, in Carbon County. Extensive mining operations are carried on in the vicinity of Red Lodge and Bear Creek, the production amounting to approximately 1,200,000 short tons annually. The coal is so nearly on the line between subbituminous and bituminous coal that classification is difficult. Second in importance, and the district that is now attracting the most attention, is the Bull Mountain field, in Musselshell County. It was opened in 1908, following the completion of the Chicago, Milwaukee & Puget Sound Railway, and from a production of less than 100,000 tons in that year has increased to over 960,000 tons in 1913. This coal is a good grade of subbituminous.

Until superseded in 1912 by the Bull Mountain field, the Great Falls field, in Cascade County, was second in point of production, and still is in its future potentiality as important as any, if not the most important, in the State. Mining is extensively carried on at Cottonwood, Stockett, and Belt, and, up to 1907, Cascade County was credited with more than half the production of the State. This coal is bituminous in grade, but somewhat dirty.

An extensive area of subbituminous coal underlies a large part of Chouteau County in the north-central part of the State, but the mining operations are comparatively small. Coal mining, principally for local consumption, is also carried on in Fergus, Gallatin, Hill, Missoula, Park, Rosebud, and Valley counties.

The first record of coal production in Montana was 32 years ago, in 1880, when the output amounted to only 224 tons. Up to 1888 the development had been rather slow, amounting to 41,467 tons in that year. In 1889 it rose to 363,301 tons and increased rapidly until 1895, when it reached a total of about 1,500,000 tons, and averaged approximately that quantity each year until 1904. Since 1904 it has shown an increasing tendency, reaching the maximum of 3,240,973 tons in 1913.

Production of coal in Montana from 1880 to 1913, in short tons.

Year.	Quantity.	Year.	Quantity.	Year.	Quantity.	Year.	Quantity.
1880	224	1889	363,301	1898	1,479,803	1907	2,016,857
1881	5,000	1890	517,477	1899	1,496,451	1908	1,920,190
1882	10,000	1891	541,861	1900	1,661,775	1909	2,553,940
1883	19,795	1892	564,648	1901	1,396,081	1910	2,920,970
1884	80,376	1893	892,309	1902	1,560,823	1911	2,976,358
1885	86,440	1894	927,395	1903	1,488,810	1912	3,048,495
1886	49,846	1895	1,504,193	1904	1,358,919	1913	3,240,973
1887	10,202	1896	1,543,445	1905	1,643,832		
1888	41,467	1897	1,647,882	1906	1,829,921	Total	41,400,059

NEW MEXICO.

Total production in 1913, 3,708,806 short tons; spot value, $5,401,260.

In 1913, as in 1912, New Mexico outstripped all previous records in the production of coal. The output in 1912 was 3,536,824 short tons, valued at $5,037,051, compared with which that of 1913 showed an increase of 171,982 tons, or 4.86 per cent, in quantity and of $364,209, or 7.23 per cent, in value. As stated in previous reports, slight variations in values of New Mexico coal do not necessarily indicate any rise or fall in price, as in Colfax County, which produces 75 per cent of the total output of the State; the principal mining operations are carried on by companies affiliated with or subordinate to railroad and smelting interests, which consume the larger part of the product, and the fixing of values is simply a matter of accounting in which mining expense is an important factor. Colfax County in 1913 produced 2,749,765 short tons out of a total for the State of 3,708,806 tons. The average value per ton reported for Colfax County in 1913 was $1.33, against $1.31 in 1912 and $1.33 in 1911. More than one-third (938,432 tons) of the production of the county in 1913 was made into coke. Coke is not made in any other county in the State.

The number of men employed in the coal mines of New Mexico increased from 3,928 in 1912 to 4,329 in 1913, and the average number of working days increased from 274 to 289. The average production per man decreased from 900 tons for the year and 3.28 tons per day in 1912 to 857 tons and 2.97 tons, respectively, in 1913. This decreased tonnage per man was not due to any falling off in efficiency, but was one of the minor effects of an appalling disaster which occurred at mine No. 2 of the Stag Canon Fuel Co., at Dawson, in October, 1913. This accident, one of the most disastrous of the year in coal mining and the worst in the history of the State, caused the death of 261 persons. It occurred in one of the mines of a company which had spared no expense and had taken every precaution human intelligence could suggest to reduce the hazard of coal-mining operations. The other fatalities reported to the Bureau of Mines outside of the explosion at Dawson were 11, making a total of 272. The death rate per 1,000 for the year was 62.8, and the number of tons mined for each life lost was 13,635.

Most of the coal mined in New Mexico is undercut by hand, 2,548,243 tons, or 68.7 per cent of the total in 1913, being hand-mined. The quantity "powder-mined," or shot off the solid, was 652,969 tons, or 17.6 per cent of the total, and the machine-mined output was 497,070 tons, or 13.4 per cent. The number of machines in use increased from 25 in 1912, when 285,362 tons were produced by their use, to 44 in 1913. Short-wall, or continuous cutter, machines constituted 70 per cent of the total in 1913, 30 being of this type. Punchers numbered 7, chain-breast 6, and long-wall 1.

Only one instance of labor disaffection was reported in 1913, and in this 8 men were on strike for 130 days.

One company washes its slack coal used for coking, and in 1913, 587,853 tons of slack were washed, yielding 487,473 tons of cleaned coal and 100,380 tons of refuse.

The statistics of production, by counties, during 1912 and 1913, with the distribution of the product for consumption, are shown in the following table:

Coal production of New Mexico in 1912 and 1913, by counties, in short tons.

1912.

County.	Loaded at mines for shipment.	Sold to local trade and used by employees.	Used at mines for steam and heat.	Made into coke.	Total quantity.	Total value.	Average price per ton.	Average number of days active.	Average number of employees.
Colfax	1,816,057	13,230	22,755	839,264	2,691,306	$3,514,360	$1.31	280	2,692
McKinley	709,015	6,662	19,867		735,544	1,213,590	1.65	263	1,013
Other counties [a]	95,860	4,471	8,706		109,037	307,032	2.82	246	223
Small mines		937			937	2,069	2.21		
Total	2,620,932	25,300	51,328	839,264	3,536,824	5,037,051	1.42	274	3,928

1913.

County.	Loaded at mines for shipment.	Sold to local trade and used by employees.	Used at mines for steam and heat.	Made into coke.	Total quantity.	Total value.	Average price per ton.	Average number of days active.	Average number of employees.
Colfax	1,774,776	12,345	24,212	938,432	2,749,765	$3,652,245	$1.33	288	3,200
McKinley	795,375	6,867	22,520		824,762	1,367,364	1.66	293	862
Other counties [b]	115,729	5,299	10,251		131,279	374,318	2.85	283	267
Small mines		3,000			3,000	7,333	2.44		
Total	2,685,880	27,511	56,983	938,432	3,708,806	5,401,260	1.46	289	4,329

[a] Lincoln, San Juan, Santa Fe, and Socorro.
[b] Bernalillo, Lincoln, Rio Arriba, San Juan, Santa Fe, and Socorro.

In the following table are presented the statistics of production, by counties, during the last five years, with increase and decrease in 1913 as compared with 1912:

Coal production of New Mexico, 1909–1913, by counties, in short tons.

County.	1909	1910	1911	1912	1913	Increase (+) or decrease (−), 1913.
Colfax	2,013,318	2,651,585	2,297,611	2,691,306	2,749,765	+ 58,459
Lincoln	1,466	2,476	1,658	435	124	− 311
McKinley	665,423	698,730	731,365	735,544	824,762	+ 89,218
Rio Arriba	12,266	10,200	2,625		7,500	+ 7,500
Santa Fe	46,495	73,106	58,726	57,239	67,852	+ 10,613
Other counties and small mines	62,160	72,224	56,173	52,300	58,803	+ 6,503
Total	2,801,128	3,508,321	3,148,158	3,536,824	3,708,806	+ 171,982
Total value	$3,619,744	$4,877,151	$4,525,925	$5,037,051	$5,401,260	+$364,209

As in Montana, the coal-bearing areas of New Mexico are in somewhat widely separated localities, as follows: (1) The Raton field of Colfax County, which is the southern extension of the Trinidad field of Colorado; (2) the San Juan River region, which extends from Durango, Colo., southward through Rio Arriba, San Juan, and McKinley counties to Gallup and Mount Taylor, and which embraces the producing districts of Gallup and Monero; (3) a large area farther south and east than the one noted above in Valencia, Bernalillo, and Sandoval counties, of which very little is known; (4) the Los Cerrillos field in Santa Fe County, including the little known areas east, south, and west of the Ortiz Mountains; and (5) the White Oaks field in Lincoln County. There are several other areas of little economic importance.

From the standpoint of production the most important field at the present time is the Raton field of Colfax County, about 75 per cent of the production being from this region. The product is a true coking coal and most of the operations are on an extensive scale. In 1913 there were 12 mines that produced over 100,000 tons. Over 900,000 tons, chiefly washed slack, were made into coke. There are five known coal beds of workable thickness, but most of the mining operations are on the lowest bed of the series.

In point of area the San Juan River field in the northwestern part of the State is the most important. It has in New Mexico an area of about 13,000 square miles, and like the Raton field crosses the northern boundary into Colorado. In the southern part of this field the coal is subbituminous in quality but grades into bituminous coal at the north in Colorado and at the northeast in New Mexico. The principal mining operations in the San Juan River field are in McKinley (formerly a part of Bernalillo) County. Three mines in this county produce over 100,000 tons each, and one of them over 200,000 tons.

The Los Cerrillos field in Santa Fe County and the White Oaks field in Lincoln County are relatively small in area, but contain true bituminous coal. In the former some of the coal has been locally altered into anthracite, of which 34,345 tons were mined in 1913. Operations in Lincoln County are small and the production is limited to local consumption. Mining on a small scale is also carried on in Socorro County from an isolated area containing bituminous coking coal.

The first record of coal production in New Mexico is that contained in the first volume of Mineral Resources of the United States, published in 1882. In that year the production amounted to 157,092 tons, about 4 per cent of what it is at the present time. The maximum was reached in 1913, when the production of coal in New Mexico was 3,708,806 short tons.

Production of coal in New Mexico from 1882 to 1913, in short tons.

Year.	Quantity.	Year.	Quantity.	Year.	Quantity.	Year.	Quantity.
1882	157,092	1891	462,328	1900	1,299,299	1909	2,801,128
1883	211,347	1892	661,330	1901	1,086,546	1910	3,508,321
1884	220,557	1893	665,094	1902	1,048,763	1911	3,148,158
1885	306,202	1894	597,196	1903	1,541,781	1912	3,536,824
1886	271,285	1895	720,654	1904	1,452,325	1913	3,708,806
1887	508,034	1896	622,626	1905	1,649,933		
1888	626,665	1897	716,981	1906	1,964,713	Total	41,496,606
1889	486,943	1898	992,288	1907	2,628,959		
1890	375,777	1899	1,050,714	1908	2,467,937		

NORTH DAKOTA.

Total production in 1913, 495,320 short tons; spot value, $750,652.

All of the present mineral-fuel production of North Dakota is brown coal, or lignite. Considerable areas of subbituminous coal of usable quality and workable thickness are believed to underlie portions of the lignite areas, but no attempt to exploit the subbituminous coals has been made. The output of lignite in North Dakota decreased from 499,480 short tons, valued at $765,105, in 1912 to 495,320 tons, valued at $750,652, in 1913. Compared with 1911, when the production attained its maximum record (502,628 short tons), the output in 1913 shows a decrease of 7,308 tons. The relatively small differences in production during the last three years indicate an absence of any fluctuating influences and that active development of lignite properties will wait upon increased population. At present the consumption of lignite is chiefly for domestic purposes, but when properly handled and with proper equipment it can be used with satisfaction as a boiler fuel. A convincing example of what may be accomplished with lignite for such use is presented by the irrigation plant of the United States Reclamation Service at Williston. The lignite used is from the only coal mine owned and operated by the Government. The Reclamation Service operates the mine and uses the product in the generation of steam for its pumping plant connected with the irrigation project at Williston. The water is raised from Missouri River and delivered to an extensive system of canals and ditches by which a large section of the Missouri River Valley is irrigated. The mine of the Reclamation Service is located about 3 miles north of Williston and about a quarter of a mile from the power plant. It consists of a series of drifts in a 9-foot flat vein. The galleries or underground workings are at an average depth of about 100 feet below the surface. The main entry is about 2,000 feet in length, 6 feet wide and 6 feet high. The rooms are 100 to 150 feet long, 16 feet wide, and 8 feet high, with pillars between rooms 14 feet in width. Ventilation was at first obtained by the double-entry system, but on account of the increasing expense, due to the length of workings, artificial ventilation is to be resorted to with the aid of motor-driven fans and ventilating shafts at intervals. The mine is wet, the coal containing about 40 per cent of moisture, and drainage is effected by sumps from which the water is carried out in barrels. On account of vertical seams in the overlying soapstone rock, timbering is resorted to, the timber used being round tamarack or spruce. The main entry is permanently timbered and the headings are temporarily timbered. Because of a fungus growth all timbers are treated with a preservative.

The system of double entry mining is in use and the rooms, 16 feet in width, are widened on the return to 20 or 24 feet, by robbing the 14-foot pillars, after which the timbers are pulled and the mine is permitted to cave in. The average output at present is 100 tons a day. Coal is transported to the crusher near the power plant on cars hauled by mules and is there broken to nut size. The mine employs from 12 to 15 miners during the irrigation season of about five months in each year. The average output is from 6 to 10 tons of lignite per miner per day, and the net average earnings of the miners are from $3.50 to $5 a day of eight hours. The miners are furnished with permissible explosives at a slight advance above cost. Sleeping quarters are furnished free and meals can be obtained at 25 cents each. A bathroom, with individual lockers, gives the men an opportunity to use hot and cold shower baths. During the six months the mine was in operation in 1913 no fatal accidents were recorded, and only two or three serious ones. The average cost for producing lignite at the Reclamation Service mine was $1.56 per ton in 1911, $1.89 in 1912, and $1.44 in 1913. The value of the product in 1913 has been estimated at $1.60 per ton, as this was the average value of the commercial lignite produced in the county.[1]

At Kenmare, Scranton, and Dickinson lignite is successfully used in the burning of brick, for which purpose its smokeless and sootless qualities and relatively low cost make it adaptable. As the gas-producer and internal-combustion engines in large units come into more general use in the West, as they are rapidly doing in the East, the lignites of North Dakota will be found to possess great potentialities in the settlement and economic development of the State.

In Survey Bulletin 531 Frank A. Herald discusses the possibilities of using North Dakota lignite in the manufacture of briquets, as follows:[2]

> Some briquetting tests have been made with North Dakota lignite and have proved that the fuel can be treated successfully in that way. Tests at the Pittsburgh laboratory of the Bureau of Mines indicate that lignite from the Williston field can be economically briquetted.[3] Lignite from this field has been briquetted successfully at the North Dakota Mining and Experiment Station at Hebron, N. Dak.[4] The Pittsburgh tests were made with high pressure without binder, whereas the others were made with lower pressure and binder. As both methods gave favorable results, experimenters believe that the lignite can be successfully briquetted on a commercial basis both with and without binders. When briquetted the lignite can compete with higher-grade coal, as the briquets withstand weathering and do not crumble badly when handled. The process of briquetting removes 75 per cent of the water in the lignite, thus decreasing the weight about 30 per cent, and considerably increasing the heating value, by saving the heat otherwise needed to remove the moisture. Excessive moisture not only wastes heat during combustion but is also an important factor in freight charges, approximately one-third of the weight of most lignites being water. Briquetting, therefore, is especially useful because it increases the heat value and decreases the cost of transportation. In the tests mentioned above the heat value of the briquets made without binder was about 50 per cent greater than that of the raw material, and the briquets made at the Hebron experimental substation by a different process involving more thorough drying and the addition of binders showed a heat value about 70 per cent greater than the raw lignite.

The utilization of lignite, unless briquetted, to be successfully accomplished must be in the vicinity of the mines from which it is taken. When freshly mined North Dakota lignite contains about 40 per cent of moisture. Upon exposure to the atmosphere it gives up a large part of the moisture and then "slacks," or crumbles. Prolonged exposure reduces it to a rather fine powder with probably considerable oxidation and loss of volatile combustible material.

The lignite mines of North Dakota gave employment in 1913 to 641 men, who worked an average of 221 days, as compared with 622 men for an average of 232 days in 1912. The average production per man was 773 tons for the year and 2.9 tons each working day in 1913, against 803 and 3.5 tons, respectively, in 1912. The mines were entirely free from strikes, suspensions, or lockouts in 1913. Thirteen mining machines, 4 chain-breast, and 9 short-wall, were reported in use in 1913, and the quantity mined by machine was 222,227 short tons, or 44.9 per cent of the total. The quantity of lignite shot off the solid was 130,341 tons, or 26.3 per cent of the total.

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[1] Reclamation Record, pp. 9-10, January, 1914, and p. 58, February, 1914.
[2] Herald, F. A., The Williston lignite field, Williams County, N. Dak.: U. S. Geol. Survey Bull., pp. 104-105, 1913.
[3] Wright, C. L., Briquetting tests of lignite at Pittsburgh, Pa., 1908-9: Bureau of Mines Bull. 14, 1911.
[4] Babcock, E. J., Investigations of lignite coal relative to the production of gas and briquets: North Dakota School of Mines and Exper. Sta. Rept., 1911.

The statistics of production, by counties, in 1912 and 1913, with the distribution of the product for consumption, are shown in the following table:

Coal production of North Dakota in 1912 and 1913, by counties, in short tons.

1912.

County.	Loaded at mines for shipment.	Sold to local trade and used by employees.	Used at mines for steam and heat.	Total quantity.	Total value.	Average price per ton.	Average number of days active.	Average number of employees.
Adams	3,390	6,150	28	9,568	$11,630	$1.22	212	12
Burke	5,500	6,350	100	11,950	15,482	1.30	168	29
Burleigh	169,302	9,812	7,894	187,008	286,177	1.53	261	165
Hettinger	....	11,005	24	11,029	12,921	1.17	265	16
Morton	18,190	17,806	330	36,326	51,276	1.41	186	45
Stark	55,308	2,800	1,677	59,785	78,546	1.31	240	55
Ward	63,380	25,384	510	89,274	160,995	1.80	211	190
Williams	12,495	9,527	931	22,953	35,821	1.56	227	37
Other counties [a]	27,330	13,691	140	41,161	65,859	1.60	263	73
Small mines	....	30,426	....	30,426	46,398	1.52	....	....
Total	354,895	132,951	11,634	499,480	765,105	1.53	232	622

1913.

County.	Loaded at mines for shipment.	Sold to local trade and used by employees.	Used at mines for steam and heat.	Total quantity.	Total value.	Average price per ton.	Average number of days active.	Average number of employees.
Adams	4,707	4,822	55	9,584	$13,368	$1.39	201	17
Burke	5,139	6,861	175	12,175	14,885	1.22	190	20
Burleigh	176,208	9,475	8,319	194,002	283,918	1.46	202	234
Hettinger	....	7,550	....	7,550	8,435	1.12	177	7
McLean	676	7,827	213	8,716	12,601	1.45	250	6
Morton	19,605	20,076	805	40,486	57,232	1.41	222	53
Stark	50,632	3,475	1,450	55,557	79,380	1.43	208	52
Ward	53,270	19,426	4,414	77,110	137,245	1.78	256	154
Williams	2,595	24,602	561	27,758	44,474	1.60	196	50
Other counties [b]	37,000	8,015	....	45,015	72,365	1.61	262	48
Small mines	....	17,367	....	17,367	26,749	1.54	....	....
Total	349,832	129,496	15,992	495,320	750,652	1.52	221	641

[a] Bowman, Divide, Dunn, McLean, Mercer, and Oliver.
[b] Bowman, Divide, Mercer, and Oliver.

The statistics of production, by counties, during the last five years, with increase and decrease in 1913, as compared with 1912, are shown in the following table:

Coal production of North Dakota, 1909–1913, by counties, in short tons.

County.	1909	1910	1911	1912	1913	Increase(+) or decrease (−), 1913.
Burke	....	....	16,585	11,950	12,175	+ 225
Burleigh	122,422	142,597	173,214	187,008	194,002	+ 6,994
McLean	9,325	4,090	7,163	4,145	8,716	+ 4,571
Morton	18,634	23,250	20,034	36,326	40,486	+ 4,160
Stark	72,550	56,700	58,377	59,785	55,557	− 4,228
Ward	139,996	117,382	138,105	89,274	77,110	− 12,164
Williams	18,722	17,380	20,916	22,953	27,758	+ 4,805
Other counties and small mines	40,398	37,642	68,234	88,039	79,516	− 8,523
Total	422,047	399,041	502,628	499,480	495,320	− 4,160
Total value	$645,142	$595,139	$720,489	$765,105	$750,652	−$14,453

The lignite areas of North Dakota occupy nearly all of the western half of the State and are estimated to contain about 35,000 square miles. According to the reports of the North Dakota Geological Survey, there are 97 townships which contain at least one bed of lignite 7 feet or more in thickness, in some places as much as 30 feet. At least 100 other townships contain beds from 4 to 7 feet in thickness. The lignite is well exposed along Missouri, Little Missouri, Knife, Heart, and Mouse rivers. Mining is carried on to some extent along the Northern Pacific Railway west of Mandan; on the Milwaukee, St. Paul & Sault Ste. Marie Railway in the Mouse River Valley and north of Bismarck; to less extent along the Great Northern Railway in the northwestern part of the State; and along the Chicago, Milwaukee & St. Paul Railway in the southwestern part. The principal mining operations are in the vicinity of Wilton, in Burleigh County, where the proximity to Bismarck and the markets provided by the State institutions, compelled by law to use North Dakota lignite for fuel, have encouraged development.

Lignite has doubtless been mined and used in North Dakota by ranchmen and others since the time when the State was a Territory, but it was not until 1884 that any record of production was obtained. This was published in the volume of Mineral Resources of the United States covering that year. The production since 1884 is given in the following table:

Production of coal in North Dakota from 1884 to 1913, in short tons.

Year.	Quantity.	Year.	Quantity.	Year.	Quantity.	Year.	Quantity.
1884	35,000	1892	40,725	1900	129,883	1908	320,742
1885	25,000	1893	49,630	1901	166,601	1909	422,047
1886	25,955	1894	42,015	1902	226,511	1910	399,041
1887	21,470	1895	38,997	1903	278,645	1911	502,628
1888	34,000	1896	78,050	1904	271,928	1912	499,480
1889	28,907	1897	77,246	1905	317,542	1913	495,320
1890	30,000	1898	83,895	1906	305,689		
1891	30,000	1899	98,809	1907	347,760	Total	5,423,516

OHIO.

Total production in 1913, 36,200,527 short tons; spot value, $39,948,058.

All previous records in the coal production of Ohio were exceeded in 1913 both in quantity and in value, notwithstanding that coal-mining operations, like all other industries of the State, were seriously interfered with by an unprecedented inundation in the spring of the year. Mines were flooded and the transportation companies were practically out of business throughout a good part of the State for more than a month, so that the possible production was cut down probably 5,000,000 tons. In spite of this interruption the production increased from the previous maximum output of 34,528,727 short tons in 1912 to 36,200,527 tons in 1913, a gain of 1,671,800 tons, or 4.84 per cent. The value showed an increase of $2,864,695, or 7.73 per cent, from $37,083,363 to $39,948,058, and the average value per ton showed an advance of 3 cents, from $1.07 in 1912 to $1.10 in 1913. In spite of the interruption by the floods and the losses necessarily incident thereto, the year 1913 was one of the most satisfactory the coal operators of Ohio have experienced in recent history. Railroad consumption was larger than usual, and the demand from iron and steel furnaces and other manufacturing enterprises was good, except during the last quarter of the year. As if to equalize the excess of rainfall in the spring, there was during September, October, and November a deficiency in the water supply, drought conditions existing during a great part of that period, at which time also there was a shortage in transportation facilities due probably to the demands for crop movement. Some complaint was also made of shortage of labor and of the exacting character of its demands, with particular reference to the agitation for legislation requiring a mine-run basis of payment, instead of a screened-coal basis. The mine-run law was passed at the winter session of the legislature and has since been held constitutional by the courts.

Although the spring floods caused many of the mines to remain idle for a month or more, the average number of working days made by the employees and the average tonnage by each employee, both for the year and for each working day, were above the normal. The gain in total production was nearly 5 per cent, but there was an increase of only six-tenths of 1 per cent in the number of employees, from 45,527 in 1912 to 45,815 in 1913, which probably accounts for the complaints of labor shortage. The average working time was 206 days in 1913 against 201 days in 1912. The average production by each man employed was 790 tons for the year and 3.83 tons for each working day in 1913, against 758 tons and 3.77 tons, respectively, in 1912. The gains in individual production were due in large part to the larger production of machine-mined coal, in the proportion of which to the total tonnage Ohio stands well at the head among the coal-producing States. In 1913, 32,642,848 tons, or 90.2 per cent of Ohio's total production, were mined by machines. The increase in machine-mined coal was 2,594,017 tons, or 922,217 tons more than the total increase. At the present time Ohio enjoys the excellent record of having less than 4 per cent of the total output reported as shot off the solid or powder-mined. It will be interesting to note how this good record is maintained if the mine-run payment system is put into effect. A little over 4 per cent of the total production (1,600,605 tons) in 1913 was mined by hand. Electrically driven chain-breast machines far outnumber all other types of machines in the Ohio mines, as out of a total of 1,681 machines in use in 1913, 1,421, or nearly 85 per cent, were chain-breast. Short-wall machines are growing in popularity, as indicated by an increase in their number from 106 in 1912 to 187 in 1913. The number of long-wall machines increased from 2 to 17, and the number of pick machines decreased from 77 to 56.

Comparatively little of the coal product of Ohio is washed. In 1913 that item amounted to 306,713 tons, and yielded 269,178 tons of cleaned coal and 37,535 tons of refuse.

The total time lost by strikes and suspensions in 1913 was 263,234 days, 10,029 men being affected and their average time lost being 26 days. Distributed among the total number of employees, the average time lost was a fraction over 5 days, or about 3 per cent of the average time made.

Reports to the Bureau of Mines show that the coal-mining fatalities in 1913 numbered 165, of which 159 were underground, 4 in shafts, and 2 on the surface. The principal causes were falls of roof and coal, 93, or 56 per cent of the total; haulage accidents, 32; gas explosions, 15; and electricity, 9. The death rate per thousand was 3.6 and the number of tons mined for each life lost was 219,397. In 1912 there were 133 fatal accidents, and the rate per thousand was 2.9.

The statistics of production by counties, in 1912 and 1913, with the distribution of the product for consumption, are shown in the following table:

Coal production of Ohio in 1912 and 1913, by counties, in short tons.

1912.

County.	Loaded at mines for shipment.	Sold to local trade and used by employees.	Used at mines for steam and heat.	Made into coke.	Total quantity.	Total value.	Average price per ton.	Average number of days active.	Average number of employees.
Athens	4,660,471	32,183	117,920	9,200	4,819,774	$5,279,234	$1.10	186	6,711
Belmont	8,844,252	444,171	93,907	....	9,382,330	9,063,554	.97	222	10,253
Carroll	272,377	44,675	5,917	....	322,969	364,922	1.13	208	495
Columbiana	406,706	34,343	7,729	....	448,778	538,314	1.20	163	854
Coshocton	315,635	52,277	3,487	....	371,399	462,454	1.25	198	634
Guernsey	4,140,058	30,412	76,485	....	4,246,955	4,153,222	.98	203	5,029
Harrison	773,130	28,223	11,600	....	812,953	801,111	.99	248	871
Hocking	1,688,889	34,409	39,879	....	1,763,177	2,003,839	1.14	207	2,600
Holmes	530	9,599	128	....	10,257	13,523	1.32	158	33
Jackson	560,763	145,868	30,653	....	737,284	1,236,512	1.68	153	1,843
Jefferson	4,341,988	430,958	84,918	665	4,858,529	5,016,305	1.03	216	5,772
Lawrence	24,890	41,268	....	....	66,158	74,610	1.13	131	243
Mahoning	18,270	14,482	442	....	33,194	55,144	1.66	144	149
Medina	....	6,457	222	....	6,679	12,013	1.71	186	18
Meigs	597,920	37,225	9,318	....	644,463	787,322	1.22	181	1,161
Muskingum	395,210	68,830	1,589	....	465,629	498,643	1.07	198	656
Noble	615,253	6,209	2,942	....	624,404	585,631	.94	211	635
Perry	2,052,737	45,317	47,862	....	2,145,916	2,402,799	1.12	177	3,341
Stark	267,547	130,014	16,891	....	414,452	722,457	1.74	190	836
Summit	69,685	4,391	5,386	....	79,462	145,152	1.83	185	153
Tuscarawas	1,058,072	238,123	28,399	....	1,324,594	1,516,645	1.14	213	1,863
Vinton	76,626	17,355	3,957	....	97,938	111,852	1.14	135	277
Wayne	165,294	14,737	14,005	....	194,036	372,202	1.92	133	429
Other counties [a]	364,625	9,243	6,930	....	380,798	520,509	1.37	183	671
Small mines	....	276,599	....	....	276,599	345,394	1.25	....	....
Total	31,710,928	2,197,368	610,566	9,865	34,528,727	37,083,363	1.07	201	45,527

1913.

County.	Loaded at mines for shipment.	Sold to local trade and used by employees.	Used at mines for steam and heat.	Made into coke.	Total quantity.	Total value.	Average price per ton.	Average number of days active.	Average number of employees.
Athens	4,801,707	37,559	125,067	4,300	4,968,633	$5,538,778	$1.11	186	7,143
Belmont	9,893,361	413,596	129,302	....	10,436,259	10,745,972	1.03	222	10,946
Carroll	329,160	44,404	5,500	....	379,064	424,546	1.12	217	623
Columbiana	471,425	34,467	16,912	....	522,804	632,682	1.21	226	717
Coshocton	292,782	63,114	8,515	....	364,411	473,401	1.30	247	621
Guernsey	4,215,033	44,497	62,462	....	4,321,992	4,405,009	1.02	202	4,749
Harrison	701,310	16,659	12,252	....	730,221	751,452	1.03	225	778
Hocking	1,605,021	35,308	38,294	....	1,678,623	1,914,339	1.14	205	2,218
Holmes	500	8,472	15	....	8,987	12,607	1.40	181	18
Jackson	473,187	94,386	19,471	....	587,044	935,420	1.59	135	1,718
Jefferson	4,739,434	352,654	86,373	461	5,178,922	5,693,434	1.10	232	5,763
Lawrence	129,280	45,624	1,194	....	176,098	216,058	1.23	200	388
Mahoning	4,875	10,771	140	....	15,786	29,678	1.88	154	72
Meigs	595,457	38,453	8,815	....	612,725	771,868	1.20	192	1,208
Muskingum	417,074	53,548	2,126	....	472,748	515,986	1.09	228	653
Noble	767,367	9,534	10,240	....	787,141	822,108	1.04	210	778
Perry	2,068,207	52,839	56,518	....	2,177,564	2,412,031	1.11	188	3,235
Stark	252,532	143,040	21,666	....	417,238	760,036	1.82	187	939
Tuscarawas	1,177,211	209,580	33,131	....	1,419,922	1,603,968	1.13	230	1,853
Vinton	96,946	22,597	2,949	....	122,492	140,771	1.15	171	248
Wayne	68,580	14,467	14,186	....	97,233	203,811	2.10	126	273
Other counties [b]	424,647	13,111	19,160	....	456,918	639,057	1.40	188	844
Small mines	....	237,702	....	....	237,702	305,046	1.28	....	....
Total	33,525,096	1,996,382	674,288	4,761	36,200,527	39,948,058	1.10	206	45,815

[a] Gallia, Morgan, Portage, Scioto, and Trumbull.
[b] Gallia, Medina, Morgan, Portage, Scioto, Summit, and Trumbull.

Of the 28 counties included in the table, 16 showed increased and 12 decreased output in 1913. Sixty per cent of the total increase was made in Belmont County, which exhibited a gain of 1,053,929 tons, or a little more than 10 per cent over 1912. Jefferson County came second with an increase of 320,393 tons; and the combined production of Noble and Scioto counties showed an increase of 160,650 tons. Athens County gained 148,859 tons, and Lawrence 109,940 tons. The largest loss was in Jackson County, 150,240 tons. Increases and decreases in other counties were less than 100,000 tons.

The statistics of production, by counties, during the last five years, with increase and decrease in 1913 as compared with 1912, are shown in the following table:

Coal production of Ohio, 1909–1913, in short tons.

County.	1909	1910	1911	1912	1913	Increase(+) or decrease (−), 1913.
Athens	4,131,270	5,593,560	4,292,527	4,819,774	4,968,633	+ 148,859
Belmont	6,061,573	8,265,019	8,092,127	9,382,330	10,436,259	+ 1,053,929
Carroll	390,273	313,517	269,167	322,969	379,064	+ 56,095
Columbiana	657,285	715,252	660,196	448,778	522,804	+ 74,026
Coshocton	373,981	427,341	390,812	371,399	364,411	− 6,988
Gallia	7,700	9,187	10,805	91,575	11,810	− 79,765
Guernsey	3,085,377	4,686,994	3,895,682	4,246,955	4,321,992	+ 75,037
Harrison	576,963	560,937	559,267	812,953	730,221	− 82,732
Hocking	1,194,895	1,635,575	1,576,119	1,763,177	1,678,623	− 84,554
Holmes	12,886	10,157	10,930	10,257	8,987	− 1,270
Jackson	784,463	878,656	669,591	737,284	587,044	− 150,240
Jefferson	3,908,118	5,241,681	4,687,731	4,858,529	5,178,922	+ 320,393
Lawrence	184,940	148,568	59,192	66,158	176,098	+ 109,940
Mahoning	40,904	60,434	52,748	33,194	15,786	− 17,408
Medina	13,017	24,148	14,187	6,679	5,445	− 1,234
Meigs	564,904	599,492	516,845	644,463	642,725	− 1,738
Morgan	191,391	124,336	174,513	193,745	279,481	+ 85,736
Muskingum	487,179	238,795	376,446	465,629	472,748	+ 7,119
Perry	2,133,266	2,283,257	2,086,799	2,145,916	2,177,564	+ 31,648
Portage	100,497	101,826	109,727	84,903	91,940	+ 7,037
Stark	486,272	496,509	450,256	414,452	417,238	+ 2,786
Summit	84,872	101,243	85,579	79,462	59,859	− 19,603
Trumbull	620	700	....	1,035	930	− 105
Tuscarawas	1,577,303	816,189	677,330	1,324,594	1,419,922	+ 95,328
Vinton	151,954	86,801	104,338	97,938	122,492	+ 24,554
Wayne	101,050	159,138	209,059	194,036	97,233	− 96,803
Noble } Scioto }	381,327	438,398	477,294	633,944	794,594	+ 160,650
Small mines	255,361	191,958	250,719	276,599	237,702	− 38,897
Total	27,939,641	34,209,668	30,759,986	34,528,727	36,200,527	+ 1,671,800
Total value	$27,789,010	$35,932,288	$31,810,123	$37,083,363	$39,948,058	+$2,864,695

The coal fields of Ohio belong to the Appalachian Province and lie entirely within the eastern part of the State. The areas formerly underlain by coal are estimated at 12,600 square miles, or about one-third of the entire State. There are 16 different beds, of which the more important are No. 1, or Sharon (block) coal; No. 2, or Wellston; No. 5, or Lower Kittanning; No. 6, or Middle Kittanning; No. 7, or Upper Freeport; No. 8, or Pittsburgh; Pomeroy; and Meigs Creek. All of these beds have been developed on a large scale. The other eight beds have been developed chiefly by small mines for local trade.

Coal No. 1, the block coal, is mined in the northeastern part of the State, principally in Mahoning, Stark, and Summit counties. It is a dry, free-burning, noncoking coal, very pure, and consumed, largely raw, in blast furnaces. This coal was the first mineral fuel to supplant charcoal in the blast furnaces of the State. As a domestic fuel it is known as Massillon coal and is highly prized for household use in Cleveland and other Lake cities. The annual production from this bed at the present time is about 600,000 tons. Twenty years ago, in 1892, the production exceeded 1,200,000 tons, indicating that this coal in that particular area is being worked out.

The No. 2, or Wellston coal, lies above the block (or No. 1) and has its highest development in the southwestern part of the Ohio field. The principal mining operations are at Jackson and Wellston, in Jackson County, whose production in 1913 was 587,044 short tons. This coal also appears to be approaching exhaustion, as in 1892 the production of Jackson County was 1,833,910 tons, and as late as 1906 it amounted to 1,370,000 tons.

Bed No. 5 (Lower Kittanning) is extensive, having been traced from Mahoning County, in the northeastern part of the State, to Lawrence County, at the southwestern extremity of the Ohio field. It is not extensively mined, however, being of workable thickness and quality in but few places. The principal mining operations are in Lawrence County, which had a total production of 176,098 tons in 1913, and part of this was probably from the No. 7 bed.

No. 6 (or Middle Kittanning) yields the justly celebrated Hocking Valley coal mined extensively in Athens, Hocking, and Perry counties. Like the block, it is a free-burning, noncoking coal, chiefly popular as a blast-furnace fuel, for which purpose it is used raw, but it is also highly regarded as a steam and domestic coal. The production of the three counties mentioned was 8,824,820 tons in 1913. In 1892 the same counties produced 4,640,647 tons. A small part of the Athens County production may be credited to the Pittsburgh (No. 8) bed, which is present in the county, and some little of Perry County's output may be from No. 7.

Bed No. 7, the Upper Freeport, mined in Gallia, Guernsey, Lawrence, and Muskingum counties and in portions of Perry County, is a high-grade steam fuel, and except for its content of sulphur would make an excellent coke. No coke is made from this bed in Ohio, however. The production of the three counties (Gallia, Guernsey, and Muskingum) from this bed in 1913 was 4,806,550 short tons.

No. 8, the Pittsburgh bed, is the most extensive and valuable in North America, underlying considerable portions of Pennsylvania, Maryland, West Virginia, and Ohio. Its area in Ohio probably amounts to over 1,000 square miles and it is extensively mined in Belmont, Jefferson, Harrison, and Noble counties, and to less extent in Athens, Gallia, Guernsey, Meigs, Monroe, and Morgan counties. The production of the first four counties, mostly Pittsburgh coal, in 1913, was 17,132,543 short tons. To this may be added about 500,000 tons mined in other counties. How the development of this coal has progressed in 20 years is shown by the fact that the four counties which produced over 17,000,000 tons in 1913 produced only 1,973,697 tons in 1892.

The Pomeroy bed, correlated with the Redstone of Pennsylvania, lies a short distance above the Pittsburgh and is worked in Gallia, Lawrence, and Meigs counties, the most of the production of Meigs County being from this bed.

The Meigs Creek coal, 80 to 100 feet above the Pittsburgh bed, is correlated with the Sewickley bed of western Pennsylvania. It is workable in portions of Morgan, Noble, Washington, Muskingum, Harrison, Belmont, and Monroe counties, and will ultimately prove a most valuable reserve, though its variable thickness and lower grade subordinate it to the Pittsburgh, and its exploitation is at present local and generally on a small scale.

One of the early reports published by Ohio states that in 1838 there were 119,952 short tons produced in the coal mines of the State. It is probable that some coal was mined in Ohio prior to that date, but there is no record of such production. The United States census of 1840 credited Ohio with an output of 140,536 tons of coal. The census of 1850 did not consider the coal-mining industry, and the next report of coal production in the State was that of the census of 1860, which recorded an output of 1,265,600 short tons.

A statement of the annual production of coal in Ohio from 1838 to the close of 1913 will be found in the following table:

Production of coal in Ohio from 1838 to 1913, in short tons.

Year.	Quantity.	Year.	Quantity.	Year.	Quantity.	Year.	Quantity.
1838	119,952	1858	1,000,000	1878	5,500,000	1898	14,516,867
1839	125,000	1859	1,060,000	1879	6,000,000	1899	16,500,270
1840	140,536	1860	1,265,600	1880	6,008,595	1900	18,988,150
1841	160,000	1861	1,150,000	1881	9,240,000	1901	20,943,807
1842	225,000	1862	1,200,000	1882	9,450,000	1902	23,519,894
1843	280,000	1863	1,204,581	1883	8,229,429	1903	24,838,103
1844	340,000	1864	1,815,622	1884	7,640,062	1904	24,400,220
1845	390,000	1855	1,536,218	1885	7,816,179	1905	25,552,950
1846	420,000	1866	1,887,424	1886	8,435,211	1906	27,731,640
1847	480,000	1867	2,092,334	1887	10,300,708	1907	32,142,419
1848	540,000	1868	2,475,844	1888	10,910,951	1908	26,270,639
1849	600,000	1869	2,461,986	1889	9,976,787	1909	27,939,641
1850	640,000	1870	2,527,285	1890	11,494,506	1910	34,209,668
1851	670,000	1871	4,000,000	1891	12,868,683	1911	30,759,986
1852	700,000	1872	5,315,294	1892	13,562,927	1912	34,528,727
1853	760,000	1873	4,550,028	1893	13,253,646	1913	36,200,527
1854	800,000	1874	3,267,585	1894	11,909,856		
1855	890,000	1875	4,864,259	1895	13,355,806	Total	682,678,546
1856	930,000	1876	3,500,000	1896	12,875,202		
1857	975,000	1877	5,250,000	1897	12,196,942		

OKLAHOMA.

Total production in 1913, 4,165,770 short tons; spot value, $8,542,748.

Oklahoma, more than any of the coal-producing States in the Mississippi Valley and the Rocky Mountain regions, was benefited by the labor troubles in Colorado, as is shown by an increase in production from 3,675,418 short tons in 1912 to 4,165,770 tons in 1913. The gain in output was 490,352 tons, or 13.34 per cent; the value of the product increased from $7,867,331 to $8,542,748, a gain of $675,417, or 8.6 per cent. The smaller relative gain in value in 1913 was due to the fact that in 1912 prices were somewhat inflated because of the rather abrupt withdrawal of fuel oil from the markets where it had been in competition with Oklahoma coal and to a diminution in the supply of natural gas from the northern part of the Mid-Continent field, particularly in Kansas. The average value per ton of Oklahoma coal advanced from $2.05 in 1911 to $2.14 in 1912. The deficiency in the Kansas production of natural gas is being made up, however, by developments in Oklahoma, and the result of this and of the supply of coal catching up with the demand by the increased production in 1913 is exhibited in the return to the lower prices of 1911. The average value per ton in 1913 was the same as in 1911. Oklahoma, being nearer than Arkansas to the markets usually supplied with Colorado coal, was called upon to a greater extent to supply the deficiency caused by the strike conditions in the Rocky Mountain State; otherwise what has been said concerning weather, transportation, and labor conditions in Arkansas applies with about equal force to Oklahoma, except that less time was lost in Arkansas than in Oklahoma by labor troubles. The total number of men on strike in Oklahoma in 1913 was 1,696, and the average time lost by each was 80 days.

Oklahoma continues to show a disgracefully high percentage of coal shot off the solid, a practice encouraged by the laws of the State which compel the payment of wages on the basis of mine-run coal. An increase in the production of machine-mined coal from 259,719 tons, or 7.1 per cent of the total, in 1912, to 670,629 tons, or 16.1 per cent of the total, in 1913, reduced the percentage of coal shot off the solid from 86.4 to 81, but at the same time the quantity of "powder-mined" coal increased nearly 200,000 tons, from 3,175,455 tons in 1912 to 3,371,218 in 1913, so the record for the latter year can hardly be considered much of an improvement over 1912.

The number of days the men were able to work in 1913 shows a marked improvement over the two preceding years, and if no time had been lost by strikes the average number of days worked would have exceeded 200 by a good margin. As it was, the average time made by the 9,044 men employed was 197 days, as compared with 8,785 men for 174 days in 1912 and 8,790 men for 156 days in 1911. The average total production per man in 1913 was 461 tons, against 418 tons in 1912, but the average daily production by each employee fell off slightly, from 2.4 to 2.34.

The fatality record for Oklahoma in 1913, according to the Bureau of Mines, shows a decided improvement over 1912, when, owing to explosion of gas and dust in the San Bois mine at McCutcheon, the death toll was high. In that one explosion the lives lost amounted to more than three times the total number of deaths in 1913, when 23 fatal accidents occurred. Falls of roof and coal claimed 7 victims in 1913, the same number of deaths as in 1912; 6 deaths were due to haulage-way accidents, 4 to careless use of explosives, and 6 to miscellaneous causes. The death rate per thousand was 2.54 in 1913, and the number of tons mined for each life lost was 181,120.

The statistics of production in 1912 and 1913, by counties, with the distribution of the product for consumption, are shown in the following table:

Coal production of Oklahoma in 1912 and 1913. by counties, in short tons.

1912.

County.	Loaded at mines for shipment.	Sold to local trade and used by employees.	Used at mines for steam and heat.	Total quantity.	Total value.	Average price per ton.	Average number of days active.	Average number of employees.
Coal	766,099	13,611	36,445	816,155	$1,805,804	$2.21	222	1,929
Haskell and Latimer	711,596	3,269	51,933	766,798	1,550,562	2.02	152	1,753
Le Flore	138,333	4,445	7,733	150,511	238,360	1.58	163	256
Okmulgee	605,532	12,493	11,964	629,989	1,123,473	1.78	158	1,120
Pittsburg	1,143,969	13,109	77,256	1,234,334	2,992,830	2.42	165	3,524
Tulsa	22,184	17,710	70	39,964	75,934	1.90	179	75
Other counties [a]	28,245	2,511	....	30,756	63,061	2.05	178	128
Small mines	....	6,911	....	6,911	17,307	2.50	....	....
Total	3,415,958	74,059	185,401	3,675,418	7,867,331	2.14	174	8,785

1913.

County.	Loaded at mines for shipment.	Sold to local trade and used by employees.	Used at mines for steam and heat.	Total quantity.	Total value.	Average price per ton.	Average number of days active.	Average number of employees.
Coal	828,158	10,434	50,707	889,299	$1,948,204	$2.19	232	2,049
Haskell & Latimer	673,077	4,930	60,672	738,679	1,455,810	1.97	171	1,491
Le Flore	185,303	4,141	12,409	201,853	321,857	1.59	161	358
Okmulgee	803,655	1,225	15,779	820,659	1,419,919	1.73	208	1,361
Pittsburg	1,295,560	8,418	125,372	1,429,350	3,225,836	2.26	188	3,556
Tulsa	27,168	24,972	160	52,300	101,905	1.95	208	108
Other countries [b]	28,175	2,792	100	31,067	63,634	2.05	195	121
Small mines	....	2,563	....	2,563	5,583	2.18	....	....
Total	3,841,096	59,475	265,199	4,165,770	8,542,748	2.05	197	9,044

[a] Atoka, Rogers, and Wagoner. [b] Rogers and Wagoner.

The production of coal, by counties, during the last five years, with increase and decrease in 1913 as compared with 1912, is shown in the following table:

Coal production of Oklahoma in 1909–1913, by counties, in short tons.

County.	1909	1910	1911	1912	1913	Increase(+) or decrease (−), 1913.
Coal	658,159	498,658	778,546	816,155	889,299	+ 73,144
Haskell and Latimer	738,806	675,953	701,374	766,798	738,679	− 28,119
Le Flore	128,376	87,628	122,468	150,511	201,853	+ 51,342
Okmulgee	262,310	227,107	408,202	629,989	820,659	+ 190,670
Pittsburg	1,271,109	1,083,243	1,018,742	1,234,334	1,429,350	+ 195,016
Rogers and Wagoner	14,556	27,618	18,784	30,126	31,067	+ 941
Tulsa	39,834	40,007	21,422	39,964	52,300	+ 12,336
Small mines	6,227	6,012	[a] 4,704	[b] 7,541	2,563	− 4,978
Total	3,119,377	2,646,226	3,074,242	3,675,418	4,165,770	+ 490,352
Total value	$6,253,367	$5,867,947	$6,291,494	$7,867,331	$8,542,748	+$675,417

[a] Includes Atoka and Johnston counties. [b] Includes Atoka County.

The coal areas of Oklahoma belong to the western interior coal field. They lie entirely in the eastern and northeastern part of the State, forming the connection between the Kansas fields on the north and the Arkansas fields on the east. The principal developments are in the southern portion of the field in what was formerly the Choctaw Nation of the Indian Territory and is now included within the counties of Coal, Haskell, Latimer, and Pittsburg. The total area underlain by workable coal is estimated at about 10,000 square miles. The coals, of which there are 10 or more beds, range from a medium-grade to a high-grade bituminous, some of the latter approaching semianthracite. Coking qualities are present in some of the higher grades, but efforts to make coke in the several hundred beehive ovens constructed for that purpose have not been conspicuously successful. Transportation and a considerable portion of the markets for the coals of Oklahoma are furnished by the Missouri, Kansas & Texas, the St. Louis & San Francisco, the Kansas City Southern, and the Rock Island Railway systems.

The Tenth United States Census (1880) contains the first published record of coal production in Oklahoma (Indian Territory), although as a small quantity of coal was mined in Arkansas as early as 1840, it is probable that some was produced in the Territory earlier than 1880. The maximum production (4,165,770 short tons) was mined in 1913, although, as shown in the following table, the industry during the last 10 years has been practically stationary, and has not shown the development and progress exhibited in other States:

Production of coal in Oklahoma from 1880 to 1913, in short tons.

Year.	Quantity.	Year.	Quantity.	Year.	Quantity.	Year.	Quantity.
1880	120,947	1889	752,832	1898	1,381,466	1907	3,642,658
1881	150,000	1890	869,229	1899	1,537,427	1908	2,948,116
1882	200,000	1891	1,091,032	1900	1,922,298	1909	3,119,377
1883	350,000	1892	1,192,721	1901	2,421,781	1910	2,646,226
1884	425,000	1893	1,252,110	1902	2,820,666	1911	3,074,242
1885	500,000	1894	969,606	1903	3,517,388	1912	3,675,418
1886	534,580	1895	1,211,185	1904	3,046,539	1913	4,165,770
1887	685,911	1896	1,366,646	1905	2,924,427		
1888	761,986	1897	1,336,380	1906	2,860,200	Total..	59,474,164

OREGON.

Total production in 1913, 46,063 short tons; spot value, $116,724.

The only productive coal field in Oregon is situated in the southwestern part of the State, in Coos County, and is known as the Coos Bay field, from the fact that it entirely surrounds that body of water. It occupies a total area of about 230 square miles, its length north and south being about 30 miles and its maximum breadth at the middle about 11 miles, tapering regularly toward both ends. Other coal fields have been prospected in different parts of the State. Among them are the upper Nehalem field, in Columbia County; the lower Nehalem, in Clatsop and Tillamook counties; the Yaquima field, in Lincoln County; the Eckley and Shasta Costa fields, in Curry County; the Eden field, in Coos County, and the Rogue River Valley field, in Jackson County. All of these fields lie west of the Cascade Range, but none has been developed to the point of production. Another field has been located in the basin of John Day River, east of the Cascade Range, but little is known concerning it. All of the fields west of the range, with the exception of the Coos Bay, are of small area, the largest, outside of the Coos Bay, being the upper Nehalem, which has an area of less than 20 square miles. All of the coal of these fields is lignitic in character, except the best coals of Coos Bay, which are properly regarded as subbituminous. Transportation is confined exclusively to Coos Bay and the Pacific Ocean, and San Francisco is the principal market.

The production of coal in Oregon has never been one of the important industries of the State, and has been of less importance during the last few years than formerly because of the large increase in the production of petroleum in California and in its use for fuel. Before the advent of the liquid fuel considerable quantities of Oregon coal were shipped to San Francisco, where it served to some extent as a moderator of prices, particularly for domestic fuel. In only four years, however, has the production exceeded 100,000 tons, and in each of the last three years it has been below 50,000 tons. The production in 1913 of 46,063 tons was an increase of 4,426 tons over 1912, but a little less than the output of 1911.

The statistics of production in Oregon, with the distribution of the product for consumption during the last five years, are shown in the following table:

Distribution of coal production of Oregon, 1909–1913, in short tons.

Year.	Loaded at mines for shipment.	Sold to local trade and used by employees.	Used at mines for steam and heat.	Total quantity.	Total value.	Average price per ton.	Average number of days active.	Average number of employees.
1909	44,236	25,700	17,340	87,276	$235,085	$2.69	....	235
1910	40,497	13,583	13,453	67,533	235,229	3.48	257	153
1911	22,407	10,216	14,038	46,661	108,033	2.32	179	189
1912	14,361	19,646	7,630	41,637	108,276	2.60	239	222
1913	31,582	8,617	5,864	46,063	116,724	2.53	283	203

Coal was first noted in the Coos Bay region about 60 years ago, Prof. J. S. Newberry having reported in 1855 that the coal deposits of Coos Bay had begun to attract attention.

The first cargo was shipped from the Empire Basin, but the discovery of coal near the head of Coos Bay soon transferred the point of production to Newport, which remained the principal mine until within the last decade, since the Beaver Hill mine has been more successfully managed and become the chief producer. The first record of coal production is contained in the census report of 1880, when 43,205 short tons were mined.

The total production of coal in Oregon to the close of 1913 has amounted to 2,165,821 short tons, as shown in the following table:

Production of coal in Oregon, 1880–1913, in short tons.

Year.	Quantity.	Year.	Quantity.	Year.	Quantity.	Year.	Quantity.
1880	43,205	1889	64,359	1898	58,184	1907	70,981
1881	33,600	1890	61,514	1899	86,888	1908	86,259
1882	35,000	1891	51,826	1900	58,864	1909	87,276
1883	40,000	1892	34,661	1901	69,011	1910	67,533
1884	45,000	1893	41,683	1902	65,648	1911	46,661
1885	50,000	1894	47,521	1903	91,144	1912	41,637
1886	45,000	1895	73,685	1904	111,540	1913	46,063
1887	37,696	1896	101,721	1905	109,641		
1888	75,000	1897	107,289	1906	79,731	Total.	2,165,821

PENNSYLVANIA.

Total production in 1913, 265,306,139 short tons; spot value, $388,220,933.

Anthracite.—Total production in 1913, 81,718,680 long tons (equivalent to 91,524,922 short tons); spot value, $195,181,127.

Bituminous.—Total production in 1913, 173,781,217 short tons; spot value, $193,039,806.

In the production of both anthracite and bituminous coal in 1913 Pennsylvania exceeded all previous records, the combined production of 265,306,139 short tons being larger than that of 1912, the year of previous maximum production, by 19,079,053 short tons, or 7.7 per cent. The percentage of increase was nearly the same for both bituminous coal and anthracite, the former showing an increase of 11,915,729 short tons, or 7.4 per cent, and the latter a gain of 6,395,825 long tons (equivalent to 7,163,324 short tons), or 8.5 per cent. Prices for bituminous coal showed larger advances, however, than those for anthracite, and the gain in value for the bituminous product was $23,669,309, or 14 per cent, whereas the value of anthracite increased $17,558,501, or 9.9 per cent. The combined value of $388,220,933 exceeded that of 1912 by $41,227,810, or 11.9 per cent. It will be observed that in proportion to the output the value of anthracite greatly exceeds that of bituminous coal. In 1913 the prices for bituminous coal in Pennsylvania were unusually high, and yet, although the production of bituminous coal was more than twice as much as anthracite, the value of the latter exceeded the value of the bituminous product by more than $2,000,000.

The magnitude of the coal-mining industry in Pennsylvania, as represented by the output of the anthracite and bituminous mines, is little realized. The combined production of 265,306,139 short tons in 1913 exceeded by more than 20 per cent the total production of the United States in 1898, 15 years before, and was more than two and one-half times the country's total production in 1882, the year for which the first volume of the series, "Mineral Resources of the United States," was published. Pennsylvania's production of coal, anthracite and bituminous combined, exceeds that of any other country in the world, except Great Britain and Germany, and approaches within less than 10 per cent of the latter. In 1913 it was nearly five times the production of the Austro-Hungarian Empire (next to Germany in coal-producing importance), nearly six times that of France, nine times that of Russia and Finland, and ten times that of Belgium. It is equal to nearly 20 per cent of the world's total production, and exceeds the combined output of all the countries of the world, leaving out Great Britain, Germany, and the United States. The combined value of the anthracite and bituminous coal produced in Pennsylvania in 1913 was more than 15 per cent of the value of the total mineral production of the United States in that year and was equal to 87 per cent of the total mineral production in 1893. From 1829 to and including the first year of the present century Pennsylvania contributed over 50 per cent of the total coal production of the United States and still produces between 45 and 50 per cent of the total, but the relative importance of Pennsylvania as a coal producer has steadily declined in recent years. Whereas in 1880 Pennsylvania produced 66 per cent of the total, in 1890 its percentage was 56; in 1900 it was 51; in 1910 it was 46.9; in 1911 it was 47.4; in 1912 it was 46.1; and in 1913 it was 46.6. The smaller percentage in the later years as compared with the earlier must not be taken as an indication of any decline in the coal-mining industry of Pennsylvania, for that industry has, particularly in the bituminous districts, kept pace with the manufacturing industries and has increased in considerably larger ratio than the population of the State and of the United States as a whole. The falling off in the relative importance of Pennsylvania has been due to the more rapid increase in the production of other States—notably West Virginia, Illinois, Alabama, and the Rocky Mountain States.

The following table shows the total production of the United States and of Pennsylvania since 1880, with the percentage of the total tonnage produced by Pennsylvania in each year:

Production of Pennsylvania coal compared with total production of the United States, 1880–1913, in short tons.

Year.	Total United States.	Pennsylvania.	Percentage of Pennsylvania to total.	Year.	Total United States.	Pennsylvania.	Percentage of Pennsylvania to total.
1880	71,481,570	47,074,975	66	1897	200,223,665	107,029,654	53
1881	85,881,030	54,320,018	63	1898	219,976,267	118,547,777	54
1882	103,285,789	57,254,507	55	1899	253,741,192	134,568,180	53
1883	115,212,125	62,488,190	54	1900	269,684,027	137,210,241	51
1884	119,735,051	62,404,488	52	1901	293,299,816	149,777,613	51
1885	110,957,522	62,137,271	56	1902	301,590,439	139,947,962	46
1886	112,743,403	62,857,210	56	1903	357,356,416	177,724,246	49.7
1887	129,975,557	70,372,857	54	1904	351,816,398	171,094,996	49
1888	148,659,402	77,719,624	52	1905	392,722,635	196,073,487	49.9
1889	141,229,514	81,719,059	58	1906	414,157,278	200,575,617	48.4
1890	157,770,963	88,770,814	56	1907	480,363,424	235,747,489	49.1
1891	168,566,668	93,453,921	55	1908	415,842,698	200,448,281	48.2
1892	179,329,071	99,167,080	55	1909	460,814,616	219,037,150	47.5
1893	182,352,774	98,038,267	54	1910	501,596,378	235,006,762	46.9
1894	170,741,526	91,833,584	54	1911	496,371,126	235,025,324	47.4
1895	193,117,530	108,216,565	56	1912	534,466,580	246,227,086	46.1
1896	191,986,357	103,903,534	54	1913	570,048,125	265,306,139	46.6

There was a decided gain in 1913 in the number of working days made by the employees in both the anthracite and the bituminous mines, the former making an average of 257 days, as compared with 231 days in 1912, and the latter, 267 days, as compared with 252 days in 1912. The anthracite mines gave employment to 175,745 men and the bituminous mines to 172,196 men. The unusually large number of working days enabled the employees to make exceptionally high records in the number of tons produced per man for the year, but, as is frequently the case when more opportunity is given for working a larger number of days, the average daily production per man was less. The bituminous workers established a new record for tonnage per employee, with an average of 1,009 tons each. The anthracite workers averaged 465 long tons (or 520 short tons). The average daily tonnage per man in the bituminous fields was 3.78 in 1913, against 3.89 in 1912 and 3.69 in 1911. The average daily tonnage per man in the anthracite region has decreased steadily since 1910 from 2.17 short tons in that year to 2.13 tons in 1911, to 2.10 tons in 1912, and to 2.02 tons in 1913.

It is pretty generally conceded by those interested in the production of anthracite that the limit of annual production has about been reached and that the yearly output will remain fairly constant until the period of decline begins. Some have expressed the opinion that the yearly production will exceed 100,000,000 tons before the limit is reached, but the opinion is not shared by many. Anthracite as a manufacturing fuel has been eliminated, and the increasing use of coke and gas (particularly the latter) for domestic purposes in the territory supplied by anthracite coal is keeping approximately in step with the increase in population. In the larger cities the tendency toward apartment-house residence is growing rapidly, as compared with the individual homes; and as the former are largely heated by steam raised by bituminous coal, and furnished with gas ranges for cooking, it can not be seen where the expanding markets for anthracite are to be obtained.

The following table shows the average production of Pennsylvania anthracite and of bituminous coal in the United States, by five-year periods, from 1876 to 1910, and for the three years, 1911–1913, with the percentage that each bears to the total. It will be observed from this table that the average annual production of anthracite during the last five years of this period (1906 to 1910) was 3.1 times the average yearly production from 1876 to 1880. The average annual bituminous production in the five years from 1906 to 1910 was 10.4 times that of the first five years. The percentage of anthracite production to the total has decreased steadily from 41.44 per cent in the five years from 1876 to 1880 to 16.6 per cent in the three years from 1811 to 1913. On the other hand, the percentage of bituminous production to the total has increased from 58.56 in the period from 1876 to 1880 to 83.4 in the three years from 1911 to 1913.

Production of anthracite and bituminous coal since 1876, by averages of five-year periods, in short tons.

Period.	Anthracite.		Bituminous.	
	Quantity.	Percentage of total.	Quantity.	Percentage of total.
1876–1880	25,800,169	41.44	36,460,776	58.56
1881–1885	36,198,188	33.74	71,092,930	66.26
1886–1890	43,951,763	31.76	94,446,451	68.24
1891–1895	53,405,187	29.87	125,416,327	70.13
1896–1900	55,625,265	24.49	171,498,143	75.51
1901–1905	66,853,778	19.70	272,503,363	80.30
1906–1910	81,142,214	17.85	373,412,644	82.15
1911–1913	88,783,529	16.6	444,845,081	83.4

It is interesting to note how the production of anthracite and of bituminous coal has increased in comparison with the growth in population. This is shown in the following table. It will be observed that from 1880 to 1913 the per capita production of anthracite has increased from 0.57 ton to 0.94 ton, while that of bituminous coal has increased from 0.85 ton to 4.93 tons.

Production of anthracite and bituminous coal per capita of population, 1880–1913, in short tons.

Year.	Population.	Production of anthracite.		Production of bituminous.	
		Quantity.	Per capita.	Quantity.	Per capita.
1880	50,189,209	28,649,812	0.57	42,831,758	0.85
1890	63,069,756	46,468,641	.74	111,302,322	.76
1900	76,303,387	57,367,915	.75	212,316,112	2.78
1910	91,972,266	84,485,236	.92	417,111,142	4.54
1911	[a] 93,927,342	90,464,067	.96	405,907,059	4.32
1912	[a] 95,545,336	84,361,598	.88	450,104,982	4.71
1913	[a] 97,163,330	91,524,922	.94	478,523,203	4.93

[a] Estimated by Bureau of the Census.

Anthracite mining began between 1790 and 1800, when a small quantity was produced for local consumption. The first shipment was made from the Wyoming region in 1807, when 55 tons were sent from Plymouth to Columbia. Between then and 1820, when the first shipments were sent out from the Lehigh region, it is estimated that approximately 10,000 long tons were produced. To the close of 1913 the total production of anthracite had amounted to 2,184,550,009 long tons, or 2,446,696,010 short tons.

The first records of bituminous-coal production in Pennsylvania cover the year 1840, when 464,826 short tons were mined. The total output of bituminous coal from 1840 to the close of 1913 has amounted to 2,731,945,059 short tons, from which it appears that the total production of bituminous coal in Pennsylvania has exceeded that of anthracite by something over 285,000,000 short tons.

PENNSYLVANIA ANTHRACITE.

The production of anthracite in Pennsylvania in 1913 exceeded the best previous output by nearly a million tons, and established a new record for the region. Including the coal recovered from old culm banks by washeries and a small quantity dredged from Susquehanna River, the production of anthracite in 1913 amounted to 81,718,680 long tons, valued at $195,181,127. In 1912, when mining opeartions were suspended from April 1 until the latter part of May, pending the adjustment of the wage scale, the production was 75,322,855 long tons, valued at $177,622,626, compared with which the record for 1913 shows an increase of 6,395,825 long tons, or 8.5 per cent, in quantity, and of $17,558,501, or 9.9 per cent in value. Prior to 1913 the maximum production was that made in 1911—80,771,488 long tons, valued at $174,952,415. That was exceeded in 1913 by 947,192 long tons in quantity and by $20,228,712 in value. When, about June 1, 1912, mining operations were resumed, it was under an agreement which reextended, with some modifications, the awards of the Anthracite Coal Strike Commission, which had been in force through renewals by mutual consent since the expiration of the original awards, March 31, 1906. In consequence of the miners and operators again extending the terms of the awards, this time for a period of four years, there were no serious interruptions to coal-mining operations by labor troubles in 1913, and industrial peace is assured in the anthracite region until 1916. No exceptional influences affected the anthracite trade in 1913, the somewhat unusual gain in tonnage over 1912 being the natural result of the reduced output in that year; nor was any difficulty experienced in transportation, the mild winter of 1912–13 and the favorable weather in November and December, 1913, being all that could be asked, although they may not have created a demand such as the coal dealers and producers desire. As the use of anthracite as a manufacturing fuel has been eliminated, it is not affected to the same extent as bituminous coal by trade conditions, the principal influence being the temperature during the winter months. The increase in the use of artificial gas and of coke for domestic purposes will probably keep pace with the increase of population in the markets supplied by anthracite, and there is little probability that the production of anthracite will show any marked increase in the future.

Changes in temperature and labor conditions will continue to be the most important factors affecting the production of anthracite.

The most notable feature of the anthracite trade in 1913 was the decreased tonnage recovered by washeries from the old culm banks, that item in 1913 being less than in 1912 by more than a million tons, or about one-third. To this fact is due in part, at least, the advance of 3 cents in the average value per ton from $2.36 in 1912 to $2.39 in 1913. The major part of the washery product consists of pea, buckwheat, rice, and barley, and all of it sells at much lower prices than coal fresh from the mine and breaker. Since the first washery was constructed, in 1890, the total recovery for shipment of usable fuel from the waste heaps or culm banks has amounted to 49,329,376 long tons, and the decline in their productivity is not difficult to understand. These figures represent shipments only. They do not include the washery product sold locally or used at the collieries, of which no record is made. The maximum washery production was made in 1907, when 4,301,082 tons were recovered for shipment. It has shown a decreasing tendency since that date, falling in six years to less than one-half the maximum of 1907. In discussing the washery product it should be remembered that only that coal recovered from the culm banks is considered. "Washery" product does not include any freshly mined coal that passes through a washery operated in connection with the breakers. The decrease in washery output is reflected in a decrease in the percentage of small sizes in 1913, as compared with any of the eight preceding years, although in quantity the small sizes in 1913 exceeded that of 1912 by about 1,700,000 tons.

The total shipments [1] from the anthracite region, reported to the United States Geological Survey for 1913 were 71,295,716 long tons, of which 43,934,919 tons, or 61.6 per cent, consisted of the prepared or domestic sizes, and 27,360,797 tons, or 38.4 per cent, consisted of pea, buckwheat, rice, barley, and screenings. In the last few years pea coal has become an important factor in the domestic trade, particularly for household furnaces, and probably should be included among the prepared sizes. It is no longer sold below the cost of production as are the smaller sizes with which it has been customary to include it. The circular price per long ton for pea coal at the mines in 1912 and 1913 was $2.50; buckwheat was quoted at $1.50 a ton. The average price per ton for rice in 1913 was 65.4 cents, and for barley 40.2 cents.

Of the total production of 81,718,680 long tons in 1913, 71,343,172 tons, or 87.3 per cent, were loaded at the mines for shipment to distant points, 1,793,814 tons, or 2.2 per cent, were sold to local trade or used by employes, and 8,581,694 tons, or 10.5 per cent, were consumed in the generation of heat and power at the collieries. Prior to 1907, the quantity of coal consumed at the collieries was included in the production, but no value was placed upon it. In 1907 and 1908 an arbitrary value of 20 cents a ton was given this factor. Since and including 1909 the colliery consumption has been assumed to have the same value as similar coal placed upon the market. When it is apparent from the schedules returned to the Survey that the values reported include only the coal sold, the colliery consumption has been valued at 50 cents a ton. In the earlier days of anthracite

[1] Only shipments of anthracite are reported by sizes. Coal sold to local trade and the colliery consumption are not so reported.

mining the colliery consumption consisted of a portion of the product which otherwise would have gone to the culm banks. Nowadays there is a market for almost any grade of anthracite that will burn. No more coal goes to the culm banks except for temporary storage and subsequent recovery by washeries. The old culm banks themselves are contributing their share to the total production, and these unsightly monuments to former waste are rapidly disappearing. Even the waste from the culm-bank washeries is being made to serve a useful purpose, as it is flushed into the mines and partly fills old workings, where it cements together and furnishes supports to the roof when the coal previously left for pillars is removed. This utilization of the waste prevents, too, the injury to farm lands in the valleys, a serious cause of complaint among the farmers when, as in earlier days, the waste from the washeries was spread over their lands in flood seasons.

Another record in addition to that of tonnage and value was established in the anthracite region in 1913. The average working time, 257 days, exceeded anything in the history of the region, the nearest approach to this record being in 1911, when an average of 246 working days was made. In 1912, despite the seven-weeks' shut-down, the men averaged 231 working days during the year. The average number of men employed in the anthracite mines in 1913 was 175,745, against 174,030 men in 1912. The larger number of days worked in 1913 resulted in a larger average tonnage per man for the year, but the average daily production by each employee was less. In 1912 the average output per man for the year was 434 long tons; in 1913 it was 466 tons. The average daily tonnage per man has decreased steadily since 1910 from 1.94 in that year to 1.9 in 1911, 1.88 in 1912, and 1.81 in 1913.

Reports to the Bureau of Mines show that there were 618 fatal accidents in the anthracite mines in 1913, the principal contributing causes and the number of deaths from them being falls of roof and coal, 257; mine cars and locomotives, 85 underground and 35 on the surface; gas explosions, 50; explosions of powder, etc., 75; falls in shafts, 30. The death rate per 1,000 employees was 3.52, and the coal mined for each life lost was 132,231 tons. In 1912 the death rate was 3.4, and the quantity of coal mined for each fatality was 128,977 tons.

The statistics of anthracite production during the last six years are presented in the following table:

Statistics of anthracite production, 1908–1913.

Year.	Quantity (long tons).	Value.	Average price per ton.	Average number of men employed.	Average number of days worked.
1908	74,347,102	$158,178,849	$2.13	174,174	200
1909	72,384,249	149,181,587	2.06	{[a]171,195 [b]166,801}	205
1910	75,433,246	160,275,302	2.12	169,497	229
1911	80,771,488	174,852,415	2.17	172,585	246
1912	75,322,855	177,622,626	2.36	174,030	231
1913	81,718,680	195,181,127	2.39	175,745	257

[a] State mining department figures. [b] U. S. Census figures.

The production, by counties, in 1912 and 1913, with the distribution of the product for consumption, is shown in the following table:

Anthracite production in 1912 and 1913, by counties, in long tons.

1912.

County.	Shipped.	Sold to local trade and employees.	Used at mines for steam and heat.	Total.
Carbon	2,163,896	118,852	285,557	2,568,305
Columbia	936,704	15,684	127,478	1,079,866
Dauphin	625,570	21,594	196,677	843,841
Lackawanna	16,901,030	644,797	1,737,987	19,283,814
Luzerne	24,645,483	822,840	2,821,556	28,289,879
Northumberland	5,238,591	116,320	665,529	6,020,440
Schuylkill	13,676,628	299,802	2,062,077	16,038,507
Sullivan	534,004	7,597	38,072	579,673
Susquehanna and Wayne	479,347	9,594	43,867	532,808
River dredges	28,002	56,824	896	85,722
Total	65,229,255	2,113,904	7,979,696	75,322,855

1913.

County.	Shipped.	Sold to local trade and employees.	Used at mines for steam and heat.	Total.
Carbon	2,600,127	111,227	354,960	3,066,314
Columbia	922,532	16,136	139,813	1,078,481
Dauphin	712,349	20,048	214,273	946,670
Lackawanna	18,022,318	450,949	1,767,223	20,240,490
Luzerne	27,713,933	731,667	3,093,779	31,539,379
Northumberland	5,447,529	116,290	697,683	6,261,502
Schuylkill	14,859,215	252,526	2,216,925	17,328,666
Sullivan	537,404	7,509	48,000	592,913
Susquehanna and Wayne	480,309	7,865	42,105	530,279
River dredges	47,456	79,597	6,933	133,986
Total	71,343,172	1,793,814	8,581,694	81,718,680

The circular prices of anthracite at the mines during the last four years, according to sizes, are shown in the following table. These prices are common for the entire region, except for rice and barley, which are not included in the circular. Prices quoted for these sizes are the average, as reported by the Philadelphia & Reading Coal & Iron Co. on actual sales:

Circular prices for anthracite at the mines, 1910–1913, per long ton.

Size.	1910	1911	1912	1913
Lump	$3.50	$3.50	$3.50	$3.50
Steamboat	3.00	3.00	3.00	3.00
Broken (furnace)	[a] 3.50	[a] 3.50	[b] 3.50	3.50
Egg	[a] 3.75	[a] 3.75	[b] 3.75	3.75
Stove	[a] 3.75	[a] 3.75	[b] 4.00	4.00
Chestnut	[a] 3.75	[a] 4.00	[b] 4.15	4.15
Pea	2.00	2.00	2.50	2.50
Buckwheat	1.50	1.50	1.50	1.50
Rice		[c] .538	[c] .634	.654
Barley		[c] .339	[c] .388	.402

[a] Subject to 50 cents reduction in April, 40 cents in May, 30 cents in June, 20 cents in July, and 10 cents in August.
[b] Discounts omitted in April and May, but resumed in June.
[c] Average price received for all coal of these sizes sold by Philadelphia & Reading Coal & Iron Co.

Circular prices of anthracite at New York Harbor ports and at Port Richmond (Philadelphia) in 1912 and 1913 were as follows:

Circular prices for free-burning, white-ash anthracite f. o. b. New York Harbor ports and Port Richmond in 1912 and 1913, per long ton.

Size.	New York Harbor.		Port Richmond.	
	1912	1913	1912	1913
Broken [a]	$5.00	$5.00	$4.75	$4.75
Egg [a]	5.25	5.25	5.00	5.00
Stove [a]	5.25	5.25	5.00	5.00
Chestnut [a]	5.50	5.50	5.25	5.25
Pea	[b] 3.35	3.35	3.197	3.284
No. 1, buckwheat	2.45	2.45	2.296	2.25
No. 2, buckwheat	[c] 1.95	1.94	1.815	1.85
No. 3, buckwheat	[c] 1.548	1.62	1.50	1.45

[a] Philadelphia & Reading Coal & Iron Co. circular.
[b] Lehigh Coal & Navigation Co. quotations.
[c] Average prices f. o. b.

Since 1901 it has been customary to allow discounts from the circular prices during the spring in order to induce consumers to buy their supplies for the following winter during the summer months, when ordinary demand is light and when operations and transportation are not liable to interruption by inclement weather. The wisdom of this policy has been clearly evinced by the marked increase in the number of working days the employees have been able to make and in the uniform distribution of the shipments throughout the 12 months of the year. The effect upon the working time is exhibited by the fact that in the 10 years from 1892 to 1901 the mean average time worked in the anthracite regions was 179 days, with a range from 150 days in 1897 to 198 days in 1892. The year of the great anthracite strike, 1902, is excluded from the comparison, as in that year conditions were abnormal and only 116 days were made. Since 1902 the average number of working days has fallen below 200 in only one year, 1906, when there was a long suspension following the termination of the Anthracite Strike Commission's awards and pending their renewal. From this minimum of 195 days in 1906 the average has ranged as high as 257, in 1913, with a mean average for the 10 years of 220 days. The average working time in the later period exceeds that of the earlier by 23 per cent. Wage rates have been advanced 21 per cent (10 per cent in 1902 and 10 per cent more in 1912), from which it may be computed that the average yearly earnings in 1913 were nearly 45 per cent more than before the spring reductions went into effect and before the strike of 1902 resulted in the first 10 per cent advance in wages. In 1913 the railroad shipments reported to the Bureau of Anthracite Coal Statistics amounted to 69,069,628 long tons, of which 34,707,619 tons, or 50.3 per cent, were sent out during the winter months and 34,362,009 tons, or 49.7 per cent, in the summer months, the difference between the winter and summer shipments being less than 350,000 tons in a total exceeding 69,000,000. This statement shows that employment in the anthracite region is evenly distributed throughout the year, and when this is considered, with the increase in wages already referred to, it makes no straining stretch of credulity to believe the claim that in no time in its history has the anthracite region of Pennsylvania enjoyed such a period of peace and prosperity as that of the last 10 years.

The following table shows the shipments, by months, during the last five years, as reported by the Bureau of Anthracite Coal Statistics. The table does not include the shipments from Sullivan County nor the shipments of coal recovered from Susquehanna River:

Monthly shipments of anthracite, 1909–1913, in long tons.

Months.	1909	1910	1911	1912	1913
January	5,183,345	5,306,618	5,904,117	5,763,696	6,336,419
February	4,576,004	5,031,784	5,070,948	5,875,968	5,674,169
March	6,332,474	5,174,166	5,996,894	6,569,687	4,909,288
April	5,891,176	6,224,396	5,804,915	266,625	5,966,189
May	5,063,873	5,679,661	6,317,352	1,429,357	5,995,742
June	4,904,858	5,398,123	6,215,357	6,191,646	5,970,047
July	4,020,765	4,202,059	4,804,065	6,285,153	5,487,852
August	4,198,273	4,996,044	5,531,796	6,576,591	5,369,900
September	4,116,120	4,967,516	5,730,935	5,876,496	5,572,279
October	5,579,759	5,622,095	6,269,179	6,665,321	6,338,194
November	6,027,800	6,071,746	6,193,314	6,165,536	5,786,931
December	5,775,438	6,231,578	6,115,427	5,944,502	5,662,618
Total	61,969,885	64,905,786	69,954,299	63,610,578	69,069,628

In the report for 1912 it was stated that the disproportionate increase in the quantities of small sizes sent to market had come to an end, and the returns for 1913 bear out this assertion. The larger increase in the production of small sizes had been due to two causes: (1) The elimination of anthracite as a blast-furnace and steamer fuel, and (2) the working over of the old culm banks by washeries; the former necessitated the breaking down of lump coal, with the consequent quantity of smalls from such treatment, and much the larger part of the washery coal was below the size of nut coal. There is no further increase due to the breaking down of the larger coal, as it is now plactically all broken and sized, and the gradual disappearance of the crum banks as a source of coal is shown by the reduction in 1913 as compared with 1912 of nearly one-third in the washery product.

The probability is that the proportions of prepared and small sizes will remain fairly steady. From 1890 to 1907 there was a marked increase in the output of steam sizes compared with the production of the prepared or domestic sizes, as shown by the fact that in the earlier years the shipments of anthracite represented by the sizes above pea coal were 76.9 per cent of the total and that 23.1 per cent was made up of pea coal and smaller. In 1907 the percentage of the sizes above pea coal had fallen to 58.6, and that of pea coal and smaller had increased to 41.4 per cent. The smallest percentage in the shipments of domestic sizes was in 1909, when these constituted 58.1 per cent of the total, while the steam sizes represented 41.9 per cent. Since 1909 the proportion of the shipments made up from pea coal and smaller has grown steadily less. Inclusive of washery output the percentages of steam sizes in 1911, 1912, and 1913 were respectively 40.8, 39.4, and 38.4, the proportions of domestic sizes increasing correspondingly. Exclusive of washery coal the percentages of shipments of small sizes during the last three years were 38 in 1911, 36.5 in 1912, and 36.7 in 1913. Owing to the suspension in the spring of 1912, the washery shipments showed a relative gain, though the quantity shipped was a little less than in 1911.

The first washery was installed in 1890, and 41,600 long tons of coal thus recovered were shipped in that year. In 1907 this recovery had increased to 4,301,082 tons. From this maximum the percentage of washery product has declined each year and in 1913 was less than half that of 1907. About the time that washeries were introduced to recover this small coal from the culm banks they were also installed at the breakers, with the result that the small sizes, instead of being thrown upon the culm banks, were added to the daily production. In the following table the shipments (not production) of anthracite are given for 1890, 1900, 1911, 1912, and 1913, exclusive of the washery product obtained from the old culm banks:

Shipments of anthracite, excluding washery and dredge product, by sizes, 1890, 1900, 1911, 1912, and 1913, in long tons.

Year.	Sizes above pea.		Pea and smaller.		Total shipments.
	Quantity.	Percentage.	Quantity.	Percentage.	
1890	28,154,678	76.98	8,419,181	23.02	36,573,859
1900	29,162,459	69.4	12,885,676	30.6	42,048,135
1911	41,667,415	62.0	25,585,104	38.0	67,252,519
1912	39,438,732	63.6	22,607,371	36.4	62,046,103
1913	43,781,936	63.3	25,423,610	36.7	69,205,546

In the following table are given the shipments, including the washery product, since 1890, the statement showing the growth in the proportion of small sizes up to 1909 and then the gradual falling off:

Shipments of anthracite, according to sizes, 1890–1913, in long tons.

Year.	Sizes above pea.		Pea and smaller.		Total shipments.
	Quantity.	Percentage.	Quantity.	Percentage.	
1890	28,154,678	76.9	8,460,781	23.1	36,615,459
1891	30,604,566	75.7	9,843,770	24.3	40,448,336
1892	31,868,278	76.0	10,025,042	24.0	41,893,320
1893	32,294,233	74.9	10,795,304	25.1	43,089,537
1894	30,482,203	73.7	10,908,997	26.3	41,391,200
1895	32,469,367	69.9	14,042,110	30.1	46,511,477
1896	30,354,797	70.3	12,822,688	29.7	43,177,485
1897	28,510,370	68.5	13,127,494	31.5	41,637,864
1898	28,198,532	67.3	13,701,219	32.7	41,899,751
1899	31,506,700	66.1	16,158,504	33.9	47,665,204
1900	29,162,459	64.7	15,945,025	35.3	45,107,484
1901	34,412,974	64.2	19,155,627	35.8	53,568,601
1902	19,025,632	61.0	12,175,258	39.0	31,200,890
1903	37,738,510	63.6	21,624,321	36.4	59,362,831
1904	35,636,661	62.0	21,855,861	38.0	57,492,522
1905	37,425,217	60.9	23,984,984	39.1	61,410,201
1906	32,894,124	59.1	22,804,471	40.9	55,698,595
1907	39,332,855	58.6	27,776,538	41.4	67,109,393
1908	38,319,325	59.3	26,345,689	40.7	64,665,014
1909	36,437,762	58.1	[a] 26,250,597	41.9	[a] 62,688,359
1910	38,415,323	58.5	[a] 27,297,438	41.5	[a] 65,712,761
1911	41,728,071	59.2	[a] 28,696,126	40.8	[a] 70,424,197
1912	39,538,583	60.6	[a] 25,662,670	39.4	[a] 65,201,253
1913	[a] 43,934,919	61.6	[a] 27,360,797	38.4	[a] 71,295,716

[a] Exclusive of coal recovered by river dredges.

To present statistically the comments made on size division and washery production, the following table, showing washery production since 1890, is given:

Shipments of anthracite from washeries and total shipments, 1890–1913, in long tons.

Year.	Shipments from washeries.	Total shipments.	Percentage of washery output to total shipments.
1890	41,600	36,615,459	0.11
1891	85,702	40,448,336	.21
1892	90,495	41,893,320	.22
1893	245,175	43,089,537	.57
1894	634,116	41,391,200	1.53
1895	1,080,800	46,511,477	2.52
1896	895,042	43,177,485	2.07
1897	993,603	41,637,864	2.39
1898	1,099,019	41,899,751	2.62
1899	1,368,275	47,665,204	2.87
1900	2,059,349	45,107,484	4.57
1901	2,567,335	53,568,601	4.79
1902	1,959,466	31,200,890	6.28
1903	3,563,269	59,362,831	6.00
1904	2,800,466	57,492,522	4.87
1905	2,644,045	61,410,201	4.31
1906	3,846,501	55,698,595	6.91
1907	4,301,082	67,109,393	6.41
1908	3,646,250	64,665,014	5.64
1909	3,694,470	62,688,359	5.26
1910	3,296,318	65,712,761	5.02
1911	3,171,678	70,424,197	4.50
1912	3,155,150	65,201,253	4.84
1913	2,090,170	71,295,716	2.93

The figures showing the washery product are not absolutely exact, for the reason that a few washeries are operated at the mines, the small sizes of the freshly mined coal being washed to remove the slate, and no separate report of the coal so washed is made by the mining companies. "Washery coal" as here reported is for the most part that which is recovered from the old culm banks.

The following table shows the quantities of the different sizes of freshly mined coal and of washery coal shipped in 1912 and 1913:

Shipments, by sizes, from mines and washeries in 1912 and 1913, in long tons.

Size.	1912		1913	
	From mines.	From washeries.	From mines.	From washeries.
Lump and steamboat	418,601		362,084	630
Broken	3,754,567		3,501,211	2,284
Egg	8,932,305	2,759	8,957,166	20,941
Stove	11,825,975	3,425	13,900,576	21,210
Chestnut	14,507,284	93,667	17,060,899	107,918
Pea	6,999,919	206,272	8,056,919	151,762
Buckwheat:				
No. 1	8,115,124	582,460	9,135,587	368,574
No. 2 and rice	3,903,276	772,426	5,081,314	552,723
No. 3 and barley	3,234,598	1,483,914	2,836,147	852,410
Screenings	354,454	10,227	313,643	11,718
Total	62,046,103	3,155,150	69,205,546	2,090,170

As shown in the preceding table, the stove and chestnut sizes are in the greatest demand and make up over 40 per cent of the total shipments. They are essentially domestic sizes, and the relatively large proportion they make of the shipments serves as an index to the conditions governing the anthracite trade. Egg coal finds its way principally to the furnaces of residences, and pea coal is used in the same way to some extent, though it is also used for kitchen ranges, and some of it goes with the buckwheat, rice, and barley for use as steam coal. The small sizes come directly into competition with bituminous and sometimes are used mixed with bituminous coal for steam purposes, chiefly in hotels, apartment houses, and office buildings. If egg and chestnut are considered as domestic coals, the shipments of domestic sizes in 1913 aggregated 48,277,391 tons of the 71,295,716 tons of mine coal shipped during the year.

The standard screens used in the preparation of anthracite have the following dimensions:

Standard sizes of anthracite.

Size.	Through—	Over—
Broken or grate	4-inch square	$2\frac{3}{4}$-inch square.
Egg	$2\frac{3}{4}$-inch square	2-inch square.
Stove	2-inch square	$1\frac{3}{8}$-inch square.
Chestnut	$1\frac{3}{8}$-inch square	$\frac{3}{4}$-inch square.
Pea	$\frac{3}{4}$-inch square	$\frac{1}{2}$-inch square.
Buckwheat No. 1	$\frac{1}{2}$-inch square	$\frac{1}{4}$-inch square.
Buckwheat No. 2 or rice	$\frac{1}{4}$-inch square	$\frac{1}{8}$-inch square.
Buckwheat No. 3 or barley	$\frac{1}{8}$-inch square	$\frac{1}{16}$-inch round.

In the following table are presented statements showing the quantity of each size shipped from each county in 1912 and 1913, with the percentage that each size bears to the total shipments:

Quantity of each size of anthracite shipped from each county in 1912 and 1913, in long tons, and percentage of total.

1912.

County.	Lump and steam-boat.	Broken.	Egg.	Stove.
Carbon	12,465	164,130	253,626	300,390
Columbia	20,593	11,547	145,855	149,906
Dauphin	....	26,688	38,272	132,250
Lackawanna	17,229	578,994	2,230,739	3,212,447
Luzerne	152,717	1,790,303	3,752,474	4,778,433
Northumberland	11,200	228,907	639,230	962,872
Schuylkill	204,397	924,307	1,764,971	2,140,653
Sullivan	....	11,298	51,946	72,796
Susquehanna	....	18,393	57,951	79,653
Total	418,601	3,754,567	8,935,064	11,829,400
Percentage of total	.64	5.76	13.70	18.14

Quantity of each size of anthracite shipped from each county in 1912 and 1913, in long tons, and percentage of total—Continued.

1912—Continued.

County.	Chestnut.	Pea.	Buck-wheat No. 1.	Buck-wheat No. 2 and rice.
Carbon	425,749	293,306	309,092	292,090
Columbia	210,383	108,780	151,662	121,616
Dauphin	97,202	54,730	121,830	132,583
Lackawanna	3,785,627	1,842,760	2,012,050	929,564
Luzerne	6,026,189	2,463,387	2,722,603	1,208,348
Northumberland	1,154,954	624,010	947,288	550,698
Schuylkill	2,696,948	1,695,045	2,369,046	1,430,942
Sullivan	103,581	68,050	....	....
Susquehanna	100,449	56,171	64,602	25,818
Total	14,601,082	7,206,239	8,698,173	4,691,659
Percentage of total	22.38	11.05	13.33	7.19

County.	Buckwheat No. 3 and barley.	Screenings.	Total.
Carbon	101,447	11,601	2,163,896
Columbia	16,362	....	936,704
Dauphin	32,820	995	637,370
Lackawanna	a 2,247,148	44,472	16,901,030
Luzerne	b 1,735,888	18,114	24,648,456
Northumberland	101,954	17,478	5,238,591
Schuylkill	416,669	46,879	13,689,857
Sullivan	....	226,333	534,004
Susquehanna	76,310	....	479,347
Total	4,728,598	365,872	65,229,255
Percentage of total	7.25	.56	100.00

1913.

County.	Lump and steamboat.	Broken.	Egg.	Stove.	Chestnut.
Carbon	15,358	134,842	298,758	390,827	551,536
Columbia	18,157	51,391	107,372	177,850	196,741
Dauphin	....	24,582	43,435	135,587	112,358
Lackawanna	12,563	504,002	2,304,933	3,790,759	4,386,779
Luzerne	109,915	1,745,626	3,680,454	5,784,859	7,181,114
Northumberland	30,798	170,648	567,634	1,039,617	1,326,782
Schuylkill	175,923	858,688	1,881,280	2,426,315	3,192,963
Sullivan	....	13,716	49,315	80,009	103,185
Susquehanna and Wayne	....	....	44,926	95,963	117,359
Total	362,714	3,503,495	8,978,107	13,921,786	17,168,817
Percentage of total	.51	4.92	12.59	19.53	24.08

County.	Pea.	Buckwheat No. 1.	Buckwheat No. 2 and rice.	Buckwheat No. 3 and barley.	Screenings.	Total.
Carbon	372,972	359,128	299,760	176,946	....	2,600,127
Columbia	134,600	141,587	86,146	8,688	....	922,532
Dauphin	64,665	132,562	113,989	84,463	708	712,349
Lackawanna	2,096,974	2,225,647	1,439,209	1,247,806	13,646	18,022,318
Luzerne	2,912,235	3,100,103	1,733,441	1,435,449	30,737	27,713,933
Northumberland	622,441	976,798	582,045	117,677	13,089	5,447,529
Schuylkill	1,880,397	2,495,723	1,365,335	540,479	42,112	14,859,215
Sullivan	66,110	....	....	....	225,069	537,404
Susquehanna and Wayne	58,287	72,613	14,112	77,049	....	480,309
Total	8,208,681	9,504,161	5,634,037	3,688,557	325,361	71,295,716
Percentage of total	11.51	13.33	7.90	5.17	.46	100.00

a Includes 423,673 tons of "birdseye," a mixture of buckwheat Nos. 2 and 3.
b Includes 251,597 tons of birdseye.

Distributed by trade regions the shipments of anthracite in 1912 and 1913 were as follows:

Shipments of anthracite, by regions and sizes, 1912 and 1913, in long tons.

1912.

	Lehigh region.	Schuylkill region.	Wyoming region.	Total.
Lump	38,159	230,351	150,091	418,601
Broken	513,068	1,024,884	2,205,317	3,743,269
Egg	1,220,610	2,308,107	5,354,401	8,883,118
Stove	1,435,541	3,061,408	7,259,655	11,756,604
Chestnut	1,885,646	3,683,667	8,928,057	14,497,370
Pea	1,079,167	2,179,384	3,879,590	7,138,141
Buckwheat No. 1	1,299,714	3,202,299	4,195,571	8,697,584
Buckwheat No. 2	945,597	1,973,126	1,756,979	4,675,702
Buckwheat No. 3	366,372	486,573	3,865,567	4,718,512
Screenings	16,251	64,161	57,936	138,348
Total	8,800,125	18,213,960	37,653,164	64,667,249

1913.

	Lehigh region.	Schuylkill region.	Wyoming region.	Total.
Lump	33,299	222,884	106,531	362,714
Broken	395,795	986,679	2,107,305	3,489,779
Egg	1,262,448	2,264,762	5,401,582	8,928,792
Stove	1,797,062	3,397,668	8,647,047	13,841,777
Chestnut	2,311,631	4,282,944	10,471,057	17,065,632
Pea	1,291,412	2,366,797	4,484,362	8,142,571
Buckwheat No. 1	1,439,307	3,361,591	4,703,263	9,504,161
Buckwheat No. 2	1,044,988	1,912,700	2,676,349	5,634,037
Buckwheat No. 3	592,592	565,451	2,530,514	3,688,557
Screenings	11,487	55,909	32,896	100,292
Total	10,180,021	19,417,385	41,160,906	70,758,312

The figures in the foregoing table differ slightly, although not materially, from the returns made by the railroads to the bureau of anthracite coal statistics at Philadelphia. The shipments from Sullivan County and from dredges are not included in either statement.

The table showing the shipments of anthracite reported by the bureau of anthracite coal statistics has been published annually in this chapter. In this table the initial shipments are credited to the Lehigh region, from which 365 tons were shipped in 1820. Exception to this statement is taken by residents of the Wyoming region, and Mr. William Griffith, of Scranton, Pa., has recently contributed to the Wyoming Historical and Geological Society a paper setting forth the claims of that region to priority in the shipments of anthracite. The first authentic shipment of anthracite was certainly from the Wyoming region, for in 1807 a shipment of 55 tons was made by Abijah Smith & Co. from Plymouth to Columbia. So far as the writer knows, there is no record of further shipments from that region before 1820, but Mr. Griffith, quoting from Mr. George B. Kulp, gives the following table to show the probable annual shipments from 1807 to 1820, inclusive. Mr. Griffith, however, does not fill the gap between 1820 and 1829, when, according to the bureau figures, the regular shipments from the Wyoming region began.

Shipments of anthracite from Wyoming region (Pennsylvania) from 1807 to 1820, as estimated by George B. Kulp.

	Long tons.		Long tons.		Long tons.
1807	55	1812	500	1817	1,000
1808	150	1813	500	1818	1,000
1809	200	1814	700	1819	1,400
1810	350	1815	1,000	1820	2,500
1811	450	1816	1,000		

The following table gives the yearly shipments of anthracite reported by the bureau of anthracite coal statistics from 1820 to the close of 1913, distributed according to the three trade regions. These shipments include only coal loaded on cars for line or tide points, and do not include any coal sold locally and used at and about the mines, nor do they include the shipments from Sullivan County. According to this table, the first regular shipments of coal from the anthracite region were made in 1820 and consisted of 365 tons (one ton for each day of the year) shipped from the Lehigh region, although in order to be historically accurate, credit should be given to the Wyoming region for the 55 tons shipped from Plymouth to Columbia, Pa., in 1807. The estimates of shipments between 1807 and 1820 contained in the preceding table prepared by Mr. Kulp are not official.

Annual shipments from the Schuylkill, Lehigh, and Wyoming regions in 1807 and from 1820 to 1913, in long tons.

Year.	Schuylkill region.		Lehigh region.		Wyoming region.		Total.
	Quantity.	Percentage.	Quantity.	Percentage.	Quantity.	Percentage.	Quantity.
1807					55		55
1820			365				365
1821			1,073				1,073
1822	1,480	39.79	2,240	60.21			3,720
1823	1,128	16.23	5,823	83.77			6,951
1824	1,567	14.10	9,541	85.90			11,108
1825	6,500	18.60	28,393	81.40			34,893
1826	16,767	34.90	31,280	65.10			48,047
1827	31,360	49.44	32,074	50.56			63,434
1828	47,284	61.00	30,232	39.00			77,516
1829	79,973	71.35	25,110	22.40	7,000	6.25	112,083
1830	89,984	51.50	41,750	23.90	43,000	24.60	174,734
1831	81,854	46.29	40,966	23.17	54,000	30.54	176,820
1832	209,271	57.61	70,000	19.27	84,000	23.12	363,271
1833	252,971	51.87	123,001	25.22	111,777	22.91	487,749
1834	226,692	60.19	106,244	28.21	43,700	11.60	376,636
1835	339,508	60.54	131,250	23.41	90,000	16.05	560,758
1836	432,045	63.16	148,211	21.66	103,861	15.18	684,117
1837	530,152	60.98	223,902	25.75	115,387	13.27	869,441
1838	446,875	60.49	213,615	28.92	78,207	10.59	738,697
1839	475,077	58.05	221,025	27.01	122,300	14.94	818,402
1840	490,596	56.75	225,313	26.07	148,470	17.18	864,379
1841	624,466	65.07	143,037	14.90	192,270	20.03	959,773
1842	583,273	52.62	272,540	24.59	252,599	22.79	1,108,412
1843	710,200	56.21	267,793	21.19	285,605	22.60	1,263,598
1844	887,937	54.45	377,002	23.12	365,911	22.43	1,630,850
1845	1,131,724	56.22	429,453	21.33	451,836	22.45	2,013,013
1846	1,308,500	55.82	517,116	22.07	518,389	22.11	2,344,005
1847	1,665,735	57.79	633,507	21.98	583,067	20.23	2,882,309
1848	1,733,721	56.12	670,321	21.70	685,196	22.18	3,089,238
1849	1,728,500	53.30	781,556	24.10	732,910	22.60	3,242,966
1850	1,840,620	54.80	690,456	20.56	827,823	24.64	3,358,899

Annual shipments from the Schuylkill, Lehigh, and Wyoming regions in 1807 and from 1820 to 1913, in long tons—Continued.

Year.	Schuylkill region.		Lehigh region.		Wyoming region.		Total.
	Quantity.	Percentage.	Quantity.	Percentage.	Quantity.	Percentage.	Quantity.
1851	2,328,525	52.34	964,224	21.68	1,156,167	25.98	4,448,916
1852	2,636,835	52.81	1,072,136	21.47	1,284,500	25.72	4,993,471
1853	2,665,110	51.30	1,054,309	20.49	1,475,732	28.41	5,195,151
1854	3,191,670	53.14	1,207,186	20.13	1,603,478	26.73	6,002,334
1855	3,552,943	53.77	1,284,113	19.43	1,771,511	26.80	6,608,567
1856	3,603,029	52.91	1,351,970	19.52	1,972,581	28.47	6,927,580
1857	3,373,797	50.77	1,318,541	19.84	1,952,603	29.39	6,644,941
1858	3,273,245	47.86	1,380,030	20.18	2,186,094	31.96	6,839,369
1859	3,448,708	44.16	1,628,311	20.86	2,731,236	34.98	7,808,255
1860	3,749,632	44.04	1,821,674	21.40	2,941,817	34.56	8,513,123
1861	3,160,747	39.74	1,738,377	21.85	3,055,140	38.41	7,954,264
1862	3,372,583	42.86	1,351,054	17.17	3,145,770	39.97	7,869,407
1863	3,911,683	40.90	1,894,713	19.80	3,759,610	39.30	9,566,006
1864	4,161,970	40.89	2,054,669	20.19	3,960,836	38.92	10,177,475
1865	4,356,959	45.14	2,040,913	21.14	3,254,519	33.72	9,652,391
1866	5,787,902	45.56	2,179,364	17.15	4,736,616	37.29	12,703,882
1867	5,161,671	39.74	2,502,054	19.27	5,325,000	40.99	12,988,725
1868	5,330,737	38.52	2,502,582	18.13	5,968,146	43.25	13,801,465
1869	5,775,138	41.66	1,949,673	14.06	6,141,369	44.28	13,866,180
1870	4,968,157	30.70	3,239,374	20.02	7,974,660	49.28	16,182,191
1871	6,552,772	41.74	2,235,707	14.24	6,911,242	44.02	15,699,721
1872	6,694,890	34.03	3,873,339	19.70	9,101,549	46.27	19,699,778
1873	7,212,601	33.97	3,705,596	17.46	10,309,755	48.57	21,227,952
1874	6,866,877	34.09	3,773,836	18.73	9,504,408	47.18	20,145,121
1875	6,281,712	31.87	2,834,605	14.38	10,596,155	53.75	19,712,472
1876	6,221,934	33.63	3,854,919	20.84	8,424,158	45.53	18,501,011
1877	8,195,042	39.35	4,332,760	20.80	8,300,377	39.85	20,828,179
1878	6,282,226	35.68	3,237,449	18.40	8,085,587	45.92	17,605,262
1879	8,960,829	34.28	4,595,567	17.58	12,586,293	48.14	26,142,689
1880	7,554,742	32.23	4,463,221	19.05	11,419,279	48.72	23,437,242
1881	9,253,958	32.46	5,294,676	18.58	13,951,383	48.96	28,500,017
1882	9,459,288	32.48	5,689,437	19.54	13,971,371	47.98	29,120,096
1883	10,074,726	31.69	6,113,809	19.23	15,604,492	49.08	31,793,027
1884	9,478,314	30.85	5,562,226	18.11	15,677,753	51.04	30,718,293
1885	9,488,426	30.01	5,898,634	18.65	16,236,470	51.34	31,623,530
1886	9,381,407	29.19	5,723,129	17.89	17,031,826	52.82	32,136,362
1887	10,609,028	30.63	4,347,061	12.55	19,684,929	56.82	34,641,018
1888	10,654,116	27.93	5,639,236	14.78	21,852,366	57.29	38,145,718
1889	10,486,185	29.28	6,294,073	17.57	19,036,835	53.15	35,817,093
1890	10,867,822	29.68	6,329,658	17.28	19,417,979	53.04	36,615,459
1891	12,741,258	31.50	6,381,838	15.78	21,325,240	52.72	40,448,336
1892	12,626,784	30.14	6,451,076	15.40	22,815,480	54.46	41,893,340
1893	12,357,444	28.68	6,892,352	15.99	23,839,741	55.33	43,089,537
1894	12,035,005	29.08	6,705,434	16.20	22,650,761	54.72	41,391,200
1895	14,269,932	30.68	7,298,124	15.69	24,943,421	56.63	46,511,477
1896	13,097,571	30.34	6,490,441	15.03	23,589,473	54.63	43,177,485
1897	12,181,061	29.26	6,249,540	15.00	23,207,263	55.74	41,637,864
1898	12,078,875	28.83	6,253,109	14.92	23,567,767	56.25	41,899,751
1899	14,199,009	29.79	6,887,909	14.45	26,578,286	55.76	47,665,204
1900	13,502,732	29.94	6,918,627	15.33	24,686,125	54.73	45,107,484
1901	16,019,591	29.92	7,211,974	13.45	30,337,036	56.63	53,568,601
1902	8,471,391	27.15	3,470,736	11.12	19,258,763	61.73	31,200,890
1903	16,474,790	27.75	7,164,783	12.07	35,723,258	60.18	59,362,831
1904	16,379,293	28.49	7,107,220	12.36	34,006,009	59.15	57,492,522
1905	17,703,099	28.83	7,849,205	12.78	35,857,897	58.39	61,410,201
1906	16,011,285	28.75	7,046,617	12.65	32,640,693	58.60	55,698,595
1907	20,141,288	30.01	8,320,653	12.41	38,638,452	57.58	67,109,393
1908	18,006,464	27.85	7,786,255	12.04	38,872,295	60.11	64,665,014
1909	16,864,147	27.21	7,532,271	12.16	37,573,467	60.63	61,969,885
1910	17,845,020	27.49	8,627,539	13.29	38,433,227	59.22	64,905,786
1911	19,375,369	27.70	9,775,018	13.97	40,803,912	58.33	69,954,299
1912	18,013,406	28.32	8,571,861	13.47	37,025,311	58.21	63,610,578
1913	19,338,870	28.00	9,347,583	13.53	40,388,175	58.47	69,069,628
Total	614,097,380	31.46	301,172,559	15.43	1,036,760,952	53.11	1,952,030,891

A tabular statement of the several sections of the anthracite fields is given in the following table:

Anthracite coal fields, by field, local district, and trade region.

Coal field or basin.	Local district.	Trade region.
Northern	Carbondale Scranton Pittston Wilkes-Barre Plymouth Kingston	Wyoming.
Eastern middle	Green Mountain Black Creek Hazleton Beaver Meadow Panther Creek	Lehigh.
Southern	East Schuylkill Western Schuylkill Lorberry Lykens Valley	Schuylkill.
Western middle	East Mahanoy West Mahanoy Shamokin	Schuylkill.

The anthracite fields are reached by 11 so-called initial railroads as follows:

Philadelphia & Reading Railway.
Lehigh Valley Railroad.
Central Railroad of New Jersey.
Delaware, Lackawanna & Western Railroad.
Delaware & Hudson Co.'s Railroad.
Pennsylvania Railroad.
Erie Railroad.
New York, Ontario & Western Railway.
Delaware, Susquehanna & Schuylkill Railroad (part of Lehigh Valley system).
New York, Susquehanna & Western Railroad (part of Erie system).
Lehigh & New England Railroad.

PENNSYLVANIA BITUMINOUS COAL.

Total production in 1913, 173,781,217 short tons; spot value, $193,039,806.

The output of bituminous coal in Pennsylvania in 1913 again broke the record and established a new maximum, exceeding the previous high figure of 1912 by 11,915,729 short tons, or 7.4 per cent, in quantity and by $23,669,309 in value. The increased production in 1913 was due in part to generally improved trade conditions in 1912, in part to the fact that in the earlier year operations were partly suspended on April 1, pending the adjustment of the wage scale, and in part to the labor troubles in the Kanawha district of West Virginia, which increased the demand for Pennsylvania bituminous coal, particularly in the western part of the State. Operators complained of shortage of labor, chiefly of miners, in the central part of the State, in the Westmoreland gas-coal field, and in the Connellsville coking-coal district. The effect of the labor shortage was accentuated, it is claimed, by the tendency on the part of the miners to work fewer days. The latter appears to be borne out by the fact that although opportunity to work was given for more days in 1913 than in any recent year the average production per miner per day declined.

Increased production in 1913 was well distributed over the entire bituminous district, only 3 counties out of 26 showing decreases. Westmoreland County led in increased output, with a gain of 2,669,153 tons, and supplanted for first place its neighbor and rival, Fayette County, which since 1908 had been the leading coal-producing county of the State. The two counties, Fayette and Westmoreland, which constitute the Connellsville coking district, had a combined production in 1913 of over 65,850,000 short tons, within 10 per cent of the total production of West Virginia, the second coal-producing State in the Union, and exceeding that of Illinois by about 4,000,000 tons. Cambria County showed the second largest gain in 1913, with an addition of 2,036,248 tons to its production in 1912. Allegheny, Armstrong, Indiana, and Washington counties all showed increases of over 1,000,000 tons, the last by more than 1,600,000 tons.

The average value per ton of Pennsylvania bituminous coal advanced from $1.05 in 1912 to $1.11 in 1913. The average in 1912 was the highest obtained for bituminous coal in Pennsylvania for a period of 30 years, with the exception of the strike years, 1902 and 1903, when, because of a scarcity of all kinds of fuel, prices were abnormally inflated. The advance of 6 cents a ton in 1913 over 1912 put the record of that year within 7 cents of the abnormally high value in 1903. As the leading coal-producing State, Pennsylvania sets a good example in the small tonnage that is won by the powder without being previously undercut or sheared. In 1913 the quantity of coal reported to the Survey as shot off the solid was less than 3 per cent of the total output. The quantity mined by machines was 92,487,438 short tons, or 53.2 per cent of the total, against 82,192,042 tons, or 50.8 per cent of the machine-mined coal, in 1912. The number of machines in use increased from 6,176 in 1912 to 6,301 in 1913, although there was a decrease in the number of one type of machine, the punchers, from 3,660 to 3,341. A notable increase from 439 to 736 was made in the number of short-wall machines, and the long-wall type showed a greater proportionate increase, from 52 to 137. The number of chain-breast machines increased from 2,023 to 2,086. The quantity of coal reported as mined by hand in 1913 was 61,509,942 tons.

The number of men employed in the bituminous-coal mines of Pennsylvania in 1913 was 172,196, and they made the unprecedented high average of 267 days, against 165,144 men for 252 days in 1912. In four counties, two of them the Connellsville coking-coal counties, Fayette and Westmoreland, the average working time exceeded 280 days. The average production per man for the year exceeded any previous record of any State and amounted to 1,009 short tons. The average daily production per man fell off slightly, from 3.89 tons in 1912 to 3.78 tons in 1913.

About 10 per cent of the men employed in the bituminous-coal mines of Pennsylvania were on strike in 1913 and the average time lost by them was 16 days. There was no general strike or suspension.

Only a small part of the bituminous-coal production in Pennsylvania is washed, and practically all of the washed product is used in the manufacture of coke. In 1913 the quantity washed was 6,011,172 short tons, or about 3½ per cent of the total production. It yielded 5,400,444 tons of cleaned coal and 610,728 tons of refuse. The quantity of washed coal used, as reported by the coke operators, was 5,374,759 short tons.

The fatality record compiled by the Bureau of Mines shows that there was an increase in the number of men killed in the bituminous-coal mines of Pennsylvania from 437 in 1912 to 609 in 1913. The chief cause of the larger number of deaths in 1913 was an explosion of dust at the Cincinnati mine, in Washington County, which occurred in April and resulted in the death of 96 men. This was the only instance of an explosion or other accident in which more than one or two men were killed at one time. As usual, the most prolific cause of accident was falls of roof and coal, which in 1913 claimed 313 victims, or more than one-half the total number. Haulage-way accidents were responsible for 102 deaths, and electric shocks and burns for 23. Altogether, 554 men out of a total of 609 were killed underground, 7 were killed by falls into shafts, and 48 were killed on the surface. The death rate per thousand was 3.54 in 1913, against 2.65 in 1912 and 3.14 in 1911. The quantity of coal mined for each life lost was 285,355 tons in 1913, against 370,402 tons in 1912 and 273,637 tons in 1911.

The statistics of production, by counties, with the distribution of the product for consumption in 1912 and 1913, are shown in the following table:

Bituminous-coal production of Pennsylvania in 1912 and 1913, by counties, in short tons.

1912.

County.	Loaded at mines for shipment.	Sold to local trade and used by employees.	Used at mines for steam and heat.	Made into coke.	Total quantity.	Total value.	Average price per ton.	Average number of days active.	Average number of employees.
Allegheny	18,087,903	474,116	305,096	150	18,867,265	$20,528,181	$1.09	249	20,756
Armstrong	3,849,829	126,031	127,329	1,800	4,104,989	4,054,301	.99	216	5,589
Beaver	160,937	82,912	3,616	....	247,465	309,304	1.25	261	392
Bedford	503,985	9,511	16,750	201,231	731,477	795,031	1.09	233	1,067
Blair	274,795	366	8,666	40,509	324,336	378,511	1.17	209	467
Butler	969,075	11,284	20,588	....	1,000,947	1,131,503	1.13	266	1,285
Cambria	14,563,434	1,314,170	407,268	1,300,258	17,585,130	19,200,298	1.09	241	21,356
Center	1,275,221	13,412	2,741	....	1,291,374	1,292,301	1.00	236	1,788
Clarion	1,158,837	13,249	27,236	....	1,199,322	1,223,537	1.02	229	1,629
Clearfield	7,149,021	220,326	234,867	334,123	7,938,337	8,230,763	1.04	233	10,372
Clinton	332,974	11,005	1,475	....	345,454	427,192	1.24	248	393
Elk	1,099,827	11,915	25,344	9,410	1,146,496	1,132,363	.99	245	1,727
Fayette	7,233,920	317,476	588,535	24,226,636	32,366,567	32,595,749	1.01	275	22,776
Huntingdon	811,586	6,087	16,126	1,115	834,914	1,025,646	1.23	254	1,112
Indiana	8,394,140	38,560	317,843	424,384	9,174,927	8,872,019	.97	259	10,992
Jefferson	4,367,620	59,750	109,723	879,443	5,416,536	5,168,998	.95	244	5,940
Lawrence	59,906	3,578	12,339	....	75,823	94,124	1.24	256	127
Mercer	751,772	51,111	43,345	....	846,228	1,052,367	1.24	249	1,284
Somerset	9,549,469	112,170	226,505	....	9,888,144	11,034,445	1.12	257	9,586
Tioga	956,170	29,967	11,650	....	997,787	1,569,289	1.57	218	1,865
Washington	14,972,227	122,573	367,339	1,182,988	16,645,127	18,012,167	1.08	236	18,714
Westmoreland	19,899,766	659,743	770,489	9,259,551	30,589,549	30,971,778	1.01	272	25,693
Other counties [a] and small mines.	55,294	161,583	12,497	17,920	247,294	270,630	1.09	220	234
Total	116,477,708	3,850,895	3,657,367	37,879,518	161,865,488	169,370,497	1.05	252	165,144

[a] Cameron, Fulton, Greene, Lycoming, and McKean.

Bituminous-coal production of Pennsylvania in 1912 and 1913, by counties, in short tons—Continued.

1913.

County.	Loaded at mines for shipment.	Sold to local trade and used by employees.	Used at mines for steam and heat.	Made into coke.	Total quantity.	Total value.	Average price per ton.	Average number of days active.	Average number of employees.
Allegheny	19,014,187	786,049	315,166	2,421	20,117,823	$23,158,897	$1.15	252	21,650
Armstrong	5,068,536	102,739	150,347		5,321,622	5,476,228	1.03	260	6,134
Beaver	170,782	74,149	3,654		248,585	337,372	1.36	282	355
Bedford	589,949	139,988	15,146	105,709	850,792	927,379	1.09	244	1,154
Blair	323,030	317	9,354	59,016	391,717	463,225	1.18	217	553
Butler	1,033,292	17,578	29,132		1,080,002	1,210,524	1.12	263	1,368
Cambria	16,761,239	1,177,991	387,358	1,294,790	19,621,378	21,903,291	1.12	272	21,976
Center	1,475,751	17,271	4,249		1,497,271	1,499,395	1.00	260	1,833
Clarion	1,390,163	4,395	33,290		1,427,848	1,517,316	1.06	252	1,877
Clearfield	7,435,828	234,358	228,701	379,128	8,278,015	8,579,446	1.04	258	10,121
Clinton	330,028	11,578	1,448		343,054	441,249	1.29	281	290
Elk	1,140,364	30,455	30,246		1,201,065	1,251,090	1.04	270	1,721
Fayette	7,727,676	339,125	661,835	23,879,327	32,607,963	37,810,508	1.16	284	23,704
Greene	248,152	6,227	18,423	43,950	316,752	321,001	1.01	207	428
Huntingdon	882,040	5,936	16,761	31,037	935,774	1,060,367	1.13	268	1,262
Indiana	9,638,385	59,051	251,872	255,376	10,204,684	10,297,482	1.01	277	12,026
Jefferson	4,563,844	70,956	120,981	1,046,083	5,801,864	5,794,490	.99	271	5,790
Lawrence	78,478	2,701	13,104		94,283	118,835	1.26	259	220
Mercer	687,869	41,875	47,857		777,601	960,624	1.24	260	1,231
Somerset	9,601,406	77,348	250,022		9,928,776	11,119,355	1.12	270	9,666
Tioga	903,161	31,240	9,347		943,748	1,544,537	1.64	224	1,757
Washington	16,607,903	134,102	424,734	1,142,578	18,309,317	20,497,946	1.12	249	20,012
Westmoreland	22,240,531	598,925	780,723	9,638,523	33,258,702	36,490,802	1.10	281	26,847
Other counties [a] and small mines	45,810	158,076	2,779	15,916	222,581	258,447	1.16	201	221
Total	127,958,404	4,122,430	3,806,529	37,893,854	173,781,217	193,039,806	1.11	267	172,196

[a] Cameron, Lycoming, and McKean.

The statistics of production, by counties, during the last five years, with increase and decrease in 1913 as compared with 1912, are shown in the following table:

Bituminous-coal production of Pennsylvania, 1909–1913, by counties, in short tons.

County.	1909	1910	1911	1912	1913	Increase (+) or decrease (−), 1913.
Allegheny	16,087,010	18,835,336	17,863,795	18,867,265	20,117,823	+ 1,250,558
Armstrong	2,787,508	3,304,915	3,799,227	4,104,989	5,321,622	+ 1,216,633
Beaver	224,450	228,226	203,556	247,465	248,585	+ 1,120
Bedford	435,129	716,833	528,170	731,477	850,792	+ 119,315
Blair	410,161	380,870	294,048	324,336	391,717	+ 67,381
Butler	828,043	1,017,809	957,074	1,000,947	1,080,002	+ 79,055
Cambria	15,545,185	16,629,461	16,928,628	17,585,130	19,621,378	+ 2,036,248
Center	1,239,049	1,293,622	1,140,263	1,291,374	1,497,271	+ 205,897
Clarion	941,059	1,156,697	1,057,390	1,199,322	1,427,848	+ 228,526
Clearfield	7,573,322	8,463,910	7,852,426	7,938,337	8,278,015	+ 339,678
Clinton	272,184	310,973	314,643	345,454	343,054	− 2,400
Elk	1,150,675	1,202,323	1,223,856	1,146,496	1,201,065	+ 54,569
Fayette	28,866,229	31,097,233	26,610,162	32,366,567	32,607,963	+ 241,396
Greene	137,448	77,321	31,743	35,839	316,752	+ 280,913
Huntingdon	502,823	669,226	806,199	834,914	935,774	+ 100,860
Indiana	7,681,205	8,954,366	8,780,983	9,174,927	10,204,684	+ 1,029,757
Jefferson	4,934,907	5,668,883	5,550,816	5,416,536	5,801,864	+ 385,328
Lawrence	156,749	95,102	90,151	75,823	94,283	+ 18,460
Lycoming	28,016	25,725	13,271	7,777	26,953	+ 19,176
Mercer	893,880	867,754	859,355	846,228	777,601	− 68,627
Somerset	7,902,338	8,837,682	9,177,421	9,888,144	9,928,776	+ 40,632
Tioga	785,922	1,037,417	830,330	997,787	943,748	− 54,039
Washington	12,982,179	16,638,677	15,343,772	16,645,127	18,309,317	+ 1,664,190
Westmoreland	25,432,320	22,885,404	24,102,195	30,589,549	33,258,702	+ 2,669,153
Small mines	[a] 169,000	[a] 125,761	[b] 201,783	[c] 203,678	[d] 195,628	− 8,050
Total	137,966,791	150,521,526	144,561,257	161,865,488	173,781,217	+ 11,915,729
Total value	$130,085,237	$153,029,510	$146,154,952	$169,370,497	$193,039,806	+$23,669,309

[a] Includes production of Bradford and Cameron counties.
[b] Includes production of Bradford, Cameron, and McKean counties.
[c] Includes Cameron, Fulton, and McKean counties.
[d] Includes Cameron and McKean counties.

The bituminous fields of Pennsylvania underlie the greater part of the western half of the State and comprise a total area of about 14,200 square miles. Coal is, or has been mined in about 30 different counties, but the principal mining activities are confined to 10 counties, which contribute about 95 per cent of the total output of the State and about one-third the total production of the United States. The larger developments may be divided into three principal mining districts: (1) The Pittsburgh, embracing Allegheny and Washington counties, in which the Pittsburgh bed furnishes the most of the steam and gas coals for which the district is celebrated; (2) the Connellsville (including the Lower Connellsville, or Klondike), lying in Fayette and Westmoreland counties, in which district the Pittsburgh bed yields the renowned Connellsville coking coal, of which in the two counties alone nearly 66,000,000 short tons, or approximately 14 per cent of the country's total, were produced in 1913; (3) the Cambria-Clearfield, including the areas in Cambria, Clearfield, Indiana, and Jefferson counties, where the production is cheifly from the Lower Freeport "D" bed, which has a fine development in these counties, but which is worthless over most of the rest of the State. Geologically, the principal bituminous-producing formations are the Allegheny and the Monongahela, formerly known as the "Lower" and the "Upper Productive Coal Measures." The Allegheny has at least seven beds, all of which are workable at some point. They are the Brookville, Clarion, Lower, Middle, and Upper Kittanning, and Lower and Upper Freeport. The Lower Kittanning and the two Freeport beds are the principal producers. The Monongahela formation contains, in addition to the Pittsburgh, four other beds, the Redstone, Sewickley, Uniontown, and Waynesburg, all of which are workable locally. The Pittsburgh bed, on account of its nearly uniform thickness over enormous territory (several thousand square miles), its high grade, its adaptability to the production of coke and gas, and its use as a steam fuel, is the most famous coal bed in America and is probably unequaled in the world.

The statistics of the early production of bituminous coal in Pennsylvania, particularly as compared with the anthracite records, are sadly wanting. The United States Census of 1840 showed a production of bituminous coal in the State which amounted to 464,826 short tons. The census of 1860 showed a production of 2,690,786 short tons; that of 1870 showed a production of 7,798,518 short tons. The production for the intervening years, as shown in the table following, has been estimated from the best information obtainable. Since 1871 the records are official.

Production of bituminous coal in Pennsylvania from 1840 to 1913, in short tons.

Year.	Quantity.	Year.	Quantity.	Year.	Quantity.	Year.	Quantity.
1840	464,826	1859	2,400,000	1878	15,120,000	1897	54,417,974
1841	475,000	1860	2,690,786	1879	16,240,000	1898	65,165,133
1842	500,000	1861	3,200,000	1880	18,425,163	1899	74,150,175
1843	650,000	1862	4,000,000	1881	22,400,000	1900	79,842,326
1844	675,000	1863	5,000,000	1882	24,640,000	1901	82,305,946
1845	700,000	1864	5,839,000	1883	26,880,000	1902	98,574,367
1846	760,000	1865	6,350,000	1884	28,000,000	1903	103,117,178
1847	399,840	1866	6,800,000	1885	26,000,000	1904	97,938,287
1848	500,000	1867	7,300,000	1886	27,094,501	1905	118,413,637
1849	750,000	1868	7,500,000	1887	31,516,856	1906	129,293,206
1850	1,000,000	1869	6,750,000	1888	33,796,727	1907	150,143,177
1851	1,200,000	1870	7,798,518	1889	36,174,089	1908	117,179,527
1852	1,400,000	1871	9,040,565	1890	42,302,173	1909	137,966,791
1853	1,500,000	1872	11,695,040	1891	42,788,490	1910	150,521,526
1854	1,650,000	1873	13,098,829	1892	46,694,576	1911	144,561,257
1855	1,780,000	1874	12,320,000	1893	44,070,724	1912	161,865,488
1856	1,850,000	1875	11,760,000	1894	39,912,463	1913	173,781,217
1857	2,000,000	1876	12,880,000	1895	50,217,228		
1858	2,200,000	1877	14,000,000	1896	49,557,453	Total	2,731,945,059

TENNESSEE.

Total production in 1913, 6,903,784 short tons; spot value, $7,883,714.

More satisfactory labor conditions, better transportation facilities, and an improvement in market conditions were evident in the coal trade of Tennessee in 1913, and the effect of these three influences is exhibited in an increased production of 430,556 short tons, or 6.65 per cent, in quantity, and of $503,811, or 6.83 per cent, in value, as compared with 1912, when the output amounted to 6,473,228 tons, valued at $7,379,903. In neither 1912 nor 1913, however, did the production reach as high a figure as in 1910, when the maximum of 7,121,380 tons was obtained. On the other hand, in both of the later years the average value per ton was higher than in 1910, and in 1913, although the quantity of coal produced was 220,000 tons less than in 1910, the value was within $42,000 of the earlier year.

The principal market for steam coal from the Tennessee mines is with the transportation interests, and most of the railroads traversing the southeastern States buy some of their coal from the Tennessee mines. The railroad purchases in 1913 were somewhat larger than in 1912, and one of the important systems which for several years had been buying its supply from another source again became a buyer of Tennessee coal. Prices on railroad contracts made in 1913 were reported as from 2½ to 5 per cent higher than those made in 1912, but they do not seem to have affected the general average, as the gain in value in 1913 over 1912 was only a fraction of 1 per cent, when compared with the gain in output, and the advance in the average value per ton was only a small fraction of 1 cent.

The coal mines of Tennessee were not entirely free from labor troubles in 1913, as there were 857 men on strike during the year, with an average of 50 days each of lost time. As the total time lost was, however, less than 2 per cent of the time worked, there was no appreciable effect upon the production. The total number of men employed in 1913 was 11,263 and the average working time made by each man was 241 days, as compared with 10,309 men for an average of 234 days in 1912, when the time lost by strikes was about half what it was in 1913. The average production per man in 1913 was 613 tons for the year and 2.54 tons for each working day, against 628 and 2.68 tons, respectively, in 1912.

Something over one-third of the total coal production of Tennessee was shot off the solid. In 1913 this item amounted to 2,555,482 tons, or 37 per cent of the total; the quantity mined by machines was 1,842,658 tons, or 26.7 per cent of the total; and the hand-mined coal amounted to 2,464,970 tons, or 35.7 per cent. The mines, most of them small ones, which did not report the method of mining, had a total production of 40,674 tons. In 1912 the "powder-mined" product amounted to 2,127,917 tons, or 33 per cent of the total, and the machine-mined product to 1,201,895 tons, or 18.6 per cent, both of these items showing increases in 1913 in quantity as well as percentage of the total, and the hand-mined product was less in both respects. The number of machines in use increased from 227 in 1912 to 252 in 1913. The latter included 176 punchers, 21 chain-breast, 4 long-wall, 50 short-wall or continuous cutters, and 1 radialaxe.

The quantity of coal washed in 1913 was 707,773 tons, which yielded 624,426 tons of cleaned coal and 83,347 tons of refuse. Most of the coal washed is slack used in the manufacture of coke.

The coal-mining fatalities in Tennessee in 1913 numbered 35, an increase of nearly 100 per cent over 1912, when 18 men were killed. In neither year was there an explosion of dust or gas. Falls of roof and coal claimed 25 victims in 1913, and 6 deaths were due to haulage-way accidents. No other one cause was responsible for more than one death. The mortality rate per thousand was 3.1 and the quantity of coal mined for each life lost was 197,251 tons.

The statistics of production, by counties, during 1912 and 1913, with the distribution of the product for consumption, are shown in the following table:

Coal production of Tennessee in 1912 and 1913, by counties, in short tons.

1912.

County.	Loaded at mines for shipment.	Sold to local trade and used by employees.	Used at mines for steam and heat.	Made into coke.	Total quantity.	Total value.	Average price per ton.	Average number of days active.	Average number of employees.
Anderson	523,358	7,060	12,049	....	542,467	$565,782	$1.04	208	798
Campbell	1,706,104	17,511	40,303	....	1,763,918	2,208,877	1.25	226	2,934
Claiborne	1,226,335	3,529	21,786	....	1,251,650	1,264,231	1.01	226	1,565
Grundy	249,776	2,691	652	37,470	290,589	314,629	1.08	238	256
Hamilton	310,832	15,122	12,497	57,392	395,843	453,778	1.15	242	667
Marion	621,665	5,129	9,397	14,839	651,030	807,839	1.24	264	924
Morgan	342,053	2,718	8,789	73,696	427,256	425,273	1.00	264	1,035
Overton	55,714	615	1,143	....	57,472	62,125	1.08	195	122
Rhea	21,998	4,223	7,129	102,334	135,684	159,677	1.18	246	194
Scott	124,824	16,812	3,495	....	145,131	174,293	1.20	244	415
Other counties[a]	620,120	8,541	20,142	161,682	810,485	939,840	1.16	229	1,399
Small mines	....	1,703	....	....	1,703	3,559	2.09	....	....
Total	5,802,779	85,654	137,382	447,413	6,473,228	7,379,903	1.14	234	10,309

[a] Bledsoe, Cumberland, Fentress, Roane, Sequatchie, and White.

Coal production of Tennessee in 1912 and 1913, by counties, in short tons—Continued.

1913.

County.	Loaded at mines for shipment.	Sold to local trade and used by employees.	Used at mines for steam and heat.	Made into coke.	Total quantity.	Total value.	Average price per ton.	Average number of days active.	Average number of employees.
Anderson	641,363	5,864	12,118		659,345	$719,196	$1.09	235	913
Campbell	1,713,092	18,394	47,852		1,779,338	2,227,378	1.25	224	3,169
Claiborne	1,422,536	9,500	24,432		1,456,468	1,492,273	1.02	256	1,686
Grundy	263,796	5,084	1,751	49,105	319,736	344,209	1.08	273	495
Hamilton	238,398	6,077	14,623	107,447	366,545	432,971	1.18	225	704
Marion	640,673	6,652	5,853	24,327	677,505	853,570	1.26	263	1,029
Morgan	410,329	3,013	12,127	72,015	497,484	497,794	1.00	266	1,185
Overton	128,486	402	877		129,765	134,068	1.03	219	140
Scott	132,473	10,310	3,300		146,083	183,811	1.26	222	336
Other counties [b]	534,675	9,864	37,247	286,093	867,879	992,234	1.14	233	1,606
Small mines		3,636			3,636	6,210	1.71		
Total	6,125,821	78,796	160,180	538,987	6,903,784	7,883,714	1.14	241	11,263

[b] Bledsoe, Cumberland, Fentress, Rhea, Roane, Sequatchie, and White.

The statistics of production, by counties, during the last five years, with increase and decrease in 1913 as compared with 1912, are shown in the following table:

Coal production of Tennessee, 1909–1913, in short tons.

County.	1909	1910	1911	1912	1913	Increase(+) or decrease (−), 1913.
Anderson	822,803	808,214	735,135	542,467	659,345	+ 116,878
Campbell	1,631,339	1,705,537	1,703,666	1,763,918	1,779,338	+ 15,420
Claiborne	1,320,290	1,495,814	1,287,708	1,251,650	1,456,468	+ 204,818
Cumberland	67,606	49,982	28,852	36,165	3,588	− 32,577
Grundy	422,898	354,398	264,040	290,589	319,736	+ 29,147
Hamilton	217,080	327,392	365,131	395,843	366,545	− 29,298
Marion	480,067	564,667	517,116	651,030	677,505	+ 26,475
Morgan	469,537	482,313	458,097	427,256	497,484	+ 70,228
Overton	50,864	74,035	75,669	57,472	129,765	+ 72,293
Rhea	104,128	156,296	147,599	135,684	109,413	− 26,271
Roane	188,016	193,918	180,293	176,360	162,732	− 13,628
Scott	127,376	359,374	128,728	145,131	146,083	+ 952
White	316,510	346,206	324,339	364,112	347,878	− 16,234
Other counties and small mines	140,131	203,234	216,783	235,551	247,904	+ 12,353
Total	6,358,645	7,121,380	6,433,156	6,473,228	6,903,784	+ 430,556
Total value	$6,920,564	$7,925,350	$7,209,734	$7,379,903	$7,883,714	+$503,811

The Coal Measures of the Appalachian region cross the eastern part of Tennessee in a comparatively narrow belt (from 50 to 70 miles wide) in a northeast-southwest direction. The total area underlain by coal is about 4,400 square miles, and the greater part of the area contains one or more beds of workable thickness and quality. There are three principal basins: (1) The Wartburg, lying north of Emory River and embracing portions of Scott, Anderson, and Morgan counties; it is continuous northward with the Jellico Basin, lying partly in Tennessee and partly in Kentucky; (2) the Walden, a long and narrow basin extending southwestward from Emory River to the Georgia line, and underlying portions of Rhea, Hamilton, and Marion counties; (3) the Sewanee Basin, also long and narrow, to the west of and parallel with the Walden, underlying most of Cumberland County and portions of Bledsoe, Sequatchie, Grundy, and Marion counties. In addition to these the Cumberland Basin of Kentucky extends southward into Claiborne County, Tenn., where it is extensively developed.

All of the coals of Tennessee are bituminous, generally high-grade, and some of them make a good quality of coke. Smithing coal is produced in the southern part of the field.

The United States Census of 1840 states that 558 short tons of coal were produced in Tennessee in that year. It is probable that very little was mined in the State prior to that date. By 1860 the production had increased to 165,300 tons, but after that date development was retarded by the Civil War. Since 1870 the production of Tennessee has increased rather regularly, but not so rapidly as that of Alabama. The annual production of the State since 1840 is shown in the following table:

Coal production of Tennessee from 1840 to 1913, in short tons.

Year.	Quantity.	Year.	Quantity.	Year.	Quantity.	Year.	Quantity.
1840	558	1859	150,000	1878	375,000	1897	2,888,849
1841	600	1860	165,300	1879	450,000	1898	3,022,896
1842	1,000	1861	150,000	1880	495,131	1899	3,330,659
1843	4,500	1862	140,000	1881	840,000	1900	3,509,562
1844	10,000	1863	100,000	1882	850,000	1901	3,633,290
1845	18,000	1864	100,000	1883	1,000,000	1902	4,382,968
1846	25,000	1865	100,000	1884	1,200,000	1903	4,798,004
1847	30,000	1866	100,000	1885	1,440,957	1904	4,782,211
1848	40,000	1867	110,000	1886	1,714,290	1905	5,766,690
1849	52,000	1868	125,000	1887	1,900,000	1906	6,259,275
1850	60,000	1869	130,000	1888	1,967,297	1907	6,810,243
1851	70,000	1870	133,418	1889	1,925,689	1908	6,199,171
1852	75,000	1871	180,000	1890	2,169,585	1909	6,358,645
1853	85,000	1872	224,000	1891	2,413,678	1910	7,121,380
1854	90,000	1873	350,000	1892	2,092,064	1911	6,433,156
1855	100,000	1874	350,000	1893	1,902,258	1912	6,473,228
1856	115,000	1875	360,000	1894	2,180,879	1913	6,903,784
1857	125,000	1876	550,000	1895	2,535,644		
1858	135,000	1877	450,000	1896	2,663,106	Total	123,793,965

TEXAS.

Total production in 1913, 2,429,144 short tons; spot value, $4,288,920.

The coal production of Texas is nearly evenly divided between lignite and bituminous coal, with the balance slightly in favor of the latter. Both showed increases in production in 1913 and both made their record output. The total production in 1913 exceeded that of 1912 by 240,532 short tons, or 11 per cent, in quantity and by $633,176, or 17.3 per cent, in value. Most of the increase in tonnage was from the lignite mines, whose output showed a gain of 190,451 tons—from 990,705 tons in 1912 to 1,181,156 tons in 1913—while the production of bituminous coal increased 50,081 tons—from 1,197,907 tons in 1912 to 1,247,988 tons in 1913. In point of value, however, the advantage was as much in favor of bituminous coal as the gain in quantity was in favor of lignite. The value of lignite increased from $880,788 in 1912 to $1,104,759 in 1913, a gain of $223,971, while the value of the bituminous product increased from $2,774,956 to $3,184,161, a gain of $409,205. The increase in lignite tonnage was 3.8 times that of bituminous coal, and the gain in the value of bituminous coal was 1.8 times that of lignite.

The increased production of both bituminous coal and lignite in 1913 is attributed to the labor troubles in Colorado—which reduced the supply of coal from that State coming into western Texas, the continually declining supply of natural gas in the Mid-Continent field, and the decreased supply of fuel oil. In connection with the last item it should be stated that the decreased supply is not due to any falling-off in the production of crude oil, but to the larger output of distillation products, which reduced the residue previously sold as fuel oil.

Both the coal and the lignite mines of Texas were entirely free from labor disturbances in 1913, and in 1912 there were only four instances of idleness from that cause, the longest strike lasting but 10 days.

Notwithstanding the increased production in 1913, there were fewer men employed in the mines of Texas than in either 1911 or 1912, but the average number of days worked increased from 226 in 1911 and 230 in 1912 to 253 in 1913. There were 5,101 men who were reported from the coal mines of the State, as compared with 5,127 in 1912 and 5,353 in 1911. Most of the bituminous mines are operated on the basis of an 8-hour day, and the lignite mines are worked 10 hours daily. The decline in the number of men employed was confined entirely to the lignite fields, there being 1,563 employed in 1913, against 1,609 in 1912, but the average number of days worked increased from 191 in 1912 to 235 in 1913. The number of employees in the bituminous mines increased from 3,518 in 1912 to 3,538 in 1913, and the average number of days worked, from 248 to 261. The average production per man in the bituminous mines of Texas was 353 tons for the year and 1.35 tons for each working day, in 1913, against 340.5 and 1.37 tons, respectively, in 1912. In the lignite mines the average annual production per man in 1913 was 756 tons and 3.22 tons for each working day, against 615.7 tons for the year and the same daily average tonnage, in 1912. The general average production per man was 476 tons per year and 1.88 tons per day in 1913, against 424 and 1.84 tons, respectively, in 1912.

Most of the lignite produced in Texas is mined by hand, and of the bituminous production, nearly one-half is shot off the solid. The use of mining machines has not made much progress in the State, and those that are employed are in the bituminous mines. The production of machine-mined coal in 1913 was slightly less than in 1912, the machine-mined output in 1913 being 100,889 tons as compared with 105,400 tons in 1912. The quantity of coal shot from the solid in 1913 was 612,132 tons, or 25 per cent of the total, and the quantity mined by hand was 1,494,996 tons, or 62 per cent of the total. The number of machines reported for 1913 was 24, of which 20 were punchers, 3 long-wall, and 1 short-wall.

In order to improve the quality of the coal sent to market from the mines at Eagle Pass, washing plants have been installed, and the output is considerably beneficiated thereby. In 1913 the quantity of coal washed was 28,701 tons, which yielded 21,761 tons of cleaned coal and 6,940 tons of refuse, the latter amounting to a little over 30 per cent of the cleaned product. According to statistics collected by the Bureau of Mines, there were 4 fatal accidents in the coal and lignite mines of Texas in 1913, all underground, and 3 of them due to falls of roof and coal.

The statistics of production, by counties, in 1912 and 1913, with the distribution of the product for consumption, are shown in the following table. Owing to the fact that there are only one or two mines in each county, the counties producing lignite and bituminous coal, respectively, are combined.

Coal production of Texas in 1912 and 1913, in short tons.

1912.

County.	Loaded at mines for shipment.	Sold to local trade and used by employees.	Used at mines for steam and heat.	Total quantity.	Total value.	Average price per ton.	Average number of days active.	Average number of employees.
Bituminous:								
Eastland, Erath, Maverick, Palo Pinto, Webb, Wise, Young	1,153,231	8,688	35,988	1,197,907	$2,774,956	$2.31	248	3,518
Lignite:								
Bastrop, Fayette, Hopkins, Houston, Lee, Leon, Medina, Milam, Robertson, Titus, Wood	931,023	33,072	26,610	990,705	880,788	.89	191	1,609
Total	2,084,254	41,760	62,598	2,188,612	3,655,744	1.67	230	5,127

1913.

County.	Loaded at mines for shipment.	Sold to local trade and used by employees.	Used at mines for steam and heat.	Total quantity.	Total value.	Average price per ton.	Average number of days active.	Average number of employees.
Bituminous:								
Eastland, Erath, Maverick, Palo Pinto, Webb, Wise, Young	1,214,063	7,700	26,225	1,247,988	$3,184,161	$2.55	261	3,538
Lignite:								
Bastrop, Fayette, Henderson, Hopkins, Houston, Lee, Leon, Medina, Milam, Robertson, Titus, Wood	1,144,515	4,488	32,153	1,181,156	1,104,759	.94	235	1,563
Total	2,358,578	12,188	58,378	2,429,144	4,288,920	1.77	253	5,101

The coal areas of Texas belong to three of the geologic systems, the Carboniferous, the Cretaceous, and the Tertiary. The Carboniferous coals are found in the north-central part of the State and belong to the southwestern region of the Central Province. The principal mining operations are in Eastland, Palo Pinto, Erath, Wise, and Young counties, the mines in the last-mentlned county having been developed only within the last three years. Smaller quantities of coal have been mined in Bowie, Coleman, and McCulloch counties, but none was produced in these counties in 1913. The Cretaceous coals occur in the southern part of the State and are mined chiefly near Eagle Pass, in Maverick County. Although of Cretaceous age, the coals of this district, which extend into Mexico and are mined extensively at El Fenix, near Sabinas, and at Esperanzas, are classed as bituminous coals, and in the southern portions of the field in Mexico make a fair-grade coke. The lignite beds are of enormous extent and occur in a wide belt which stretches from the Sabine on the northeast to the Rio Grande on the southwest. Like the Cretaceous coals, these seem to improve in quality to the southwest, and near Laredo, in Webb County, the lignite is changed to a higher-grade coal, approaching cannel in character and classed as bituminous. The principal lignite operations have been carried on in Anderson, Bastrop, Fayette, Henderson, Hopkins, Houston, Lee, Leon, Medina, Milan, Rains, Robertson, Shelby, Titus, Van Zandt, and Wood counties, but no production was reported from Anderson, Rains, Shelby, and Van Zandt counties in 1913.

The development of the lignite resources of Texas began in the closing decade of the nineteenth century, and except for a temporary setback in 1902 and 1903, following the discovery of petroleum near Beaumont, has progressed steadily with the development and growth in population.

As stated with regard to the utilization of the lignites of North Dakota, lignite is found to be an excellent fuel for the gas producer, and the vast resources of Texas in this regard possess great potentialities for the future.

The first record of the production of bituminous coal in Texas is contained in the volume, Mineral Resources of the United States, 1884. The quantity mined was 125,000 tons. The total production of lignite and bituminous coal in 1913 was almost twenty times the output of 1884, and the 30 years' growth of the coal-mining industry in Texas is exhibited in the following table:

Coal production of Texas from 1884 to 1913, in short tons.

Year.	Quantity.	Year.	Quantity.	Year.	Quantity.	Year.	Quantity.
1884	125,000	1892	245,690	1900	968,373	1908	1,895,377
1885	100,000	1893	302,206	1901	1,107,953	1909	1,824,440
1886	100,000	1894	420,848	1902	901,912	1910	1,892,176
1887	75,000	1895	484,959	1903	926,759	1911	1,974,593
1888	90,000	1896	544,015	1904	1,195,944	1912	2,188,612
1889	128,216	1897	639,341	1905	1,200,684	1913	2,429,144
1890	184,440	1898	686,734	1906	1,312,873		
1891	172,100	1899	883,832	1907	1,648,069	Total	26,649,290

UTAH.

Total production in 1913, 3,254,828 short tons; spot value, $5,384,127.

The coal production of Utah in 1912 exceeded for the first time a total of 3,000,000 tons, the output in that year amounting to 3,016,149 short tons, valued at $5,046,451, a gain of more than half a million tons and of nearly $800,000 over 1911. Nearly a quarter of a million tons more (238,679) were added in 1913, with an increase in value of $337,676. The percentages of increase were 7.9 in quantity and 6.7 in value, the average value per ton showing a decline from $1.67 to $1.65. In 1912 the industry suffered from a scarcity of labor due to the exodus of foreign miners to the scene of war in the Balkan States. The returns for 1913 indicate a plentiful supply of labor, with an increase of more than 800 employed in the coal mines as compared with the preceding year.

The increased production in 1913 over 1912 appears to have been due principally to activity among the metalliferous mines and the smelting industry, as nearly all of the increased production was in the quantity of coal made into coke, this item alone indicating a gain of 225,461 short tons out of a total increase of 238,679 tons.

Nearly 90 per cent of the total coal production of Utah is mined in Carbon County, which contains a large part of the great Uinta Basin. This county produced in 1913 2,830,102 short tons out of a total for the State of 3,254,828 tons. Its gain in 1913 over 1912 was 145,371 tons. Carbon County is the only one in the State in which coke is made. The combined output of Emery and Grand counties, with a small local production from Sevier County, was 314,915 tons in 1913, a gain of 102,097 tons over 1912.

The efficiency record of the Utah miners shows a considerable falling off in 1913 as compared with other recent years. There were 4,158 men employed in 1913 for an average of 273 days and the average output per man was 783 tons for the year and 2.87 tons for each working day. In 1912, 3,328 men worked an average of 285 days and produced an average per man of 906 tons for the year and 3.18 tons per day. In 1911 the average production was 821 tons and 3.48 tons, respectively. The decreased production per man in 1913 was in spite of a marked increase in the use of machines and in the quantity and percentage of coal mined by them. In 1912 there were only 13 machines in use and the quantity of machine-mined coal was 114,716 tons, or less than 4 per cent of the total. In 1913 there were 50 machines in use and the quantity of coal mined by them was 625,475 tons, or nearly 20 per cent of the total. All but one of the new installations were short-wall machines, the number of this type increasing from 2 to 38. Punchers numbered 5 in both years and chain-breast machines increased from 6 to 7.

The industry was practically free from labor troubles in 1913, only one company reporting idleness from this cause and only 5 men were disaffected. No strikes of any kind were reported in 1912 and only one of 3 days in 1911. Practically all the mines of the State work 8 hours a day.

According to statistics collected by the Bureau of Mines there were 17 fatal accidents in the coal mines of Utah in 1913, a decrease of 1 from 1912. Eleven of the fatalities occurred underground, 1 in a shaft, and 5 on the surface. There were no gas or dust explosions, and all of the deaths occurred singly. Mine cars and locomotives claimed 9 of the 17 victims, 6 underground and 3 on the surface. The death rate per thousand was 4.1, against 5.4 in 1912, and the number of tons mined for each life lost was 191,460, against 167,064.

The statistics of production, by counties, in 1912 and 1913, with the distribution of the product for consumption, are as follows:

Coal production of Utah in 1912 and 1913, by counties, in short tons.

1912.

County.	Loaded at mines for shipment.	Sold to local trade and used by employees.	Used at mines for steam and heat.	Made into coke.	Total quantity.	Total value.	Average price per ton.	Average number of days active.	Average number of employees.
Carbon	2,232,803	15,536	91,666	344,726	2,684,731	$4,429,857	$1.65	290	2,936
Emery and Grand	201,434	8,021	3,363		212,818	425,547	2.00	278	201
Summit	94,276	2,309	11,272		107,857	164,267	1.52	211	175
Uinta		6,700	100		6,800	17,560	2.58	208	16
Small mines		3,943			3,943	9,220	2.34		
Total	2,528,513	36,509	106,401	344,726	3,016,149	5,046,451	1.67	285	3,328

1913.

County.	Loaded at mines for shipment.	Sold to local trade and used by employees.	Used at mines for steam and heat.	Made into coke.	Total quantity.	Total value.	Average price per ton.	Average number of days active.	Average number of employees.
Carbon	2,134,669	29,442	95,804	570,187	2,830,102	$4,661,865	$1.65	279	3,545
Emery, Grand, and Sevier	300,994	7,774	6,147		314,915	537,083	1.71	253	460
Summit	91,447	2,202	8,893		102,542	166,521	1.62	192	138
Uinta		5,433	52		5,485	14,435	2.63	218	15
Small mines		1,784			1,784	4,223	2.37		
Total	2,527,110	46,635	110,896	570,187	3,254,828	5,384,127	1.65	273	4,158

The production by counties during the last five years, with increase and decrease in 1913 as compared with 1912, has been as follows:

Coal production of Utah, 1909–1913, by counties, in short tons.

County.	1909	1910	1911	1912	1913	Increase(+) or decrease (−), 1913.
Carbon	2,125,789	2,311,749	2,264,038	2,684,731	2,830,102	+ 145,371
Emery	1,690	40,657	[a] 120,256	[b] 212,818	[c] 314,915	+ 102,097
Morgan, Sanpete	2,000					
Summit, Uinta	134,838	163,193	126,228	114,657	108,027	− 6,630
Small mines	2,582	2,210	2,653	3,943	1,784	− 2,159
Total	2,266,899	2,517,809	2,513,175	3,016,149	3,254,828	+ 238,679
Total value	$3,751,810	$4,224,556	$4,248,666	$5,046,451	$5,384,127	+$337,676

[a] Includes Sanpete County. [b] Includes Grand County. [c] Includes Grand and Sevier counties.

The coal fields of Utah are important and widely distributed over the State. The areas known to contain workable beds of coal aggregate about 13,130 square miles, in addition to which there are about 2,000 square miles less known but which may contain workable coal. The largest and commercially the most important coal field in Utah is that of the great Uinta Basin, which lies parallel with and along the southern side of the Uinta Mountains. The field extends from Crested Butte about one-third of the way across Colorado on the east, to the western part of Carbon and Emery counties in Utah on the west. In Utah this basin underlies a large portion of Uinta, Wasatch, and Carbon counties, its southern border being in Grand, Emery. and Sevier counties. The coal-bearing rocks are exposed along the northern rim of the basin, but this portion of the area is far removed from transportation and has been little developed. The most important coal field is on the southern rim of the basin in the Book Cliffs of western Colorado and eastern Utah. For this reason the productive area in Utah is generally known as the Book Cliffs field. The principal mining operations are carried on in Carbon County, at Castle Gate, Sunnyside, Clear Creek, Winter Quarters, Black Hawk, Hiawatha, Kenilworth, and Pleasant Valley, more than 85 per cent of the total production of the State (2,830,102 tons in 1913) being from Carbon County. The output of Emery and Grand counties (314,715 tons in 1913) is from the same field, and if this be added to the Carbon County production the percentage of Utah's output from this area is approximately 97 per cent. A large field in the southern part of the State underlies considerable portions of Garfield, Kane, and Iron counties, and a small section in the eastern part of Washington County. This area has not been developed on a commercial scale, as it is not at present reached by any railroad and has been opened only for small local consumption. A small area in Summit County, in the northern part of the State, known as the Weber field, although only a few miles in extent in Utah, has been commercially developed, as it is convenient to the markets of Ogden and Salt Lake City. Summit County's production exceeds 100,000 tons annually, having been 107,857 short tons in 1912 and falling off to 102,542 tons in 1913. There are several other small areas in Sanpete, Sevier, and Wayne counties. An insignificant amount of coal has been mined in Sanpete County, but the other areas are practically untouched.

The Ninth United States Census recorded the first production of coal in Utah with an output of 5,800 tons. Ten years later the production amounted to less than 15,000 tons. It assumed some importance in 1882, when the production amounted to 100,000 tons and reached the million-ton mark in 1900. In 1909 it exceeded 2,000,000 tons.

The annual production since 1870 has been as follows:

Annual production of coal in Utah, 1870–1913, in short tons.

Year.	Quantity.	Year.	Quantity.	Year.	Quantity.	Year.	Quantity.
1870	5,800	1882	100,000	1894	431,550	1906	1,772,551
1871	....	1883	200,000	1895	471,836	1907	1,947,607
1872	....	1884	200,000	1896	418,627	1908	1,846,792
1873	....	1885	213,120	1897	521,560	1909	2,266,899
1874	....	1886	200,000	1898	593,709	1910	2,517,809
1875	....	1887	180,021	1899	786,049	1911	2,513,175
1876	50,400	1888	258,961	1900	1,147,027	1912	3,016,149
1877	50,400	1889	236,651	1901	1,322,614	1913	3,254,828
1878	67,200	1890	318,159	1902	1,574,521		
1879	50,000	1891	371,045	1903	1,681,409	Total	34,252,834
1880	14,748	1892	361,013	1904	1,493,027		
1881	52,000	1893	413,205	1905	1,332,372		

VIRGINIA.

Total production in 1913, 8,828,068 short tons; spot value, $8,952,653.

Virginia exceeded all previous records in 1913 in the quantity of coal produced, and for the first time in six years the value of the output per ton exceeded $1. The chapter added to the history of coal mining in Virginia by the record of 1913 is an interesting one. The quantity of coal produced exceeded that of 1912 by 981,430 short tons, or 12.5 per cent, with a gain in value of $1,434,077, or 19.1 per cent; the quantity of coal mined by machines increased a little over a million tons; the average number of working days was exceptionally large; the average production per man reached nearly a thousand tons for the year; the quantity of coal shot off the solid was reduced nearly a million tons, as compared with 1912; the number of fatal accidents was reduced by a little more than two-thirds, and there was not a single strike or lockout reported. This record bears on its face the evidence that the year was exceptionally gratifying to both operators and employees.

As in 1912, the principal increase in 1913 was in Wise County, whose output showed an advance of 603,385 tons, or more than 60 per cent of the total increase. In 1912 Wise County contributed more than 75 per cent of the total increase, and during the last six years there has not been an exception to a steady increase in the production from that county. Russell County, the latest in which coal-mining operations have been developed (having been opened up by the completion in 1908 of the Carolina, Clinchfield & Ohio Railway from Dante, Va., to Spartanburg, S. C.), increased its putput in 1913 more than 200,000 tons over that of the preceding year; and Tazewell County, the oldest of the important producing counties in southwest Virginia, had an increase of 145,308 tons. Lee County showed only a small gain (12,039 tons).

In the reports for 1911 and 1912 mention was made of the unfavorable comparison made by Virginia with the other States of the Appalachian province in the quantity and percentage of coal shot off the solid. A marked improvement in that respect is presented in the present report. In 1912 the powder-mined coal amounted to 3,741,533 short tons, or 47.7 per cent of the total; in 1913 that item was reduced to 2,879,108 tons, or 32.6 per cent of the total. The quantity of machine-mined coal on the other hand increased from 3,205,504 tons, or 40.8 per cent of the total, in 1912, to 4,206,988 tons, or 47.6 per cent of the total, in 1913. The number of machines in in use in 1913 was 187 (against 185 in 1912), of which 106 were chain-breast, 76 were short-wall, 1 was long-wall, and 4 were punchers. The quantity of coal mined by hand was 1,740,485 short tons in 1913, against 898,821 in 1912.

For several years Virginia has stood relatively high in the quantity of coal produced by each man employed, and 1913 was no exception to the rule. The number of men employed in the coal mines of the State increased from 8,678 in 1912 to 9,162 in 1913, and the average working time from 251 days to 280. The average production per man in 1912 was 904 tons, and in 1913 it was 964 tons. The average daily production per man was slightly less in 1913, being 3.44 tons against 3.6 tons in 1912.

The most gratifying part of the record of 1913 was in the reduction of the number of fatal accidents, as shown by the report of the bureau of mines. In 1912 there were 75 men killed in the coal mines of Virginia and the death rate per thousand was 8.6—unfortunately high; in 1913 there were 24 fatalities and the death rate per thousand was 2.6. The quantity of coal mined for each life lost in 1913 was 367,836 tons against 104,622 tons in 1912.

The statistics of production, by counties, in 1912 and 1913, with the distribution of the product for consumption, are shown in the following table:

Coal production of Virginia in 1912 and 1913, in short tons.

1912.

County.	Loaded at mines for shipment.	Sold to local trade and used by employees.	Used at mines for steam and heat.	Made into coke.	Total quantity.	Total value.	Average price per ton.	Average number of days active.	Average number of employees.
Lee	718,570	5,245	15,725	11,736	751,276	$875,092	$1.16	269	1,081
Tazewell	1,057,788	26,369	36,805	181,081	1,302,043	1,318,762	1.01	203	1,367
Wise	3,008,443	65,277	90,872	1,335,582	4,500,174	4,094,905	.91	261	4,451
Other counties [a] and small mines	1,242,911	10,766	39,468	....	1,293,145	1,229,817	.95	252	1,779
Total	6,027,712	107,657	182,870	1,528,399	7,846,638	7,518,576	.96	251	8,678

1913.

County.	Loaded at mines for shipment.	Sold to local trade and used by employees.	Used at mines for steam and heat.	Made into coke.	Total quantity.	Total value.	Average price per ton.	Average number of days active.	Average number of employees.
Lee	704,941	7,509	20,637	30,228	763,315	$874,674	$1.15	263	1,023
Tazewell	1,207,487	22,938	31,966	184,960	1,447,351	1,610,548	1.11	236	1,460
Wise	3,236,005	35,260	94,119	1,738,175	5,103,559	4,899,390	.96	291	4,933
Other counties [a] and small mines	1,467,048	17,725	29,070	....	1,513,843	1,568,041	1.04	296	1,746
Total	6,615,481	83,432	175,792	1,953,363	8,828,068	8,952,653	1.01	280	9,162

[a] Henrico, Montgomery, Pulaski, and Russell.

The statistics of production, by counties, for the last five years, with increase and decrease in 1913 as compared with 1912, are shown in the following table:

Coal production of Virginia, 1909–1913, by counties, in short tons.

County.	1909	1910	1911	1912	1913	Increase (+) or decrease (−), 1913.
Lee	....	797,096	720,695	751,276	763,315	+ 12,039
Tazewell	975,665	1,187,146	1,281,224	1,302,043	1,447,351	+ 145,308
Wise	2,841,448	3,730,992	3,754,360	4,500,174	5,103,559	+ 603,385
Russell	[a] 931,276	[b] 790,066	[b] 1,107,056	[b] 1,292,365	[b] 1,512,356	+ 219,991
Small mines	3,828	2,697	1,332	780	1,487	+ 707
Total	4,752,217	6,507,997	6,864,667	7,846,638	8,828,068	+ 981,430
Total value	$4,251,056	$5,877,486	$6,254,804	$7,518,576	$8,952,653	+$1,434,077

[a] Includes Lee, Montgomery, and Pulaski counties.
[b] Includes Henrico, Montgomery, and Pulaski counties.

The coal areas of Virginia which have produced or are producing coal belong to (1) the Atlantic coast region, which includes the Richmond Basin covering portions of Henrico, Chesterfield, Powhatan, Goochland, and Amelia counties, and a small area in Prince Edward, Cumberland, and Buckingham counties; (2) the Appalachian region which includes a number of separate areas extending across the western part of the State from Frederick County on the north to the Tennessee line on the south. The Richmond Basin is the only area of free-burning coal located immediately adjacent to the Atlantic seaboard. The first coal mined in the United States was from this area, mines having been opened and worked as early as 1750. The coal areas of the Appalachian region in Virginia include a portion of the Pocahontas or Flat Top, and the Big Stone Gap or Clinch Valley, fields of Tazewell, Russell, Wise, Lee, Scott, Dickenson, and Buchanan counties. It also embraces small scattered areas in Frederick, Augusta, Botetourt, Bland, and Wythe counties, which are nonproductive at present, and two areas in Montgomery and Pulaski counties. Coal mining in the last two counties was carried on to a limited extent prior to the Civil War. During the period that the zinc smelter at Bertha was in operation (the smelter was abandoned in 1911) the coal mines of Pulaski County were worked by the smelter company for its own fuel. The production at the present time amounts to between 25,000 and 40,000 tons a year. The Montgomery County production is for relatively local consumption, though a considerable amount of development work has been done by the Virginia Anthracite Coal Co.

Coal mining on an extensive scale in southwestern Virginia began with the completion of the New River division of the Norfolk & Western Railway in 1883, which opened the Pocahontas coal field. Ten years later the completion of the Clinch Valley branch of the same line permitted the development of the Wise County coal field. There were no other new developments in Virginia until 1905 when with the construction of the Virginia & Southwestern Railway from Bristol to Pennington Gap and Appalachia the Black Mountain district of Lee County was made available. The first shipments were made from this district in 1907. Lee County is now producing at the rate of 750,000 tons a year. The latest field to be developed is in Russell County, opened by the completion in 1908 of the Carolina, Clinchfield & Ohio Railway from Dante, Va., to Spartanburg, S. C. Russell County's production has increased from about 220,000 tons in 1908 to nearly 1,500,000 tons in 1913.

During the last four years new life has been introduced into the Richmond Basin areas by the reopening of the old Gayton mines in Henrico County. For many years after the opening of the southwest Virginia and the southern West Virginia coals the mines of the Richmond Basin lay idle or were worked only for a restricted local market. A considerable tonnage was reported for each of the last two years.

The annual production of Virginia from 1822 to the close of 1913 is shown in the following table:

Production of coal in Virginia from 1822 to 1913, in short tons.

Year.	Quantity.	Year.	Quantity.	Year.	Quantity.	Year.	Quantity.
1822	54,000	1846	340,000	1870	61,803	1894	1,229,083
1823	60,000	1847	325,000	1871	70,000	1895	1,368,324
1824	67,040	1848	318,000	1872	69,440	1896	1,254,723
1825	75,000	1849	315,000	1873	67,200	1897	1,528,302
1826	88,720	1850	310,000	1874	70,000	1898	1,815,274
1827	94,000	1851	310,000	1875	60,000	1899	2,105,791
1828	100,080	1852	325,000	1876	55,000	1900	2,393,754
1829	100,000	1853	350,000	1877	50,000	1901	2,725,873
1830	102,800	1854	370,000	1878	50,000	1902	3,182,993
1831	118,000	1855	380,782	1879	45,000	1903	3,451,307
1832	132,000	1856	352,687	1880	43,079	1904	3,410,914
1833	125,000	1857	363,605	1881	50,000	1905	4,275,271
1834	124,000	1858	377,690	1882	112,000	1906	4,254,879
1835	120,000	1859	359,055	1883	252,000	1907	4,710,895
1836	124,000	1860	473,360	1884	336,000	1908	4,259,042
1837	160,000	1861	445,165	1885	567,000	1909	4,752,217
1838	300,000	1862	445,124	1886	684,951	1910	6,507,997
1839	396,000	1863	a 40,000	1887	825,263	1911	6,864,667
1840	424,894	1864	40,000	1888	1,073,000	1912	7,846,638
1841	379,600	1865	40,000	1889	865,786	1913	8,828,068
1842	373,640	1866	40,000	1890	784,011		
1843	370,000	1867	50,000	1891	736,399	Total	96,287,781
1844	365,000	1868	59,051	1892	675,205		
1845	350,000	1869	65,000	1893	820,339		

a West Virginia separated from Virginia.

WASHINGTON.

Total production in 1913, 3,877,891 short tons; spot value, $9,243,137.

For the first time in three years the coal production of Washington showed an increase over that of the preceding year. The increase over 1912 was substantial, amounting to 516,959 short tons, or 15.38 per cent, in quantity, with a gain of $1,200,266, or 14.92 per cent, in value. Even this increase, however, did not bring the output up to the record made in 1910, when the maximum product of 3,911,899 tons was mined. It indicates, nevertheless, a recovery from the depressed condition into which coal mining in Washington was forced in 1911 and 1912 by the competition of California petroleum as a railroad and manufacturing fuel. The use of petroleum continues, but the increase in population, improved business conditions, and a strike of several months' duration in the coal mines of British Columbia, furnished a better market for Washington coal in 1913 than was experienced in 1911 and 1912. The slightly lower values in 1913 (the average value per ton declining from $2.39 to $2.38) were due rather to the ability of operators to dispose of some of the less desirable grades than to any actual decline in price. In 1912 the average value per ton was 10 cents higher than in 1911, although demand was light and production decreased over 200,000 tons, the fact being that in 1912 such demand as existed was largely for domestic consumption, which preferred higher grades of screened coal, and left the slack and lower grades a drug on the market. It did not necessarily mean a better return to the operators on the gross production of the mines. Conversely, the slightly lower values in 1913 probably resulted in actually better returns per ton of coal mined than was obtained in 1912. The generally improved tone in the coal-mining business of the State in 1913 is shown by the fact that increased production was made in every county. The largest gain was made in King County, whose output increased 310,589 tons, or nearly 30 per cent, over that of 1912. The quantity of coal made into coke, all from Pierce County, increased from 76,741 tons to 118,698 tons. Most of the coke goes to the smelter at Tacoma.

The number of men employed in the coal mines of Washington increased from 5,519 to 5,794, and the average working time increased from 226 to 260 days. The average production per man was 669 tons for the year, and 2.57 tons for each working day in 1913, compared with 609 tons and 2.69 tons, respectively, in 1912. There were 1,239 men on strike during 1913, with an average lost time of 49 days. The total time lost was about 4 per cent of the total time made.

Of the total production of coal in 1913, 2,120,257 tons, or 55 per cent, were mined by hand; 1,465,248 tons, or 38 per cent, were powder-mined, or shot off the solid, and 280,515 tons, or 7 per cent, were mined by machines, of which 63 were reported in use. All but two of the machines in use were of the radialaxe, or post-puncher type, which is best adapted to the steep inclination of most of the coal beds. The two exceptions consisted of one puncher and one short-wall machine, in the Roslyn field, where the bed lies relatively flat.

Probably a larger percentage of coal is washed in the State of Washington than in any other coal-producing State. In 1913

1,643,282 tons, or 42 per cent of the total, were washed, yielding 1,343,120 tons of cleaned coal and 300,162 tons of refuse.

Reports to the Bureau of Mines show that there were 22 fatalities among the coal miners of Washington in 1913. Of that number, 21 were underground, and 1 was in a shaft. Seven of the accidents underground were due to falls of roof, 4 to mine cars and locomotives, 5 to gas explosions, and 5 to other causes. The death rate per thousand was 3.8, and there were 176,268 tons of coal mined for each life lost.

The statistics of production, by counties, in 1912 and 1913, with the distribution of the product for consumption, are shown in the following table:

Coal production of Washington in 1912 and 1913, by counties, in short tons.

County.	Loaded at mines for shipment.	Sold to local trade and used by employees.	Used at mines for steam and heat.	Made into coke.	Total quantity.	Total value.	Average price per ton.	Average number of days active.	Average number of employees.
1912.									
King	942,296	51,266	69,548	....	1,063,110	$2,329,397	$2.19	232	1,891
Kittitas	1,182,704	14,541	40,182	....	1,237,427	3,371,651	2.72	188	1,737
Lewis	114,751	8,646	4,980	....	128,377	240,541	1.87	178	244
Pierce	660,985	4,712	45,855	76,741	788,293	1,864,838	2.37	275	1,477
Other counties *a*	140,541	1,130	2,054	....	143,725	236,444	1.65	172	170
Total	3,041,277	80,295	162,619	76,741	3,360,932	8,042,871	2.39	226	5,519
1913.									
King	1,278,813	22,659	72,227	....	1,373,699	$3,198,662	$2.33	277	2,280
Kittitas	1,273,353	16,831	43,971	....	1,334,155	3,600,900	2.70	228	1,587
Lewis	128,528	16,433	6,485	....	151,446	266,408	1.76	196	241
Pierce	681,534	6,104	50,089	118,698	856,425	1,919,254	2.24	286	1,499
Other counties *a*	158,326	675	3,165	....	162,166	257,913	1.59	209	187
Total	3,520,554	62,702	175,937	118,698	3,877,891	9,243,137	2.38	260	5,794

a Thurston and Whatcom.

The statistics of production, by counties, during the last five years, with increase in 1913 as compared with 1912, are shown in the following table:

Production of coal in Washington, 1909–1913, in short tons.

County.	1909	1910	1911	1912	1913	Increase, 1913.
King	1,216,012	1,242,340	1,259,521	1,063,110	1,373,699	310,589
Kittitas	1,550,539	1,661,650	1,256,745	1,237,427	1,334,155	96,728
Lewis	121,573	179,484	172,734	128,377	151,446	23,069
Pierce	609,467	786,096	783,196	788,293	856,425	68,132
Other counties	*a* 104,672	42,329	100,619	143,725	162,166	18,441
Total	3,602,263	3,911,899	3,572,815	3,360,932	3,877,891	516,959
Total value	$9,158,999	$9,764,465	$8,174,170	$8,042,871	$9,243,137	$1,200,266

a Includes small mines.

The coals of Washington, although limited to six or seven somewhat scattered areas in the western half of the State, chiefly along the eastern border of Puget Sound, have a wide range in character. Lignites occur in the southwestern part of the State in Cowlitz, Lewis, and Thurston counties; and in Lewis County, as the measures approach the mountians, the coal grades into subbituminous and bituminous quality. The areas along Puget Sound contain subbituminous and bituminous coals, some of the latter possessing fair coking quality, and in the northwestern part of the State on the slopes of Mount Baker in Whatcom County anthracite has been reported. Some natural coke has been observed. The coking coals of Washington are the only ones of that grade on the Pacific coast. They are found in the Wilkeson-Carbonado district in Pierce County, in the North Puget Sound field in Skagit and Whatcom counties, and in the northern part of the Roslyn field in Kittitas County; but at present coke is made only in the Wilkerson-Carbonado district. This coal is somewhat high in ash and is usually washed before coking. The smelter at Tacoma takes most of the coke. The coal areas are divided into four principal fields known as (1) the North Puget Sound, including the counties of Whatcom and Skagit; (2) the South Puget Sound, containing the operations in King and Pierce counties; (3) the Roslyn field, in Kittitas County; and (4) the Southwestern field, embracing the counties of Cowlitz, Lewis, and Thurston. Two small subbituminous areas, one just east of Everett in Snohomish County, and the other in the northeastern part of King County, are not mined at the present time. The coal-mining industry of Washington has suffered considerably during the last few years from the competition of fuel oil from California, the Puget Sound steamers (the former principal consumers of Washington coal) and the railroads having adopted petroleum for fuel. Even the railroads that have their own coal mines immediately on their lines are using oil for their locomotives, particularly through the forested areas where the sparkless character of that fuel gives protection against fire. The cleanliness of the liquid fuel and its greater economy in labor give it a decided advantage over coal as a steam fuel on the Sound steamers.

The consumption of California oil for fuel in 1913 was approximately 63,000,000 barrels, equivalent to about four and one-half times the total production of coal in the Pacific coast States. It is estimated that the consumption of fuel oil in markets tributary to the coal mines in Washington displaced 5,000,000 tons of coal. The railroads alone used nearly 4,000,000 barrels of oil, equivalent to 1,150,000 tons of coal, or about half of the coal production of the State in 1913.

Coal was first discovered in Washington in 1848, when a lignite of rather low grade was found in the Cowlitz Valley. Four years later bituminous coal was discovered on Bellingham Bay, Whatcom County, and the first mine in the State was opend on this bed. Shipments did not begin, however, until 1860. This mine was operated continuously from 1860 until 1878, when on account of a fire caused by spontaneous combustion the workings were abandoned, and they have not since been reopened. Shipments were not resumed from any of the mines in the northern district until 13 years later in 1891. Coal was discovered in King County in 1859, and mining began near the present Issaquah in 1862. Shipments to San Francisco began in 1871, since which time the Washington mines have been an important source of coal supply to the San Francisco market. About the same time the Talbot and the Renton mines, which are in King County, began shipping, and rail connection between the Renton mines and Seattle was obtained in 1877. Production in the Green River district, also in King County, began between 1880 and 1885; and the Pierce County fields, which had been opened in 1875 and afterwards abandoned, again began shipping about the same time.

The Roslyn mines, on the east side of the Cascade Range, were opened in the first half of the same decade. The Bellingham Bay mines in the first year of their recorded production, 1860, shipped 5,374 tons. Washington's maximum output of coal was 3,911,899 short tons, made in 1910.

The production of coal in Washington since 1860, when the industry in the State began, has amounted to 64,459,440 short tons, as shown in the following table:

Production of coal in Washington, 1860–1913, in short tons.

Year.	Quantity.	Year.	Quantity.	Year.	Quantity.	Year.	Quantity.
1860	5,374	1874	30,352	1888	1,215,750	1902	2,681,214
1861	6,000	1875	99,568	1889	1,030,578	1903	3,193,273
1862	7,000	1876	110,342	1890	1,263,689	1904	3,137,681
1863	8,000	1877	120,896	1891	1,056,249	1905	2,864,926
1864	10,000	1878	131,660	1892	1,213,427	1906	3,276,184
1865	12,000	1879	142,666	1893	1,264,877	1907	3,680,532
1866	13,000	1880	145,015	1894	1,106,470	1908	3,024,943
1867	14,500	1881	196,000	1895	1,191,410	1909	3,602,263
1868	15,000	1882	177,340	1896	1,195,504	1910	3,911,899
1869	16,200	1883	244,990	1897	1,434,112	1911	3,572,815
1870	17,844	1884	166,936	1898	1,884,571	1912	3,360,932
1871	20,000	1885	380,250	1899	2,029,881	1913	3,877,891
1872	23,000	1886	423,525	1900	2,474,093		
1873	26,000	1887	772,601	1901	2,578,217	Total	64,459,440

WEST VIRGINIA

Total production in 1913, 71,308,982 short tons; spot value, $71,872,165.

With a production in 1913 exceeding for the first time in its history a total of 70,000,000 tons, West Virginia became firmly established the second in rank among the coal-producing States. Compared with 1912, when the output of coal amounted to 66,786,687 short tons, up to that time the record tonnage, the quantity produced in 1913 showed a gain of 4,522,295 short tons, or 6.77 per cent. The increased production was accompanied by a considerably larger gain in value, which showed an increase over 1912 of $9,079,931, or 14.46 per cent. The average value per ton for the first time in 10 years and for the fifth time in the last 25 years, exceeded $1. The increased production in 1913 was in spite of the fact that the labor troubles in the Paint Creek and Cabin Creek districts of the Kanawha field which began in the early part of 1912, were not settled until well into the spring of 1913, and unprecedented floods in the Ohio Valley (also in the spring of the year) reduced shipments to the west for a considerable length of time. A few of the mines that were closed by the strike were not reopened during 1913, and the total production from the two districts affected was much below the normal output. The deficiency from these districts, however, was more than offset by the gains in other districts, and Kanawha County itself, in which the affected districts are located, showed an increase in 1913 over 1912 of nearly 260,000 tons. The increased production was well distributed over the State, there being but 3 counties out of 30 whose output is published, in which decreases were shown. These 3 counties were relatively small producers and the total decrease was less than 70,000 tons. The principal increases were made in McDowell County, 689,158 tons; Raleigh County, 563,364 tons, Logan County, 556,772 tons; and Harrison County, 412,665 tons, all but Harrison County being in the southern part of the State.

Of the total increase of over 4,500,000 tons, the quantity of coal made into coke in 1913 made up only 75,585 tons, indicating that coke manufacture in the State fell relatively behind. This does not mean, however, that less coke is being made from West Virginia coal. Large quantities of West Virginia coal are made into coke in ovens (principally of the retort type) located outside the State, and in 1913 the coal shipped from West Virginia mines for coking at distant ovens was about twice as much as that used for the same purpose in the State.

Notwithstanding the increased production and improved prices in 1913, the year was not a satisfactory one to the operators, and the situation has been described as feverish. The labor difficulties were followed by an investigation by a committee from the United States Senate, and when the legislature met in January nearly 50 bills (most of which the operators considered prejudicial to the industry) were introduced and some of them became laws. One of the bills, not in itself of the prejudicial class, was a workman's compensation bill, enacted in February, which provided that 1 per cent of the pay rolls should be paid into the compensation fund, 90 per cent by the employers and 10 per cent by the employees. During the year an amendment to the constitution of the State was adopted, which provides for the prohibition of the manufacture and sale of intoxicating liquors after July 1, 1914. This is expected to result in the exodus of some of the miners, but the operators are hopeful of replacing the deserters with a better class of labor, and it is believed that the improved accident record of 1913 will be continued with even better results after the State-wide prohibition goes into effect.

According to the Bureau of Mines, the number of fatal accidents in the coal mines of West Virginia showed a decrease of 22, from 359 in 1912 to 337 in 1913, although there was an increase of nearly 10 per cent in the number of men employed. There was no explosion of gas or dust in 1913, and 60 per cent of the fatalities, or 200 altogether, were caused by falls of roof or coal. Mine cars and locomotives killed 86; electric shocks and burns, 17, and explosions of powder, 8. Altogether 319 of the accidents occurred underground, 2 in shafts, and 16 on the surface. The death rate per thousand was 4.5 against 5.26 in 1912, and the quantity of coal mined for each life lost was 211,599 tons, against 186,035 tons in 1912.

Labor was in better supply in 1913 than for some years past, but not equal to the demand. The number of men employed in 1913 was 74,786, compared with 68,248 in 1912, but there was a decrease in the average working time, largely because of the strike, from 266 days to 234 days. The average production per man was 954 tons for the year, and 4.08 tons for each working day. In 1912 the corresponding averages were 979 and 3.68 tons. The gain in daily efficiency was due in no small degree to the increased use of mining machines. The quantity of coal mined by machines increased from 34,946,394 tons in 1912 to 39,410,264 tons, an increase of 4,453,870 tons, or within 60,000 tons of the total increased production. The number of machines in use increased from 2,253 to 2,541. Chain-breast machines constituted more than half of the total number, there being 1,364 of that type employed. Pick machines numbered 562; short-wall machines, including 7 Hess dustless machines, 365; long-wall machines, 231; and radialaxe or post-punchers, 19.

Labor troubles caused the loss of 377,405 working days, or an average of 43 days for 8,800 men idle. Only a small percentage of

West Virginia coal is washed before being sold or used. In 1913 the quantity of coal reported as washed was 1,580,819 short tons, which yielded 1,493,903 tons of cleaned coal, and 86,916 tons of refuse.

The statistics of production, by counties, in 1912 and 1913, with the distribution of the product for consumption, are shown in the following table:

Coal production of West Virginia in 1912 and 1913, by counties, in short tons.

1912.

County.	Loaded at mines for shipment.	Sold to local trade and used by employees.	Used at mines for steam and heat.	Made into coke.	Total quantity.	Total value.	Average price per ton.	Average number of days active.	Average number of employees.
Barbour	1,123,533	5,077	23,479	11,272	1,163,361	$845,877	$0.73	221	1,110
Boone	372,830	3,161	3,985	....	379,976	324,333	.85	210	397
Braxton	229,433	2,540	3,015	....	234,988	200,085	.85	189	205
Brooke	482,846	9,766	1,859	....	494,471	549,168	1.11	240	473
Clay	207,023	1,791	3,311	....	212,125	176,976	.83	209	277
Fayette	8,477,752	144,330	219,650	794,498	9,636,230	9,549,855	.99	227	11,983
Gilmer	69,675	6,060	1,000	....	76,735	68,887	.90	214	120
Harrison	5,092,440	18,603	53,503	7,226	5,171,772	4,173,029	.81	211	4,322
Kanawha	4,912,806	115,737	85,014	....	5,113,557	4,957,392	.97	181	7,040
Logan	4,121,966	29,390	45,388	....	4,196,744	3,779,439	.90	233	3,419
McDowell	13,634,755	216,618	302,588	1,655,328	15,809,289	15,384,767	.97	234	14,401
Marion	5,409,121	46,182	176,423	161,398	5,793,124	4,942,834	.85	258	4,603
Marshall	601,856	181,173	14,999	....	798,028	800,027	1.00	268	825
Mason	104,734	24,313	2,256	....	131,303	128,314	.98	134	327
Mercer	2,654,704	34,446	49,707	370,714	3,109,571	2,961,587	.95	231	3,010
Mineral	717,500	2,265	6,551	....	726,316	697,448	.96	206	922
Mingo	2,503,910	33,531	60,038	....	2,597,479	2,518,305	.97	231	3,300
Monongalia	299,318	6,538	3,612	100,111	409,579	325,820	.80	240	299
Ohio	320,067	90,860	1,567	....	412,494	408,384	.99	277	403
Preston	756,066	22,379	17,857	371,456	1,167,758	1,038,999	.89	243	1,303
Putnam	592,266	14,300	5,500	....	612,066	730,260	1.19	243	980
Raleigh	4,994,524	45,916	93,777	....	5,134,217	5,165,826	1.01	232	5,131
Randolph	379,609	10,421	8,677	217,703	616,410	527,913	.86	245	539
Taylor	836,922	5,370	7,688	21,872	871,852	655,989	.75	234	690
Tucker	1,171,351	8,572	40,725	49,930	1,270,578	1,242,301	.98	265	1,400
Upshur	40,659	4,133	1,082	13,456	59,330	46,966	.79	169	88
Other counties [a] and small mines	441,528	125,670	18,419	1,717	587,334	591,453	1.01	230	681
Total	60,549,194	1,209,142	1,251,670	3,776,681	66,786,687	62,792,234	.94	266	68,248

1913.

County.	Loaded at mines for shipment.	Sold to local trade and used by employees.	Used at mines for steam and heat.	Made into coke.	Total quantity.	Total value.	Average price per ton.	Average number of days active.	Average number of employees.
Barbour	1,350,250	5,700	27,547	31,804	1,415,301	$1,102,649	$0.78	227	1,234
Boone	438,735	2,845	4,276	....	445,856	457,594	1.03	232	454
Braxton	277,281	1,919	3,317	....	282,517	248,702	.88	220	237
Clay	364,572	2,348	4,376	....	371,296	344,301	.93	241	280
Fayette	8,686,215	181,899	227,256	848,657	9,944,027	10,367,363	1.04	249	12,729
Gilmer	89,602	2,635	1,100	....	93,337	96,316	1.03	211	151
Grant	204,729	851	17,465	....	223,045	204,228	.92	242	264
Harrison	5,482,959	13,635	53,347	34,496	5,584,437	4,718,287	.84	209	5,128
Kanawha	5,165,027	110,134	97,792	....	5,372,953	5,304,644	.99	209	7,493
Logan	4,595,398	91,405	64,214	2,499	4,753,516	4,544,140	.96	208	4,384
McDowell	14,417,048	199,716	284,838	1,596,845	16,498,447	17,713,909	1.07	234	16,276
Marion	5,678,643	25,903	190,766	157,360	6,052,672	5,497,820	.91	235	5,185
Marshall	663,471	183,708	18,870	....	866,049	889,251	1.03	263	929
Mason	104,356	40,593	3,742	....	148,691	155,266	1.04	219	291
Mercer	2,815,111	33,390	50,018	418,493	3,317,012	3,635,080	1.10	236	2,894
Mineral	841,709	2,820	6,946	....	851,475	807,075	.95	236	932
Mingo	2,592,347	32,882	65,189	....	2,690,418	2,878,750	1.07	242	2,965
Monongalia	239,248	26,968	5,137	123,287	394,640	340,649	.86	231	428
Ohio	346,613	64,544	1,483	....	412,640	435,824	1.06	276	407
Preston	978,594	16,376	34,552	302,385	1,331,907	1,303,143	.98	265	1,420
Putnam	600,676	13,700	8,400	....	622,776	765,304	1.23	266	1,036
Raleigh	5,503,813	91,765	102,003	....	5,697,581	6,393,590	1.12	243	5,842
Randolph	387,038	7,295	9,941	244,097	648,371	582,194	.90	249	516
Taylor	1,011,155	5,207	10,053	20,355	1,046,770	839,822	.80	264	815
Tucker	1,200,705	12,075	34,444	46,265	1,293,489	1,214,094	.94	238	1,324
Upshur	76,399	3,470	1,407	15,546	96,822	80,854	.84	227	94
Other counties [b] and small mines	700,630	135,380	6,750	10,177	852,937	951,316	1.12	259	1,078
Total	64,812,324	1,309,163	1,335,229	3,852,266	71,308,982	71,872,165	1.01	234	74,786

[a] Grant, Greenbrier, Hancock, Lewis, Lincoln, Nicholas, Wayne, and Webster.

[b] Brooke, Greenbrier, Hancock, Lewis, Lincoln, Nicholas, Wayne, Webster, and Wyoming.

The statistics of production, by counties, during the last five years, with increase and decrease in 1913 as compared with 1912, are shown in the following table:

Coal production of West Virginia, by counties, 1909-1913, in short tons.

County.	1909	1910	1911	1912	1913	Increase(+) or decrease (−), 1913.
Barbour	1,024,805	1,368,391	1,024,784	1,163,361	1,415,301	+ 251,940
Boone	....	....	160,523	379,976	445,856	+ 65,880
Braxton	105,714	167,123	209,167	234,988	282,517	+ 47,529
Brooke	380,887	470,674	451,430	494,471	448,255	− 46,216
Clay	43,212	44,602	146,713	212,125	371,296	+ 159,171
Fayette	9,877,521	10,410,983	9,976,784	9,636,230	9,944,027	+ 307,797
Gilmer	40,201	45,190	53,580	76,735	93,337	+ 16,602
Grant	190,575	283,072	209,530	199,926	223,045	+ 23,119
Hancock	75,633	71,211	49,200	2,980	7,435	+ 4,455
Harrison	3,385,291	4,641,304	4,241,098	5,171,772	5,584,437	+ 412,665
Kanawha	5,577,138	7,010,487	5,671,026	5,113,557	5,372,953	+ 259,396
Lincoln	51,227	71,917	81,770	67,212	58,740	− 8,472
Logan	2,147,965	2,896,328	3,149,671	4,196,744	4,753,516	+ 556,772
McDowell	11,964,836	13,488,076	13,386,749	15,809,289	16,498,447	+ 689,158
Marion	4,195,473	4,795,549	4,830,540	5,793,124	6,052,672	+ 259,548
Marshall	356,619	538,402	678,172	798,028	866,049	+ 68,021
Mason	117,209	221,217	201,943	131,303	148,691	+ 17,388
Mercer	2,511,000	2,876,834	2,924,714	3,109,571	3,317,012	+ 207,441
Mineral	892,245	883,586	610,727	726,316	851,475	+ 125,159
Mingo	2,039,640	2,442,630	2,341,000	2,597,479	2,690,418	+ 92,939
Monongalia	371,890	554,073	495,657	409,579	394,640	− 14,939
Nicholas	36,714	79,714	54,731	70,986	99,787	+ 28,801
Ohio	236,870	309,049	326,195	412,494	412,640	+ 146
Preston	996,767	1,164,382	870,447	1,167,758	1,331,907	+ 164,149
Putnam	575,009	540,632	568,222	612,066	622,776	+ 10,710
Raleigh	2,411,513	3,347,129	4,409,430	5,134,217	5,697,581	+ 563,364
Randolph	392,846	600,907	553,935	616,410	648,371	+ 31,961
Taylor	483,906	719,230	745,578	871,852	1,046,770	+ 174,918
Tucker	1,157,753	1,317,967	1,152,116	1,270,578	1,293,489	+ 22,911
Upshur	80,615	92,760	38,225	59,330	96,822	+ 37,492
Other counties and small mines	128,146	217,600	217,923	246,230	238,720	− 7,510
Total	51,849,220	61,671,019	59,831,580	66,786,687	71,308,982	+ 4,522,295
Total value	$44,661,716	$56,665,061	$53,670,515	$62,792,234	$71,872,165	+$9,079,931

The coal fields of West Virginia belong to the Appalachian region, all of the State west of the escarpment of the Allegheny Mountains being in the coal-bearing formation. The coal area contains about 17,000 square miles out of a total of 24,022 square miles in the State.

Nearly all of the production comes from seven principal mining districts, three in the northern part of the State and four in the southern part. The three principal districts in the northern part of West Virginia are the Fairmont (or Clarksburg), which includes Harrison and Marion counties; the Elk Garden (or Piedmont), which includes Mineral, Grant, and Tucker counties and is part of a detached basin extending northward into Maryland, where it is known as Georges Creek; and the Philippi district, which includes Preston, Barbour, and Randolph counties. The most important bed in the Fairmont and Elk Garden districts is the famous Pittsburgh, although in the Fairmont district the Waynesburg and the Sewickley coals are present, though but little worked, and in the Elk Garden the "Thomas" (Upper Freeport) and the "Davis" (Upper Kittanning) are present, both of which are extensively worked.

The four important districts in the southern part of the State are the New River, Kanawha, Pocahontas, and Big Sandy.

The New River district, as its name implies, is chiefly within the area drained by New River and its tributaries, but includes also the drainage areas of Slab Fork and Winding Gulf, tributaries of Guyandot River. The productive portions are in Fayette and Raleigh counties, though some of the coal mined in the western part of Fayette County belongs to the coal series of the Kanawha district. The principal beds worked are the Sewell, the Beckley, and the Quinnimont.

Most of the New River coal is a high-grade "smokeless" coking coal, much prized for its steaming as well as its coking quality.

The Kanawha district lies immediately west of the New River field. It includes all of Kanawha County and parts of Putnam and Boone counties. Eight different beds are worked, of which the Eagle and "No. 2 Gas" are the most important. The others are the Coalburg, North Coalburg, No. 5, Stockton, Winifrede, and Cedar Grove.

The Pocahontas district lies in the extreme southern corner of the State in McDowell and Mercer counties and extends across the State line into Tazewell County, Va. It produces the celebrated high-carbon Pocahontas steaming and coking coal, one of the purest coals in the United States, mined from the "No. 3" bed. Pocahontas No. 4 has been extensively developed in recent years. Other beds known locally as the War Creek (Beckley), the Welch, and the Davey (Sewell) are also mined.

The Big Sandy district, like the Philippi in the northern part of the State, has become of importance through recent development. It is really a continuation of the Kanawha field into Logan and Mingo counties, and the beds worked are those of the Kanawha district.

The coals of West Virginia are all of bituminous or semibituminous variety, and mostly high grade. Some cannel and a peculiar type known as splint are mined in the southern part of the State.

The statistics of coal production in West Virginia since 1863, when the State was formed out of Virginia, to the close of 1913 are shown in the following table:

Production of coal in West Virginia, 1863–1913, in short tons.

Year.	Quantity.	Year.	Quantity.	Year.	Quantity.	Year.	Quantity.
1863	444,648	1877	1,120,000	1891	9,220,665	1905	37,791,580
1864	454,888	1878	1,120,000	1892	9,738,755	1906	43,290,350
1865	487,897	1879	1,400,000	1893	10,708,578	1907	48,091,583
1866	512,068	1880	1,829,844	1894	11,627,757	1908	41,897,843
1867	589,360	1881	1,680,000	1895	11,387,961	1909	51,849,220
1868	609,227	1882	2,240,000	1896	12,876,296	1910	61,671,019
1869	603,148	1883	2,335,833	1897	14,248,159	1911	59,831,580
1870	608,878	1884	3,360,000	1898	16,700,999	1912	66,786,687
1871	618,830	1885	3,369,062	1899	19,252,995	1913	71,308,982
1872	700,000	1886	4,005,796	1900	22,647,207		
1873	1,000,000	1887	4,881,620	1901	24,068,402	Total	787,543,870
1874	1,120,000	1888	5,498,800	1902	24,570,826		
1875	1,120,000	1889	6,231,880	1903	29,337,241		
1876	896,000	1890	7,394,654	1904	32,406,752		

WYOMING.

Total production in 1913, 7,393,066 short tons; spot value, $11,510,045.

Wyoming's coal production in 1913 showed only a small increase (24,942 short tons) over 1912 in quantity, and this was accompanied by an apparent decline of 2 cents in the average price per ton, which resulted in a decrease of $138,043 in the total value. This decrease in value, however, is probably not an actual loss. Reports from Sweetwater County, which produces nearly 40 per cent of the total for the State, show a decline in the average value per ton from $1.69 in 1912 to $1.64 in 1913. The output from Sweetwater County is largely from mines controlled by the Union Pacific Railroad, and this portion of the product is not commercial coal, but is consumed entirely by the controlling interests. The placing of a value on it is purely arbitrary and does not represent market conditions. In Lincoln County a large part of the production is also controlled by railroad interests, and this county also showed a slight decline in the average value, while in Sheridan County, whose product is chiefly commercial coal, there was a slight advance. Conditions were generally satisfactory throughout the year, and up to the last quarter of the year production was considerably ahead of the corresponding period in 1912, but the exceptionally mild weather in the last three months of 1913 materially affected the commercial demand and reduced production to below the normal for that part part of the year. The labor situation was entirely satisfactory throughout 1913, operators and miners working harmoniously under a contract signed on September 1, 1912, and there was not a single strike or lockout reported. The troubles between operators and the miners' union in Colorado benefited Wyoming by an influx of labor from the Colorado fields and increased the demand for domestic coal from Kansas, Nebraska, and northern Colorado.

There was a slight improvement in demand for railroad coal, due to increased business in transportation, and a small increase was noted in the demand for slack at furnaces in Colorado and Utah. A drought in southern Nebraska and Kansas released for coal use a considerable railroad equipment usually in demand for hauling crops, so that the customary complaint of short car supply was lacking, except for a short period in October.

In 1912 a new county, Lincoln, was carved out of Uinta County, and in 1913 the portion of Big Horn County in which coal is mined was made into Hot Springs County, Big Horn ceasing to be a coal-producing county.

Wyoming continues to maintain a high record for efficiency in the rate of production per man employed, though there was a slight falling off in the average tonnage for the year and per day in 1913 as compared with 1912. The number of men employed in 1913 was 8,331, who worked an average of 232 days in the production of 7,393,066 tons of coal, against 7,368,124 tons produced by 8,036 men working an average of 238 days in 1912. The average tonnage per man decreased from 917 in 1912 to 887 in 1913, and the average for each man per day decreased from 3.85 to 3.82 tons.

It is gratifying to record a decreased percentage in the production of "powder-mined" coal. In 1912, 3,180,067 tons, or more than

40 per cent of the total, were shot off the solid. In 1913 that part of the output amounted to 2,719,884 tons, or not quite 37 per cent. The machine-mined production increased from 2,367,882 tons, or 32 per cent, in 1912 to 3,050,784 tons, or a little more than 41 per cent, in 1913. The coal mined by hand decreased from 1,810,559 tons, or 25 per cent, to 1,618,696 tons, or 22 per cent. The number of machines in use increased from 179 to 195, the latter including 84 chain-breast, 61 punchers, 27 short-wall, 11 long-wall, and 12 radial-axe or post machines.

Another gratifying record made by Wyoming in 1913 was a decrease in the number of fatalities reported by the Bureau of Mines. In 1912 there were 34 deaths by accident in the coal mines of Wyoming, and in 1913 there were 26, a decrease of 8, or 23.5 per cent. Of the deaths in 1913, 13, or just one-half, were due to falls of roof, 2 to falls of coal, and 4 to haulage-way accidents. Of the other 7 deaths, 2 occurred on the surface and 5 were due to miscellaneous causes underground. The record for the year was free of gas or dust explosions. The death rate per thousand in 1913 was 3.12, against 4.23 in 1912, and the number of tons mined for each life lost was 284,349, against 216,710.

The statistics of production, by counties, in 1912 and 1913, with the distribution of the product for consumption, are as follows:

Coal production of Wyoming in 1912 and 1913, by counties, in short tons.

1912.

County.	Loaded at mines for shipment.	Sold to local trade and used by employees.	Used at mines for steam and heat.	Total quantity.	Total value.	Average price per ton.	Average number of days active.	Average number of employees.
Bighorn	179,960	925	13,220	194,105	$371,481	$1.91	225	273
Carbon	604,504	9,057	23,450	637,011	1,009,262	1.58	288	675
Converse	11,451	1,930	1,500	14,881	27,631	1.86	109	79
Johnson		7,675	175	7,850	13,944	1.78	218	9
Sheridan	1,050,995	17,684	17,603	1,086,282	1,324,793	1.22	201	1,233
Sweetwater	2,871,328	14,303	83,970	2,969,601	5,015,484	1.69	230	3,375
Uinta	438,819	13,793	37,078	489,690	720,308	1.47	268	530
Other counties[a]	1,836,206	11,708	114,477	1,962,391	3,153,969	1.61	258	1,862
Small mines		6,313		6,313	11,216	1.78		
Total	6,993,263	83,388	291,473	7,368,124	11,648,088	1.58	238	8,036

1913.

County.	Loaded at mines for shipment.	Sold to local trade and used by employees.	Used at mines for steam and heat.	Total quantity.	Total value.	Average price per ton.	Average number of days active.	Average number of employees.
Converse	5,000	2,011	100	7,111	$13,158	$1.85	239	14
Lincoln	1,735,243	11,469	124,749	1,871,461	2,854,434	1.53	271	1,960
Sheridan	1,177,761	18,470	14,936	1,211,167	1,486,215	1.23	186	1,333
Sweetwater	2,738,822	14,234	79,419	2,832,475	4,693,775	1.64	224	3,424
Other counties[b]	1,347,164	34,737	86,199	1,468,100	2,455,528	1.67	239	1,600
Small mines		2,752		2,752	6,935	2.52		
Total	7,003,990	83,673	305,403	7,393,066	11,510,045	1.56	232	8,331

[a] Crook, Fremont, Lincoln, Park, and Weston.
[b] Carbon, Crook, Fremont, Hot Springs, Park, Johnson, Uinta, and Weston.

The statistics of the production of coal, by counties, during the last five years, with increase and decrease in 1913 as compared with 1912, are shown in the following table:

Coal production of Wyoming, 1909–1913, by counties, in short tons.

County.	1909	1910	1911	1912	1913	Increase(+) or decrease (—), 1913.
Bighorn	133,389	181,259	172,884	194,105	....	— 194,105
Carbon	590,969	665,659	597,496	637,011	615,430	— 21,581
Converse	16,885	8,950	16,992	14,881	7,111	— 7,770
Lincoln	....	....	....	1,440,435	1,871,461	+ 431,026
Sheridan	970,165	1,303,354	1,140,466	1,086,282	1,211,167	+ 124,885
Sweetwater	2,641,860	2,875,449	2,628,202	2,969,601	2,832,475	— 137,126
Uinta	1,586,320	1,960,671	1,725,311	489,690	67,065	— 422,625
Weston	354,182	416,714	325,114	392,714	353,656	— 39,058
Crook, Fremont, Johnson	[a] 91,751	[a] 118,803	[a] 135,932	[a] 137,092	[b] 431,949	+ 294,857
Small mines	7,588	2,229	2,467	6,313	2,752	— 3,561
Total	6,393,109	7,533,088	6,744,864	7,368,124	7,393,066	+ 24,942
Total value	$9,896,848	$11,706,187	$10,508,863	$11,648,088	$11,510,045	—$138,043

[a] Crook, Fremont, Johnson, and Park counties.
[b] Crook, Fremont, Hot Springs, Johnson, and Park counties.

Probably more than half of the entire area of Wyoming is coal bearing. Coal is believed to exist in every county of the State, although in some portions it lies under such heavy cover as to be unworkable under present conditions. The reserves are estimated at approximately 424,000,000,000 short tons, a supply exceeding that of any other State, with the possible exception of North Dakota. The coals of the latter State, however, are almost entirely lignite, with a small amount of subbituminous coal, whereas those of Wyoming range from subbituminous to medium-grade bituminous. Some of the Wyoming coals go to markets as far distant as the Pacific coast. The coal fields of Wyoming are numerous, some of them of very large area, and contain many beds, some of them of great thickness. One bed in the southwestern part of the State is about 90 feet thick. The largest coal field in the area is the Powder River field, in the northeastern part of the State. It occupies a trough or basin between the Black Hills and the Big Horn Mountains and extends from the Montana line on the north to North Platte River on the south. At least 11,000 of the 15,000 square miles contained in this area are underlain by coal beds of known workable thickness. The principal mining operations are at Sheridan, Dietz, and Monarch, in Sheridan County, and at Cambria, in Weston County. The production in 1913 was 1,564,823 short tons, or about 20 per cent of the total output of the State. The Chicago, Burlington & Quincy Railroad furnishes transportation for and consumes a large part of the product.

Second in size but first in productive importance at the present time is the Green River basin in the southwestern part of the State. This field contains over 6,000 square miles believed to cover available coal. In addition to this, there are 20,000 square miles in which the coal beds are so deeply covered that their ultimate availability is doubtful. The principal mining operations are at Rock Springs, on the Union Pacific Railroad, in Sweetwater County, and some of the production in Carbon County is from this basin. Sweetwater County alone produces 40 per cent of the State's total—2,832,475 tons out of a total of 7,393,066 tons in 1913.

The Bear River region in Uinta and Lincoln counties (Lincoln County having been created out of Uinta County in 1912) is relatively small in area but second in quantity of coal produced, having in 1913 an output of 1,938,526 tons, or more than 25 per cent of the State's total. The product is largely bituminous coal and comes chiefly from the Kemmerer district. Shipments are made over the Union Pacific Railroad.

A region that has assumed some importance in the last five years is the Big Horn basin, in the northern part of the State. In this district (at Gebo, Hot Springs County) is the one coal mine in the United States opened on public land and now operated on a royalty basis from the Federal Government under the supervision of the Bureau of Mines. In 1906, before railroad transportation was available, Big Horn County (now Hot Springs County) produced less than 5,000 tons; in 1913 the production was 271,910 tons.

The Hanna field, in the eastern part of Carbon County, is one of the older areas in point of development. The principal operations are the Union Pacific Coal Co.'s mines at Hanna, and most of the coal goes to the Union Pacific Railroad. This district produces a little less than 10 per cent of the State's total output.

The Green River and Bear River basins and a small area in Weston County produce bituminous coal. The output from the other districts is subbituminous. Other fields of minor importance are the Wind River basin, in Fremont County; the Henrys Fork field, in southern Sweetwater County; the Powder River field, in Natrona and Fremont counties; the Muddy Creek field, in the Shoshone Indian Reservation, in Fremont County; the Fall River basin and the Upper Green River field, in Uinta and Fremont counties; the Mount Leidy field, the Lander Peak field, and the Grays River field, in Uinta County.

The first production of coal in Wyoming was reported in 1865, one year later than the first reported output of coal in Colorado. This pioneer coal mining was probably carried on in connection with the construction of the Union Pacific Railroad. The total output in that year amounted to 800 tons. Five years later, when the railroad was completed, the production amounted to about 50,000 tons.

The growth of the coal-mining industry, indicating as it does the increase in population and in industrial development in the State since 1865 and up to the close of 1913, is shown in the following table:

Production of coal in Wyoming from 1865 to 1913, in short tons.

Year.	Quantity.	Year.	Quantity.	Year.	Quantity.	Year.	Quantity.
1865	800	1878	333,200	1891	2,327,841	1904	5,178,556
1866	2,500	1879	400,991	1892	2,503,839	1905	5,602,021
1867	5,000	1880	589,595	1893	2,439,311	1906	6,133,994
1868	6,925	1881	420,000	1894	2,417,463	1907	6,252,990
1869	49,382	1882	707,764	1895	2,246,911	1908	5,489,902
1870	50,000	1883	779,689	1896	2,229,624	1909	6,393,109
1871	147,328	1884	902,620	1897	2,597,886	1910	7,533,088
1872	221,745	1885	807,328	1898	2,863,812	1911	6,744,864
1873	259,700	1886	829,355	1899	3,837,392	1912	7,368,124
1874	219,061	1887	1,170,318	1900	4,014,602	1913	7,393,066
1875	300,808	1888	1,481,540	1901	4,485,374		
1876	334,550	1889	1,388,947	1902	4,429,491	Total	118,740,918
1877	342,853	1890	1,870,366	1903	4,635,293		

RECENT PUBLICATIONS OF THE UNITED STATES GEOLOGICAL SURVEY RELATING TO COAL, COKE, LIGNITE, AND PEAT.

Compiled by JOHN M. NICKLES.

The following is a list of the more important papers dealing with coal, coke, lignite, and peat, published by the United States Geological Survey since the preparation of the bibliography published in Mineral Resources of the United States for 1910. This supplementary list, like the complete list in the report for 1910, deals with the geologic work in the several States alphabetically arranged.

ALASKA.

The Bonnifield region, Alaska, by S. R. Capps. Bull. 501, pp. 54–62, 1912.

The mining industry in 1911, by Alfred H. Brooks. Bull. 520, pp. 42–43, 1912.

The Yentna district, Alaska, by Stephen R. Capps. Bull. 534, p. 72, map of coal distribution (Pl. III in pocket), 1913.

The Noatak-Kobuk region, Alaska, by P. S. Smith. Bull. 536, pp. 151–153, 1913.

COLORADO.

The coal resources of Gunnison Valley, Mesa and Delta counties, Colo., by E. G. Woodruff. Bull. 471, pp. 565–573, 1912.

Coal fields of Grand Mesa and the West Elk Mountains, Colo., by W. T. Lee. Bull. 510, 219 pp., 1912.

IDAHO.

Coal at Horseshoe Bend and Jerusalem Valley, Boise County, Idaho, by C. F. Bowen. Bull. 531, pp. 245–251, 1913.

Lignite in the Goose Creek district, Cassia County, Idaho, by C. F. Bowen. Bull. 531, pp. 252–262, 1913.

The Horseshoe Creek district of the Teton Basin coal field, Fremont County, Idaho, by E. G. Woodruff. Bull. 541, pp. 379–388, 1914.

ILLINOIS.

Geology and mineral resources of the Peoria quadrangle, Illinois, by J. A. Udden. Bull. 506, pp. 80–89, 1912.

Murphysboro-Herrin folio, Illinois, description by E. W. Shaw and T. E. Savage. Geol. Atlas U. S., folio 185, pp. 13–15, 1912.

Tallula-Springfield folio, Illinois, description by E. W. Shaw and T. E. Savage. Geol. Atlas U. S., folio 188, pp. 11–12, 1913.

KENTUCKY.

Kenova folio, Kentucky-West Virginia-Ohio, description by W. C. Phalen. Geol. Atlas U. S., folio 184, pp. 8–14, 1912.

The coal resources and general geology of the Pound quadrangle of Virginia and Kentucky, by Charles Butts. Bull. 541, pp. 165–221, 1914.

MISSOURI.

The coal resources of a part of northeastern Missouri, by F. C. Greene. Bull. 541, pp. 223–242, 1914.

MONTANA.

The southern extension of the Milk River coal field, Chouteau County, Mont., by L. J. Pepperberg. Bull. 471, pp. 359–383, 1912.

The electric coal field, Park County, Mont., by W. R. Calvert. Bull. 471, pp. 406–422, 1912.

The Livingston and Trail Creek coal fields, Park, Gallatin, and Sweetgrass counties, Mont., by W. R. Calvert. Bull. 471, pp. 384–405, 1912.

The Culbertson lignite field, Valley County, Mont., by A. L. Beekly. Bull. 471, pp. 319–358, 1912.

The Sidney lignite field, Dawson County, Mont., by Eugene Stebinger. Bull. 471, pp. 284–318, 1912.

The Terry lignite field, Custer County, Mont., by F. A. Herald. Bull. 471, pp. 227–270, 1912.

The Glendive lignite field, Dawson County, Mont., by J. H. Hance. Bull. 471, pp. 271–283, 1912.

The Baker lignite field, Custer County, Mont., by C. F. Bowen. Bull. 471, pp. 202–226, 1912.

Geology of certain lignite fields in eastern Montana, by W. R. Calvert. Bull. 471, pp. 187–201, 1912.

The Little Sheep Mountain coal field, Dawson, Custer, and Rosebud counties, Mont., by G. S. Rogers. Bull. 531, pp. 159–227, 1913.

Coal in the Tertiary lake beds of southwestern Montana, by J. T. Pardee. Bull. 531, pp. 229–244, 1913.

Lignite in the vicinity of Plentywood and Scobey, Sheridan County, Mont., by C. M. Bauer. Bull. 541, pp. 293–315, 1914.

Geology and coal resources of the area southwest of Custer, Yellowstone, and Bighorn counties, Mont., by G. S. Rogers. Bull. 541, pp. 316–328, 1914.

Coal discovered in a reconnaissance survey between Musselshell and Judith, Mont., by C. F. Bowen. Bull. 541, pp. 329–337, 1914.

The Cleveland coal field, Blaine County, Mont., by C. F. Bowen. Bull. 541, pp. 338–355, 1914.

The Big Sandy coal field, Chouteau County, Mont., by C. F. Bowen. Bull. 541, pp. 356–378, 1914.

NEVADA.

The Coaldale coal field, Esmeralda County, Nev., by J. H. Hance. Bull. 513, pp. 313–322, 1913.

NEW MEXICO.

The Tijeras coal field, Bernalillo County, N. Mex., by W. T. Lee. Bull. 471, pp. 574–578, 1912.

The Cerrillos coal field, Sante Fe County, N. Mex., by W. T. Lee. Bull. 531, pp. 285–312, 1913.

Geology and coal resources of the Sierra Blanca coal fields, Lincoln and Otero counties, N. Mex., by C. H. Wegemann. Bull. 541, pp. 419–452, 1914.

NORTH CAROLINA.

Coal on Dan River, North Carolina, by R. W. Stone. Bull. 471, pp. 137–169, 1912.

NORTH DAKOTA.

Lignite in the Fort Berthold Indian Reservation, N. Dak., north of Missouri River, by M. A. Pishel. Bull. 471, pp. 170–186, 1912.

Bismarck folio, North Dakota, description by A. G. Leonard. Geol. Atlas U. S., folio 181, pp. 6–7, 1912.

The Williston lignite field, Williams County, N. Dak., by F. A. Herald. Bull. 531, pp. 91–157, 1913.

Geology of the Standing Rock and Cheyenne River Indian Reservations, by W. R. Calvert, A. L. Beekly, V. H. Barnett, and M. A. Pishel. Bull. 575, pp. 26–49, 1914.

OHIO.

Kenova folio, Kentucky-West Virginia-Ohio, description by W. C. Phalen. Geol. Atlas U. S., folio 184, pp. 8–14, 1912.

OREGON.

The Eden Ridge coal field, Coos County, Oreg., by C. E. Lesher. Bull. 541, pp. 399–418, 1914.

Mineral resources of southwestern Oregon, by J. S. Diller. Bull. 546, pp. 130–141, 1914.

PENNSYLVANIA.

Foxburg-Clarion folio, Pennsylvania, description by E. W. Shaw and M. J. Munn. Geol. Atlas U. S., folio 178, pp. 12–13 (field edition, pp. 97–103), 1911.

Claysville folio, Pennsylvania, description by M. J. Munn. Geol. Atlas U. S., folio 180, pp. 12–13, 1912.

Barnesboro-Patton folio, Pennsylvania, description by M. R. Campbell, F. G. Clapp and Charles Butts. Geol. Atlas U. S., folio 189, pp. 10–11, 1913.

RHODE ISLAND.

Rhode Island anthracite, by George H. Ashley. Bull. 541, pp. 155–162, 1914.

SOUTH DAKOTA.

Coal near the Black Hills, Wyoming-South Dakota, by R. W. Stone. Bull. 499, 66 pp., 1912.

Geology of the Standing Rock and Cheyenne River Indian Reservations, by W. R. Calvert, A. L. Beekly, V. H. Barnett, and M. A. Pishel. Bull. 575, pp. 26–49, 1914.

UTAH.

The Deep Creek district of the Vernal coal field, Uintah County, Utah, by C. T. Lupton. Bull. 471, pp. 579–594, 1912.

The Blacktail (Tabby) Mountain coal field, Wasatch County, Utah, by C. T. Lupton. Bull. 471, pp. 595–628, 1912.

Coal near Thompson, Grand County, Utah, by F. R. Clark. Bull. 541, pp. 453–477, 1914.

Coal near Wales, Sanpete County, Utah, by F. R. Clark. Bull. 541, pp. 478–489, 1914.

VIRGINIA.

Coking coal in Powell Mountain, Scott County, Va., by M. R. Campbell. Bull. 541, pp. 163–164, 1914.

The coal resources and general geology of the Pound quadrangle of Virginia and Kentucky, by Charles Butts. Bull. 541, pp. 165–221, 1914.

WASHINGTON.

Coal resources of Cowlitz River Valley, Cowlitz and Lewis counties, Wash., by A. J. Collier. Bull. 531, pp. 323–330, 1913.

The Glacier coal field, Whatcom County, Wash., by E. G. Woodruff. Bull. 541, pp. 389–398, 1914.

WEST VIRGINIA.

Kenova folio, Kentucky-West Virginia-Ohio, description by W. C. Phalen. Geol. Atlas U. S., folio 184, pp. 8–14, 1912.

WYOMING.

The Sussex coal field, Johnson, Natrona, and Converse counties, Wyo., by C. H. Wegemann. Bull. 471, pp. 441–471, 1912.

The Little Powder River coal field, Campbell County, Wyo., by J. A. Davis. Bull. 471, pp. 423–440, 1912.

Coal fields of the Wind River region, Fremont and Natrona counties, Wyo., by E. G. Woodruff and D. E. Winchester. Bull. 471, pp. 516–564, 1912.

The Lost Spring coal field, Converse County, Wyo., by D. E. Winchester. Bull. 471, pp. 472–515, 1912.

Coal near the Black Hills, Wyoming-South Dakota, by R. W. Stone. Bull. 499, 66 pp., 1912.

The Barber coal field, Johnson County, Wyo., by C. H. Wegemann. Bull. 531, pp. 263–284, 1913.

Geology and geography of a portion of Lincoln County, Wyo., by A. R. Schultz. Bull. 543, pp. 90–115, 1914.

TECHNOLOGIC.

Miscellaneous analyses of coal samples from various fields of the United States. Bull. 471, pp. 629–655, 1912.

Miscellaneous analyses of coal samples from various fields of the United States. Bull. 531, pp. 331–355, 1913.

Resins in Paleozoic plants and in coals of high rank, by David White. Prof. Paper 85, pp. 65–96, 1914.

Analyses of coal samples from various fields in the United States. Bull. 541, 1914.

PETROLEUM.

By David T. Day.

INTRODUCTION.

The aim of this report is to show the developments of the crude petroleum industry during the year which ended December 31, 1913. In order to be concise, the report presupposes a knowledge of the oil fields both of the United States and of other countries as given in the previous reports of this series and limits the discussion in this regard to the new developments of 1913. These are mentioned in the treatment of individual States. Many statements also refer to events which occurred after the close of 1913 where mention of them is necessary for clearness. Some of the analyses of crude oil, for example, were made within the last six months. The developments of the industry are shown chiefly by the statement of the quantity and value of the petroleum produced in each field in 1913 and by the comparison of this output with the production in previous years. In order that the changes in production may be more clearly understood, a table is given showing the production of each State for all the years since the beginning of the industry in the United States, and a similar table shows the total production of all nations from the beginning. Technological data are introduced when necessary to explain changes in production and value.

Production.—The study of the domestic production of petroleum yields a story of progressive maxima for the last seven years, until in 1913 the product reached 248,446,230 barrels, or 33,126,164 metric tons. The yield of 1912 was 222,935,044 barrels, or 29,724,673 metric tons.

Although the product of 1912 exceeded all previous records, the yield of 1913 surpassed it by the greatest gain in any year since 1910. In fact, the increase of 1913 over 1912—more than 25,000,000 barrels—was greater than the total production in any year until 1880, and the output of 1913 equalled the total production of the United States for the first 25 years of the industry. The production of the United States in 1913 was greater than the world's production in 1906, seven years earlier.

Still more remarkable in regard to the growth of the domestic oil industry is the amount of money received by the producers. In 1912 this amounted to $164,213,247, or an average of 73.7 cents a barrel, and in 1913 this average was 95.4 cents a barrel, or a total of $237,121,388, a gain of $72,908,141 over 1912. This is the greatest gain for any year in the history of the industry, and the gain alone outvalues the total receipts for oil in any year up to and including 1899 and is greater than the value of the oil in all the years combined up to and including 1866.

These statistics show the quantity of oil produced in the United States since the beginning of the industry in 1859 to be 3,069,694,605 barrels and the total value to be $2,575,704,530.

World's production.—The world's production in 1913 was 381,508,916 barrels, or 50,929,576 metric tons, of which the United States produced 65.12 per cent. Russia still ranks next to the United States, and Mexico third.

Prices.—It is obvious from these figures that the condition of prices for oil was the feature of second greatest interest in 1913. At the end of 1912 oil of Pennsylvania grade sold for $2 a barrel. In January, 1913, the price began to rise rapidly, with increments of 5 or 10 cents at a time until it reached $2.50 a barrel. Usually each advance caused a proportionate rise in price of other grades of oil in all parts of the country except California, where the price relations were not affected by eastern conditions.

The higher prices of crude oils were largely neutralized in the refineries, where there was an evident tendency to turn out greater proportions of high-grade products, such as gasoline, the supply of which was also increased by its recovery from natural gas in larger quantity than in 1912. As a rule the prices of gasoline, lamp oils, lubricants, and paraffin wax remained low, and in some cases showed a decline due to a surfeit of kerosene. But the higher prices of crude oil were felt in the prices of fuel oil, which increased generally—except in the California trade. A few railroads returned to the use of coal.

The advance in prices of fuel oil within the last few years caused the Secretary of the Navy to propose the development of oil supplies by the Government from deposits tributary to the Atlantic and the Gulf coasts, in addition to the oil reserves for naval purposes already established on the Pacific coast. Under a resolution of Congress this proposition is now under investigation by a committee from the Departments of the Interior and the Navy.

General conditions.—As to the production of individual fields, there was no great variation in their relative importance. It is noteworthy that the normal decline in the oil fields of New York and Pennsylvania was changed into a slight increase under the spur of greatly increased prices. West Virginia and Ohio declined, but only slightly. Even in Indiana the decrease was subnormal, because of new developments on the western border of the State. The decline in Illinois was decided and reflected the inability of the producers to continue the development of new pools; the older localities had passed their prime and decline was inevitable. Nevertheless, wildcatting is still active in many widely separated regions in Illinois, as is shown by discoveries of some new deep sands southeast of Bridgeport and by the development of the New Plymouth pool, in the western-central region.

The great gains in production came from the Mid-Continent field and from California. In the Mid-Continent field more new drilling took place than in 1912. A few new pools such as the Wicey, Boston, Wheeler, and others, were developed, but the great increase came rather from the large number of wells drilled within known pools or on their edges. These new wells were so generally prolific that their production added greatly to the total. The Cushing pool, in Oklahoma, was extended in various directions; its output decreased for a few months, and then with active drilling to establish extensions on the south, southeast, and north the product, which had declined from 30,000 to 16,000 barrels, gradually rose again to over 30,000 barrels a day. Just at the close of the year a well on the edge of the Cushing region was drilled 600 feet deeper, to the Bartlesville sand, and a sensational flow was encountered. This started the general policy of drilling to the thick and prolific Bartlesville sand, and oil came with a rush. Stocks were accumulating heavily at the end of the year. Late in September a small amount of oil was obtained in a well drilled near Healdton, Carter County, in the southern part of the State. By the close of the year several other wells had been drilled in that locality which were sufficiently successful to arouse the excitement that proved justified in 1914.

At the close of 1912 consumption in California had so nearly balanced production as to encourage the producers and to defeat concerted effort toward the restriction of drilling. Many of the wells of 1913 were gushers of the phenomenal type and aided greatly in increasing the supply. The efforts to increase consumption succeeded fairly well, so that, except during the month of greatest production, September, when about 9,000,000 barrels were produced, consumption almost kept pace with output and the quantity sent to storage was less than 1,000,000 barrels. The Fullerton field continued to yield large gushers with sufficient frequency to justify the expense in reaching the unusual depth of the oil sands. The "West Side" fields of Kern County continued as strong factors in increasing the output of the State, and the Buena Vista Hills, Elk Hills, and other new districts gained in interest. Even the comparatively old Kern River field, near Bakersfield, sustained interest by wildcatting to the northwest, where the Standard Oil Co.'s well went into oil and aroused geologic and financial speculation over a large area. The product of the field, however, declined. Coalinga's year had many eventful features, including extensions of territory to the east and the discovery of additional deep sands yielding oils containing paraffin.

As to Texas and Louisiana, the Electra and the Burkburnett fields in Texas progressed satisfactorily and a new field was developed at Moran, in Shackelford County. In the Gulf field Sour Lake furnished a surprise by yielding gushers sufficient to increase the total yield and to contribute to a decline in prices. It became evident during the year that the prospects of increase in the Gulf region, together with the abundant Mexican field, presage a plentiful supply of fuel oil. The Caddo field proved as irregular as in previous years, but gushers were so frequent and so large as to keep up the supply. To the south the De Soto region furnished several large gushers. The consequent excitement was tempered by the advent of water from a substratum, but the importance of the region was demonstrated.

Stocks.—The apparent paradox of advance in oil prices in spite of increased production is easily explained by the absence of any but a merely negligible advance in stocks. In fact, the decline in the high-grade fields would have threatened the extinction of the Pennsylvania and New York industry, except for this stimulus of higher prices. It is evident that the great increase in the production of petroleum has aroused sufficient confidence in a permanent supply to cause capitalists to increase the consumptive capacity of pipe lines, refineries, and distributing agencies. Largest returns on such investment is dependent on running the plants to full capacity, and the greater the investment in large refining capacity the more instantly does any threatened shortage of supply stimulate an advance in price.

METHODS OF COLLECTING STATISTICS.

The act establishing the United States Geological Survey makes it a duty of this organization to examine the mineral resources and products of the United States, and accordingly for about 30 years the Survey has published annually a report showing the production of petroleum in the United States and describing the new fields discovered and the new markets opened to this product.

In the early years covered by these investigations the Survey was obliged to rely wholly upon statistics collected and contributed by the pipe-line and other oil-transportation companies and upon statements showing the quantities of oil delivered directly to refineries. These statistics have proved to be accurate as far as they go, but their value is increased by comparing them with the results of more extended and direct statistical inquiry described below. Further, the returns obtained from producers furnish valuable details as to the growth of individual oil pools, the yield and rate of decline of individual wells, the character of the oil in the separate pools, and the relations of the oil to the surrounding rocks—details that are necessary to a careful scrutiny of the industry. The facts thus ascertained are also valuable in the field work of the geologists of the Survey who are studying the country's petroleum resources.

The canvass of all the petroleum-producing companies was begun seven years ago and has been gradually developed with the purpose of obtaining from each operator a brief statement of his actual production. The general recognition of the necessity and value of this work by the oil companies, which now furnish to the Survey more than 14,000 contributions of statistical returns, has afforded statistics that are trustworthy and valuable, and the returns received from these companies serve to show the accuracy of the statistics annually collected from the pipe-line companies.

The statistics published in this volume thus represent the results of two independent systems of inquiry. Under one system every pipe-line company in the United States and all railroad companies that handle crude petroleum furnish directly to the Survey, on blanks supplied to them for that purpose, corrected statements of their runs soon after the close of the calendar year. These statements are supplemented by returns solicited from refineries that obtain their oil directly from wells and by other returns required to prevent duplication of statistics.

At the end of the calendar year for which the statistics are collected, statistical inquiries relating to the production of oil, the conditions of wells drilled and abandoned, the acreage owned and leased, and other subordinate matters are addressed to every oil producer in the

United States. In the States of Illinois, Kansas, Michigan, Missouri, New Mexico, Oklahoma, and Pennsylvania the statistics of the producers have been collected in cooperation with the State geologists.

The totals obtained from the producers have gradually approached those obtained from the pipe lines, and as the returns from important producing States have given promise of eventually becoming complete they have been published separately in the report. Meanwhile the producers' statistics have been of substantial aid as a check or control upon the returns showing pipe-line runs and have added to the accuracy of the final statement, which is therefore not merely a pipe-line statement, even of the totals, but is one modified in many details by the producers' figures. It will always be impossible to make the statistics obtained by the two methods or by any other two methods "check" absolutely with each other, but as a check in the sense of a means of control each system is of vital aid to the other, and the producers' statistics have thus been useful from the beginning. In the new regions where pipe lines did not exist or were inadequate the producers' statistics have been invaluable.

The length of time necessary for canvassing all the producers each year is the one element which prevents completeness. Less than 1 per cent of the producers in 1913 objected to answering the questions. Instead of waiting until every producer responds, the returns are published as soon as the producers' figures have served the purpose of controlling and supplementing the pipe-line returns, and essential accuracy has thus been obtained. This can be well illustrated by a comparison with the final statistics of the preliminary statement showing the total production for the United States, issued by the Survey promptly at the end of 1913 and based essentially upon the pipe-line returns published for 11 months. This preliminary statement showed a production of 243,000,000 barrels, in round numbers, for the United States—a fairly close approximation to the 248,446,230 barrels shown as the final figures based on producers' returns, final pipe-line returns, and the returns of the railroads and the refineries. The principal difference was due to the increase in deliveries to refineries in Oklahoma and Kansas, the key to which was furnished by the returns from producers in those States—yet the producers' statistics vary from the pipe-line results in those States more than in most other States.

In California the producers' statistics have always been preferred to those of the pipe lines for an interesting reason: The pipe-line statistics of the Eastern States were developed long before the production of oil became significant in California. At first this California oil was not transported by pipe lines, but was largely delivered from loading racks direct to the railroads to be burned as fuel oil. It was obviously necessary to obtain the statistics from the producers and to control these by the receipts of railroads and other consumers. As the industry spread and pipe lines were developed the system of pipe-line statistics was introduced. At present the two systems agree within negligible limits, because the pipe-line figures are published promptly at the close of the year and are available for control of the later producers' figures. It seems evident that eventually the producers' statistics must outvalue in every way those obtained on the pipe-line basis. This has proved true for all other mineral industries, even natural gas.

ACKNOWLEDGMENTS.

Because of the constant interest in the peculiarly sensational features of the oil industry, the work of the petroleum press in the United States and elsewhere is more complete and satisfactory than that of the technical press devoted to any other branch of the mineral industry. The general information printed every week from the extensive system of correspondence maintained by the petroleum press is deserving of special recognition by the public and is emphatically acknowledged in these reports. Without it the more complete statistical work of the Federal Government would be more expensive, and, therefore, to a large extent impracticable.

In the early days of the industry the Oil City Derrick, whose field reports have been accepted as authoritative, developed a system of statistical returns which have been of the utmost value to the public. Similar reports organized by the Independence Daily Reporter, the Oil and Gas Journal, of Tulsa, Okla., whose field reports are accepted for Texas and Louisiana, Fuel Oil, and Oil and Gas, and the Oil, Paint, and Drug Reporter, have been developed to a condition of extreme promptness and commendable accuracy.

In the California field the California Derrick, the California Oil World, and the Oil Age have developed similarly important and efficient systems of reports in a field where statistical accuracy was unusually difficult. In addition the Petroleum Gazette, Oildom, the Petroleum Age, the National Petroleum News, and many other papers have added to the large amount of detailed information available to the public.

Abroad the Journal Petroleum, the Rohölindustrie, the Moniteur du Pétrole Roumain, the Revue du Pétrole, the Petroleum Review and the Petroleum World, of London, and the Pétrole, of Paris, afford similar service concerning foreign countries.

The aid given in the preparation of this report on the production of petroleum in the United States, not only by the numerous reports in these papers, but by answers to much correspondence, has been of the greatest value and is most heartily acknowledged. The statistics of foreign countries have been obtained chiefly by direct correspondence with the officials of the governments concerned as well as by the aid of many private authorities.

The statistical work and compilation of tables has been under the charge of Miss Anne B. Coons, statistician.

PRODUCTION.

The statement of the production of petroleum in 1912 and 1913 is given in detail by States in the tables which follow:

Total quantity and value of petroleum produced in the United States and the average price per barrel in 1912 and 1913, by States, in barrels.

State.	1912			1913		
	Quantity.	Value.	Average price per barrel.	Quantity.	Value.	Average price per barrel.
Alaska	(a)	(a)		(b)	(b)	
California	c 87,272,593	c $39,624,501	$0.454	97,788,525	$45,709,400	$0.467
Colorado	206,052	199,661	.973	188,799	174,779	.926
Illinois	28,601,308	24,332,605	.851	23,893,899	30,971,910	1.296
Indiana	970,009	885,975	.913	956,095	1,279,226	1.337
Kansas	1,592,796	1,095,698	.688	2,375,029	2,248,283	.947
Kentucky	484,368	424,842	.877	524,568	675,748	1.288
Louisiana	9,263,439	7,023,827	.758	12,498,828	12,255,931	.981
Michigan	(d)	(d)		(b)	(b)	
Missouri				(b)	(b)	
New Mexico				(b)	(b)	
New York	874,128	1,401,880	1.604	902,211	2,169,357	2.404
Ohio	e 8,969,007	e 12,085,998	1.347	8,781,468	17,538,452	1.997
Oklahoma	51,427,071	34,672,604	.674	63,579,384	59,581,948	.937
Pennsylvania	7,837,948	12,886,752	1.644	7,963,282	19,805,452	2.487
Texas	11,735,057	8,852,713	.754	15,009,478	14,675,593	.978
West Virginia	12,128,962	19,927,721	1.643	11,567,299	28,828,814	2.492
Wyoming	1,572,306	798,470	.507	2,406,522	1,187,232	.493
Other States				f 10,843	f 19,263	1.777
Total	222,935,044	164,213,247	.737	248,446,230	237,121,388	.954

a Included in California.
b Included in other States.
c Includes Alaska.
d Included in Ohio.
e Includes Michigan.
f Includes Alaska, Michigan, Missouri, and New Mexico.

Total production of petroleum and percentage of increase or decrease, by States, in 1913, as compared with 1912, in barrels.

State.	Production.		Increase.	Decrease.	Percentage.	
	1912	1913			Increase.	Decrease.
Alaska	(a)	(b)				
California	c 87,272,592	97,788,525	10,515,932		12.05	
Colorado	206,052	188,799		17,253		8.37
Illinois	28,601,308	23,893,899		4,707,409		16.45
Indiana	970,009	956,095		13,914		1.43
Kansas	1,592,796	2,375,029	782,233		49.111	
Kentucky	484,368	524,568	40,200		8.300	
Louisiana	9,263,439	12,498,828	3,235,389		34.93	
Michigan	(d)	(b)				
Missouri		(b)				
New Mexico		(b)				
New York	874,128	902,211	28,083		3.212	
Ohio	e 8,969,007	8,781,468		187,539		2.09
Oklahoma	51,427,071	63,579,384	12,152,313		23.63	
Pennsylvania	7,837,948	7,963,282	125,334		1.60	
Texas	11,735,057	15,009,478	3,274,421		27.90	
Wyoming	1,572,306	2,406,522	834,216		53.056	
West Virginia	12,128,962	11,567,299		561,663		4.631
Other States f		10,843	10,843			
Total	222,935,044	248,446,230	25,511,186		11.44	

a Included in California.
b Included in other States.
c Includes Alaska.
d Included in Ohio.
e Includes production of Michigan.
f Includes Alaska, Michigan, Missouri, and New Mexico.

RANK OF STATES.

QUANTITY.

The rank of the three great producing States, California, Oklahoma, and Illinois, remained the same in 1913 as in 1912, and there were few changes in the States of lower rank, though the increased production in northern Texas and northern Louisiana advanced those States above West Virginia. In the less productive States, Wyoming exceeded Kansas by a hundredth of 1 per cent of the total; both States showed increased production.

As to the outlook for 1914, it is evident from the general conditions that Oklahoma will approach much more closely to California and that the Mid-Continent field as a whole will assume the dominant position. Similarly an increase in Texas and a decrease in Illinois in 1914 will probably change the relative position of those States.

Rank of petroleum-producing States, with quantity and percentage of total produced by each in 1912 and 1913, in barrels.

State.	1912			State.	1913		
	Rank.	Quantity.	Percentage.		Rank.	Quantity.	Percentage.
California	1	[a] 87,272,593	39.15	California	1	97,788,525	39.356
Oklahoma	2	51,427,071	23.07	Oklahoma	2	63,579,384	25.59
Illinois	3	28,601,308	12.83	Illinois	3	23,893,899	9.62
West Virginia	4	12,128,962	5.44	Texas	4	15,009,478	6.04
Texas	5	11,735,057	5.26	Louisiana	5	12,498,828	5.03
Louisiana	6	9,263,439	4.16	West Virginia	6	11,567,299	4.66
Ohio	7	[b] 8,969,007	4.02	Ohio	7	8,781,468	3.53
Pennsylvania	8	7,837,948	3.52	Pennsylvania	8	7,963,282	3.20
Kansas	9	1,592,796	.71	Wyoming	9	2,406,522	.97
Wyoming	10	1,572,306	.70	Kansas	10	2,375,029	.96
Indiana	11	970,009	.44	Indiana	11	956,095	.39
New York	12	874,128	.39	New York	12	902,211	.36
Kentucky	13	484,368	.22	Kentucky	13	524,568	.21
Colorado	14	206,052	.09	Colorado	14	188,799	.08
Alaska	15	(c)		Alaska	15	10,843 (Alaska, New Mexico, Missouri, Michigan)	.004
Michigan	16	(d)		New Mexico	16		
				Missouri	17		
				Michigan	18		
Total		222,935,044	100.00	Total		248,446,230	100.000

[a] Includes Alaska.
[b] Includes Michigan.
[c] Included in California.
[d] Included in Ohio.

VALUE.

The one significant change in the relative value of the petroleum produced in the several States was the reversal of rank of California and Oklahoma, by which the latter State took first place by a large margin. This change was due not only to the great gain in production in Oklahoma but to the increased prices paid for Oklahoma oil, whereas in California there was almost no gain in price during 1913. The other States remained in about the same relative positions as in 1912, except that Kansas and New York changed places.

Rank of petroleum-producing States with regard to value of production and percentage of total of each in 1912 and 1913.

State.	1912 Rank.	1912 Value.	1912 Percentage.	State.	1913 Rank.	1913 Value.	1913 Percentage.
California	1	a$39,624,501	24.13	Oklahoma	1	$59,581,948	25.13
Oklahoma	2	34,672,604	21.11	California	2	45,709,400	19.28
Illinois	3	24,332,605	14.82	Illinois	3	30,971,910	13.06
West Virginia	4	19,927,721	12.13	West Virginia	4	28,828,814	12.16
Pennsylvania	5	12,886,752	7.85	Pennsylvania	5	19,805,452	8.35
Ohio	6	b 12,085,998	7.36	Ohio	6	17,538,452	7.40
Texas	7	8,852,713	5.39	Texas	7	14,675,593	6.19
Louisiana	8	7,023,827	4.28	Louisiana	8	12,255,931	5.17
New York	9	1,401,880	.85	Kansas	9	2,248,283	.95
Kansas	10	1,095,698	.67	New York	10	2,169,357	.91
Indiana	11	885,975	.54	Indiana	11	1,279,226	.54
Wyoming	12	798,470	.49	Wyoming	12	1,187,232	.50
Kentucky	13	424,842	.26	Kentucky	13	675,748	.28
Colorado	14	199,661	.12	Colorado	14	174,779	.07
Alaska	15	(c)	....	Alaska	15	19,263	.01
Michigan	16	(d)	....	New Mexico	16		
				Missouri	17		
				Michigan	18		
Total	......	164,213,247	100.00	Total	......	237,121,388	100.00

a Includes Alaska. b Includes Michigan. c Included in California. d Included in Ohio.

PRODUCTION OF PETROLEUM IN THE UNITED STATES FROM 1859 TO 1913, INCLUSIVE.

In the following table will be found a statement of the production of petroleum from each producing State of the United States from the year 1859 to and including the production of the year 1913:

Production of petroleum in the United States, 1859–1913,

Year.	Pennsylvania and New York.	Ohio.	West Virginia.	California.	Kentucky and Tennessee.	Colorado.	Indiana.	Illinois.
1859	2,000	....	....	....	....	....	....	....
1860	500,000	....	....	....	....	....	....	....
1861	2,113,609	....	....	....	....	....	....	....
1862	3,056,690	....	....	....	....	....	....	....
1863	2,611,309	....	....	....	....	....	....	....
1864	2,116,109	....	....	....	....	....	....	....
1865	2,497,700	....	....	....	....	....	....	....
1866	3,597,700	....	....	....	....	....	....	....
1867	3,347,300	....	....	....	....	....	....	....
1868	3,646,117	....	....	....	....	....	....	....
1869	4,215,000	....	....	....	....	....	....	....
1870	5,260,745	....	....	....	....	....	....	....
1871	5,205,234	....	....	....	....	....	....	....
1872	6,293,194	....	....	....	....	....	....	....
1873	9,893,786	....	....	....	....	....	....	....
1874	10,926,945	....	....	....	....	....	....	....
1875	8,787,514	....	....	....	....	....	....	....
1876	8,968,906	31,763	120,000	12,000	....	....	....	....
1877	13,135,475	29,888	172,000	13,000	....	....	....	....
1878	15,163,462	38,179	180,000	15,227	....	....	....	....
1879	19,685,176	29,112	180,000	19,858	....	....	....	....
1880	26,027,631	38,940	179,000	40,552	....	....	....	....
1881	27,376,509	33,867	151,000	99,862	....	....	....	....
1882	30,053,500	39,761	128,000	128,636	....	....	....	....
1883	23,128,389	47,632	126,000	142,857	4,755	....	....	....
1884	23,772,209	90,081	90,000	262,000	4,148	....	....	....
1885	20,776,041	661,580	91,000	325,000	5,164	....	....	....
1886	25,798,000	1,782,970	102,000	377,145	4,726	....	....	....
1887	22,356,193	5,022,632	145,000	678,572	4,791	76,295	....	....
1888	16,488,668	10,010,868	119,448	690,333	5,096	297,612	....	....
1889	21,487,435	12,471,466	544,113	303,220	5,400	316,476	33,375	1,460
1890	28,458,208	16,124,656	492,578	307,360	6,000	368,842	63,496	900
1891	33,009,236	17,740,301	2,406,218	323,600	9,000	665,482	136,634	675
1892	28,422,377	16,362,921	3,810,086	385,049	6,500	824,000	698,068	521
1893	20,314,513	16,249,769	8,445,412	470,179	3,000	594,390	2,335,293	400
1894	19,019,990	16,792,154	8,577,624	705,969	1,500	515,746	3,688,666	300
1895	19,144,390	19,545,233	8,120,125	1,208,482	1,500	438,232	4,386,132	200
1896	20,584,421	23,941,169	10,019,770	1,252,777	1,680	361,450	4,680,732	250
1897	19,262,066	21,560,515	13,090,045	1,903,411	322	384,934	4,122,356	500
1898	15,948,464	18,738,708	13,615,101	2,257,207	5,568	444,383	3,730,907	360
1899	14,374,512	21,142,108	13,910,630	2,642,095	18,280	390,278	3,848,182	360
1900	14,559,127	22,362,730	16,195,675	4,324,484	62,259	317,385	4,874,392	200
1901	13,831,996	21,648,083	14,177,126	8,786,330	137,259	460,520	5,757,086	250
1902	13,183,610	21,014,231	13,513,345	13,984,268	185,331	396,901	7,480,896	200
1903	12,518,134	20,480,286	12,899,395	24,382,472	554,286	483,925	9,186,411	....
1904	12,239,026	18,876,631	12,644,686	29,649,434	998,284	501,763	11,339,124	....
1905	11,554,777	16,346,660	11,578,110	33,427,473	1,217,337	376,238	10,964,247	181,084
1906	11,500,410	14,787,763	10,120,935	33,098,598	1,213,548	327,582	7,673,477	4,397,050
1907	11,211,606	12,207,448	9,095,296	39,748,375	820,844	331,851	5,128,037	24,281,973
1908	10,584,453	10,858,797	9,523,176	44,854,737	[f] 727,767	379,653	3,283,629	33,686,238
1909	10,434,300	10,632,793	10,745,092	55,471,601	[f] 639,016	310,861	2,296,086	30,898,339
1910	9,848,500	9,916,370	11,753,071	73,010,560	[f] 468,774	239,794	2,159,725	33,143,262
1911	9,200,673	8,817,112	9,795,464	81,134,391	[f] 472,458	226,926	1,695,289	31,317,038
1912	8,712,076	[a] 8,969,007	12,128,962	[g] 87,272,593	[f] 484,368	206,052	970,009	28,601,308
1913	8,865,495	8,781,468	11,567,299	97,788,525	[f] 524,568	188,799	956,093	23,893,899
Total	745,070,906	424,225,652	250,552,782	641,498,232	8,593,529	10,426,370	101,488,342	210,406,867

[a] Includes the production of Michigan.
[b] Includes the production of Oklahoma.
[c] Included with Kansas.
[d] Estimated.
[e] Includes production of Utah.

by years and by States, in barrels of 42 gallons.

Kansas.	Texas.	Missouri.	Oklahoma.	Wyoming.	Louisiana.	United States.	Total value.	Year.
...	...	...	...	...	...	2,000	$32,000	1859
...	...	...	...	...	...	500,000	4,800,000	1860
...	...	...	...	...	...	2,113,609	1,035,668	1861
...	...	...	...	...	...	3,056,690	3,209,525	1862
...	...	...	...	...	...	2,611,309	8,225,663	1863
...	...	...	...	...	...	2,116,109	20,896,576	1864
...	...	...	...	...	...	2,497,700	16,459,853	1865
...	...	...	...	...	...	3,597,700	13,455,398	1866
...	...	...	...	...	...	3,347,300	8,066,993	1867
...	...	...	...	...	...	3,646,117	13,217,174	1868
...	...	...	...	...	...	4,215,000	23,730,450	1869
...	...	...	...	...	...	5,260,745	20,503,754	1870
...	...	...	...	...	...	5,205,234	22,591,180	1871
...	...	...	...	...	...	6,293,194	21,440,503	1872
...	...	...	...	...	...	9,893,786	18,100,464	1873
...	...	...	...	...	...	10,926,945	12,647,527	1874
...	...	...	...	...	...	8,787,514	7,368,133	1875
...	...	...	...	...	...	9,132,669	22,982,822	1876
...	...	...	...	...	...	13,350,363	31,788,566	1877
...	...	...	...	...	...	15,396,868	18,044,520	1878
...	...	...	...	...	...	19,914,146	17,210,708	1879
...	...	...	...	...	...	26,286,123	24,600,638	1880
...	...	...	...	...	...	27,661,238	23,512,051	1881
...	...	...	...	...	...	30,349,897	23,631,165	1882
...	...	...	...	...	...	23,449,633	25,740,252	1883
...	...	...	...	...	...	24,218,438	20,476,924	1884
...	...	...	...	...	...	21,858,785	19,193,694	1885
...	...	...	...	...	...	28,064,841	20,028,457	1886
...	...	...	...	...	...	28,283,483	18,856,606	1887
...	...	...	...	...	...	27,612,025	17,950,353	1888
500	48	20	...	...	...	35,163,513	26,963,340	1889
1,200	54	278	...	...	...	45,823,572	35,365,105	1890
1,400	54	25	30	...	...	54,292,655	30,526,553	1891
5,000	45	10	80	...	...	50,514,657	25,950,463	1892
18,000	50	50	10	...	...	48,431,066	28,932,326	1893
40,000	60	8	130	2,369	...	49,344,516	35,522,095	1894
44,430	50	10	37	3,455	...	52,892,276	57,632,296	1895
113,571	1,450	43	170	2,878	...	60,960,361	58,518,709	1896
81,098	65,975	19	625	3,650	...	60,475,516	40,874,072	1897
71,980	546,070	10	...	5,475	...	55,364,233	44,193,359	1898
69,700	669,013	132	...	5,560	...	57,070,850	64,603,904	1899
74,714	836,039	[a] 1,602	6,472	5,450	...	63,620,529	75,989,313	1900
179,151	4,393,658	[a] 2,335	10,000	5,400	...	69,389,194	66,417,334	1901
331,749	18,083,658	[a] 757	37,100	6,253	548,617	88,766,916	71,178,910	1902
932,214	17,955,572	[a] 3,000	138,911	8,960	917,771	100,461,337	94,694,050	1903
4,250,779	22,241,413	[a] 2,572	1,366,748	11,542	2,958,958	117,080,960	101,175,455	1904
[b]12,013,495	28,136,189	[a] 3,100	(c)	8,454	8,910,416	134,717,580	84,157,399	1905
[b]21,718,648	12,567,897	[a] 3,500	(c)	[d] 7,000	9,077,528	126,493,936	92,444,735	1906
2,409,521	12,322,696	[a] 4,000	43,524,128	[e] 9,339	5,000,221	166,095,335	120,106,749	1907
1,801,781	11,206,464	[a] 15,246	45,798,765	[e] 17,775	5,788,874	178,527,355	129,079,184	1908
1,263,764	9,534,467	[a] 5,750	47,859,218	[e] 20,056	3,059,531	183,170,874	128,328,487	1909
1,128,668	8,899,266	[a] 3,615	52,028,718	[e] 115,430	6,841,395	209,557,248	127,899,688	1910
1,278,819	9,526,474	[a] 7,995	56,069,637	[e] 186,695	10,720,420	220,449,391	134,044,752	1911
1,592,796	11,735,057	(h)	51,427,071	1,572,306	9,263,439	222,935,044	164,212,247	1912
2,375,029	15,009,478	[i] 10,843	63,579,384	2,406,522	12,498,828	248,446,230	237,121,388	1913
51,798,007	183,731,197	64,920	361,847,234	4,404,569	75,585,998	3,069,694,605	2,575,704,530	Total.

[f] No production in Tennessee recorded.
[g] Includes small production of Alaska.
[h] No production in Missouri; Michigan included in Ohio.
[i] Includes production of Alaska, Michigan, and New Mexico.

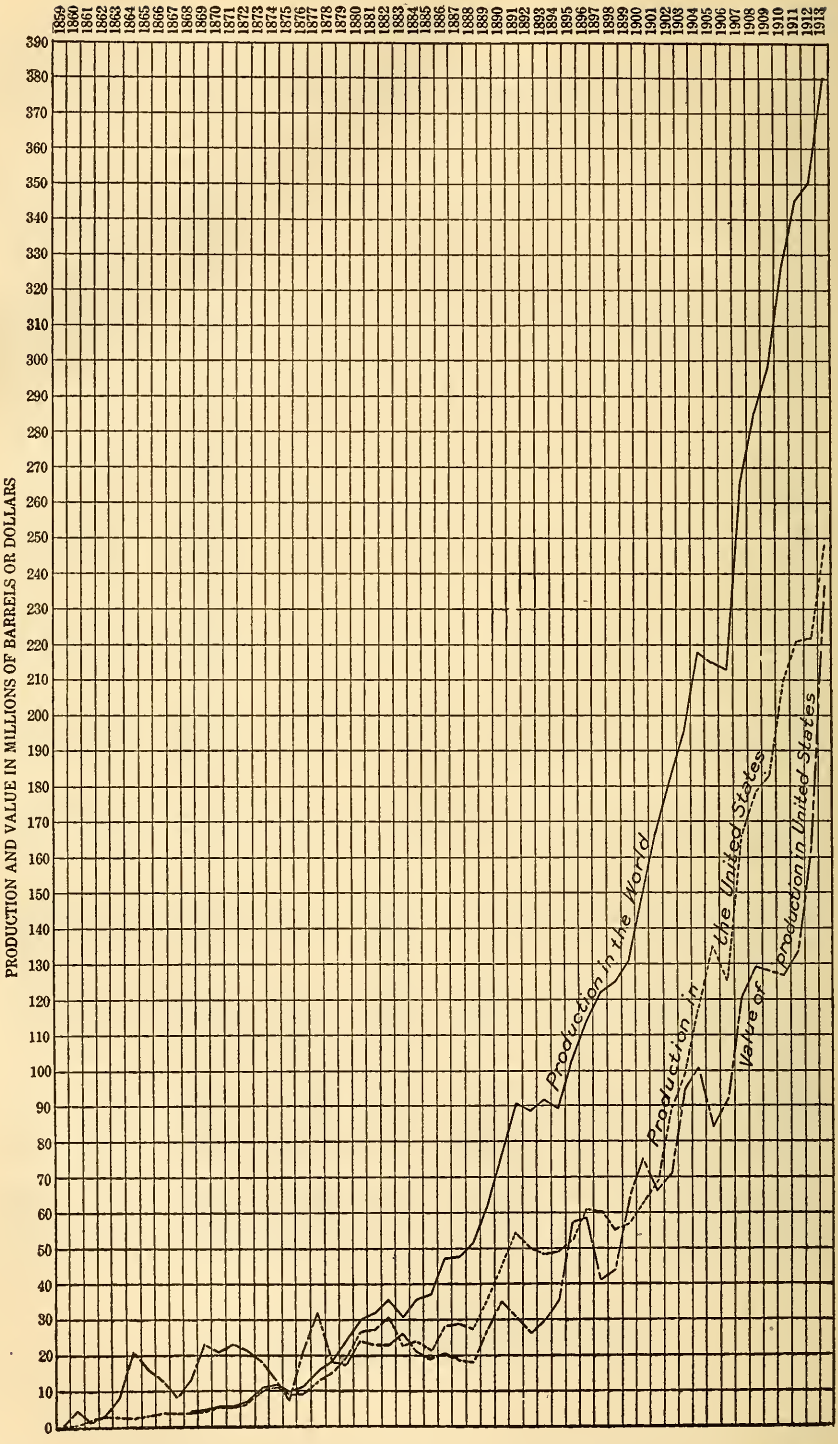

FIGURE 21.—Diagram showing the quantity and value of petroleum produced in the United States, and the production in the world from 1859 to 1913.

It should be noted that the total production of petroleum in the United States has now passed 3,000,000,000 barrels and that the value has passed $2,500,000,000. It required 42 years for the total production of petroleum from all the fields of the United States to reach the first billion barrels, and the same period of time to reach a total value of $1,000,000,000. In less than nine years the second billion barrels of oil was contributed, and with the rapid growth of the industry the third billion was the product of less than five years. At the present time (July 1, 1914) the production in the United States is in excess of one-fourth of a billion barrels a year. In other words, at the present rate the United States is producing as much oil in one year as was produced during the first 25 years of the petroleum industry.

WORLD'S PRODUCTION OF PETROLEUM FROM 1857 TO 1913, INCLUSIVE.

WORLD'S PRODUCTION IN 1913 AND IN 1857–1913.

The following table shows the world's production of crude petroleum in 1913 by countries, in barrels and metric tons, with percentage of total production for each country for the year, and also the total quantity produced by each country from the first industrial production in 1857 to the end of 1913, in barrels and metric tons, with percentage of total for each country:

World's production of crude petroleum in 1913 and in 1857–1913, by countries, in barrels and metric tons.

[Compiled by Anne B. Coons.]

Country.	Production, 1913.			Total production, 1857–1913.		
	Barrels.	Metric tons.	Percentage of total.	Barrels.	Metric tons.	Percentage of total.
United States	248,446,230	33,126,164	65.12	3,069,694,605	409,292,614	59.16
Russia	60,935,482	8,124,731	15.97	1,553,314,449	207,108,593	29.93
Mexico	25,696,291	3,426,172	6.74	68,965,294	9,195,373	1.33
Roumania	13,554,768	1,885,225	3.53	105,155,895	14,020,786	2.03
Dutch East Indies	11,966,857	1,534,223	3.14	125,573,184	16,743,091	2.42
Galicia	7,818,130	1,087,286	2.05	126,840,251	16,912,033	2.44
India	[a]7,500,000	1,000,000	1.98	65,549,770	8,739,969	1.26
Japan	1,942,009	258,934	.51	24,312,780	3,241,704	.47
Peru	1,857,355	247,647	.49	12,113,264	1,615,102	.23
Germany	[a]995,764	132,769	.27	11,969,805	1,595,974	.23
Canada	228,080	30,410	.06	23,278,805	3,103,841	.45
Italy	[a]50,334	7,000	.01	765,759	102,101	.02
Other countries	517,616	69,015	.13	1,493,616	199,149	.03
Total	381,508,916	50,929,576	100.00	5,189,027,477	691,870,330	100.00

[a] Estimated.

The increase in the annual production of petroleum in the United States and the close relation which it bears to the total production of the world is illustrated on the accompanying diagram.

WORLD'S PRODUCTION, 1857–1913, BY COUNTRIES.

The following table shows the world's production by countries from 1857 to the end of 1913, in barrels:

World's total production of crude petroleum, 1857–1913, by years and by countries, in barrels of 42 gallons.

[Compiled by Anne B. Coons.]

	Roumania.	United States.	Italy.	Canada.	Russia.	Galicia.	Japan.
1857	1,977						
1858	3,560						
1859	4,349	2,000					
1860	8,542	500,000	36				
1861	17,279	2,113,609	29				
1862	23,198	3,056,690	29	11,775			
1863	27,943	2,611,309	58	82,814	40,816		
1864	33,013	2,116,109	72	90,000	64,586		
1865	39,017	2,497,700	2,265	110,000	66,542		
1866	42,534	3,597,700	992	175,000	83,052		
1867	50,838	3,347,300	791	190,000	119,917		
1868	55,369	3,646,117	367	200,000	88,327		
1869	58,533	4,215,000	144	220,000	202,308		
1870	83,765	5,260,745	86	250,000	204,618		
1871	90,030	5,205,234	273	269,397	165,129		
1872	91,251	6,293,194	331	308,100	184,391		
1873	104,036	9,893,786	467	365,052	474,379		
1874	103,177	10,926,945	604	168,807	583,751	149,837	
1875	108,569	8,787,514	813	220,000	697,364	158,522	4,566
1876	111,314	9,132,669	2,891	312,000	1,320,528	164,157	7,708
1877	108,569	13,350,363	2,934	312,000	1,800,720	169,792	9,560
1878	109,300	15,396,868	4,329	312,000	2,400,960	175,420	17,884
1879	110,007	19,914,146	2,891	575,000	2,761,104	214,800	23,457
1880	114,321	26,286,123	2,035	350,000	3,001,200	229,120	25,497
1881	121,511	27,661,238	1,237	275,000	3,601,441	286,400	16,751
1882	136,610	30,349,897	1,316	275,000	4,537,815	330,076	15,549
1883	139,486	23,449,633	1,618	250,000	6,002,401	365,160	20,473
1884	210,667	24,218,438	2,855	250,000	10,804,577	408,120	27,923
1885	193,411	21,858,785	1,941	250,000	13,924,596	465,400	29,237
1886	168,606	28,064,841	1,575	584,061	18,006,407	305,884	37,916
1887	181,907	28,283,483	1,496	525,655	18,367,781	343,832	28,645
1888	218,576	27,612,025	1,251	695,203	23,048,787	466,537	37,436
1889	297,666	35,163,513	1,273	704,690	24,609,407	515,268	52,811
1890	383,227	45,823,572	2,998	795,030	28,691,218	659,012	51,420
1891	488,201	54,292,655	8,305	755,298	34,573,181	630,730	52,917
1892	593,175	50,514,657	18,321	779,753	35,774,504	646,220	68,901
1893	535,655	48,431,066	19,069	798,406	40,456,519	692,669	106,384
1894	507,255	49,344,516	20,552	829,104	36,375,428	949,146	171,744
1895	575,200	52,892,276	25,843	726,138	46,140,174	1,452,999	141,310
1896	543,348	60,960,361	18,149	726,822	47,220,633	2,443,080	197,082
1897	570,886	60,475,516	13,892	709,857	54,399,568	2,226,368	218,559
1898	776,238	55,364,233	14,489	758,391	61,609,357	2,376,108	265,389
1899	1,425,777	57,070,850	16,121	808,570	65,954,968	2,313,047	536,079
1900	1,628,535	63,620,529	12,102	913,498	75,779,417	2,346,505	866,814
1901	1,678,320	69,389,194	16,150	756,679	85,168,556	3,251,544	1,110,790
1902	2,059,935	88,766,916	18,933	530,624	80,540,044	4,142,159	1,193,038
1903	2,763,117	100,461,337	17,876	486,637	75,591,256	5,234,475	1,209,371
1904	3,599,026	117,080,960	25,476	552,575	78,536,655	5,947,383	1,419,473
1905	4,420,987	134,717,580	44,027	634,095	54,960,270	5,765,317	1,472,804
1906	6,378,184	126,493,936	53,577	569,753	58,897,311	5,467,967	1,710,768
1907	8,118,207	166,095,335	59,875	788,872	61,850,734	8,455,841	2,001,838
1908	8,252,157	178,527,355	50,966	527,987	62,186,447	12,612,295	2,070,145
1909	9,327,278	183,170,874	42,388	420,755	65,970,350	14,932,799	1,889,563
1910	9,723,806	209,557,248	50,830	315,895	70,336,574	12,673,688	1,930,661
1911	11,107,450	220,449,391	74,709	291,096	66,183,691	10,519,270	1,658,903
1912	12,976,232	222,935,044	53,778	243,336	68,019,208	8,535,174	1,671,405
1913	13,554,768	248,446,230	[a]50,334	228,080	60,935,482	7,818,130	1,942,009
Total	105,155,895	3,069,694,605	765,759	23,278,805	1,553,314,449	126,840,251	24,312,780

[a] Estimated.

World's total production of crude petroleum, 1857–1913, by years and by countries in barrels of 42 gallons—Continued.

[Compiled by Anne B. Coons.]

	Germany.	India.	Dutch East Indies.	Peru.	Mexico.	Other countries.	Total.
1857							1,977
1858							3,560
1859							6,349
1860							508,578
1861							2,130,917
1862							3,091,692
1863							2,762,940
1864							2,303,780
1865							2,715,524
1866							3,899,278
1867							3,708,846
1868							3,990,180
1869							4,695,985
1870							5,799,214
1871							5,730,063
1872							6,877,267
1873							10,837,720
1874							11,933,121
1875							9,977,348
1876							11,051,267
1877							15,753,938
1878							18,416,761
1879							23,601,405
1880	9,310						30,017,606
1881	29,219						31,992,797
1882	58,025						35,704,288
1883	26,708						30,255,479
1884	46,161						35,968,741
1885	41,360						36,764,730
1886	73,864						47,243,154
1887	74,284						47,807,083
1888	84,782						52,164,597
1889	68,217	94,250					61,507,095
1890	108,296	118,065					76,632,838
1891	108,929	190,131					91,100,347
1892	101,404	242,284					88,739,219
1893	99,390	298,969	600,000				92,038,127
1894	122,564	327,218	688,170				89,335,697
1895	121,277	371,536	1,215,757				103,662,510
1896	145,061	429,979	1,427,132	47,536			114,159,183
1897	165,745	545,704	2,551,649	70,831			121,948,575
1898	183,427	542,110	2,964,035	70,905			124,924,682
1899	192,232	940,971	1,795,961	89,166			131,143,742
1900	358,297	1,078,264	2,253,355	274,800			149,132,116
1901	313,630	1,430,716	4,013,710	274,800		[a] 20,000	167,424,089
1902	353,674	1,617,363	2,430,465	286,725		[a] 26,000	181,965,876
1903	445,818	2,510,259	5,770,056	278,092		[a] 36,000	194,804,294
1904	637,431	3,385,468	6,508,485	345,834	220,653	[a] 40,000	218,299,419
1905	560,963	4,137,098	7,849,896	447,880	320,379	[a] 30,000	215,361,296
1906	578,610	4,015,803	8,180,657	536,294	1,097,264	[a] 30,000	214,010,124
1907	756,631	4,344,162	9,982,597	756,226	1,717,690	[a] 30,000	264,958,008
1908	1,009,278	5,047,038	10,283,357	1,011,180	3,481,610	[a] 30,000	285,089,815
1909	1,018,837	6,676,517	11,041,852	1,316,118	2,488,742	[a] 30,000	298,326,073
1910	1,032,522	6,137,990	11,030,620	1,330,105	3,332,807	[a] 30,000	327,482,746
1911	1,017,045	6,451,203	12,172,949	1,368,274	14,051,643	[a] 200,000	345,545,624
1912	1,031,050	7,116,672	10,845,624	1,751,143	16,558,215	[b] 474,000	352,210,881
1913	[a] 995,764	[a] 7,500,000	11,966,857	1,857,355	25,696,291	[b] 517,616	381,508,916
Total	11,969,805	65,549,770	125,573,184	12,113,264	68,965,294	1,493,616	5,189,027,477

[a] Estimated. [b] Includes 461,986 barrels from Trinidad in 1912 and 503,616 barrels in 1913.

PRODUCTION BY FIELDS.

It is customary to group the oil pools of the United States in certain fields. This grouping not only represents the geographic arrangement convenient with reference to the accessibility of the fields to market, but also points out certain more or less fundamental characteristics of the oils and their consequent adaptability to refining methods. Thus, the oils of the Appalachian field are simplest in composition, free from asphalt and objectionable sulphur, and capable of yielding products of the highest grade at minimum cost of refining. Contrasted with them is the petroleum of Lima, Ohio, and of the Indiana field. This contains little asphalt and consists chiefly of paraffin hydrocarbons similar to those in the Appalachian oils. But it is contaminated with sulphur compounds which necessitate unusual cost for their elimination by special processes. Once freed from the objectionable sulphur compounds the products are of high grade.

Most of the oils produced in Illinois can be refined without the use of any special process, but only with great care and with small yields of the more valuable products. Some of the oils are asphaltic; some are not.

Oils of the Mid-Continent field vary in composition within wide limits, from asphaltic oil, poor in gasoline and illuminants, among those found in Kansas and in the Healdton field of Oklahoma, to oils of much higher grade, especially those in the Cushing field of Oklahoma. The products extracted from the Healdton petroleum are of lower grade than from the other oils in Oklahoma (the Cushing pool, for example) on account of the sulphur, which approximates three times the average sulphur content of Oklahoma oils. This sulphur is present in a form resembling that of the Lima petroleum, and it has not been removed without special processes of refining.

The oils from the Gulf field are characterized by varying but considerable percentages of asphalt and low yields in the lighter products. They also contain sulphuretted hydrogen in solution and sulphur in other forms, the total percentage of sulphur being higher than in the Mid-Continent field or even in the Lima-Indiana field, but it can usually be more readily removed and without excessive cost.

The investigations of Prof. C. F. Mabery, of Cleveland, Ohio, and the experience of the oil refineries in the Gulf field have shown that lubricating oils of exceedingly high quality are produced from these Gulf oils. The quantity of lubricating oils that can be produced in the United States is far greater than the market demands; and hence, as the oils of the Appalachian, the Lima-Indiana, the Illinois, and the Gulf fields have proved valuable and amply sufficient for the market, the quality of the lubricating oils which can be produced from the other fields has been left as a practically untested matter.

Production of petroleum in the United States, 1909–1913, by fields, in barrels.

Field.	1909	1910	1911	1912	1913
Appalachian	26,535,844	26,892,579	23,749,832	26,338,516	25,921,785
Lima-Indiana	8,211,443	7,253,861	6,231,164	a 4,925,906	4,773,138
Illinois	30,898,339	33,143,362	31,317,038	28,601,308	23,893,899
Mid-Continent	50,833,740	59,217,582	66,595,477	65,473,345	84,920,225
Gulf	10,883,240	9,680,465	10,999,873	8,545,018	8,542,494
California	55,471,601	73,010,560	81,134,391	b 87,272,593	97,788,525
Colorado and Wyoming	c 336,667	c 358,839	c 421,616	1,778,358	2,595,321
Other fields					d 10,843
Total	183,170,874	209,557,248	220,449,391	222,935,044	248,446,230

a Includes Michigan.
b Includes Alaska.
c Includes Michigan and Missouri.
d Includes Alaska, Michigan, Missouri, and New Mexico.

Percentages of total production in the several fields, 1909–1913.

Field.	1909	1910	1911	1912	1913
Appalachian	14.49	12.83	10.77	11.81	10.430
Lima-Indiana	4.48	3.46	2.83	2.21	1.930
Illinois	16.87	15.82	14.21	12.83	9.620
Mid-Continent	27.75	28.26	30.21	29.37	34.180
Gulf	5.94	4.62	4.99	3.83	3.440
California	30.29	34.84	36.80	39.15	39.356
Colorado and Wyoming	.18	.17	.19	.80	1.040
Other fields					.004
Total	100.00	100.00	100.00	100.00	100.000

Production of petroleum in the United States in 1912 and 1913, by fields, showing percentage of increase or decrease, in barrels.

Field.	Production.		Increase.	Decrease.	Percentage.	
	1912	1913			Increase.	Decrease.
Appalachian	26,338,516	25,921,785		416,731		1.58
Lima-Indiana	a 4,925,906	4,773,138		152,768		3.10
Illinois	28,601,308	23,893,899		4,707,409		16.45
Mid-Continent	65,473,345	84,920,225	19,446,880		29.70	
Gulf	8,545,018	8,542,494		2,524		.03
California	b 87,272,593	97,788,525	10,505,932		12.05	
Colorado and Wyoming	1,778,358	2,595,321	816,963		45.94	
Other fields		c 10,843	10,843			
Total	222,935,044	248,446,230	25,511,186		11.44	

a Includes Michigan. b Includes Alaska. c Includes Alaska, Michigan, Missouri, and New Mexico.

Quantity, total value, and average price per barrel received at wells for petroleum produced in the United States in 1912 and 1913, by fields, in barrels.

Field.	1912			1913		
	Quantity.	Value.	Average price per barrel.	Quantity.	Value.	Average price per barrel.
Appalachian	26,338,516	$42,818,384	$1.626	25,921,785	$63,708,981	$2.458
Lima-Indiana	a 4,925,906	a 4,794,784	.932	4,773,138	6,588,068	1.380
Illinois	28,601,308	24,332,605	.851	23,893,899	30,971,910	1.296
Mid-Continent	65,473,345	45,300,669	.692	84,920,225	80,767,758	.951
Gulf	8,545,018	6,344,173	.742	8,542,494	7,993,997	.936
California	b 87,272,593	b 39,624,501	.454	97,788,525	45,709,400	.467
Colorado and Wyoming	1,778,358	998,131	.561	2,595,321	1,362,011	.525
Other fields				c 10,843	c 19,265	1.227
Total	222,935,044	164,213,247	.737	248,446,230	237,121,388	.954

a Includes Michigan. b Includes Alaska. c Includes Alaska, Michigan, Missouri, and New Mexico.

Deliveries to trade of petroleum and purposes for which shipped in 1912 and 1913, by fields, in barrels.

Field.	1912			1913		
	Delivered for—		Total.	Delivered for—		Total.
	Refining.	Fuel.		Refining.	Fuel.	
Appalachian	[a]27,042,540	....	27,042,540	[b]25,333,879	....	25,333,879
Lima-Indiana	[c]5,688,025	13,325	5,701,350	5,419,533	[c]26,791	5,446,324
Illinois	36,820,455	134,985	36,955,440	31,316,426	[d]43,790	31,360,216
Kansas-Oklahoma	[e]58,108,633	954,924	59,063,557	[f]56,697,071	3,893,693	60,590,764
Louisiana	6,122,753	4,693,135	10,815,888	10,946,262	1,818,766	12,765,028
Texas	[g]7,574,605	4,528,310	12,102,915	[g]9,227,608	4,438,723	13,666,331
California	[h]35,739,993	48,220,326	83,960,319	67,934,167	[i]29,104,358	97,038,525
Colorado and Wyoming Other fields	1,641,297	15,034	1,656,331	[g]2,167,497	13,180	2,169,834 10,843
Total	178,738,301	58,560,039	237,298,340	209,042,443	30,339,301	248,381,744

[a] Includes 55,812 barrels of lubricating oil.
[b] Includes 40,266 barrels of lubricating oil.
[c] Includes 3,221 barrels used for street sprinkling.
[d] Includes 2,155 barrels used for hog dip and street sprinkling.
[e] Includes 271,252 barrels shipped by rail that can not be classified.
[f] Includes 1,927,688 barrels shipped by rail that can not be classified.
[g] Includes small amount of lubricating oil.
[h] 6,000,000 barrels estimated as used for road oil and gas manufacture.
[i] Estimated.

STOCKS.

The total production of crude oil in 1913 amounted to 248,446,230 barrels. The deliveries to trade in the same period aggregated almost the same quantity—248,381,744 barrels. Stocks remained unchanged—122,869,702 barrels at the close of 1912 and 122,934,188 barrels at the close of 1913. The evident fact is most extraordinary that the consuming interests were able to absorb the greatest product ever recorded without adding to stocks. This result would have been impossible without important additions to the refining capacity of the country and similar additions to the facilities for transporting the products to markets here and abroad. The rate at which production has increased during the last few years foreshadowed the necessity for such manufacturing expansion, and on account of the phenomenal elasticity of the petroleum industry it has been met successfully.

Once provided, this vast refining capacity must continue to be supplied with sufficient crude oil. In spite of the increase of production, therefore, the logic of the situation called for higher prices because of the belief that as soon as the first flood of oil had passed from the fields which were causing an increase, a decline in production would deprive the refineries of the full complement of crude oil necessary for successful operation. The total stocks only suffice for six months' supply. Nevertheless those stocks represent one-eighth of a billion dollars invested in a raw material all of which contains dissolved gas and gasoline sufficient—so long as it is crude—to inflame when struck by lightning and to cause losses by evaporation and leakage. Only a 3 per cent loss of this crude material means a loss of over $7,000,000 a year, even under fairly normal conditions and with the application of most intelligent measures of conservation

Such an investment of money has certainly not proved tempting in any country except the United States.

The obvious ideal method of furnishing an adequate supply of petroleum for commercial needs without the hazardous investment of enormous capital in stocks is to determine with the greatest geologic and engineering skill the reserve of oil underground in each locality and to allow it to remain there with sufficient wells drilled and capped ready to augment the supply at short notice. In spite of theoretical excellence, this scheme fails, however, for three reasons: First, the doubt of the consumer of crude oil as to whether the geologist and the engineer have correctly estimated the productive capacity of a region. This doubt was very thoroughly justified in earlier years by the inadequate knowledge of the conditions of accumulation of oil in the earth. It is even now only of considerable value where it has been supported by the actual drilling of wells, which, after their supply is determined, may be capped for future use. It was this doubt as to the ability of the oil regions to furnish an adequate supply, no less than the desire to control that supply, which led the Standard Oil Co., many years ago, to provide a cash market for oil. This second reason, that is, the ability of the oil producer to find an instant sale for his product, has in turn developed the third reason why oil is not allowed to remain in natural storage, and that is, if one lessee does not immediately take his oil from the earth, he loses because his neighbor who "offsets" him will drain the oil into his own tanks.

Just at this time, July, 1914, the conditions of oil production in the United States have developed into a position involving in all probability radical change in the economic conditions of the oil industry. The production and the known productive capacity of the oil lands in Oklahoma have increased beyond all expectation and reasonable demands, and the extension of oil fields in Texas and Louisiana indicates a possibility of further floods of oil that will require a rearrangement of the productive system. The condition in Oklahoma threatens the axiom that "oil has an instant spot value." So long as oil can be taken from the ground and sold for more than the cost of production so long will active drilling be continued and so long will agreements as to limiting production fail. The point at which the exploration for oil in a new region is no longer logical and the drilling should, therefore, naturally cease, depends upon the yield of the wells when drilled. Oil was probably profitable at 10 cents a barrel in Texas in 1901 on account of the size of the wells yielding it at Spindletop. But at this price all pumping wells would now be unprofitable, and even small flowing wells would not tempt the driller. It is the uncertainty of the size of the well which may be obtained that tempts the speculators in a new region and clouds any clear and rational plan of development of oil territory. The speculative tendency is well illustrated by the fact that in many parts of the United States oil shales could be mined and made to yield oil on a basis as safe and sane as the mining of coal. Nevertheless, few prominent oil producers would leave the speculative thrill of the oil fields for the unexciting development of oil shales.

The solution of the problem of sufficient stock of oil for the enormous refining capacity of the United States must in the future rest chiefly on more accurate knowledge of the supplies of oil under ground, and, based upon this, the consequent application by the State of rigid rules whereby it shall become impossible for one operator to interfere with the oil contained in the property of another.

Stocks of all grades of petroleum at the close of 1912 and 1913, in barrels.

Grade of oil.	Held by eastern pipe lines[a] and refineries.		In pipe line storage outside of eastern field.		Total.		Increase.	Decrease.
	1912	1913	1912	1913	1912	1913		
Pennsylvania [b]	3,804,483	4,387,718			3,804,483	4,387,718	583,235	
Lima	2,419,541	1,746,355			1,746,355			673,186
Illinois [c]	2,368,271	1,079,468	13,341,467	7,163,953	15,709,738	8,243,421		7,466,317
Kentucky	226,035	230,706			226,035	230,706	4,671	
Kansas Oklahoma	2,034,695	2,569,305	46,350,913	51,179,952	48,385,608	53,749,257	5,363,649	
Texas			2,487,144	3,830,291	2,487,144	3,830,291	1,343,147	
Louisiana			2,137,274	1,871,074	2,137,274	1,871,074		266,998
California			49,552,392	48,302,392	47,552,392	48,302,392	750,000	
Colorado and Wyoming			147,487	572,974	147,487	572,974	425,487	
Total	10,853,025	10,013,552	112,016,677	112,930,636	122,869,702	122,934,188	64,486	

[a] These pipe lines connect with the delivering lines of the Illinois, Kansas, and Oklahoma fields and receive and transfer large quantities of these western oils to the Atlantic seaboard in addition to the oil from wells directly tributary to their own systems.
[b] Includes natural lubricating oil from Pennsylvania and West Virginia.
[c] Includes some Indiana oil of Illinois grade.

Stocks, runs, and deliveries to trade of petroleum in 1912 and 1913, by fields, in barrels.

Field.	Stocks Dec. 31, 1911.	Production in 1912.	Deliveries to trade in 1912.	Stocks Dec. 31, 1912.	Production in 1913.	Deliveries to trade in 1913.	Stocks Dec. 31, 1913.
Appalachian	4,734,542	26,338,516	27,042,540	4,030,518	25,921,785	25,333,879	4,618,424
Lima-Indiana	3,194,985	[a] 4,925,906	5,701,350	2,419,541	4,773,138	5,446,324	1,746,355
Illinois	24,063,870	28,601,308	36,955,440	15,709,738	23,893,899	31,360,216	8,243,421
Kansas Oklahoma	54,429,298	53,019,867	59,063,557	48,385,608	65,954,413	60,590,764	53,749,257
Louisiana	3,689,723	9,263,439	10,815,888	2,137,274	12,498,828	12,765,028	1,871,074
Texas	2,855,002	11,735,057	12,102,915	2,487,144	15,009,478	13,666,331	3,830,291
California	44,240,118	[b] 87,272,593	83,960,319	47,552,392	97,788,525	97,038,525	48,302,392
Colorado and Wyoming	25,460	1,778,358	1,656,331	147,487	2,595,321	2,169,834	572,974
Other fields [c]					[c] 10,843	10,843	
Total	137,232,998	222,935,044	237,298,340	122,869,702	248,446,230	248,381,744	122,934,188

[a] Includes production in Michigan.
[b] Includes Alaska.
[c] Includes Alaska, Michigan, Missouri, and New Mexico.

WELL RECORD.

The following tables give the well record for the United States for 1912 and 1913, by fields:

Well record in the United States in 1912 and 1913, by fields.

1912.

Field.	Wells completed.				Initial daily production (barrels).	
	Oil.	Gas.	Dry.	Total.	Total.	Average per well.
Appalachian:						
Pennsylvania and New York	1,911	239	322	2,472	6,771	3.5
Central and southeastern Ohio	846	411	460	1,717	24,193	28.6
West Virginia	1,062	361	234	1,657	109,804	103.4
Kentucky	112	5	61	178	1,943	17.3
Total	3,931	1,016	1,077	6,024	142,711	36.3
Lima-Indiana:						
Lima, Ohio	482	14	55	551	7,229	15.0
Indiana	65	4	20	89	1,083	16.7
Total	547	18	75	640	8,312	15.2
Illinois	980	23	257	1,260	65,686	67.0
Mid-Continent:						
Kansas	536	253	160	949	7,245	13.5
Oklahoma	4,712	438	843	5,993	228,886	48.6
Northern Texas	299	11	124	434	28,213	94.3
Caddo, La	239	52	62	353	84,098	351.9
Total	5,786	754	1,189	7,729	348,442	60.2
Gulf:						
Coastal Texas	353	....	109	462	33,082	93.7
Coastal Louisiana	59	....	25	84	25,520	432.5
Total	412	....	134	546	58,602	142.2
Alaska	2	....	....	2	....	....
California	776	....	71	847	....	....
Colorado	15	....	13	28	....	....
Wyoming and Utah	59	....	25	84	....	....
Michigan	6	....	2	8	....	....
Miscellaneous	....	....	12	12	....	....
Total for 1912	12,514	1,811	2,855	17,180	....	....
Corresponding total for 1911	9,825	1,580	2,363	13,768	....	....

1913.

Field.	Oil.	Gas.	Dry.	Total.	Total.	Average per well.
Appalachian:						
Pennsylvania and New York	3,420	310	521	4,251	8,958	2.6
Central and southeastern Ohio	1,246	342	603	2,191	16,302	13.1
West Virginia	1,285	441	339	2,065	34,835	27.1
Kentucky	133	8	69	210	2,215	16.7
Total	6,084	1,101	1,532	8,717	62,310	10.2
Lima, Ohio	873	9	90	972	11,181	12.8
Indiana	213	12	86	311	7,393	34.7
Total	1,086	21	176	1,283	18,574	17.1
Illinois	1,363	80	278	1,721	47,405	34.8
Mid-Continent:						
Kansas	1,422	334	260	2,016	22,467	15.8
Oklahoma	6,965	578	1,308	8,851	334,050	48.0
Northern Texas	581	10	208	799	57,435	98.9
Caddo, La	356	70	92	518	151,955	426.8
Total	9,324	992	1,868	12,184	565,907	60.7
Gulf:						
Coastal Texas	325	12	255	592	38,978	119.9
Coastal Louisiana	81	1	57	139	55,740	618.1
Total	406	13	312	731	94,718	233.3
Alaska	2	....	....	2	....	....
California	789	....	67	856	....	....
Colorado	8	....	13	21	....	....
Wyoming and Utah	34	....	25	59	....	....
Michigan	4	....	1	5	....	....
Miscellaneous	1	....	10	11	....	....
Total for 1913	19,101	2,207	4,282	25,590	....	....
Corresponding total for 1912	12,514	1,811	2,855	17,180	....	....

FUEL OIL.

GENERAL STATEMENT.

The use of oil in one form or another as fuel for generating power or for domestic heating should be considered under several conditions: First, where oil is the most efficient source of heat and power because of the absence or inadequate supply of cheaper fuel. This is the condition on the entire Pacific slope. Second, where the use of oil as fuel represents a means of disposing of excess accumulation of crude oil, residues, or distillates, for which no market is at hand. This condition frequently prevails in the newer fields of the United States; it always represents a means of disposal by the refineries of undesirable products which would otherwise go to waste. There is a third condition of use of crude oil or its products as fuel which is in a radically different class. This is its application to the generation of power by making steam or in internal-combustion engines in the Navy and the merchant marine. This use is not so strictly limited by the price.

The production of a sudden flood of new oil in any part of the world naturally carries with it the utilization of more or less of this oil for fuel when the price per barrel goes below the limit of competition with coal. Thus at present in Wyoming, although that State contains adequate supplies of coal, use is made of the otherwise unsalable products from the Casper refineries for locomotive service over long distances in that State. This use must naturally increase from the fact that the production of oil in Wyoming is extending faster than any possible adequate market for the heavier products.

Crude oil seldom remains cheap for a very long period, and therefore the supply for railroad use and for other fuel purposes is so unreliable that crude oil as a fuel has lost favor very rapidly, and recourse is eventually made to those products from the crude, which happen in the particular oil under consideration to more than supply the demand for those particular products.

A short time ago the separation of a given crude oil into marketable products was strictly limited by the quantity of these different products naturally occurring in the crude oil. But more advanced methods of refining have lately included the ability to break up the less salable products in crude oil, and thus increase to a very great extent the yields of those products which are most salable.

An interesting example of this is found in California, where the oils obtained a few years ago contained only small percentages of gasoline and kerosene, so that there was a very large quantity of heavier products from the oil, all of which happened to find a good market as fuel. At first, in order to make up the deficit in gasoline and kerosene, gasoline and light crude oils containing much gasoline were imported from Borneo and Sumatra; then recourse was made to extracting gasoline from such natural gas as occurs in association with oil and contains considerable quantities of gasoline vapor. Within the last two years, following this extraction of gasoline from natural gas, the supply of gasoline has also been augmented by cracking the heavy crude oils under pressure, with the resulting production of "motor spirit."

Within the last two years also, a more significant change has occurred. The oils recently produced, especially those from considerable depth, have shown a much greater content of gasoline and kerosene—so much so, indeed, that the effort to produce an adequate supply of gasoline has been overdone. This material, so much in demand in the eastern United States for automobile and other internal combustion engines, has glutted the market of the Pacific coast, with consequently greatly decreased prices.

It is evident that the ability of the refineries to furnish, from all kinds of crude oils, those products which are in greatest demand has enormously increased within the last few years. As a result there is much less of any waste product to be thrown into the waste tanks and sacrificed under the general term of fuel oil. The prices of this material rose significantly in all parts of the eastern fields. Low prices for fuel oil in the future will depend chiefly upon the production of oil of all grades, in such quantity that much of it can only find market as fuel.

Within the last few months, however, the tendency toward cheaper fuel oil has increased because of the producing of low-grade crude oils in larger quantity in the Gulf field of Louisiana and Texas—that is, at Vinton and Edgerly in Louisiana, in Orange County in Texas, and also at greater depth in the old fields of Sour Lake, Saratoga, and Batson, in Texas.

The Mid Continent fields are forcing the heavier oils of the Gulf region to find a market elsewhere, chiefly as fuel. These Gulf oils yield good lubricants, but only a small proportion of the supply can find a market for that limited use. Further, the large fleet of tank steamers lately built enables Mexican oils to invade the eastern coast of the United States. This makes it probable that a large use of fuel oil may become a feature in manufacturing enterprises of the east coast region, and that while this use is being developed careful study will be given to modern methods of burning oils in internal combustion engines. It should be borne in mind, however, that if this substitution of coal by oil receives very great favor the movement would easily overtax the limitations of all the tank steamers in the trade. In the meantime, the advantages of fuel oil for marine engines are so great that the navies of the world will demand it independent of its price, and the merchant marine will be obliged to give this matter extremely careful consideration. Should an outlet for fuel oils really be opened by one large trans-Atlantic steamship line, the effect upon the price of fuel oil would be marked.

CONSUMPTION.

The quantity of crude oil used as fuel in California may be estimated at 29,000,000 barrels, not including the fuel oil from topped California crude. The total fuel oil used in California in 1913 approximated 63,000,000 barrels. The use by railroads of oil from other fields than California and the fuel oil furnished from imported Mexican crude brought the total quantity of fuel oil consumed in the United States in 1913 to 83,000,000 barrels.

PRICES.

The following table shows the relative increase in price of fuel oil during the last three years:

Average prices of fuel oil in bulk at New York, 1911–1913, in cents per gallon.

Months.	1911	1912	1913
January	2.53	2.48	3.35
February	2.63	2.50	3.40
March	2.38	2.56	3.58
April	2.19	2.55	3.49
May	2.19	2.48	3.55
June	2.17	2.69	3.61
July	2.16	2.75	3.44
August	2.16	2.81	3.43
September	2.34	2.93	3.31
October	2.39	2.86	3.43
November	2.44	3.05	3.58
December	2.47	2.99	3.58

RAILROADS.

It has been customary to gage the use of oils for fuel in the United States largely by the consumption by railroads, because the statistics of such consumption may, by careful inquiry, be obtained with approximate accuracy, while consumption in other lines of industry is extremely difficult of determination.

The use of fuel oil by the railroads of Texas was originally due to the sudden flood of cheap oil from the Beaumont region in 1901. The continuance of this trade has lately been aided by imports from Mexico. The ease with which these Texas oils can find other markets than the railroads and the fact that the railroads can return to coal without very serious disadvantage make the future of locomotive consumption of fuel oils in Texas uncertain.

In California the railroads were the first to absorb large quantities of California oils. This legitimate use has become permanent from lack of other fuel, and it has extended to other kinds of generation of power, including marine transportation for shipments coastwise and to foreign countries.

A serious menace to the continued use of oil for fuel in California is the recent change in the character of the crude oils of that State. Many of the new pools yield oils suitable for refining and for the production of large quantities of gasoline and kerosene. Up to the beginning of 1913, about 30 per cent of the oils of California were refined and the rest was sold for fuel as crude or after very slight distillation of the lightest products. This practice changed materially during 1913, so that the proportion of crude oil used direct as fuel became reversed, and, although no accurate figures are available, 70 per cent is about the proportion of crude oil which was refined during that year before the heavier portions were sold for fuel. The result of this, however, will be not to decrease the use of oil for fuel but to change the method of its application, particularly to the internal combustion engine burning kerosene and heavier distillates.

Carefully collected statistics give the following results of the consumption of fuel oil by railroads in the United States from 1906 to 1913.

Although the use of fuel oil extended to a greater number of miles of railroad, the quantity of oil consumed by these railroads decreased slightly and the total mileage made by oil-burning engines decreased in similar proportion, leaving the average number of miles made per barrel of oil consumed the same in 1913 as in 1912.

If it were possible to give a complete statement as to the tonnage moved per barrel, it would undoubtedly show an increase on account of the heavier trains moved, which is offset as to consumption of oil by the increased efficiency of new oil burners, arrangement of oil tanks, and increased skill developed by the firemen.

During 1913 three railroad companies discontinued the use of fuel oil and returned to coal, impelled not only by the advancing tendency of fuel-oil prices but by direct notification from refineries that continuation of contracts would be impracticable. The increase in demand for light products from crude oil has reduced the volume of residuum available for locomotive and other fuel use to a point approximating only 30 per cent of that obtained when gasoline was not in strong demand.

Consumption of fuel oil by the railroads of the United States, 1906–1913.

Year.	Length of line operated by the use of fuel oil.[a]	Quantity of fuel oil consumed by railroads.	Total mileage made by oil-burning engines.	Average number of miles per barrel of oil consumed.
	Miles.	*Barrels.*	*Miles.*	*Miles.*
1906	....	15,577,677	....	....
1907	13,573	18,849,803	74,079,726	3.93
1908	15,474	16,870,882	64,279,509	3.81
1909	17,676	19,905,335	72,918,118	3.66
1910	22,709	23,817,346	89,107,883	3.74
1911	30,039	29,748,845	109,680,976	3.69
1912	28,451	33,605,598	121,393,228	3.61
1913	29,145	33,004,815	118,672,162	3.60

[a] Some of these lines also used coal.

The following are the names of the railroad companies which used fuel oil on their lines in 1913:

Arizona:
- Atchison, Topeka & Santa Fe Railway System.
- Pacific System (excluding Sonora Railway) of the Southern Pacific Co

Arkansas:
- Kansas City Southern Railway Co. (partly).
- St. Louis & San Francisco Railroad Co. and branches.

California:
- Atchison, Topeka & Santa Fe Railway System.
- Northwestern Pacific Railroad Co.
- Pacific System (excluding Sonora Railway) of the Southern Pacific Co.
- San Diego & Arizona Railway Co.
- San Diego & South Eastern Railway Co.
- San Pedro, Los Angeles & Salt Lake Railroad Co
- Tonopah & Tidewater Railroad.
- Western Pacific Railway Co.

Georgia:
- Central of Georgia Railway Co. (on Tybee district).

Idaho:
- Chicago, Milwaukee & St. Paul Railway Co.
- Idaho & Washington Northern Railroad.
- Oregon Short Line Railroad Co.
- Washington, Idaho & Montana Railway Co.

Kansas:
- Atchison, Topeka & Santa Fe Railway System.
- Kansas City Southern Railway Co. (partly).
- Rock Island Lines.[1]
- St. Louis & San Francisco Railroad Co. and branches.

Louisiana:
- Atchison, Topeka & Santa Fe Railway System.
- Houston & Shreveport Railroad Co.
- Iberia & Vermilion Railroad Co.
- Kansas City Southern Railway Co.
- Louisiana Western Railroad Co.
- Morgan's Louisiana & Texas Railroad & Steamship Co.
- New Orleans, Texas & Mexico Railroad Co.
- Texas & Pacific Railway Co.

Missouri:
- Kansas City Southern Railway Co. (partly).
- St. Louis & San Francisco Railroad Co. and branches.

Montana:
- Chicago, Milwaukee & St. Paul Railway Co. (west of Deer Lodge to the Idaho State line).
- Oregon Short Line Railroad Co.

Nebraska:
- Chicago & North Western Railway Co.

Nevada:
- Atchison, Topeka & Santa Fe Railway System.
- Bullfrog Goldfield Railroad.
- Las Vegas & Tonopah Railroad Co.
- San Pedro, Los Angeles & Salt Lake Railroad Co.
- Tonopah & Goldfield Railroad Co.
- Tonopah & Tidewater Railroad.
- Western Pacific Railway Co.

New Mexico:
- El Paso & Southwestern System.
- Pacific System (excluding Sonora Railway) of the Southern Pacific Co.

New York:
- Delaware & Hudson Co. (in the Adirondacks).
- New York Central & Hudson River Railroad Co. (in the Adirondacks, including Old Forge and the Fulton Chain).

Oklahoma:
- Atchison, Topeka & Santa Fe Railway System.
- Kansas City Southern Railway Co. (partly).
- Rock Island Lines.[1]
- St. Louis & San Francisco Railroad Co. and branches.

Oregon:
- Corvallis & Eastern Railroad Co.
- Northern Pacific Railway Co.
- Oregon-Washington Railroad & Navigation Co.
- Pacific Railway & Navigation Co.
- Spokane, Portland & Seattle Railway Co.

South Dakota:
- Chicago & North Western Railway Co.

Texas:
- Artesian Belt Railroad Co.
- Atchison, Topeka & Santa Fe Railway System.
- Galveston, Harrisburg & San Antonio Railway Co.
- Galveston, Houston & Henderson Railroad Co.
- Houston, East & West Texas Railway Co.
- Houston & Texas Central Railroad Co.
- International & Great Northern Railway Co.
- Kansas City Southern Railway Co.
- New Orleans, Texas & Mexico Railroad Co.
- Rock Island Lines (including Chicago, Rock Island & Gulf Railway).[1]
- St. Louis, Brownsville & Mexico Railway.
- St. Louis & San Francisco Railroad Co. and branches.[2]

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[1] Use of oil-burning locomotives discontinued after Apr. 1, 1913, except in switch engines.
[2] Use of oil-burning locomotives discontinued in May, 1913.

Texas—Continued.
- St. Louis, San Francisco & Texas Railway.[1]
- San Antonio & Aransas Pass Railway Co.
- Texas & Pacific Railway Co.
- Trinity & Brazos Valley Railway Co.
- Texas & New Orleans Railroad Co.

Utah:
- San Pedro, Los Angeles & Salt Lake Railroad Co.

Washington:
- Bellingham & Northern Railway Co.
- Chicago, Milwaukee & St. Paul Railway Co.
- Great Northern Railway Co.
- Idaho & Washington Northern Railroad.
- Northern Pacific Railway Co.
- Oregon-Washington Railroad & Navigation Co.
- Spokane, Portland & Seattle Railway Co.

Wyoming:
- Chicago & North Western Railway Co.
- Wyoming & Northwestern Railway.

UNITED STATES NAVY.

The policy of the United States is to use oil exclusively as a fuel in all new battleships and torpedo vessels. There are now built or building the following ships that use oil exclusively as a fuel: Four battleships, 41 destroyers, 50 submarines, 1 monitor, 3 tank ships, 3 tenders, 7 oil barges, and several tugs and small vessels.

The Navy now has the following oil-storage tanks complete: Boston, Mass., 50,000 barrels; Melville Station, R. I., 33,000 barrels; Norfolk, Va., 33,000 barrels; Charleston, S. C., 33,000 barrels; Key West, Fla., 33,000 barrels; Guantanamo, Cuba, 212,000 barrels; San Diego, Cal., 50,000 barrels; and Pearl Harbor, Hawaii, 235,000 barrels.

The naval appropriation act for the fiscal year carries $500,000 for additional fuel-oil storage at Melville, Norfolk, San Diego, Puget Sound, and San Francisco, and provides for the following new ships which will burn oil exclusively: Two battleships, 6 destroyers, 8 submarines.

For the fiscal year ended June 30, 1913, the Navy used something over 21,000,000 gallons of fuel oil.

During the year the Navy has had one representative on a commission to investigate and report upon the feasibility, desirability, and expense of the Government owning and operating a pipe line from the Mid-Continent field to the Gulf of Mexico for the purpose of supplying fuel oil for the Navy. The Navy needs an adequate, dependable supply of fuel oil that can be used at any time without the probabilities of increased cost due to forced buying in case of an emergency.

Tests have been carried out during the year at the fuel-oil testing plant at Philadelphia with a view to making the naval specifications for fuel oil less strict in order to get an oil at a cheaper price.

During 1913 a board was constituted in the Navy Department to determine a proper flash point for fuel oils to be used on battleships. The importance of this subject has been recognized by reports from various experts to foreign Governments, which have resulted in the

[1] Use of oil-burning locomotives discontinued after July 1, 1913.

adoption of the following minimum flash points for fuel oils for naval purposes:

Minimum flash points adopted for fuel oils for naval use.

	° F.
United States	[a] 150
Great Britain	175
Germany	187
France	200
Russia	212
Italy	212
Austria	248

The board began its investigation by adopting the following assumptions before proceeding with the investigation:

(a) That oils having viscosities such that they must be heated in the bunkers must have such a flash point that no explosive or inflammable mixtures are formed therein.

(b) That it is undesirable and dangerous that oil should be heated anywhere—in bunkers or in firerooms—above the point where explosive or inflammable gases are given off.

(c) That the reliability of the flash cup in determining the point at which this condition of explosive mixture begins to exist should be checked in order that a guide may be established which may be known to be safe and positive.

The board then obtained large samples of oils which showed characteristics given in the accompanying table. These oils include the characteristics of practically all known fuel oils.

The first problem investigated by the board was to find the temperature at which various oils must be heated in the bunkers in order that the pumps may take more than the quantity for full-speed steaming conditions. With pumps such as used on battleships three grades of Mexican oils were used, those designated as 15.4°, 17.3°, and 11.7° gravity Baumé, the last representing the extreme of viscous oils on the market. The suction was taken from the 1,200-gallon submerged oil tanks with about an 8-foot lift from about 100 feet of 3-inch piping bushed down to 2½ inches at the pump. The following results were obtained:

Pumping capacity of pumps for different oils at varying temperatures.

Temperature (° F.).	Toltec, Mexican, 12° B., gallons per hour.	Mexican, 15.4° B., gallons per hour.	Mexican, 17.3° B., gallons per hour.
65	87	....	41
73	120	226	....
75	130	376	1,106
80	173	717	1,414
90	295	1,365	1,997
100	458	1,904	2,546
110	683	2,486	2,970
120	987	3,000	3,348
130	1,360	3,516	3,636
140	1,775	....	....
150	....	4,190	4,063

The board estimated that the standard Blake pump used in this test, which conforms with the installation on board ship, requires that this pump should deliver 564 gallons an hour, in order to secure an adequate quantity for full power. This, then, is taken as the standard of comparison in determining the temperature to which oil must be heated in order that the suction pumps may supply an adequate quantity for full speed.

[a] Reduced from 175° by recommendation of this board.

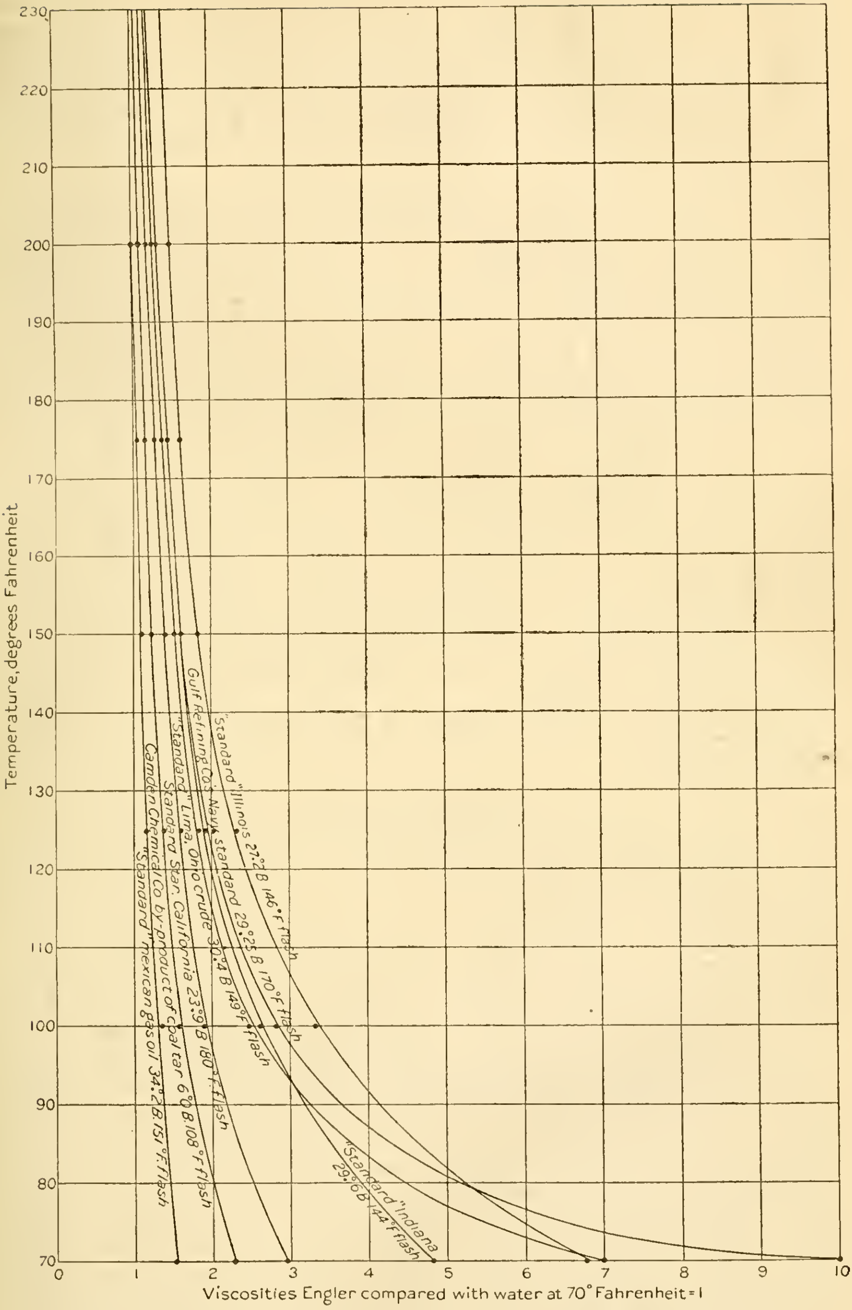


FIGURE 22.—Curves showing the relation of viscosity to temperature for various fuel oils.

It will be seen from the curve of pumping capacity that the 17.3° Mexican oil must have a temperature of 67° F. or above in order that the pump may take an adequate supply for full speed; the Mexican 15.4°, a temperature of 77° F. or above; and the Toltec (Mexican) 12° B. must be heated to 105° F. This latter result is considered by the board as the limiting temperature. The board ascertained that it is the practice on the Southern Pacific steamers burning this oil to heat up to 115° or 120° F.

The next problem was to sample and analyze and attempt to ignite the gases given off in the bunkers at these temperatures, in order to ascertain the danger of such heating of oil in the bunkers. This investigation was carried out by A. G. Hulett and C. A. Burrell, of the Bureau of Mines. The investigation showed that no inflammable gas is formed under conditions similar to those in the bunkers of ships until the oil is heated to its flash point, and that the Abel Pennsky-Martin closed flash cup gives results which check with the results obtained in the tank. The experiment showed that the fuel oils in this experiment did not contain dissolved gas or vapor sufficient to form any explosive mixture until a temperature equivalent to flash point was reached. Examination of the air over the fuel oils in the bunkers of various battleships showed that this air did not contain more than an insignificant quantity of combustible vapor. Almost 0.9 per cent of combustible vapor must be present in a mixture of vapor and air to form an explosive mixture. The largest amount found was 0.04 per cent. The following conclusions were reached:

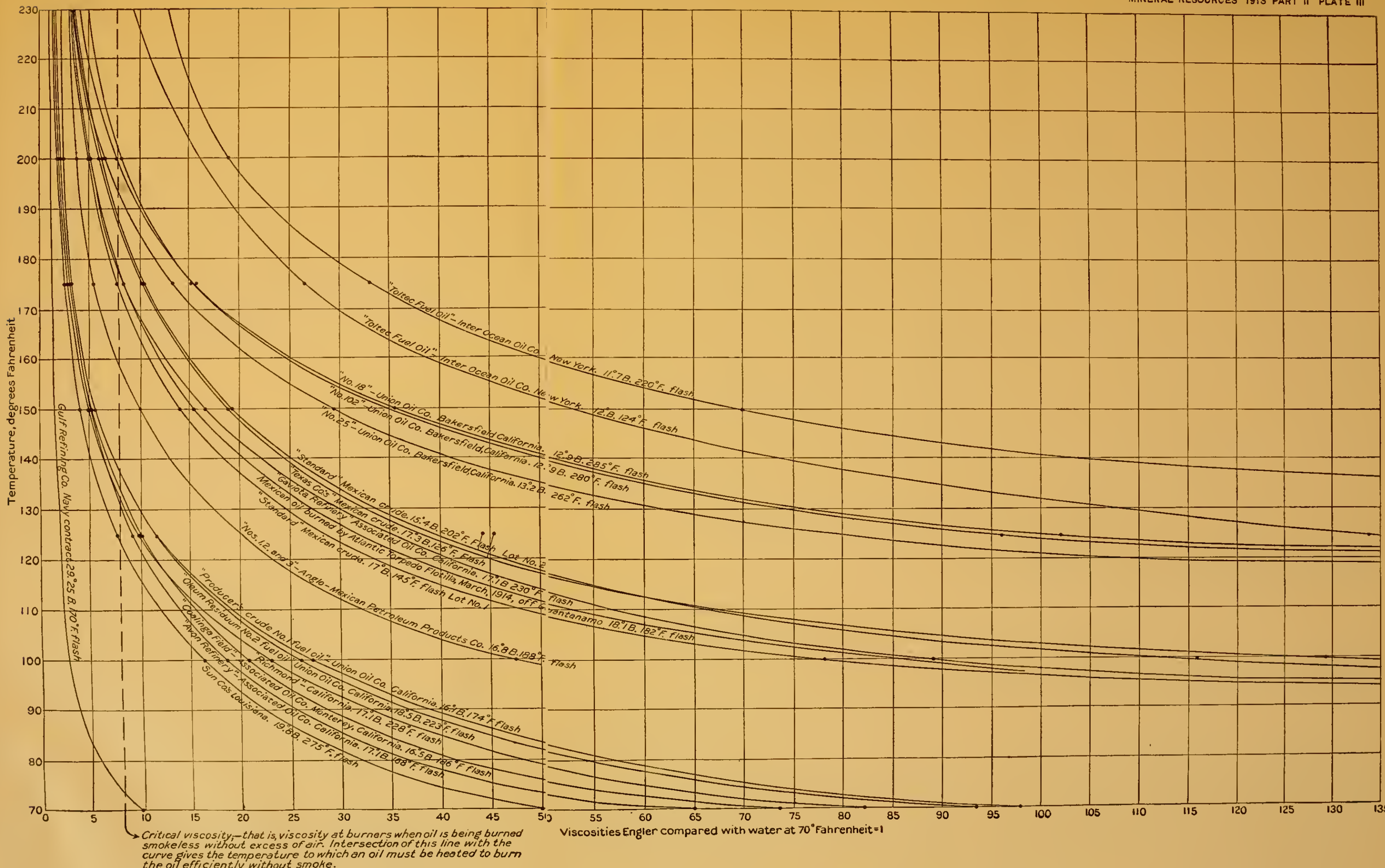
1. At the flash temperatures the vapors produced constitute about 1.0 to 1.25 per cent of the mixture of air and vapor. They consist principally of vapors of the liquid paraffins, hexane, and heptane.

2. On board ship these oils can be heated to within about 15° C. (59° F.), of their flash point before even a noticeable halo or partial burning occurs should they be accidentally inflamed.

3. The flash points shown herein are a good indication of the temperatures to which the oils can be heated before an explosion of the released vapors can occur.

The board also conducted actual tests of each kind of oil, using a type of Navy boiler, Navy standard burner, etc., to ascertain the temperature to which each type of oil must be heated in order to secure smokeless combustion.

The various oils were given an evaporative test in a Navy boiler, using the bureau type burners, pumps, etc. The record of these tests are in the files of the Bureau of Steam Engineering. All these oils were easily burned without smoke, and the temperature of the oil was noted at the oil heater. It developed that the temperatures were such in general as to indicate that all oils of whatever character must be heated to a viscosity of 8 Engler in order to burn smokelessly without undue excess of air. As a point of interest, any increase of heating in reducing the viscosity below 8 Engler is not accompanied by increase in evaporative efficiency. On all the tests the temperature of the oil was dropped for a few minutes at various times below that corresponding to 8 Engler, while keeping the oil pressure, draft, etc., steady. In every case where the temperature was dropped below the critical temperature corresponding to 8 Engler the smoke increased in density and volume; and as the temperature was again brought up the smoke disappeared at the same critical temperature. It thus appears that 8 Engler for smokelessness is well established for the present oil-burning apparatus on board United States naval vessels. (See Pl. III and fig. 22.)



CURVES SHOWING THE RELATION OF VISCOSITY TO TEMPERATURE FOR VARIOUS FUEL OILS.

In connection with the work of the board the Philadelphia Navy Yard was instructed to conduct experiments for such oils as might be available to determine the permissible content of sulphur and the extent of the corrosion which may occur with oils containing various sulphur contents. Various test pieces of steel, both dull and bright, were placed in oils of five different grades as to sulphur content, and the tanks were heated to 120° F. and maintained at that temperature for a month. The second set of tanks was maintained at 100° F., and the third set was kept at the ordinary temperature. At the end of this period a careful inspection of the different test pieces was made. No conclusion could be drawn with reference to the corrosion due to the oils having a high sulphur content. Some of the greatest losses in weight were noticed in the test pieces immersed in the low sulphur content oils, and in one case one of the high sulphur content oils lost practically nothing in weight. The experiments have not been concluded, but as far as made show that the loss of weight is not directly dependent upon the sulphur content.

The general conclusions of the board concerning the proper flash point for fuel oils are:

1. It is not necessary to heat any known fuel oil now found on the market to a temperature above 105° F. in order to obtain free flow and adequate suction with the type of pumps, piping, etc., installed on board naval vessels.
2. No inflammable or explosive mixtures are formed when a tank of oil is heated to this temperature by a steam coil, nor are they formed at any temperature below the flash point.
3. The minimum of 150° F. flash-point, as obtained with the Abel or Pennsky-Martin's cup, is safe, and further has an adequate margin of safety.
4. In order to attain smokeless burning with the present oil-burning installations on board ship, the temperature of the oil at the oil heater must be that corresponding to 8 Engler.

The work of the board, if applied to the framing of specifications for fuel oil for the Navy, would result as follows:

1. Fuel oil shall be a hydrocarbon oil, free from grit, acid, and free from fibrous and other foreign matter likely to clog or injure the burners.
2. The flash point shall not be below 150° F. (Abel or Pennsky-Martin's closed cup), nor shall it be lower than that temperature at which the oil has a viscosity of 8 by the Engler scale (water at 70° F.=1).
3. Viscosity: Not greater than 200 Engler at 100° F.[1]
4. Water and sediment shall not exceed 1 per cent; if in excess of this, the excess to be subtracted from the volume, or the oil may be rejected.

As recently explained by Mr. Winston Churchill,[2] first lord of the Admiralty, the British Admiralty has in stock, safely stored in England, considerably more than three years' consumption of fuel for their very large oil-burning fleet. The Admiralty keeps, either purchased or stored in the country or else in view under definite war contracts or other effective arrangements, sufficient oil to enable it to conduct a whole year's war, and arrangements are complete for increasing this reserve with the increase of the fleet.

In regard to the propriety of the use of oil as fuel in the British Navy, Mr. Winston Churchill states:

1. The advantages to be derived from the use of oil fuel, and the imperative necessity for such use if the fleet is to be maintained in a condition of the highest attainable efficiency, are conclusively established by the commissioners' first interim report.

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[1] The limiting viscosity of 200 Engler is suggested because it developed during the tests that the present type of oil heater installed on board ship will not heat the heaviest Mexican and California oils to a sufficient degree to allow smokeless combustion at full power. When the type of oil heater is improved, the viscosity clause can be eliminated.

[2] Petroleum Rev., March, 1914.

2. The commissioners are of opinion that the oil resources of the world are amply adequate to meet the requirements of the fleet if suitable measures are taken to secure supplies.

3. Large reserves should be accumulated in this country and at certain other storage centers in British territory. The extent of these reserves should bear a prescribed relation to the consumption under peace requirements, and this will give a definite basis.

PETROLEUM OPERATORS' STATISTICS.

As stated on a previous page, the statistics of petroleum production are collected by two different systems, and the resulting totals represent a combination of the data obtained by both systems. It is interesting also to publish the totals of the statistics obtained from the statistical cards returned by the producers only. If every operator furnished the statement requested the results would represent the exact and complete production of petroleum in the United States, whereas the pipe-line runs alone never can amount to the complete production and always require the addition of the railroad shipments and the shipments made directly from wells to refineries, the collection of statistics for which involves considerable correspondence with many operators.

The following tables of the operators' statistics alone are therefore an interesting index of the degree to which the petroleum operators recognize the advantage of cooperating with the United States Geological Survey by promptly furnishing their individual statements. The statistics for some of the States are within less than 2 per cent of the actual production of those States, as shown by the pipe-line returns plus the additional figures from railroads and other sources. To most petroleum statisticians the expression "pipe-line runs" is synonymous with "total production," whereas the production of oil shown by the pipe-line returns is always less than the total production, because considerable oil is produced which never gets into pipe lines. In Illinois, for example, the quantity of oil shown by the pipe-line runs, published monthly, differs from the actual production by 8 per cent, which is much more than the difference—1.4 per cent—between the quantity reported from producers and the total actual production. In Oklahoma the corresponding pipe-line runs are 16 per cent less than the total production, and the reported production by the operators is 8.5 per cent less than the total. In Pennsylvania this "pipe-line" total is 23 per cent less than the real production, whereas the total from the reporting operators is 10.8 per cent less. This is what might be expected in Pennsylvania, because the total of barrels is made up of statements from thousands of small producers, including part-interest owners, hundreds of whom produce less than 1,000 barrels each year. In fact, it was emphatically stated by the producers themselves that the collection of the oil statistics from the producers would be impossible, and Pennsylvania was cited as an obvious example of this impossibility. The encouraging result from Pennsylvania was largely due to the cooperation of Richard R. Hice, State geologist of Pennsylvania.

As already explained, the statistics for California, Colorado, and Wyoming have always been collected from the producers, and these are presented under the detailed statement of those particular States.

Production and value of petroleum, well records, and acreage for the United States in 1912 and 1913, by States, from statistics furnished by producers.

1912.

State.	Production (in barrels). Placed to credit of— Producer.	Production (in barrels). Placed to credit of— Land-owner.	Production (in barrels). Total.	Value.	Average price per barrel.	Wells. Productive Jan. 1.	Wells. Completed. Oil.	Wells. Completed. Dry.	Wells. Abandoned.	Wells. Productive Dec. 31.	Average daily production (in barrels) per well.	Acreage. Fee.	Acreage. Lease.	Acreage. Total.
Alabama								2				80	9,000	9,080
Alaska			(a)	(a)		3	2			5		160	9,500	9,660
Arizona								1				160		160
Arkansas								5				80	89,800	89,880
California	83,916,130	3,356,463	b87,272,593	b$39,624,501	$0.454	5,947	776	71	402	6,321	37.8	334,902	208,926	543,828
Colorado	204,852	1,200	206,052	199,661	.968	120	15	13	23	112	5.0	9,404	11,365	20,769
Georgia								1					1,500	1,500
Illinois	23,891,074	4,287,014	28,178,088	24,403,811	.866	12,753	992	208	507	13,238	5.8	3,161	255,843	259,004
Indiana	736,233	114,364	850,597	793,891	.933	5,127	82	17	1,038	4,171	.6	(c)	(c)	(c)
Kansas	1,117,325	132,184	1,249,509	832,171	.665	1,757	279	41	224	1,812	1.9	18,458	119,274	137,732
Kentucky	348,714	43,376	392,090	331,738	.846	988	96	56	148	936	1.1	(c)	(c)	(c)
Louisiana	9,140,524	1,611,172	10,751,696	7,970,977	.741	555	315	91	90	780	37.7	29,345	221,034	250,379
Michigan			(d)	(d)		44	6	2		50		(c)	(c)	(c)
Missouri														
New Mexico								1				800	1,920	2,720
New York	812,334	65,193	877,527	1,346,448	1.534	10,625	248	6	357	10,516	.2	(c)	(c)	(c)
Ohio	6,709,770	1,011,632	e7,721,402	e10,417,921	1.349	31,337	1,485	297	2,083	30,739	.7	(c)	(c)	(c)
Oklahoma	38,061,084	5,447,496	43,508,580	29,489,162	.678	15,698	3,668	440	651	18,715	6.4	43,731	1,383,705	1,427,436
Oregon								1				7,000	700	7,700
Pennsylvania	6,348,298	688,293	7,036,591	11,407,465	1.621	52,745	2,196	195	1,396	53,545	.36	(c)	(c)	(c)
Tennessee								1				684	27,500	28,184
Texas	9,776,241	1,199,738	10,975,979	8,100,329	.738	2,473	757	284	246	2,984	10.1	51,089	1,186,570	1,237,659
Utah			(f)			17		1	4	13		13,717	1,160	14,877
Wyoming	1,225,081	347,225	1,572,306	798,470	.507	160	59	24	30	189	22.7	20,144	44,666	64,810
West Virginia	10,160,301	1,424,285	11,584,586	18,785,748	1.602	13,014	1,327	140	616	13,725	2.3	310,799	1,636,611	1,947,410
Total	192,447,961	19,729,635	212,177,596	154,502,293	.728	153,363	12,303	1,898	7,815	157,851	3.7			

a Included in California.
b Includes Alaska.
c Data for 1912 not complete.
d Included in Ohio.
e Includes production of Michigan.
f No production.

Production and value of petroleum, well records, and acreage for the United States in 1912 and 1913, by States, from statistics furnished by producers—Continued.

1913.

State.	Production (in barrels).			Value.	Average price per barrel.	Wells.					Average daily production (in barrels) per well.	Acreage.		
	Placed to credit of—		Total.			Productive Jan. 1.	Completed.		Abandoned.	Productive Dec. 31.		Fee.	Lease.	Total.
	Producer.	Land-owner.					Oil.	Dry.						
Alaska			(a)	(a)		5	2			7		160	9,500	9,660
Arkansas								5					28,381	28,381
California	93,692,611	4,095,914	97,788,525	$45,709,400	$0.467	6,321	789	67	293	6,817	39.3	293,332	209,611	502,943
Colorado	187,902	897	188,799	174,779	.926	112	8	13	27	93	5.6	9,733	5,605	15,338
Illinois	19,896,114	3,669,105	23,565,219	31,038,378	1.317	13,238	1,356	187	494	14,100	4.6	3,368	244,327	247,695
Indiana	758,603	115,650	874,253	1,150,875	1.316	4,171	202	37	559	3,814	.6	7,570	99,705	107,275
Kansas	1,994,108	248,725	2,242,833	2,123,586	.947	1,812	1,336	87	94	3,054	2.0	20,566	182,438	203,004
Kentucky	428,510	51,072	479,582	584,269	1.218	936	112	51	80	968	1.3	27,579	141,479	169,058
Louisiana	10,368,537	2,008,263	12,376,800	11,897,422	.960	780	369	64	149	1,000	33.9	59,151	410,552	469,703
Michigan			(a)	(a)		27	4	1	5	26		15	3,240	3,255
Mississippi								2					1,000	1,000
Missouri			(a)	(a)		23		1		23			16,292	16,292
New Mexico			(a)	(a)		1	1	2		2			2,860	2,860
New York	807,969	62,386	870,355	2,116,679	2.432	10,516	393	17	228	10,681	.2	44,261	85,571	129,832
Ohio	6,908,361	1,039,546	7,947,907	14,951,993	1.881	30,739	2,165	335	1,957	30,947	.7	64,733	845,240	909,973
Oklahoma	50,909,222	7,245,483	58,154,705	54,971,500	.945	18,715	6,111	669	741	24,085	6.6	36,414	1,486.417	1,522,831
Pennsylvania	6,443,173	658,694	7,101,867	17,789,287	2.505	53,545	b 3,538	318	2,006	55,077	.35	315,896	767,037	1,082,933
Tennessee								1						
Texas	13,065,046	1,652,388	14,717,434	14,216,115	.966	2,984	877	299	424	3,437	11.7	61,388	628,703	690,091
Utah			(c)	(c)		13		9	4	9		23,197		23,197
Washington							1			1				
West Virginia	9,770 887	1 420,927	11,191,814	27,935,262	2.496	13,725	1,320	180	501	14,544	2.1	66,520	1,878,599	1,945,119
Wyoming	1,608,120	798,402	2,406,522	1,187,232	.493	189	34	16	25	198	33.3	18,220	35,230	53,450
Other States	10,813	30	d 10,843	d 19,263	1.777									
Total	216,849,976	23,067,482	239,917,458	225,866,040	.941	157,851	18,618	2,361	7,587	168,882	3.8	1,052,103	7,031,787	8,133,890

a Included in "Other States."
b Includes many wells previously abandoned and in 1913 cleaned out and made productive on account of increased price during the year.
c No production.
d Includes Alaska, Michigan, Missouri, and New Mexico.

The following tables give the well records of the petroleum industry in 1912 and 1913 for the respective States by counties:

Petroleum well record in 1912 and 1913, by counties.

NEW YORK.

County.	Productive Jan. 1.	1912				1913						
		Completed.		Abandoned.	Productive Dec. 31.	Completed.		Abandoned.	Productive Dec. 31.	Acreage.		
		Oil.	Dry.			Oil.	Dry.			Fee.	Lease.	Total.
Allegany	7,620	175	6	280	7,515	290	12	148	7,657	27,446	44,799	72,245
Cattaraugus	2,787	61	.....	66	2,782	97	5	72	2,807	15,285	39,768	55,053
Steuben	218	12	.....	11	219	6	.....	8	217	1,530	1,004	2,534
Total	10,625	248	6	357	10,516	393	17	228	10,681	44,261	85,571	129,832

PENNSYLVANIA.

County.	Productive Jan. 1.	1912 Completed Oil.	1912 Completed Dry.	1912 Abandoned.	1912 Productive Dec. 31.	1913 Completed Oil.	1913 Completed Dry.	1913 Abandoned.	1913 Productive Dec. 31.	Acreage Fee.	Acreage Lease.	Acreage Total.
Allegheny	1,688	50	19	74	1,664	62	18	46	1,680	2,957	68,777	71,734
Armstrong	179	8	.....	17	170	25	3	27	168	2,411	3,174	5,585
Beaver	593	33	11	17	609	29	14	48	590	2,059	12,821	14,880
Butler	5,116	258	51	106	5,268	434	80	233	5,469	21,229	59,626	80,855
Clarion	1,792	39	7	82	1,749	138	25	136	1,751	11,768	21,414	33,182
Crawford	616	24	.....	43	597	47	4	76	568	983	4,909	5,892
Elk	1,116	10	2	8	1,118	36	2	4	1,150	12,169	55,433	67,602
Forest	1,633	39	15	60	1,612	145	17	95	1,662	36,864	40,988	77,852
Greene	484	31	19	19	496	34	28	23	507	1,327	78,494	79,821
Jefferson	131	5	6	1	135	7	7	....	142	9,540	32,717	42,257
Lawrence	68	552	5	3	617	302	6	1	918	97	15,470	15,567
McKean	15,055	288	12	373	14,970	613	14	528	15,055	91,394	120,475	211,869
Mercer	266	11	.....	1	276	10	.....	11	275	230	2,995	3,225
Potter	85	......	.....	7	78	14	.....	....	92	36,337	8,861	45,198
Tioga	26	......	.....	19	7	......	.....	....	7	....	247	247
Venango	15,199	634	27	281	15,552	1,320	72	432	16,440	49,548	65,571	115,119
Warren	6,906	189	16	196	6,899	290	12	248	6,941	34,811	43,585	78,396
Washington	1,792	25	5	89	1,728	32	16	98	1,662	2,172	131,480	133,652
Total	52,745	2,196	195	1,396	53,545	[a]3,538	318	2,006	55,077	315,896	767,037	1,082,933

WEST VIRGINIA.

County.	Productive Jan. 1.	1912 Completed Oil.	1912 Completed Dry.	1912 Abandoned.	1912 Productive Dec. 31.	1913 Completed Oil.	1913 Completed Dry.	1913 Abandoned.	1913 Productive Dec. 31.	Acreage Fee.	Acreage Lease.	Acreage Total.
Braxton	1	......	1	....	1	3	.....	1	3	....	56,772	56,772
Brooke	326	5	1	58	273	9	4	19	263	824	6,310	7,134
Cabell	23	1	.....	....	24	1	2	2	23	....	5,973	5,973
Calhoun	274	37	5	21	290	24	5	11	303	73	17,440	17,513
Clay	3	11	3	2	12	18	1	4	26	234	58,586	58,820
Doddridge	554	19	5	3	570	39	16	15	594	2,324	57,527	59,851
Gilmer	83	4	.....	3	84	9	3	6	87	646	12,852	13,498
Greenbrier	....	......	.....	....	....	......	1	....	....	....	....	....
Hancock	300	52	1	4	348	16	3	36	328	1,371	5,100	6,471
Harrison	1,148	58	8	50	1,156	85	9	27	1,214	4,691	76,257	80,948
Jackson	....	......	.....	....	....	1	.....	....	1	....	90,830	90,830
Kanawha	5	409	17	4	410	184	11	22	572	733	323,056	323,789
Lewis	224	34	6	3	255	17	4	1	271	6,835	82,571	89,406
Lincoln	493	68	.....	2	559	76	1	3	632	1,182	249,644	250,826
Logan	2	......	.....	1	1	......	.....	1	....	....	33,591	33,591
Marion	640	19	2	15	644	46	5	6	684	1,307	51,910	53,217
Marshall	167	9	.....	41	135	3	1	4	134	250	6,741	6,991
Mason	....	1	2	....	1	2	4	....	3	....	10,225	10,225
Monongalia	677	20	1	13	684	34	4	14	704	15,498	80,503	96,001
Ohio	4	......	.....	2	2	5	.....	....	7	20	9,005	9,025
Pleasants	1,613	69	13	166	1,516	156	19	79	1,593	1,441	35,406	36,847
Putnam	....	......	2	....	....	2	2	....	2	....	3,972	3,972
Ritchie	1,801	110	18	64	1,847	164	30	94	1,917	6,882	122,623	129,505
Roane	714	122	10	10	826	216	18	5	1,037	4,462	257,330	261,792
Tyler	1,577	40	18	64	1,553	43	11	38	1,558	5,039	48,753	53,792
Upshur	....	......	1	....	....	......	.....	....	....	....	....	....
Wayne	2	1	.....	2	1	2	1	1	2	4,400	63,075	64,475
Wetzel	1,196	56	3	72	1,180	23	12	20	1,183	2,259	88,829	91,088
Wirt	431	56	2	10	477	57	2	41	493	4,578	9,600	14,178
Wood	756	126	21	6	876	85	11	51	910	1,471	14,118	15,589
Total	13,014	1,327	140	616	13,725	1,320	180	501	14,544	66,520	1,878,599	1,945,119

[a] Includes many wells previously abandoned and in 1913 cleaned out and made productive on account of increased price during the year.

Petroleum well record in 1912 and 1913, by counties—Continued.

KENTUCKY.

County.	Productive Jan. 1.	1912				1913						
		Completed.		Abandoned.	Productive Dec. 31.	Completed.		Abandoned.	Productive Dec. 31.	Acreage.		
		Oil.	Dry.			Oil.	Dry.			Fee.	Lease.	Total.
Allen		6			6	6	2		12		4,232	4,232
Barren	7				7	3	2		10	31	1,514	1,545
Bath	91			1	90				90		800	800
Boyd			19									
Cumberland							1					
Floyd	19	3		2	20		1		20		6,175	6,175
Hancock			2									
Knott	2				2				2		568	568
Knox							1					
Lawrence	10	14	6	6	18	11	2	2	27	1,500	21,325	22,825
Logan	5	3			8		1	2	6		8,000	8,000
Martin							1				3,600	3,600
Morgan		4			4	30	10	1	33	2,000	2,394	4,394
Ohio		3		1	2	2	1		4		6,200	6,200
Rowan	35				35				35		350	350
Shelby							1					
Wayne	688	53	28	126	615	44	21	62	597	24,048	67,821	91,869
Wolfe	131	10	1	12	129	16	7	13	132		18,500	18,500
Total	988	96	56	148	936	112	51	80	968	27,579	141,479	169,058

OHIO.

County.	Productive Jan. 1.	1912 Completed Oil.	1912 Completed Dry.	1912 Abandoned.	1912 Productive Dec. 31.	1913 Completed Oil.	1913 Completed Dry.	1913 Abandoned.	1913 Productive Dec. 31.	Fee.	Lease.	Total.
Allen	1,803	31		255	1,579	105	7	115	1,569	2,193	26,622	28,815
Athens	121	18	4	14	125	11	2	12	124	1,270	10,551	11,821
Auglaize	561	13		44	530	23	1	23	530	1,458	2,229	3,687
Belmont	185	8	2	41	152	31	4	1	182	527	25,185	25,712
Carroll	43	6		2	47	16		3	60	329	8,790	9,119
Clermont							2					
Columbiana	291	21	10	46	266	62	10	7	321	116	6,155	6,271
Coshocton	17	2	5		19	15	5	4	30		52,040	52,040
Cuyahoga						1			1			
Erie						1			1		325	325
Fairfield	242	50	1	12	280	32	6	19	293	234	18,183	18,417
Guernsey	10	4			14	11		7	18		785	785
Hancock	3,293	70	2	137	3,226	156	12	225	3,157	2,099	33,222	35,321
Hardin		2	1		2	1			3	326		326
Harrison	862	20	13	136	746	61	5	91	716	3,530	10,159	13,689
Hocking	20	79	12	2	97	57	11	8	146	3,110	90,956	94,066
Holmes	28	3			31	3			34	140	6,571	6,711
Jackson	14			14		1			1		2,000	2,000
Jefferson	426	31	16	22	435	59	39	35	459	2,805	13,336	16,141
Knox	6	3			9	2	7	1	10	192	23,003	23,195
Lake		1			1				1		1,000	1,000
Lawrence		3	2		3				3		1,868	1,868
Licking	1	23	10		24	29	3		53		36,491	36,491
Logan		3	2		3	3	1		6		10,000	10,000
Lorain	9		5	1	8				8			
Lucas	530	20	2	65	485	34	1	44	475	1,993	4,687	6,680
Mahoning						1			1		3,900	3,900
Marion			1									
Medina	3				3				3		84,359	84,359
Meigs		1	1		1			1			2,291	2,291
Mercer	702	11		57	656	96	5	50	702	1,699	12,301	14,000
Monroe	2,587	118	38	72	2,633	85	18	185	2,533	6,431	62,875	69,306
Morgan	803	141	52	69	875	113	35	29	959	1,079	8,995	10,074
Muskingum	162	8	2	8	162	19	4	3	178	320	15,967	16,287
Noble	424	59	16	36	447	82	10	34	495	1,452	9,998	11,450
Ottawa	508	21	2	49	480	12		55	437	2,376	6,897	9,273
Perry	320	212	17	33	499	170	25	36	633	2,345	78,394	80,739
Richland							1					
Sandusky	4,095	95	5	179	4,011	172	3	75	4,108	6,814	37,412	44,226
Seneca	672	20	4	55	637	35	3	46	626	1,700	5,049	6,749
Shelby	22			3	19			4	15		200	200
Stark			1									
Summit			1				1			76		76
Trumbull	16	10	1	11	15				15	728	210	938
Van Wert	842	20	4	132	730	34	6	73	691	1,006	14,586	15,592
Vinton	15			9	6				6	60	3,501	3,561
Washington	3,878	176	56	321	3,733	349	55	287	3,795	4,940	46,356	51,296
Wayne		11	5		11	24	7	1	34		10,570	10,570
Wood	7,719	168	1	258	7,629	258	46	477	7,410	12,495	54,921	67,416
Wyandot	107	3	3		110	1		6	105	890	2,300	3,190
Total	31,337	1,485	297	2,083	30,739	2,165	335	1,957	30,947	64,733	845,240	909,973

Petroleum well record in 1912 and 1913, by counties—Continued.

INDIANA.

County.	Productive Jan. 1.	1912 Completed. Oil.	1912 Completed. Dry.	1912 Abandoned.	1912 Productive Dec. 31.	1913 Completed. Oil.	1913 Completed. Dry.	1913 Abandoned.	1913 Productive Dec. 31.	1913 Acreage. Fee.	1913 Acreage. Lease.	1913 Acreage. Total.
Adams	729	18		196	551	10		58	503	1,570	9,932	11,502
Blackford	239	4		59	184	5	2	21	168	45	5,069	5,114
Daviess		1	1		1	2			3		3,500	3,500
Delaware	164	16	3	52	128	40	3	26	142	610	7,206	7,816
Gibson	115	3	1	4	114	18			132	1	5,038	5,039
Grant	850			238	612	1		97	516	200	10,637	10,837
Greene						2	2		6		799	799
Hamilton						1			1		1,200	1,200
Harrison		3	2		3		2		3		10,000	10,000
Huntington	492			70	422	4		68	358	216	5,411	5,627
Jay	912	17	3	99	830	26	3	105	751	3,802	12,894	16,696
Knox							1					
Miami							1					
Montgomery			1									
Pike	158	5	3	15	148	9	5	8	149	40	1,287	1,327
Porter			1									
Randolph	39	5			44	8			52		8,600	8,600
Sullivan	6	2			8	70	17		78	122	8,299	8,421
Vigo	8	1			9				9		179	179
Wayne			1									
Wells	1,413	5	1	305	1,113	6	1	176	943	964	9,654	10,618
Total	5,127	82	17	1,038	4,171	202	37	559	3,814	7,570	99,705	107,275

ILLINOIS.

1912.

County.	Wells. Productive Jan. 1.	Wells. Completed. Oil.	Wells. Completed. Dry.	Wells. Abandoned.	Wells. Productive Dec. 31.	Acreage. Fee.	Acreage. Lease.	Acreage. Total.
Bond			1				6,315	6,315
Clark	2,254	62	7	90	2,226	1,260	23,865	25,125
Clinton	110	39	6	15	134		4,598	4,598
Coles	54	10	11		64		630	630
Crawford	6,853	263	104	274	6,842	827	83,595	84,422
Cumberland	662	27	10	27	662	13	5,796	5,809
Edgar	6				6	470	80	550
Jasper		4			4		651	651
Jackson			3					
Lawrence	2,769	543	53	92	3,220	591	63,786	64,377
Macoupin	1	3	4		4		3,280	3,280
Madison	1	1			2		8,758	8,758
Marion	40	28	1	6	62		19,688	19,688
Montgomery			2				18,165	18,165
Perry			2				12,656	12,656
Randolph	3	3	2	3	3		600	600
Wabash		9	2		9		3,380	3,380
Total	12,753	992	208	507	13,238	3,161	255,843	259,004

Petroleum well record in 1912 and 1913, by counties—Continued.

ILLINOIS—Continued.

1913.

County.	Wells.					Acreage.		
	Productive Jan. 1.	Completed.		Abandoned.	Productive Dec. 31.	Fee.	Lease.	Total.
		Oil.	Dry.					
Clark	2,226	104	14	125	2,205	948	25,487	26,435
Clinton	134	15		1	148		36,120	36,120
Coles	64	5			69	56	740	796
Crawford	6,842	612	95	150	2,304	901	77,722	78,623
Cumberland	662	20	2	46	636		5,725	5,725
Douglas			1					
Edgar	6	3	2		9	955		955
Edwards			2					
Fulton			1					
Jackson			2					
Jasper	4		2	1	3		150	150
Jefferson			1				2,000	2,000
Lawrence	3,220	547	56	168	3,599	166	60,715	60,881
Macoupin	4	2	4		6		4,780	4,780
Madison	2				2	342		342
Marion	62	35			97		19,278	19,278
Morgan		3			3		390	390
Perry			1					
Randolph	3			3			460	460
St. Clair			1					
Wabash	9	10	1		19		2,760	2,760
Washington			1					
White			1				8,000	8,000
Total	13,238	1,356	187	494	14,100	3,368	244,327	247,695

KANSAS.

1912.

County.	Productive Jan. 1.	Oil.	Dry.	Abandoned.	Productive Dec. 31.	Fee.	Lease.	Total.
Allen	170	34	14	32	172	1,452	7,913	9,365
Chautauqua	766	106	19	61	811	10,600	47,982	58,582
Coffey	2				2		398	398
Elk	4	2			6		150	150
Franklin	26			14	12		77	77
Labette	1				1			
Miami	24	3			27	30	388	418
Montgomery	411	101	2	68	444	3,548	51,684	55,232
Neosho	183	24	5	39	168	1,778	3,860	5,638
Wilson	170	9	1	10	169	1,050	6,822	7,872
Total	1,757	279	41	224	1,812	18,458	119,274	137,732

1913.

County.	Productive Jan. 1.	Oil.	Dry.	Abandoned.	Productive Dec. 31.	Fee.	Lease.	Total.
Allen	172	142	9	5	309	1,126	13,117	14,243
Chautauqua	811	292	27	27	1,076	12,459	49,754	62,213
Cowley			2				10,622	10,622
Coffey	2	1		2	1		158	158
Elk	6				6		160	160
Franklin	12	47	2		59		1,137	1,137
Greenwood		1			1		2,107	2,107
Labette	1		2		1	60	3,000	3,060
Miami	27	15	4	14	28	510	6,733	7,243
Montgomery	444	558	25	35	967	5,647	55,203	60,850
Neosho	168	244	15	7	405	724	24,823	25,547
Wilson	169	33		4	198	40	15,624	15,664
Woodson		3	1		3			
Total	1,812	1,336	87	94	3,054	20,566	182,438	203,004

Petroleum well record in 1912 and 1913, by counties—Continued.

OKLAHOMA.

1912.

County.	Wells.					Acreage.		
	Productive Jan. 1.	Completed. Oil.	Completed. Dry.	Abandoned.	Productive Dec. 31.	Fee.	Lease.	Total.
Canadian			2			300		300
Carter	42	6	2		48	1,860	4,594	6,454
Cherokee			1				200	200
Cleveland			2				560	560
Coal			1				4,230	4,230
Comanche	3	2	3		5		20,580	20,580
Creek	1,784	238	39	43	1,979	6,547	176,252	182,799
Greer			1					
Haskell			1				1,500	1,500
Jefferson			3			5,000	14,500	19,500
Kay	4	35	10	4	35		51,456	51,456
Kiowa	5	6	2		11		6,640	6,640
Le Flore			1				10,000	10,000
Logan			1					
McIntosh			1				3,010	3,010
Marshall	3				3		3,594	3,594
Muskogee	285	36	6	18	303	684	15,248	15,932
Noble			1				5,000	5,000
Nowata	5,077	950	29	122	5,905	7,477	95,441	102,918
Okmulgee	244	189	52	37	396	3,992	111,649	115,641
Osage	1,593	366	45	91	1,868	1,400	520,754	522,154
Pawnee	317	133	27	59	391	400	42,819	43,219
Pittsburg			1				7,134	7,134
Rogers	1,763	103	12	161	1,705	1,390	23,438	24,828
Sequoyah			1				2,000	2,000
Tillman			1				10,500	10,500
Tulsa	1,306	643	70	32	1,917	7,683	105,568	113,251
Wagoner		6	4		6		4,796	4,796
Washington	3,272	955	121	84	4,143	6,998	141,242	148,240
Total	15,698	3,668	440	651	18,715	43,731	1,383,705	1,427,436

1913.

County.	Productive Jan. 1.	Completed. Oil.	Completed. Dry.	Abandoned.	Productive Dec. 31.	Fee.	Lease.	Total.
Atoka			1				1,052	1,052
Caddo			1				4,000	4,000
Canadian			2					
Carter	48	18	4		66	1,900	7,923	9,823
Cherokee			2				7,040	7,040
Choctaw			1					
Coal			1				8,500	8,500
Comanche	5	2	1		7		6,980	6,980
Cotton			2				8,000	8,000
Craig			3				2,720	2,720
Creek	1,979	903	102	95	2,787	461	37,128	37,589
Garfield			1					
Grady			1				320	320
Hughes			1				4,220	4,220
Jackson			1					
Kay	35	28	11	1	62		27,022	27,022
Kiowa	11	10	1	4	17	160	5,540	5,700
Le Flore			2				2,410	2,410
Lincoln			1				10,343	10,343
Logan			1				5,000	5,000
McIntosh			4				5,920	5,920
Marshall	3		2		3	20	1,064	1,084
Murray			2					
Muskogee	303	58	15	20	341	458	14,468	14,926
Noble			2				320	320
Nowata	5,905	929	51	248	6,586	4,732	74,407	79,139
Okfuskee		6	2		6		27,410	27,410
Okmulgee	396	380	89	30	746	5,386	140,804	146,190
Osage	1,868	464	45	60	2,272	60	552,426	552,486
Pawnee	391	271	15	24	638	266	44,919	45,185
Payne		15	3		15	124	7,609	7,733
Pittsburg			2			2,240	2,434	4,674
Pontotoc		1	1		1		8,500	8,500
Pushmataha			1				7,000	7,000
Rogers	1,705	467	48	110	2,062	1,755	31,059	32,814
Seminole			1				28,861	28,861

Petroleum well record in 1912 and 1913, by counties—Continued.

OKLAHOMA—Continued.

1913—Continued.

County.	Wells.					Acreage.		
	Productive Jan. 1.	Completed.		Abandoned.	Productive Dec. 31.	Fee.	Lease.	Total.
		Oil.	Dry.					
Stephens			1				6,790	6,790
Tillman			3				11,500	11,500
Tulsa	1,917	879	123	51	2,745	9,855	209,451	219,306
Wagoner	6	7	14	3	10	560	3,418	3,978
Washington	4,143	1,673	105	95	5,721	8,437	169,859	178,296
Total	18,715	6,111	669	741	24,085	36,414	1,486,417	1,522,831

TEXAS.

1912.

County.	Productive Jan. 1.	Oil.	Dry.	Abandoned.	Productive Dec. 31.	Fee.	Lease.	Total.
Archer		1	8		1		17,833	17,833
Baylor			3				19,000	19,000
Bexar	3		1		3	597	44	641
Brazoria	4		3		4	3,050	1,500	4,550
Brewster	1	1			2			
Brown	6			1	5		20	20
Burleson			1					
Callahan			1				2,500	2,500
Chambers			2				1,227	1,227
Clay	151	64	14	14	201	7,404	51,162	58,566
Coleman	1		8		1	2,320	7,420	9,740
Duval	1				1	500	1,200	1,700
Edwards			2				70,000	70,000
Fayette			1					
Franklin			1				12,000	12,000
Freestone			1				2,500	2,500
Gaines			1				26,974	26,974
Hardin	845	151	28	55	941	3,546	3,725	7,271
Harris	405	101	36	88	418	2,002	26,429	28,431
Hill			1			79		79
Howard			1				5,000	5,000
Jack		2			2		1,000	1,000
Jefferson	100	36	16	33	103	73	1,027	1,100
Kaufman			2				3,000	3,000
Liberty	5	1	6	2	4	603	6,214	6,817
Limestone			1					
McCulloch		5	5		5	12,206	72,000	84,206
McLennan	12			1	11	360	360	720
McMullen	19	1			20	7,000		7,000
Marion	12	3	7	4	11	3,141	10,225	13,366
Matagorda	30	19	14	12	37	124	1,173	1,297
Maverick			1				7,127	7,127
Montgomery			2					
Navarro	797	69	22	34	832	2,155	38,430	40,585
Nueces			1			554	350,000	350,554
Polk			2				3,845	3,845
Robertson	1				1		5,000	5,000
Rusk		2			2			
Scurry			1					
Shackelford			1					
Shelby			1				1,100	1,100
Smith			1				3,000	3,000
Tarrant		1			1		7,000	7,000
Walker		1		1			2,583	2,583
Wichita	80	298	82		378	5,125	371,348	376,473
Wilbarger	1		2	1			35,524	35,524
Wilson			2			90	1,942	2,032
Wise			1				13,338	13,338
Wood			1			160	2,800	2,960
Total	2,473	757	284	246	2,984	51,089	1,186,570	1,237,659

Petroleum well record in 1912 and 1913, by counties—Continued.

TEXAS—Continued.

1913.

County.	Wells.					Acreage.		
	Productive Jan. 1.	Completed.		Abandoned.	Productive Dec. 31.	Fee.	Lease.	Total.
		Oil.	Dry.					
Angelina			2					
Archer	1		6		1		1,202	1,202
Atascosa		4	7		4		18,874	18,874
Baylor			2					
Bee			1					
Bexar	3		3	3		1,249	2,528	3,777
Brazoria	4		2	4		3,005	5,325	8,330
Brazos			1					
Brewster	2				2			
Brown	5	1		1	5	1	8,000	8,001
Burleson		1		1				
Callahan			1					
Cass		1	1	1		13,565	3,112	16,677
Chambers			1				1,227	1,227
Clay	201	108	15	8	301	13,123	24,320	37,443
Coleman	1	4	12	4	1	2,200	35,242	37,442
Comanche			1					
Cottle			1				3,500	3,500
Delta		1			1	2,000	1,000	3,000
Duval	1		1		1		200	200
Eastland			3			10	580	590
Ellis			1				240	240
Freestone		2	2		2		3,200	3,200
Gonzales			1				1,047	1,047
Hall			1			800	800	1,600
Hardin	941	101	33	116	926	2,628	1,532	4,160
Harris	418	110	77	91	437	4,789	8,425	13,214
Hopkins			2				1,000	1,000
Houston			1					
Jack	2	14	2		16		11,323	11,323
Jasper			1				450	450
Jefferson	103	28	14	25	106	2,022	1,017	3,039
Liberty	4	3	2	1	6	383	1,500	1,883
Limestone			3				800	800
McCulloch	5	3	5	8		80	206	286
McLennan	11				11		365	365
McMullen	20				20		16,388	16,388
Madison			1					
Marion	11	14	3	1	24	6,655	19,019	25,674
Matagorda	37	7	6	5	39	1,103	1,103	2,206
Nacogdoches		2		2			5,031	5,031
Navarro	832	63	26	124	771	545	20,185	20,730
Orange		1			1	1	1,467	1,468
Panola			2			150	15,103	15,253
Polk			1					
Robertson	1			1				
Rusk	2			2			3,000	3,000
Shackelford		1	4		1		3,000	3,000
Shelby			2				5,800	5,800
Stephens			2					
Tarrant	1				1		12,000	12,000
Titus			2					
Tyler			4			640		640
Wichita	378	408	27	26	760	5,319	348,700	354,019
Wilbarger			2			960	16,902	17,862
Wilson			1				767	767
Wise			6				20,000	20,000
Wood			3			160	3,000	3,160
Young			2				223	223
Total	2,984	877	299	424	3,437	61,388	628,703	690,091

Petroleum well record in 1912 and 1913, by counties—Continued.

LOUISIANA.

1912.

County.	Wells.					Acreage.		
	Productive Jan. 1.	Completed.		Abandoned.	Productive Dec. 31.	Fee.	Lease.	Total.
		Oil.	Dry.					
Acadia	82	46	2	21	107	642	4,157	4,799
Caddo	413	230	58	57	586	20,844	167,188	188,032
Calcasieu	58	27	21	12	73	714	933	1,647
Evangeline	......	1	4	......	1	800	6,907	7,707
Natchitoches	......	......	2	......	......	......	41,400	41,400
St. Martin	2	11	3	......	13	6,345	449	6,794
Terrebonne	......	......	1	......	......	......	......	......
Total	555	315	91	90	780	29,345	221,034	250,379

1913.

County.	Productive Jan. 1.	Completed Oil.	Completed Dry.	Abandoned.	Productive Dec. 31.	Fee.	Lease.	Total.
Acadia	107	20	3	45	82	791	3,186	3,977
Bossier	......	......	2	......	......	1,200	2,096	3,296
Caddo	586	297	34	69	814	48,817	344,901	393,718
Calcasieu	71	30	12	21	80	464	6,008	6,472
Cameron	......	......	2	......	......	......	40	40
De Soto	......	2	......	......	2	......	23,295	23,295
Evangeline	1	......	3	1	......	4,000	1,224	5,224
Jefferson Davis	2	20	2	......	22	......	1,455	1,455
Rapides	......	......	1	......	......	......	301	301
Sabine	......	......	1	......	......	220	6,784	7,004
St. Martins	13	......	......	13	......	2	25	27
St. Tammany	......	......	1	......	......	......	1,200	1,200
Terrebonne	......	......	3	......	......	800	20,037	20,837
Webster	......	......	......	......	......	2,857	......	2,857
Total	780	369	64	149	1,000	59,151	410,552	469,703

PIPE-LINE STATISTICS.

APPALACHIAN OIL FIELD.

GENERAL CONDITIONS.

The Appalachian field embraces all oil pools east of central Ohio, including those of New York, Pennsylvania, West Virginia, southeastern Ohio, Kentucky, and Tennessee. Nearly all of this petroleum is classed as of Pennsylvania grade, with the exception of some of the oil from Kentucky and from a few isolated pools in other States. The region in general represents the oldest oil field of the United States. Most of the pools have long since passed their prime, and in New York and Pennsylvania production is kept alive chiefly by cleaning and deepening old wells or by obtaining oil from shallow sands which were passed by as too small when the wells were first drilled. Nevertheless, no pool has been entirely abandoned as exploited, and wells are still being pumped within a few yards of the original Drake well at Titusville, Pa. In West Virginia and on the eastern edge of Ohio are many pools long since on the wane, but the extension of territory and the discovery of new pools is still in actual progress in West Virginia, central Ohio, and Kentucky. Prospecting is still active in Tennessee, but so far without definitive results.

PRODUCTION.

During 1913 the Appalachian oil field showed only a very slight decrease—1.58 per cent—in the quantity produced, the total for 1912 being 26,338,516 barrels and for 1913, 25,921,785 barrels. The average price of crude petroleum in the Appalachian field was $1.626 in 1912 and this increased to $2.458 in 1913, which yielded an increase in value of nearly $21,000,000, or 48.79 per cent.

Production of the Appalachian oil field, by States and months, 1912–1913, in barrels.

1912.

Month.	Pennsylvania.	New York.	Southeastern Ohio.	West Virginia.	Kentucky.	Total.
January	562,665	64,950	333,489	694,619	38,425	1,694,148
February	575,180	63,080	356,983	801,699	37,723	1,834,665
March	686,178	73,371	443,795	983,502	40,923	2,227,769
April	699,856	79,188	440,834	1,018,955	37,375	2,276,208
May	728,127	81,935	453,807	1,153,945	44,967	2,462,781
June	657,545	73,950	416,396	1,172,331	40,311	2,360,533
July	678,789	75,875	439,778	1,174,367	44,997	2,413,806
August	675,848	74,663	460,300	1,190,552	40,866	2,442,319
September	634,114	68,884	410,131	981,052	39,146	2,133,327
October	686,184	76,766	437,877	1,013,980	38,484	2,253,291
November	610,314	68,045	397,129	918,313	40,000	2,033,801
December	643,148	73,421	422,501	1,025,647	41,151	2,205,868
Total	7,837,948	874,128	5,013,110	12,128,962	484,368	26,338,516

1913.

Month.	Pennsylvania.	New York.	Southeastern Ohio.	West Virginia.	Kentucky.	Total.
January	673,011	77,029	407,538	978,401	42,074	2,178,053
February	581,040	63,692	364,307	936,733	36,843	1,982,615
March	640,858	70,984	324,609	970,900	39,391	2,046,832
April	707,638	78,771	456,072	1,026,129	39,036	2,307,646
May	704,527	79,800	420,757	1,003,425	42,932	2,251,441
June	665,380	73,981	414,098	995,098	39,285	2,188,442
July	692,201	79,091	424,588	1,009,383	48,211	2,253,474
August	656,835	74,260	410,459	939,479	49,908	2,130,941
September	655,137	74,503	425,023	928,610	52,538	2,135,811
October	698,052	80,424	456,364	956,772	46,301	2,237,913
November	612,732	70,738	406,018	839,274	44,137	1,972,899
December	675,871	78,938	453,902	983,095	43,912	2,235,718
Total	7,963,282	902,211	4,964,425	11,567,299	524,568	25,921,785

In spite of the present decadence of the Appalachian oil field its great importance in the development of the American oil industry is depicted in the accompanying table, which shows the production of petroleum in the Appalachian oil field from 1859 to 1913; that is, the total quantity and value for each year, the total quantity and value for the entire period, and the percentage of the total production of the United States. The rise and decline of the field is illustrated by the per cent of increase or decrease of each year compared to the year before it. The actual average price per barrel shown is obtained, not from the ruling market prices but by dividing the actual amount of money received by the number of barrels. The table is also instructive in showing that up to 1875 the oil industry was entirely limited to the Appalachian field and that until 1885 this region still furnished 98.5 per cent of the total production. At this point the marked decline began, which, although not entirely continuous, has continued until the percentage of yield in the Appalachian field has fallen from 98.5 per cent in 1885 to 10.43 per cent at the end of 1913. A curious illustration of the appreciation of Appalachian oil is the fact that, while this field produced only this small percentage of the entire yield of the country in 1913, the amount of money paid for it was $63,708,981, the largest amount paid in any one year since the beginning of the industry, and this in spite of the fact that the total production has fallen from the maximum of 36,295,443 barrels in 1900 to 25,921,785 in 1913. Over $14,000,000 more was paid for the smaller yield of 1913 than for the maximum yield in 1900. This great gain in value was, of course, due to the rise in the price of oil of Pennsylvania grade in 1913. The average price for the year reached $2.458, the highest average price paid for the Appalachian oil since 1876. The total amount of money received for the oil furnished by the Appalachian field aggregates $1,435,757,094. It may be estimated that about $200,000,000 of this sum has gone to the owners of the small farms from which the oil was obtained, which would be an income since 1859 of about $45 per acre for all of the oil land in the Appalachian field, and they still own the land.

The production of petroleum in the Appalachian oil field from 1859 to 1913, inclusive, is given in the following table:

Production of petroleum in the Appalachian field, 1859–1913, by years, in barrels.

Year.	Quantity.	Percentage of total production.	Increase or decrease.	Percentage of increase or decrease.	Value.	Yearly average price per barrel.
1859	2,000	100	....	....	$32,000	$16.000
1860	500,000	100	+ 498,000	+24,900.00	4,800,000	9.590
1861	2,113,609	100	+1,613,609	+ 322.72	1,035,668	.490
1862	3,056,690	100	+ 943,081	+ 44.62	3,209,525	1.050
1863	2,611,309	100	− 445,381	− 14.57	8,225,663	3.150
1864	2,116,109	100	− 495,200	− 18.96	20,896,576	8.060
1865	2,497,700	100	+ 381,591	+ 18.03	16,459,853	6.590
1866	3,597,700	100	+1,100,000	+ 44.04	13,455,398	3.740
1867	3,347,300	100	− 250,400	− 6.96	8,066,993	2.410
1868	3,646,117	100	+ 298,817	+ 8.93	13,217,174	3.625
1869	4,215,000	100	+ 568,883	+ 15.60	23,730,450	5.638
1870	5,260,745	100	+1,045,745	+ 24.81	20,503,754	3.860
1871	5,205,234	100	− 55,511	− 1.06	22,591,180	4.340
1872	6,293,194	100	+1,087,960	+ 20.90	21,440,503	3.640
1873	9,893,786	100	+3,600,592	+ 57.21	18,100,464	1.830
1874	10,926,945	100	+1,033,159	+ 10.44	12,647,527	1.170
1875	8,787,514	100	−2,139,431	− 19.58	7,368,133	1.350
1876	9,120,669	99.87	+ 333,155	+ 3.79	22,952,822	2.563
1877	13,337,363	99.90	+4,216,694	+ 46.23	31,756,066	2.420
1878	15,381,641	99.90	+2,044,278	+ 15.33	18,009,346	1.190
1879	19,894,288	99.90	+4,512,647	+ 29.34	17,164,836	.859
1880	26,245,571	99.85	+6,351,283	+ 31.93	24,506,963	.945
1881	27,561,376	99.64	+1,315,805	+ 5.01	23,281,324	.859
1882	30,221,261	99.58	+2,659,885	+ 9.65	23,334,016	.781
1883	23,306,776	99.39	−6,914,485	− 22.88	25,410,252	1.059
1884	23,956,438	98.92	+ 649,662	+ 2.79	19,871,704	.835
1885	21,533,785	98.51	−2,422,653	− 10.11	18,442,944	.879
1886	26,549,827	94.60	+5,016,042	+ 23.29	18,714,054	.713
1887	22,878,241	80.90	−3,671,586	− 13.83	16,259,483	.668
1888	16,941,397	61.36	−5,936,844	− 25.95	14,839,434	.876
1889	22,355,225	63.57	+5,413,828	+ 31.96	24,485,407	.941
1890	30,066,560	65.61	+7,711,335	+ 34.50	30,121,968	.868
1891	35,848,777	66.03	+5,782,217	+ 19.23	24,219,863	.670
1892	33,432,377	66.19	−2,416,400	− 6.74	18,830,773	.556
1893	31,365,890	64.76	−2,066,487	− 6.18	20,327,232	.640
1894	30,783,424	62.38	− 582,466	− 1.86	26,030,125	.839
1895	30,960,639	58.54	+ 177,215	+ .58	42,206,898	1.359
1896	33,971,902	55.73	+3,011,263	+ 9.73	40,203,418	1.179
1897	35,230,271	58.25	+1,258,369	+ 3.70	27,877,213	.786
1898	31,717,425	57.29	−3,512,846	− 9.97	29,096,057	.911
1899	33,068,356	57.94	+1,350,931	+ 4.26	43,041,677	1.294
1900	36,295,433	57.05	+3,227,077	+ 9.76	49,235,298	1.353
1901	33,618,171	48.45	−2,677,262	− 7.38	40,796,827	1.210
1902	32,018,787	36.07	−1,599,384	− 4.76	40,451,593	1.238
1903	31,558,248	31.41	− 460,539	− 1.44	49,905,813	1.590
1904	31,408,567	26.83	− 149,681	− .47	50,598,184	1.628
1905	29,366,960	21.80	−2,041,607	− 6.50	40,279,635	1.394
1906	27,741,472	21.93	−1,625,488	− 5.54	43,633,601	1.598
1907	25,342,137	15.26	−2,399,335	− 8.65	43,766,686	1.745
1908	24,945,517	13.97	− 396,620	− 1.57	43,888,020	1.780
1909	26,535,844	14.49	+1,590,327	+ 6.38	43,237,233	1.646
1910	26,892,579	12.83	+ 356,735	+ 1.33	35,841,749	1.336
1911	23,749,832	10.77	−3,142,747	− 11.37	30,830,354	1.308
1912	26,338,516	11.81	+2,588,684	+ 10.90	42,818,384	1.626
1913	25,921,785	10.43	− 416,731	− 1.58	63,708,981	2.458
Total	1,101,534,279	35.88	....	....	1,435,757,094	1.303

In the following table is shown the production of the Appalachian field, by States, in the years 1912 and 1913, with the increase and decrease for each State and the percentage of increase or decrease in 1913:

Production of petroleum in the Appalachian field in 1912 and 1913, by States, showing increase or decrease and percentage of increase or decrease, in barrels.

State.	Production.		Increase.	Decrease.	Percentage.	
	1912	1913			Increase.	Decrease.
Pennsylvania	7,837,948	7,963,282	125,334	....	1.600	....
New York	874,128	902,211	28,083	....	3.212	....
Southeastern Ohio	5,013,110	4,964,425	....	48,685	....	0.971
West Virginia	12,128,962	11,567,299	....	561,663	....	4.631
Kentucky	484,368	524,568	40,200	....	8.300	....
Total	26,338,516	25,921,785	....	416,731	....	1.580

Production, value, and average price per barrel of petroleum in the Appalachian field, 1904–1913, by States, in barrels.

Year.	Pennsylvania.			New York.			Southeastern Ohio.		
	Quantity.	Value.	Average price per barrel.	Quantity.	Value.	Average price per barrel.	Quantity.	Value.	Average price per barrel.
1904..	11,125,762	$18,222,242	$1.637	1,113,264	$1,811,837	$1.627	5,526,571	$8,995,386	$1.627
1905..	10,437,195	14,653,278	1.404	1,117,582	1,557,630	1.393	5,016,736	6,992,885	1.393
1906..	10,256,893	16,596,943	1.618	1,243,517	1,995,377	1.605	4,906,579	7,839,359	1.597
1907..	9,999,306	17,579,706	1.758	1,212,300	2,127,748	1.755	4,214,391	7,344,408	1.742
1908..	9,424,325	16,881,194	1.791	1,160,128	2,071,533	1.786	4,110,121	7,316,617	1.780
1909..	9,299,403	15,424,554	1.658	1,134,897	1,878,217	1.655	4,717,436	7,773,880	1.648
1910..	8,794,662	11,908,914	1.354	1,053,838	1,414,668	1.342	4,822,234	6,469,939	1.342
1911..	8,248,158	10,894,074	1.321	952,515	1,248,950	1.311	4,281,237	5,591,423	1.306
1912..	7,837,948	12,886,752	1.644	874,128	1,401,880	1.604	5,013,110	8,177,189	1.631
1913..	7,963,282	19,805,452	2.487	902,211	2,169,357	2.404	4,964,425	12,229,610	2.463

Year.	West Virginia.			Kentucky-Tennessee.			Total.		
	Quantity.	Value.	Average price per barrel.	Quantity.	Value.	Average price per barrel.	Quantity.	Value.	Average price per barrel.
1904..	12,644,686	$20,583,781	$1.628	998,284	$984,938	$0.986	31,408,567	$50,598,184	$1.611
1905..	11,578,110	16,132,631	1.393	1,217,337	943,211	.775	29,366,900	40,279,635	1.371
1906..	10,120,935	16,170,293	1.005	1,213,548	1,031,629	.850	27,741,472	43,633,601	1.573
1907..	9,095,296	15,852,428	1.743	820,344	862,396	1.051	25,342,137	43,766,686	1.729
1908..	9,523,176	16,911,865	1.776	*a* 727,767	706,811	.971	24,945,517	43,888,020	1.759
1909..	10,745,092	17,642,283	1.642	*a* 639,016	518,299	.811	26,535,844	43,237,233	1.629
1910..	11,753,071	15,723,544	1.338	*a* 468,774	324,684	.692	26,892,579	35,841,749	1.332
1911..	9,795,464	12,767,293	1.303	*a* 472,458	328,614	.695	23,749,832	30,830,354	1.298
1912..	12,128,962	19,927,721	1.643	*a* 484,368	424,842	.877	26,338,516	42,818,384	1.625
1913..	11,567,299	28,828,814	2.492	*a* 524,568	675,748	1.288	25,921,785	63,708,981	2.458

a No production in Tennessee recorded.

In the two following tables is given the production of petroleum in the Appalachian field from 1909 to 1913—in the first by months and in the second by days:

Production of petroleum in the Appalachian oil field, 1909–1913, by months and years, in barrels.

Month.	1909	1910	1911	1912	1913
January	1,989,577	2,274,236	1,974,600	1,694,048	2,178,053
February	1,906,109	2,019,229	1,884,336	1,834,665	1,982,615
March	2,237,778	2,494,868	2,097,333	2,227,769	2,046,832
April	2,158,382	2,296,566	1,974,035	2,276,208	2,307,646
May	2,194,631	2,349,595	2,162,836	2,462,881	2,251,441
June	2,220,971	2,382,097	2,031,071	2,360,533	2,188,442
July	2,306,654	2,239,118	1,914,966	2,413,806	2,253,474
August	2,273,277	2,325,953	2,033,142	2,442,319	2,130,941
September	2,288,067	2,208,040	1,907,771	2,133,327	2,135,811
October	2,309,898	2,148,205	1,964,172	2,253,291	2,237,913
November	2,321,230	2,046,835	1,834,182	2,033,801	1,972,899
December	2,329,270	2,107,837	1,971,468	2,205,868	2,235,718
Total	26,535,844	26,892,579	23,749,832	26,338,516	25,921,785

Average daily production of petroleum in the Appalachian oil field each month, 1909–1913, by months and years, in barrels.

Month.	1909	1910	1911	1912	1913
January	64,180	73,362	63,697	54,647	70,260
February	68,075	72,115	67,298	63,264	70,808
March	72,186	80,480	67,656	71,864	66,027
April	71,946	76,552	65,801	74,259	76,921
May	70,795	75,793	69,769	82,029	72,627
June	74,032	79,403	67,702	76,684	72,948
July	74,408	72,230	61,773	77,865	72,693
August	73,332	75,031	65,585	78,784	68,740
September	76,269	73,601	63,592	71,111	71,194
October	74,513	69,297	63,360	72,687	72,191
November	77,374	68,228	61,139	67,793	75,763
December	75,138	67,995	63,594	71,157	72,120
Average	72,701	73,678	65,068	71,963	71,024

RUNS, STOCKS, AND DELIVERIES.

In the following tables are given the runs of Appalachian oil for the principal pipe lines in the Appalachian fields in 1912, and 1913, together with the stocks of the same at the close of each month:

Pipe-line runs of Appalachian oil in 1912, by lines and months, in barrels.

Month.	National Transit.	Southwest Pennsylvania.	Eureka.	Cumberland.	New York Transit.	Tidewater.
January	214,880	122,234	651,770	37,697	13,049	89,229
February	219,690	123,185	756,924	36,995	13,038	92,121
March	268,486	133,574	932,405	40,195	13,922	108,002
April	282,625	126,334	971,098	36,646	16,883	111,262
May	282,533	137,181	1,101,421	44,238	16,740	115,595
June	250,379	120,237	1,125,895	39,582	14,774	107,147
July	258,814	126,039	1,121,256	44,268	15,574	105,660
August	248,731	120,296	1,133,662	40,137	15,822	108,094
September	233,625	111,048	929,369	38,417	15,060	97,329
October	249,239	116,320	954,537	37,756	16,948	110,429
November	213,913	108,629	859,982	39 272	14,721	95,920
December	216,634	111,360	961,346	40,343	15,760	102,274
Total	2,939,549	1,456,437	11,499,665	475,546	182,291	1,243,062

Month.	Producers and Refiners.	Emery.	Buckeye Macksburg.	Franklin.	Other lines.	Total.
January	144,391	23,802	273,483	1,822	121,791	1,694,148
February	141,020	23,514	300,880	2,094	125,204	1,834,665
March	164,865	28,700	380,187	3,652	153,781	2,227,769
April	158,520	28,160	377,519	3,690	163,471	2,276,208
May	169,039	27,693	385,050	3,744	179,547	2,462,781
June	157,740	25,472	353,926	2,972	162,409	2,360,533
July	166,630	27,015	370,090	3,161	175,299	2,413,806
August	179,696	28,598	378,369	3,510	185,404	2,442,319
September	170,121	24,951	335,470	3,086	174,851	2,133,327
October	202,172	28,373	337,329	2,989	197,199	2,253,201
November	205,365	24,348	288,237	2,900	180,514	2,033,801
December	221,976	27,087	303,531	3,394	202,163	2,205,868
Total	2,081,535	317,713	4,084,071	37,014	2,021,633	26,338,516

Pipe-line runs of Appalachian oil in 1913, by lines and months, in barrels.

Month.	National Transit.	Southwest Pennsylvania.	Eureka.	Cumberland.	New York Transit.	Tidewater.
January	232,522	112,656	912,474	41,982	16,490	108,701
February	185,868	99,833	873,681	36,751	14,017	91,662
March	215,895	110,962	906,441	39,194	14,867	100,991
April	255,401	116,693	958,267	38,795	17,440	109,987
May	241,235	119,006	933,113	42,716	17,453	109,932
June	227,623	111,617	929,857	39,069	15,668	104,516
July	236,553	114,617	942,294	48,119	17,494	111,650
August	218,931	112,786	873,104	49,766	15,939	105,442
September	226,499	109,337	866,056	52,328	16,294	104,504
October	238,832	117,589	889,954	46,082	18,129	109,926
November	207,024	99,321	771,387	43,929	15,894	98,493
December	221,142	116,100	907,714	43,822	16,825	111,445
Total	2,707,525	1,340,517	10,764,342	522,553	196,510	1,267,249

Month.	Producers and Refiners.	Emery.	Buckeye Macksburg.	Franklin.	Other lines.	Total.
January	212,519	27,208	289,530	3,002	220,969	2,178,053
February	191,944	23,855	256,638	2,349	206,017	1,982,615
March	190,278	25,880	224,756	3,023	214,545	2,046,832
April	207,788	29,156	342,599	3,423	228,097	2,307,646
May	219,848	28,536	306,088	3,106	234,108	2,251,441
June	198,268	27,890	306,680	3,158	224,095	2,188,442
July	197,774	29,586	313,968	3,402	238,017	2,253,474
August	197,462	29,450	297,418	2,861	227,782	2,130,941
September	201,008	28,269	302,820	3,155	225,441	2,135,811
October	214,376	29,587	324,425	3,196	245,817	2,237,913
November	198,023	26,756	281,991	2,890	227,191	1,972,899
December	221,843	29,762	313,049	3,396	250,620	2,235,718
Total	2,451,131	335,935	3,559,962	36,961	2,739,100	25,921,785

Stocks held by eastern[a] pipe lines and refineries in the Appalachian field at close of each month in 1912 and 1913, in barrels.

1912.

Month.	National Transit.	Southwest Pennsylvania.	Eureka.	Cumberland.	Southern.	Crescent.
Dec. 31, 1911	1,161,046	996,483	1,302,420	178,544	637,852	84,612
January	1,118,967	1,031,549	1,354,971	176,431	636,789	97,443
February	1,083,298	1,027,835	1,436,968	169,683	561,145	113,489
March	1,156,060	1,030,083	1,456,423	192,189	606,793	96,290
April	1,108,056	844,441	1,450,351	197,663	617,113	102,182
May	1,271,181	843,314	1,339,603	216,700	655,708	75,367
June	1,161,394	733,850	1,484,997	212,287	606,946	92,974
July	1,104,934	754,661	1,459,698	204,665	646,831	91,460
August	1,153,372	892,819	1,442,613	202,104	613,915	85,278
September	1,208,089	627,339	1,423,452	195,895	664,063	104,004
October	1,142,205	603,213	1,332,901	170,686	557,055	56,082
November	1,027,972	554,519	1,237,112	150,953	563,915	52,703
December	889,359	522,506	1,532,946	129,225	573,740	72,121

Month.	New York Transit.	Tidewater.	Northern.	Producers and Refiners.	Emery.	United States.
Dec. 31, 1911	2,488,641	291,069	1,672,216	197,827	12,767	58,137
January	2,589,680	252,541	1,236,093	211,136	16,550	8,276
February	2,107,399	245,586	947,517	206,624	17,774	11,006
March	1,512,481	269,190	1,113,766	188,119	18,111	42,870
April	1,268,886	256,825	1,046,753	175,762	19,253	41,659
May	1,215,929	249,697	1,069,244	208,493	22,178	41,599
June	1,204,030	237,349	844,989	219,768	21,268	27,623
July	669,751	227,731	716,741	188,387	21,206	37,449
August	674,891	255,706	675,423	178,356	20,408	21,529
September	758,872	269,511	694,682	187,499	15,340	23,708
October	815,188	247,021	688,689	217,818	19,739	12,113
November	938,522	239,547	787,634	234,066	21,567	29,302
December	1,154,211	200,337	575,730	274,921	23,565	2,918

[a] These pipe lines connect with the delivering lines of the Illinois, Kansas, and Oklahoma fields and receive and transfer large quantities of these western oils to the Atlantic seaboard in addition to the oil from wells directly tributary to their own systems.

Stocks held by eastern pipe lines and refineries in the Appalachian field at close of each month in 1912 and 1913, in barrels—Continued.

Month.	Buckeye Macksburg.	Buckeye Lima.	Indiana.	Franklin.	Other lines.	Total.
Dec. 31, 1911	282,090	4,066,820	965,890	59,998	70,659	14,527,071
January	307,823	3,697,265	939,800	53,453	69,006	13,797,773
February	346,231	3,984,320	1,036,868	50,295	68,176	13,414,214
March	362,309	3,769,143	913,465	51,584	66,868	12,845,744
April	397,155	3,331,890	1,024,989	55,274	65,860	12,004,112
May	406,146	3,204,185	1,019,320	59,019	63,256	11,960,939
June	401,033	3,307,593	970,288	61,990	63,762	11,652,141
July	424,608	3,483,200	1,070,395	65,151	63,105	11,229,973
August	390,059	3,810,159	1,120,611	68,173	64,140	11,669,556
September	364,477	3,934,567	1,017,383	70,772	65,167	11,624,820
October	314,249	3,623,883	1,030,069	67,664	67,698	10,966,273
November	339,455	3,377,926	993,918	59,145	71,818	10,680,074
December	384,553	3,291,256	963,306	50,581	90,070	10,731,345

1913.

Month.	National Transit.	Southwest Pennsylvania.	Eureka.	Cumberland.	Southern.	Crescent.
January	908,334	584,821	1,516,769	130,015	542,471	70,940
February	819,841	538,377	1,672,659	127,827	482,092	63,470
March	911,573	590,253	1,425,056	134,667	528,003	54,488
April	948,189	585,328	1,465,267	119,553	554,293	69,650
May	1,016,316	614,375	1,597,633	90,505	574,943	66,310
June	1,026,373	598,138	1,423,023	69,450	619,540	84,902
July	1,016,054	713,190	1,621,131	61,753	509,805	144,145
August	1,021,246	931,360	1,567,997	74,766	621,581	152,734
September	1,062,998	884,470	1,619,751	82,315	693,024	145,609
October	1,084,617	822,227	1,562,704	93,425	750,172	149,980
November	1,066,294	742,656	1,349,754	96,980	760,959	126,903
December	995,843	688,801	1,596,501	85,107	681,649	62,409

Month.	New York Transit.	Tidewater.	Northern.	Producers and Refiners.	Emery.	Buckeye Macksburg.
January	982,526	236,694	764,454	280,289	25,897	386,633
February	1,093,300	277,971	650,356	275,146	18,127	402,421
March	914,520	244,941	599,164	272,637	14,818	411,354
April	738,626	254,972	768,128	283,399	16,581	378,585
May	698,219	231,215	635,819	271,770	17,305	329,778
June	673,314	230,944	535,306	284,821	16,596	396,723
July	643,068	219,944	675,394	287,528	16,896	402,789
August	641,373	272,061	592,229	276,350	19,826	363,288
September	740,480	247,887	635,902	297,120	16,595	348,266
October	883,814	261,607	739,086	328,447	18,628	347,057
November	762,718	244,798	583,978	333,598	18,354	351,262
December	710,769	330,265	595,555	359,730	16,789	369,687

Month.	Buckeye Lima.	Indiana.	Franklin.	Other lines.	Total.
January	2,984,167	976,297	46,815	134,732	10,571,854
February	3,093,215	909,049	45,783	105,062	10,574,696
March	3,297,015	849,428	48,806	114,621	10,411,344
April	3,316,909	809,724	49,583	126,167	10,484,954
May	2,980,576	794,842	52,689	138,559	10,110,854
June	3,218,981	844,830	55,846	152,368	10,231,155
July	2,871,264	798,754	59,249	166,498	10,207,462
August	2,817,825	867,482	62,110	156,857	10,439,085
September	2,728,819	818,690	65,019	173,455	10,560,402
October	2,362,961	912,670	63,683	141,630	10,522,708
November	2,208,108	956,283	55,478	164,070	9,822,193
December	2,177,747	965,099	58,391	196,321	9,890,658

Stocks of all grades of petroleum held by eastern [a] pipe lines and refineries in the Appalachian field at close of each month in 1912 and 1913, in barrels.

1912.

Month.	Pennsylvania.[b]	Lima.	Illinois.	Kentucky.	Kansas and Oklahoma.	Total.
Dec. 31, 1911	4,479,779	3,147,427	2,795,623	254,763	3,849,479	14,527,071
January	3,932,010	2,967,238	2,634,323	281,784	3,982,418	13,797,773
February	4,120,618	2,990,299	2,295,660	210,438	3,797,199	13,414,214
March	4,318,220	3,010,540	2,060,145	238,629	3,218,210	12,845,744
April	4,395,584	3,022,377	1,588,377	260,150	2,737,624	12,004,112
May	4,571,266	2,494,149	2,014,188	295,839	2,585,497	11,960,939
June	4,498,327	2,515,579	1,569,501	301,827	2,766,907	11,652,141
July	4,436,048	2,151,648	2,158,242	304,665	2,179,370	11,229,973
August	4,214,658	2,307,332	2,626,532	324,889	2,196,145	11,669,556
September	4,092,873	2,444,979	2,616,520	281,825	2,188,623	11,624,820
October	3,736,433	2,135,501	2,752,499	295,345	2,046,495	10,966,273
November	3,748,178	2,134,642	2,483,692	262,909	2,050,653	10,680,074
December	3,804,483	2,297,861	2,368,271	226,035	2,034,695	10,731,345

1913.

Month.	Pennsylvania.[b]	Lima.	Illinois.	Kentucky.	Kansas and Oklahoma.	Total.
January	3,936,422	2,338,451	1,908,683	262,970	2,125,328	10,571,854
February	4,102,809	2,239,049	1,866,847	214,398	2,151,593	10,574,696
March	4,126,030	2,132,306	1,744,862	249,358	2,158,788	10,411,344
April	4,166,479	2,229,721	1,559,509	224,365	2,304,880	10,484,954
May	4,203,768	2,045,213	1,544,526	230,079	2,087,268	10,110,854
June	4,121,276	1,955,272	1,903,773	127,941	2,122,893	10,231,155
July	4,184,097	2,031,608	1,792,585	184,862	2,014,310	10,207,462
August	4,249,284	1,943,838	2,068,928	147,891	2,029,144	10,439,085
September	4,484,194	2,026,513	1,638,927	191,487	2,219,279	10,560,400
October	4,552,557	1,778,509	1,680,136	211,477	2,300,029	10,522,708
November	4,373,575	1,645,457	1,093,294	192,177	2,517,690	9,822,193
December	4,387,718	1,623,461	1,079,468	230,706	2,569,305	9,890,658

[a] These pipe lines connect with the delivering lines of the Illinois, Kansas, and Oklahoma fields and receive and transfer large quantities of these western oils to the Atlantic seaboard in addition to the oil from wells directly tributary to their own systems.
[b] Includes natural lubricating oil from Pennsylvania and West Virginia.

Pipe-line runs and deliveries to trade of petroleum from the Appalachian field, by months, in barrels, in 1912 and 1913, and stocks at end of each month.

	1912			1913		
	Runs.	Deliveries.	Stocks.	Runs.	Deliveries.	Stocks.
Dec. 31, 1911			4,734,542			
January	1,694,148	2,214,896	4,213,794	2,178,053	2,009,179	4,199,392
February	1,834,665	1,717,403	4,331,056	1,982,615	1,864,800	4,317,207
March	2,227,769	2,001,976	4,556,849	2,046,832	1,988,651	4,375,388
April	2,276,208	2,177,323	4,655,734	2,307,646	2,292,190	4,390,844
May	2,462,781	2,251,410	4,867,105	2,251,441	2,208,438	4,433,847
June	2,360,533	2,427,484	4,800,154	2,188,442	2,373,072	4,249,217
July	2,413,806	2,473,247	4,740,713	2,253,474	2,133,732	4,368,959
August	2,442,319	2,643,485	4,539,547	2,130,941	2,102,725	4,397,175
September	2,133,327	2,298,176	4,374,698	2,135,811	1,857,305	4,675,681
October	2,253,291	2,596,211	4,031,778	2,237,913	2,149,560	4,764,034
November	2,033,801	2,054,492	4,011,087	1,972,899	2,171,181	4,565,752
December	2,205,868	2,186,437	4,030,518	2,235,718	2,183,046	4,618,424
Total	26,338,516	27,042,540		25,921,785	25,333,879	

Pipe-line deliveries to trade of eastern[a] pipe lines in 1912 and 1913, by lines and months, in barrels.

1912.

Month.	National Transit.	Southwest Pennsylvania.	Eureka.	Cumberland.	Southern.	Crescent.	New York Transit.
January	1,669,651	160,732	74,074	9,224	545,409	142,686	1,222,506
February	1,550,924	172,479	79,700	8,527	562,158	128,286	1,193,716
March	1,637,163	153,197	84,821	13,018	531,112	172,336	1,130,495
April	1,712,503	178,253	89,373	14,242	629,898	151,847	1,416,061
May	1,701,842	176,315	75,502	8,138	615,042	159,624	1,537,048
June	1,824,053	172,665	83,914	7,220	618,651	145,253	1,276,068
July	1,783,285	171,153	75,752	5,652	666,638	163,495	1,407,578
August	1,799,723	175,327	74,342	3,263	673,661	165,288	979,277
September	1,674,071	174,917	74,417	4,314	583,311	131,041	969,800
October	1,824,043	192,126	78,474	4,677	720,263	202,397	1,275,394
November	1,614,560	182,805	78,501	5,760	550,831	153,080	951,060
December	1,518,812	174,501	77,556	3,996	513,238	134,571	1,071,652
Total	20,310,630	2,084,470	946,426	88,031	7,210,212	1,849,904	14,430,655

Month.	Tidewater.	Producers and Refiners.	Emery.	United States.	Buckeye Macksburg.	Franklin.
January	153,929	131,082	20,019	30,453	6,349	8,367
February	180,313	145,532	22,290	19	6,460	5,252
March	166,172	183,371	28,363	7,413	6,473	2,363
April	178,791	170,877	27,018	33,082	6,802	....
May	152,875	136,308	24,768	2,945	7,105	....
June	190,278	146,466	26,383	16,241	6,431	....
July	146,629	198,010	27,077	14,277	8,484	....
August	141,793	189,728	29,396	29,758	7,287	488
September	114,922	160,977	30,019	12,209	7,569	487
October	175,835	171 853	23,974	28,277	7,636	6,097
November	174,446	189,117	22,519	9,788	7,080	11,418
December	188,023	181,122	25,089	12,811	7,234	11,959
Total	1,964,006	2,004,443	306,915	197,273	84,910	46,431

1913.

Month.	National Transit.	Southwest Pennsylvania.	Eureka.	Cumberland.	Southern.	Crescent.
January	1,552,099	1,130,864	1,877,513	5,645	560,684	153,530
February	1,248,553	806,234	1,346,751	4,070	512,211	139,194
March	1,366,476	934,991	1,778,912	5,138	477,243	138,710
April	1,569,347	1,056,217	1,822,396	4,253	458,974	111,072
May	1,523,498	995,079	1,651,699	6,731	516,293	158,982
June	1,724,225	990,236	1,888,633	6,546	491,629	132,085
July	1,659,852	1,222,957	1,763,218	6,340	400,655	95,570
August	1,686,383	1,241,033	1,997,891	6,309	455,691	148,123
September	1,536,042	1,088,071	1,761,384	6,035	404,676	147,776
October	1,801,939	1,185,241	1,914,394	2,016	323,350	142,436
November	1,671,363	1,031,435	1,812,578	2,128	418,888	108,325
December	1,478,092	1,013,789	1,510,240	3,112	489,590	116,927
Total	18,817,869	12,696,147	21,125,609	58,323	5,509,884	1,592,730

[a] These pipe lines connect with the delivering lines of the Illinois, Kansas, and Oklahoma fields and receive and transfer large quantities of these western oils to the Atlantic seaboard in addition to the oil from wells directly tributary to their own systems.

Pipe-line deliveries to trade of eastern pipe lines in 1912 and 1913, by lines and months, in barrels—Continued.

1913—Continued.

Month.	New York Transit.	Tidewater.	Producers and Refiners.	Emery.	Buckeye Macksburg.	Franklin.
January	1,035,053	146,819	207,150	24,876	7,854	6,768
February	1,233,939	104,704	197,087	31,625	6,586	3,381
March	1,028,170	181,633	192,734	29,190	7,226	....
April	1,281,569	168,434	196,702	27,393	51	2,646
May	1,484,141	166,865	220,831	27,812	721	....
June	1,352,281	159,029	185,241	28,241	1,270	....
July	1,328,813	185,651	195,068	29,286	242	....
August	1,396,158	99,260	208,614	26,519	11	....
September	1,151,096	179,971	180,236	31,500	242	246
October	1,269,135	161,263	183,004	27,554	....	4,531
November	1,332,253	157,635	192,917	27,030	....	11,095
December	1,027,792	79,786	195,711	31,327	....	482
Total	14,920,400	1,791,050	2,353,981	342,353	24,203	29,149

PRICES OF APPALACHIAN OIL.

The following table shows the range of prices paid by the Seep Purchasing Agency for the different grades of oil in the Appalachian field in 1911, 1912, and 1913:

Range of prices paid at wells by the Seep Purchasing Agency for petroleum produced in the New York, southeastern Ohio, Pennsylvania, West Virginia, and Kentucky oil regions during 1911, 1912, and 1913, per barrel of 42 gallons.

Date.	Pennsylvania and Tiona, Pa.	Mercer black, Pennsylvania.	Corning, Ohio.	New Castle, Ohio.	Cabell, W. Va.	Somerset, Ky. (light).	Ragland, Ky. (heavy).
1911.							
Jan. 1	$1.30	$0.87	$0.77	$0.84	$0.94	$0.72	$0.45
Sept. 15	....	....	....	....	....	.74	....
Dec. 26	1.35	.92	.82	.89	.99	.79	.48
1912.							
Jan. 1	1.35	.92	.82	.89	.99	.79	.48
Jan. 8	1.40	.97	.87	.94	1.04	....	....
Jan. 22	1.45	1.02	.92	.99	1.09	.81	....
Jan. 29	1.50	1.05	.95	1.02	1.12	.83	....
Apr. 19	1.55	1.08	.98	1.05	1.15	.86	.50
June 5	1.60	1.13	1.03	1.10	1.20	.91	.53
June 15	....	....	1.13	1.13	....	....	....
Oct. 29	1.65	1.18	1.18	1.18	1.25	.96	.56
Nov. 8	1.70	1.23	1.23	1.23	1.30	1.00	.60
Nov. 14	1.75	1.28	1.28	1.28	1.35	1.05	.65
Nov. 18	1.80	1.33	1.33	1.33	1.40	1.07	....
Nov. 23	1.85	1.38	1.38	1.38	1.45	1.10	....
Dec. 2	1.90	1.43	1.43	1.43	1.50	....	....
Dec. 9	1.95	1.48	1.48	1.48	1.55	1.12	....
Dec. 14	2.00	1.53	1.53	1.53	1.60	1.15	....
1913.							
Jan. 1	2.00	1.53	1.53	1.53	1.60	1.15	.65
Jan. 6	2.05	1.58	1.58	1.58	1.65	1.20	.68
Jan. 27	2.12	1.65	1.65	1.65	1.72	1.25	....
Jan. 28	2.19	1.72	1.72	1.72	1.79	1.30	....
Jan. 29	2.26	1.79	1.79	1.79	1.86	1.32	.70
Jan. 30	2.33	1.86	1.86	1.86	1.93	....	....
Feb. 1	2.40	1.93	1.93	1.93	2.00	....	....
Feb. 4	2.47	2.00	2.00	2.00	2.07	1.35	....
Feb. 5	2.50	....	....	....	....	....	....

NOTE.—In addition to these prices bonuses ranging from 2 to 10 cents a barrel were paid by various pipe lines and refineries.

In the following table is given the average price per month of the different oils of the Appalachian field during the years 1912 and 1913:

Average monthly prices of Appalachian petroleum in 1912 and 1913, per barrel.

Month.	Pennsylvania and Tiona, Pa.	Mercer black, Pennsylvania.	Corning, Ohio.	New Castle, Ohio.	Cabell, W. Va.	Somerset, Ky.	Ragland, Ky.
1912.							
January	$1.41	$0.98	$0.88	$0.95	$1.05	$0.810	$0.480
February	1.50	1.05	.95	1.02	1.12	.830	.480
March	1.50	1.05	.95	1.02	1.12	.830	.480
April	1.52	1.06	.96	1.03	1.13	.845	.490
May	1.55	1.08	.98	1.05	1.15	.860	.500
June	1.59	1.12	1.08	1.11	1.19	.885	.515
July	1.60	1.13	1.13	1.13	1.20	.910	.530
August	1.60	1.13	1.13	1.13	1.20	.910	.530
September	1.60	1.13	1.13	1.13	1.20	.910	.530
October	1.60	1.13	1.13	1.13	1.20	.935	.545
November	1.75	1.28	1.28	1.28	1.35	1.036	.603
December	1.96	1.49	1.49	1.49	1.56	1.123	.650
Average	1.598	1.136	1.091	1.123	1.206	.907	.528
1913.							
January	2.07	1.60	1.60	1.60	1.67	1.21	.68
February	2.49	1.99	1.99	1.99	2.06	1.35	.70
March	2.50	2.00	2.00	2.00	2.07	1.35	.70
April	2.50	2.00	2.00	2.00	2.07	1.35	.70
May	2.50	2.00	2.00	2.00	2.07	1.35	.70
June	2.50	2.00	2.00	2.00	2.07	1.35	.70
July	2.50	2.00	2.00	2.00	2.07	1.35	.70
August	2.50	2.00	2.00	2.00	2.07	1.35	.70
September	2.50	2.00	2.00	2.00	2.07	1.35	.70
October	2.50	2.00	2.00	2.00	2.07	1.35	.70
November	2.50	2.00	2.00	2.00	2.07	1.35	.70
December	2.50	2.00	2.00	2.00	2.07	1.35	.70
Average	2.463	1.966	1.966	1.966	2.036	1.339	.699

The average monthly and yearly prices per barrel of petroleum of Pennsylvania grade at wells in the years 1904–1913 are given in the following table:

Monthly and yearly average prices of pipe-line certificates of petroleum of Pennsylvania grade at wells in daily market, 1904–1913, per barrel.

Year.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Yearly average.
1904	$1.85	$1.82	$1.72⅛	$1.65½	$1.62	$1.58⅝	$1.52	$1.50	$1.53¾	$1.56	$1.58¾	$1.57	$1.628
1905	1.43⅛	1.39	1.38¼	1.32¾	1.28¾	1.27	1.27	1.27	1.35⅜	1.57½	1.59	1.58	1.394
1906	1.58	1.58	1.58	1.60⅜	1.64	1.64	1.63⅝	1.58	1.58	1.58	1.58	1.58	1.598
1907	1.58	1.61¼	1.72⅞	1.78	1.78	1.78	1.78	1.78	1.78	1.78	1.78	1.78	1.745
1908	1.78	1.78	1.78	1.78	1.78	1.78	1.78	1.78	1.78	1.78	1.78	1.78	1.780
1909	1.78	1.78	1.78	1.78	1.70	1.67¼	1.60¼	1.58	1.58	1.56¼	1.49	1.44⅜	1.646
1910	1.40½	1.40	1.40	1.36⅛	1.35	1.31¾	1.30	1.30	1.30	1.30	1.30	1.30	1.336
1911	1.30	1.30	1.30	1.30	1.30	1.30	1.30	1.30	1.30	1.30	1.30	1.31	1.301
1912	1.41	1.50	1.50	1.52	1.55	1.59	1.60	1.60	1.60	1.60	1.75	1.96	1.598
1913	2.07	2.49	2.50	2.50	2.50	2.50	2.50	2.50	2.50	2.50	2.50	2.50	2.463

The following table shows the range of prices of crude oil of Pennsylvania grade each year since 1859:

Highest and lowest prices of crude petroleum of Pennsylvania grade each year, 1859–1913, per barrel.

Year.	Highest.		Lowest.	
	Month.	Price.	Month.	Price.
1859	September	$20.00	December	$20.00
1860	January	20.00	.....do	2.00
1861	.....do	1.75	.....do	.10
1862	December	2.50	January	.10
1863	.....do	4.00	.....do	2.00
1864	July	14.00	February	3.75
1865	January	10.00	August	4.00
1866	.....do	5.50	December	1.35
1867	October	4.00	June	1.50
1868	July	5.75	January	1.70
1869	January	7.00	December	4.25
1870	.....do	4.90	August	2.75
1871	June	5.25	January	3.25
1872	October	4.55	December	2.67½
1873	January	2.75	November	.82½
1874	February	2.25	.....do	.62½
1875	.....do	1.82½	January	.75
1876	December	4.23¾	.....do	1.47½
1877	January	3.69⅜	June	1.53¾
1878	February	1.87½	September	.78¾
1879	December	1.28¾	June	.63⅛
1880	June	1.24⅜	April	.71¼
1881	September	1.01¼	July	.72½
1882	November	1.37	.....do	.49¼
1883	June	1.24¾	January	.83¼
1884	January	1.15⅝	June	.51¼
1885	October	1.12⅝	January	.68
1886	January	.92¼	August	.59¾
1887	December	.90	July	.54
1888	March	1.00	June	.71⅜
1889	November	1.12½	April	.79½
1890	January	1.07⅝	December	.60¾
1891	February	.81⅜	August	.50
1892	January	.64⅛	October	.50
1893	December	.80	January	.52⅞
1894	.....do	.95¾	.....do	.78½
1895	April	2.60	.....do	.95¼
1896	January	1.50	December	.90
1897	March	.96	October	.65
1898	December	1.19	January	.65
1899	.....do	1.66	February	1.13
1900	January	1.68	November	1.05
1901	January, September	1.45	May	.80
1902	December	1.54	January, February, March	1.15
1903	.....do	1.90	January, February, March, April, May, June, July.	1.50
1904	January	1.85	July, December	1.50
1905	October	1.61	May	1.27
1906	April, May, June, July	1.64	January, February, March, April, August, September, October, November, December.	1.58
1907	March to December, inclusive	1.78	January	1.58
1908	No change	1.78	No change	1.78
1909	January, February, March	1.78	December	1.43
1910	January	1.43	June to December, inclusive	1.30
1911	December	1.35	January to December	1.30
1912	.....do	2.00	January	1.35
1913	March to December, inclusive	2.50	.....do	2.00

WELL RECORD.

Number of wells completed in the Appalachian field, 1909–1913, by States.

State.	Oil.					Dry.					Total completed.[a]				
	1909	1910	1911	1912	1913	1909	1910	1911	1912	1913	1909	1910	1911	1912	1913
Pennsylvania and New York	3,560	1,673	1,491	1,911	3,420	[a] 663	[a] 528	[b] 297	[b] 322	[b] 521	4,223	2,201	2,007	2,472	4,251
Southeastern and central Ohio	1,460	953	765	846	1,246	[a] 820	[a] 686	[b] 512	[b] 460	[b] 603	2,280	1,639	1,680	1,717	2,191
West Virginia	1,134	897	622	1,062	1,285	[a] 723	[a] 719	[b] 218	[b] 234	[b] 339	1,857	1,616	1,191	1,657	2,065
Kentucky	92	70	100	112	133	[a] 79	[a] 51	[b] 33	[b] 61	[b] 69	171	121	136	178	210
Total	6,246	3,593	2,978	3,931	6,084	[a]2,285	[a]1,984	[b]1,060	[b]1,077	[b]1,532	8,531	5,577	5,014	6,024	8,717

[a] Including gas wells. [b] Not including gas wells.

Number of oil wells and dry holes drilled in the Appalachian field in 1913, by States and months.

State.	Jan.		Feb.		Mar.		Apr.		May.		June.		July.	
	Oil.	Dry.	Oil.	Dry.	Oil.	Dry.	Oil.	Dry.	Oil.	Dry.	Oil.	Dry.	Oil.	Dry.
Pennsylvania and New York	153	26	129	27	204	36	248	48	303	37	375	49	352	53
Southeastern and central Ohio	66	45	76	51	95	36	94	44	123	46	110	49	104	50
West Virginia	92	21	98	26	91	30	113	25	103	25	138	34	102	30
Kentucky	6	4	15	7	4	4	11	9	12	4	9	7	11	6
Total	317	96	318	111	394	106	466	126	541	112	632	139	569	139

State.	Aug.		Sept.		Oct.		Nov.		Dec.		Total, 1913.		Total, 1912.	
	Oil.	Dry.	Oil.	Dry.	Oil.	Dry.	Oil.	Dry.	Oil.	Dry.	Oil.	Dry.	Oil.	Dry.
Pennsylvania and New York	344	57	335	56	356	45	341	37	280	50	3,420	521	1,911	322
Southeastern and central Ohio	131	61	122	49	120	57	105	49	100	66	1,246	603	846	460
West Virginia	110	32	104	30	114	28	109	31	111	27	1,285	339	1,062	234
Kentucky	10	5	19	7	11	2	10	4	15	10	133	69	112	61
Total	595	155	580	142	601	132	565	121	506	153	6,084	1,532	3,931	1,077

Number of oil wells drilled in the Appalachian field, 1909–1913, by months.

Year.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Total.
1909	452	425	409	529	599	664	611	567	592	451	545	402	6,246
1910	277	252	251	307	402	398	354	302	307	270	279	194	3,593
1911	188	180	168	196	249	277	274	288	290	292	300	276	2,978
1912	182	173	223	300	346	397	386	429	396	386	352	361	3,931
1913	317	318	394	466	541	632	569	595	580	601	565	506	6,084

Number of dry holes drilled in the Appalachian field, 1909–1913, by months.

Year.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Total.
1909	167	165	161	177	171	189	216	239	214	186	215	185	[a] 2,285
1910	125	117	125	183	172	202	183	167	173	175	156	206	[a] 1,984
1911	81	86	90	82	82	91	101	115	77	90	83	82	[b] 1,060
1912	73	43	82	65	78	79	98	121	140	102	100	96	[b] 1,077
1913	96	111	106	126	112	139	139	155	142	132	121	153	[b] 1,532

[a] Including gas wells. [b] Not including gas wells.

Total number of wells completed in the Appalachian field, 1909–1913, by months.[a]

Year.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Total.
1909	619	590	570	706	770	853	827	806	806	637	760	587	8,531
1910	402	370	376	490	573	600	537	469	480	445	435	400	5,577
1911	347	345	326	352	405	440	459	472	459	483	491	435	5,014
1912	311	260	360	427	491	573	570	636	670	622	562	542	6,024
1913	513	528	585	675	727	829	786	846	814	855	793	766	8,717

[a] Including gas wells.

Initial daily production of new wells completed in the Appalachian field in 1913, by States and months, in barrels.

State.	Jan.	Feb.	Mar.	Apr.	May.	June	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Total, 1913	Total, 1912
Pennsylvania and New York	426	387	733	638	729	959	838	860	826	891	869	802	8,958	6,771
Southeastern and central Ohio	871	1,116	1,241	1,023	1,328	1,282	1,507	1,609	1,559	2,159	1,784	823	16,302	24,193
West Virginia	3,428	3,988	3,144	4,121	2,360	5,085	1,846	2,527	1,846	2,452	1,795	2,243	34,835	109,804
Kentucky	43	325	105	501	93	138	221	166	192	124	109	198	2,215	1,943
Total	4,768	5,816	5,223	6,283	4,510	7,464	4,412	5,162	4,423	5,626	4,557	4,066	62,310	142,711

Total and average initial production of new wells in the Appalachian field, 1909–1913, by States, in barrels.

State.	Total initial production.					Average initial production per well.				
	1909	1910	1911	1912	1913	1909	1910	1911	1912	1913
Pennsylvania and New York	11,333	6,683	4,912	6,771	8,958	3.18	3.99	3.29	3.54	2.62
Southeastern and central Ohio	26,152	18,116	10,923	24,193	16,302	17.91	19.01	14.28	28.60	13.08
West Virginia	43,464	26,194	10,443	109,804	34,835	38.33	29.20	16.79	103.39	27.11
Kentucky	2,186	829	1,822	1,943	2,215	23.76	11.84	18.22	17.35	16.65
Total	83,135	51,822	28,100	142,711	62,310	13.31	14.42	9.44	36.30	10.24

Total initial daily production of new wells in the Appalachian field, 1909–1913, by months, in barrels.

Year.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Total.	Monthly average.
1909	4,819	5,184	4,783	5,161	5,646	7,512	6,809	7,593	6,476	10,660	7,115	11,377	83,135	6,928
1910	6,429	5,429	4,741	5,498	5,903	5,316	3,616	3,356	4,049	3,186	2,720	1,579	51,822	4,319
1911	1,916	2,349	1,694	2,036	2,708	1,933	2,222	2,444	2,470	2,417	3,354	2,557	28,100	2,342
1912	4,417	10,835	11,523	18,781	22,986	22,836	16,199	9,751	6,466	6,758	4,251	7,908	142,711	11,893
1913	4,768	5,816	5,223	6,283	4,510	7,464	4,412	5,162	4,423	5,626	4,557	4,066	62,310	5,193

PENNSYLVANIA AND NEW YORK.

DEVELOPMENT.

Pennsylvania.—The stimulation by high prices was so great as to change a usual decline in production of 5 or 6 per cent into a very slight increase—1.60 per cent. A total of 7,963,282 barrels was produced in 1913, against 7,837,948 barrels in 1912. The gain in value was very great. The total value was $19,805,452 in 1913 and $12,886,752 in 1912, at an average price of $2.49 in 1913 compared with $1.64 in 1912.

The oil regions spread over so much territory in western Pennsylvania, including pools scattered from the New York to the West Virginia and Ohio boundaries, that the productive conditions vary considerably in different pools. All have long passed their prime, but they differ in their stages of exhaustion. Those in Venango County, in the Bradford area, and in the northern portion of the State generally include the pools which originated the oil industry in the United States and developed international oil commerce, although Canada's oil production began at about the same time, and Roumania also was a productive country before the advent of Drake, who drilled the first American well for oil. The wells in the southwestern counties of Pennsylvania have been drilled more recently.

It is a matter of some national pride that the spirit of thrift and conservatism in New York and Pennsylvania has kept these old wells productive, with no other aid than the homely ingenuity of the citizens of these States, who have contrived marvelously economical and efficient means to keep the wells pumping with little recourse to special legislation on the one hand or the use of large capital on the other.

The fact is to be emphasized also, in accounting for this feat in increasing the production from those old pools, that it was due chiefly to skillful work in once more cleaning out wells that have previously been cleaned again and again, rather than to new production. In the southwestern counties of Pennsylvania some encouraging wells were drilled. Thus in Washington County, near Venice, early in the year several new wells started with 35 to 50 barrels a day. In Allegheny County interest was stimulated by a 250 barrel well near Duff City, and a 40-barrel well was struck near Walkers Mills. In Greene County the Bristoria field yielded a few promising wells, and a 35-barrel well was obtained in Westmoreland County. Butler County, near Parker, gave a few 15-barrel wells.

New York.—The increase in the price of petroleum which began at the end of 1912 had the desired effect of stimulating drilling activity in all the Appalachian States. In New York this took the form chiefly of cleaning out old wells, with an immediate increase in production. In January, 1913, the production rose from a monthly total of 73,421 barrels to 77,029 barrels. February, besides being a short month, always shows low production, because of severe weather, but the production in 1913 was slightly greater than for the same month in 1912. The spring months showed a decline from the previous year, but the gain was nearly continuous during the drilling season and up to the close of the year, so that for the first time in seven years New York showed a gain in production. The increase amounted to 3.21 per cent, or from 874,128 barrels in 1912 to 902,211 barrels. Although this total is negligible in the output of the whole country, the gain is significant in showing what a rise in price can effect in a State where the average yield per well is less than anywhere else on earth. The usual course of production in New York for several years has been a decline of about 7 or 8 per cent, so that the change to 3.21 per cent increase is really significant. The total value increased from $1,401,-880 to $2,169,357, or 54.75 per cent, which was phenomenal. The average price for the year 1912 was $1.60 and for 1913 it was $2.40 per barrel of 42 gallons.

PRODUCTION.

The following table shows the production of petroleum in Pennsylvania and New York, 1909–1913, by months:

Production of petroleum in Pennyslvania and New York in 1909–1913, by months, in barrels.

PENNSYLVANIA.

Month.	1909	1910	1911	1912	1913
January	759,178	721,627	697,290	562,665	673,011
February	704,391	621,467	637,719	575,180	581,040
March	822,600	851,225	722,755	686,178	640,858
April	784,155	766,700	701,489	699,856	707,638
May	818,359	759,585	765,470	728,127	704,527
June	820,155	790,520	704,082	657,545	665,380
July	792,327	723,646	668,324	678,789	692,210
August	786,563	763,273	704,627	675,848	656,835
September	774,750	720,165	661,775	634,114	655,137
October	758,779	708,453	690,360	686,184	698,052
November	765,504	678,132	622,543	610,314	612,732
December	712,642	689,869	671,724	643,148	675,871
Total	9,299,403	8,794,662	8,248,158	7,837,948	7,963,282

NEW YORK.

Month.	1909	1910	1911	1912	1913
January	95,270	90,027	83,160	64,850	77,029
February	89,526	71,699	73,007	63,080	63,692
March	100,008	101,406	83,226	73,371	70,984
April	96,249	92,245	81,239	79,188	78,771
May	98,490	90,581	88,594	82,035	79,800
June	99,905	92,064	84,442	73,950	73,981
July	96,247	89,457	75,885	75,875	79,091
August	93,900	89,650	81,368	74,663	74,260
September	93,583	86,428	76,263	68,884	74,503
October	90,382	86,659	78,469	76,766	80,424
November	91,058	79,519	70,101	68,045	70,738
December	90,279	84,103	76,761	73,421	78,938
Total	1,134,897	1,053,838	952,515	874,128	902,211

WELL RECORD.

The impetus given by high prices to well drilling in Pennsylvania and New York is forcefully shown in the following table. The total wells drilled increased from 2,472 to 4,251. The increase was seen in every district. There are no statistics of old wells cleaned out or the evidence of activity would be still greater. The average initial daily production per well declined in 1913, as might have been expected from the greater number of wells drilled.

Number of wells completed in the Pennsylvania and New York oil fields, 1909–1913, by districts.

District.	Oil.					Dry.					Total completed.[a]				
	1909	1910	1911	1912	1913	1909	1910	1911	1912	1913	1909	1910	1911	1912	1913
Bradford	535	316	260	335	675	36	6	16	14	31	571	344	298	371	755
Allegany	419	219	128	177	441	40	13	9	17	22	459	283	194	246	509
Middle	441	195	208	226	352	65	34	39	36	66	506	235	247	266	435
Venango and Clarion	1,682	635	642	853	1,352	199	70	93	90	141	1,881	790	805	1,019	1,578
Butler and Armstrong	309	152	124	138	354	178	89	65	59	110	487	263	219	216	497
Southwest Pennsylvania	174	156	129	182	246	145	76	75	106	151	319	286	244	354	477
Total	3,560	1,673	1,491	1,911	3,420	[a] 663	[b] 288	[b] 297	[b] 322	[b] 521	4,223	2,201	2,007	2,472	4,251

[a] Including gas wells. [b] Not including gas wells.

Number of oil wells and dry holes drilled in the Pennsylvania and New York oil fields in 1913, by districts and months.

District.	Jan.		Feb.		Mar.		Apr.		May.		June.		July.		Aug.	
	Oil.	Dry.	Oil.	Dry.	Oil.	Dry.	Oil.	Dry.	Oil.	Dry.	Oil.	Dry.	Oil.	Dry.	Oil.	Dry.
Bradford	24	1	13	4	43	3	53	2	48	1	85	.....	84	2	54	4
Allegany	18	1	8	1	18	.....	31	1	44	2	46	1	45	3	54	3
Middle	13	3	9	6	14	6	20	9	37	4	41	9	42	5	34	2
Venango and Clarion	64	8	70	7	93	11	104	19	127	8	140	15	124	14	140	15
Butler and Armstrong	20	3	13	5	19	8	18	12	31	7	36	8	30	15	38	20
Southwest Pennsylvania	14	10	16	4	17	8	22	5	16	15	27	16	27	14	24	13
Total	153	26	129	27	204	36	248	48	303	37	375	49	352	53	344	57

District.	Sept.		Oct.		Nov.		Dec.		Total, 1913.		Total, 1912.	
	Oil.	Dry.	Oil.	Dry.	Oil.	Dry.	Oil.	Dry.	Oil.	Dry.	Oil.	Dry.
Bradford	68	6	63	2	79	2	61	4	675	31	335	14
Allegany	43	2	50	4	40	2	44	2	441	22	177	17
Middle	37	6	47	4	31	5	27	7	352	66	226	36
Venango and Clarion	133	16	139	8	121	7	97	13	1,352	141	853	90
Butler and Armstrong	35	7	34	8	54	6	26	11	354	110	138	59
Southwest Pennsylvania	19	19	23	19	16	15	25	13	246	151	182	106
Total	335	56	356	45	341	37	280	50	3,420	521	1,911	322

Number of oil wells drilled in Pennsylvania and New York oil fields, 1909–1913, by months.

Year.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Total.
1909	268	255	227	317	374	391	359	308	338	215	316	192	3,560
1910	114	94	82	145	213	192	170	158	140	136	146	83	1,673
1911	68	60	52	84	117	152	148	168	170	157	174	141	1,491
1912	73	71	90	150	181	210	191	224	190	190	167	174	1,911
1913	153	129	204	248	303	375	352	344	335	356	341	280	3,420

Number of dry holes drilled in the Pennsylvania and New York oil fields, 1909–1913, by months.

Year.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Total.
1909	57	43	33	53	62	57	54	76	62	59	52	55	[a] 663
1910	33	38	27	45	53	58	52	53	39	46	42	42	[a] 528
1911	22	25	23	33	33	28	19	32	22	22	25	13	[b] 297
1912	21	11	19	23	30	29	28	42	37	26	37	19	[b] 322
1913	26	27	36	48	37	49	53	57	56	45	37	50	[b] 521

Total number of wells completed in the Pennsylvania and New York oil fields, 1909–1913, by months. [a]

Year.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Total.
1909	325	298	260	370	436	448	413	384	400	274	368	247	4,223
1910	147	132	109	190	266	250	222	211	179	182	188	125	2,201
1911	100	96	87	130	168	198	191	222	205	210	227	173	2,007
1912	112	91	125	190	232	266	237	284	252	242	228	213	2,472
1913	205	183	268	329	363	439	431	427	416	431	406	353	4,251

[a] Including gas wells.

[b] Not including gas wells.

Initial daily production of new wells completed in New York and Pennsylvania in 1913, by districts and months, in barrels.

District.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Total, 1913.	Total, 1912.
Bradford	62	22	117	151	91	193	198	155	169	150	199	169	1,676	817
Allegany	27	40	42	54	72	73	66	89	91	108	76	82	820	278
Middle	39	14	19	27	63	69	85	60	64	106	49	54	649	511
Venango and Clarion	107	132	168	172	196	247	208	272	204	245	189	161	2,301	1,943
Butler and Armstrong	93	36	79	92	191	173	142	114	136	126	215	90	1,487	696
Southwest Pennsylvania	98	143	308	142	116	204	139	170	162	156	141	246	2,025	2,526
Total	426	387	733	638	729	959	838	860	826	891	869	802	8,958	6,771

Total and average initial daily production of new wells in the Pennsylvania and New York oil fields, 1909–1913, by districts, in barrels.

District.	Total initial production.					Average initial production per well.				
	1909	1910	1911	1912	1913	1909	1910	1911	1912	1913
Bradford	1,345	952	730	817	1,676	2.51	3.01	2.81	2.44	2.48
Allegany	815	368	201	278	820	1.94	1.68	1.57	1.57	1.86
Middle	977	442	541	511	649	2.22	2.27	2.60	2.26	1.84
Venango and Clarion	4,573	1,276	1,302	1,943	2,301	2.72	2.00	2.03	2.28	1.70
Butler and Armstrong	2,493	1,489	422	696	1,487	8.07	9.80	3.40	5.04	4.20
Southwest Pennsylvania	1,130	2,156	1,716	2,526	2,025	6.49	13.82	13.30	13.88	8.23
Total	11,333	6,683	4,912	6,771	8,958	3.18	3.99	3.29	3.54	2.62

Total initial daily production of new wells in the Pennsylvania and New York oil fields, 1909–1913, by months, in barrels.

Year.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Total.	Monthly average.
1909	869	785	608	930	1,084	1,027	1,011	1,148	1,046	1,082	991	752	11,333	994
1910	572	320	211	584	1,355	621	604	924	353	395	448	296	6,683	557
1911	204	345	154	313	319	368	435	611	517	507	695	444	4,912	409
1912	548	621	613	657	531	588	482	637	720	530	474	370	6,771	564
1913	426	387	733	638	729	959	838	860	826	891	869	802	8,958	746

WEST VIRGINIA.

DEVELOPMENT.

Petroleum is produced in 26 counties of West Virginia, from Harrison County on the east to the western State line, and from Pennsylvania southwest to Mingo County. This State, which is the home of the anticlinal theory, as developed by Dr. I. C. White, State geologist, possesses ideal structure for the storage of oil over so large an area that many pools have been developed and the drilling of wells yielding as much as 1,000 barrels a day of initial production is still frequent. Conditions are still favorable in the State for the development of new prolific pools that would bring the total yield of the State beyond the maximum. In 1912, for example, the development of the Blue Creek pool, in Kanawha County, increased the total production for that year to 12,128,962 barrels. During the year the pool declined, and a great result in 1913 was not to be expected; nevertheless the total reached 11,567,299 barrels, a loss of only 4.63 per cent. This good record was due to the extension of the Blue Creek pool, and chiefly to the increase in Roane County, where the Berea Grit and the Scaffold Run pools, in the Spencer district, developed a product of over 1,000 barrels a day early in the year and increased as the weather became better for drilling. Harrison, Pleasants, Wood, Monongalia, Ritchie, Gilmer, Morgan, and Brooke counties added many gushers yielding from 200 to 1,000 barrels a day.

Although no pool equivalent to the Blue Creek was developed during the year, drilling was more active than ever before, owing to the high prices for oil. The total value increased 44.67 per cent, or from $19,927,721 in 1912 to $28,828,814 in 1913.

PRODUCTION.

In the following table is given the production of petroleum in West Virginia in the years 1909 to 1913, by months:

Total production of petroleum in West Virginia, 1909–1913, by months, in barrels.

Month.	1909	1910	1911	1912	1913
January	735,379	1,026,438	814,743	694,619	978,401
February	722,045	935,252	800,712	801,699	936,733
March	851,002	1,050,163	881,172	983,502	970,900
April	833,432	962,657	810,661	1,018,955	1,026,129
May	829,833	1,001,746	882,093	1,153,945	1,003,425
June	870,909	1,018,694	832,920	1,172,331	995,098
July	904,745	984,813	787,171	1,174,367	1,009,383
August	923,438	1,020,317	838,922	1,190,552	939,479
September	950,188	976,220	773,024	981,052	928,610
October	997,295	935,166	795,687	1,013,980	956,772
November	1,016,738	906,521	757,029	918,313	893,274
December	1,110,088	935,084	821,330	1,025,647	983,095
Total	10,745,092	11,753,071	9,795,464	12,128,962	11,567,299

The quantity and value of petroleum produced in West Virginia from 1904 to 1913, inclusive, are shown in the following table:

Quantity and value of petroleum produced in West Virginia, 1904–1913, in barrels.

Year.	Regular crude.			Lubricating.			Total.		
	Quantity.	Value.	Average price per barrel.	Quantity.	Value.	Average price per barrel.	Quantity.	Value.	Average price per barrel.
1904	12,636,253	$20,557,556	$1.627	8,433	$26,225	$3.11	12,644,686	$20,583,781	$1.628
1905	11,573,545	16,117,816	1.393	4,565	14,815	3.25	11,578,110	16,132,631	1.393
1906	10,111,647	16,138,811	1.596	9,288	31,482	3.39	10,120,935	16,170,293	1.598
1907	9,089,839	15,834,714	1.740	5,457	17,714	3.25	9,095,296	15,852,428	1.743
1908	9,519,875	16,902,968	1.775	3,301	8,897	2.70	9,523,176	16,911,865	1.776
1909	10,742,026	17,634,335	1.642	3,066	7,948	2.59	10,745,092	17,642,283	1.642
1910	11,751,018	15,717,796	1.338	2,053	5,748	2.80	11,753,071	15,723,544	1.338
1911	9,792,324	12,757,861	1.302	3,140	9,432	3.00	9,795,464	12,767,293	1.303
1912	12,126,137	19,919,952	1.643	2,825	7,769	2.75	12,128,962	19,927,721	1.643
1913	11,562,730	28,813,822	2.493	4,569	14,982	3.28	11,567,299	28,828,814	2.492

WELL RECORD.

Well drilling was unusually active in West Virginia in 1913, the total number of wells increasing from 1,657 in 1912 to 2,065 in 1913. All counties shared in the increase, except Kanawha, in which the

Blue Creek excitement of 1912 led to unusual activity in that year, and Calhoun, which was not quite so active in 1913. Mannington district led in the drilling with 526 completed wells.

The total initial production and initial production per well in 1913 declined heavily from 1912, due to lack of any great gusher field comparable with the Blue Creek field in 1912.

Number of wells completed in West Virginia, 1909–1913, by districts.

District.	Oil.					Dry.					Total completed.[a]				
	1909	1910	1911	1912	1913	1909	1910	1911	1912	1913	1909	1910	1911	1912	1913
Brooke County	62	7	1	5	28	35	19	2	4	6	97	26	3	9	38
Burning Springs	48	22	22	17	49	12	8	5	3	8	60	30	31	21	60
Cabell County	4	6	1	.....	.....	10	11	2	.....	1	14	17	5	.....	1
Calhoun County	24	11	11	19	18	15	13	2	12	6	39	24	33	38	32
Hancock County	11	5	8	5	21	13	2	.....	11	7	24	7	8	16	33
Kanawha County	.....	.....	(b)	440	177	.....	.....	(b)	11	20	.....	.....	(b)	486	227
Lincoln County	234	133	58	61	66	83	15	3	1	4	317	148	68	70	75
Mannington	202	199	98	80	230	264	301	39	39	51	466	500	280	298	526
Pleasants County	91	97	60	59	108	51	44	29	31	42	142	141	90	91	150
Ritchie County	111	105	93	79	129	52	54	45	20	39	163	159	170	121	191
Roane County	169	188	160	147	253	39	81	8	13	21	208	269	194	169	295
Sistersville	34	7	8	7	16	16	3	9	8	11	50	10	18	15	29
Wetzel and Tyler counties	64	62	35	59	89	73	100	25	40	50	137	162	117	168	213
Wood County	72	44	49	61	71	34	31	31	20	36	106	75	80	81	108
Miscellaneous	8	11	18	23	30	26	37	18	21	37	34	48	94	74	87
Total	1,134	897	622	1,062	1,285	a 723	a 719	c 218	c 234	c 339	1,857	1,616	1,191	1,657	2,065

a Including gas wells. b Included in "Miscellaneous." c Not including gas wells.

Number of oil wells and dry holes drilled in West Virginia in 1913, by districts and months.

District.	Jan.		Feb.		Mar.		Apr.		May.		June.		July.		Aug.		Sept.		Oct.		Nov.		Dec.		Total, 1913.		Total, 1912.	
	Oil.	Dry.	Oil.	Dry.	Oil.	Dry.	Oil.	Dry.	Oil.	Dry.	Oil.	Dry.	Oil.	Dry.	Oil.	Dry.	Oil.	Dry.	Oil.	Dry.	Oil.	Dry.	Oil.	Dry.	Oil.	Dry.	Oil.	Dry.
Brooke County	..	..	3	..	..	..	..	..	..	..	..	..	2	1	4	..	6	..	5	2	4	1	4	2	28	6	5	4
Burning Springs	..	..	3	1	3	..	1	1	4	1	4	..	8	..	5	1	2	2	7	1	7	1	5	..	49	8	17	3
Cabell County	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	1	.....	1	.....	..
Calhoun County	1	3	3	..	..	1	1	1	2	..	2	..	..	..	2	..	..	..	2	..	2	1	3	..	18	6	19	12
Hancock County	2	..	1	..	2	..	2	2	3	1	4	1	..	..	4	1	..	1	..	1	3	..	..	..	21	7	5	11
Kanawha County	17	..	18	3	22	4	18	1	21	3	23	4	9	1	8	3	11	..	9	..	13	..	8	1	177	20	440	11
Lincoln County	..	..	4	1	4	..	7	..	4	1	8	..	7	..	8	1	5	..	6	..	8	1	5	..	66	4	61	1
Mannington	9	3	15	3	15	2	19	5	14	2	28	6	12	5	16	4	24	5	25	6	22	4	31	6	230	51	80	39
Pleasants County	5	2	7	3	8	5	12	3	13	4	11	6	8	4	12	1	8	4	10	3	9	2	5	5	108	42	59	31
Ritchie County	12	..	9	1	9	4	10	4	9	3	12	2	16	5	8	2	11	2	11	4	8	6	14	6	129	39	79	20
Roane County	27	..	25	1	14	2	22	3	16	2	23	2	21	2	18	4	21	2	24	1	17	..	25	2	253	21	147	13
Sistersville	..	..	..	1	..	..	1	..	2	..	1	3	1	2	4	1	..	2	3	1	1	..	3	1	16	11	7	8
Wetzel and Tyler counties	9	11	4	6	6	2	12	2	7	6	11	2	11	3	6	5	6	4	10	3	4	5	3	1	89	50	59	40
Wood County	7	2	2	2	5	7	5	3	7	..	5	4	6	5	12	5	8	3	2	1	8	4	4	..	71	36	61	20
Miscellaneous	3	..	4	4	3	3	3	..	1	2	6	4	1	2	3	4	2	5	..	5	3	6	1	2	30	37	23	21
Total	92	21	98	26	91	30	113	25	103	25	138	34	102	30	110	32	104	30	114	28	109	31	111	27	1,285	339	1,062	234

Number of oil wells drilled in West Virginia, 1909–1913, by months.

Year.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Total.
1909	86	78	87	88	84	102	85	101	117	107	104	95	1,134
1910	100	81	73	69	89	89	81	65	78	70	54	48	897
1911	53	47	52	45	56	44	60	51	50	58	46	60	622
1912	54	50	71	75	74	90	103	113	117	96	111	108	1,062
1913	92	98	91	113	103	138	102	110	104	114	109	111	1,285

Number of dry holes drilled in West Virginia, 1909–1913, by months.

Year.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Total.
1909	44	66	56	52	47	53	66	67	65	64	74	69	[a] 723
1910	46	42	49	77	64	68	67	64	59	62	54	67	[a] 719
1911	19	24	21	14	10	12	20	28	19	17	12	22	[b] 218
1912	18	14	30	15	12	11	18	23	21	21	15	36	[b] 234
1913	21	26	30	25	25	34	30	32	30	28	31	27	[b] 339

[a] Including gas wells. [b] Not including gas wells.

Total number of wells completed in West Virginia, 1909–1913, by months.[a]

Year.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Total.
1909	130	144	143	140	131	155	151	168	182	171	178	164	1,857
1910	146	123	122	146	153	157	148	129	137	132	108	115	1,616
1911	102	108	106	100	96	81	105	107	101	98	80	107	1,191
1912	96	80	119	113	116	134	148	171	185	167	162	166	1,657
1913	157	157	157	177	163	202	163	175	172	187	173	182	2,065

[a] Including gas wells.

Initial daily production of new wells completed in West Virginia, 1913, by districts and months, in barrels.

District.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Total, 1913.	Total 1912.
Brooke County	.....	17	.....	.....	.....	.....	95	242	260	335	210	170	1,329	19
Burning Springs	.....	7	11	2	27	24	34	12	2	28	33	32	212	105
Cabell County	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	12	.....	12	.....
Calhoun County	20	25	.....	10	30	45	.....	17	.....	20	18	14	199	340
Hancock County	8	2	6	13	15	15	.....	19	.....	.....	4	.....	82	21
Kanawha County	663	1,225	1,143	1,279	963	2,503	467	950	265	490	405	350	10,703	98,870
Lincoln County	.....	80	46	110	95	85	114	77	73	67	111	71	929	1,058
Mannington	248	640	545	791	383	845	214	288	522	853	548	952	6,829	2,001
Pleasants County	310	256	379	128	159	195	120	253	82	75	72	16	2,045	930
Ritchie County	70	46	58	122	77	69	120	58	96	115	42	95	968	726
Roane County	1,775	1,553	805	1,354	470	1,058	407	356	429	281	217	480	9,185	3,161
Sistersville	.....	.....	.....	5	12	10	10	35	.....	17	5	18	112	38
Wetzel and Tyler Counties	272	102	105	236	69	157	229	122	22	167	75	27	1,583	1,254
Wood County	47	10	29	55	55	17	28	91	92	4	41	13	482	318
Miscellaneous	15	25	17	16	5	62	8	7	3	.....	2	5	165	963
Total	3,428	3,988	3,144	4,121	2,360	5,085	1,846	2,527	1,846	2,452	1,795	2,243	34,835	109,804

Total and average initial daily production of new wells in West Virginia, 1909–1913, by districts, in barrels.

District.	Total initial production.					Average initial production per well.				
	1909	1910	1911	1912	1913	1909	1910	1911	1912	1913
Brooke County	182	59	3	19	1,329	19.06	8.43	3.00	3.80	47.46
Burning Springs	183	69	144	105	212	3.81	3.14	6.54	6.18	4.33
Cabell County	24	28	5	(a)	12	6.00	4.67	5.00	....	....
Calhoun County	1,084	196	295	340	199	45.17	17.82	26.82	17.90	11.06
Clay County	....	....	....	(a)	(a)	....	....	....	....	....
Hancock County	49	7	29	21	82	4.45	1.40	3.63	4.20	3.90
Kanawha County	....	....	(a)	98,870	10,703	....	....	....	224.70	60.47
Lincoln County	6,717	2,397	1,087	1,058	929	28.71	18.02	18.74	17.34	14.08
Mannington	24,237	12,426	2,180	2,001	6,829	119.98	62.44	22.24	25.01	29.69
Pleasants County	617	1,050	374	930	2,045	6.78	10.82	6.23	15.76	18.93
Ritchie County	3,326	3,621	1,661	726	968	29.96	34.49	17.86	9.19	7.50
Roane County	3,940	3,966	3,243	3,161	9,185	23.31	21.10	20.27	21,50	36.30
Sistersville	252	141	56	38	112	7.41	20.00	7.00	5.43	2.38
Wetzel and Tyler Counties	1,132	1,752	605	1,254	1,583	17.69	28.26	17.28	21.25	17.79
Wood County	496	402	337	318	482	6.89	9.14	6.88	5.21	6.79
Miscellaneous	225	80	424	963	165	28.13	7.27	23.56	41.87	5.50
Total	43,464	26,194	10,443	109,804	34,835	38.33	29.20	16.79	103.39	27.11

[a] Included in "Miscellaneous."

Total initial daily production of new wells in West Virginia, 1909–1913, by months, in barrels.

Year.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Total.	Monthly average.
1909	1,682	1,781	2,221	2,337	1,795	2,656	3,014	3,812	3,615	7,362	4,048	9,141	43,464	3,622
1910	4,523	3,559	2,092	2,094	2,085	2,533	1,647	1,500	2,608	1,542	1,408	603	26,194	2,183
1911	813	938	773	869	991	767	1,015	834	700	865	1,008	870	10,443	870
1912	2,010	6,602	8,577	15,925	19,930	19,926	13,528	6,383	4,586	3,901	2,696	5,740	109,804	9,150
1913	3,428	3,988	3,144	4,121	2,360	5,085	1,846	2,527	1,846	2,452	1,795	2,243	34,835	2,903

KENTUCKY

DEVELOPMENT.

The oil output of Kentucky is a little over half that of New York. It comes chiefly from a considerable number of small wells, most of them old, in Wayne County. Within the last few years, however, drilling efforts have been active to extend the West Virginia pools over into Kentucky, with only moderate success in Lawrence County. Other counties near by have shared in this excitement, and some oil has been added to the supply by deepening wells in several eastern counties. Meanwhile oil has been found in the western part of the State as a result of skillful geologic study by J. H. Gardner and others in Ohio County. This has led to much wildcatting in other western counties, more or less carelessly directed and as yet without fully compensating returns.

PRODUCTION.

Increased prices proved stimulating in Kentucky also, and the total production increased from 484,368 barrels in 1912 to 524,568 barrels in 1913, a gain of 8.3 per cent. The total value increased from $424,842 to $675,748, or 59.03 per cent.

Production of petroleum in Kentucky, by months, 1909–1913, in barrels.

Month.	1909	1910	1911	1912	1913
January	59,799	40,984	33,237	38,425	42,074
February	56,355	35,795	31,151	37,723	36,843
March	63,085	41,006	37,910	40,923	39,391
April	55,681	39,907	35,484	37,375	39,036
May	57,065	43,055	42,906	44,967	42,932
June	53,522	44,239	38,509	40,311	39,285
July	55,414	40,009	42,237	44,997	48,211
August	54,777	40,699	44,087	40,866	49,908
September	54,221	41,017	44,356	39,146	52,538
October	46,330	35,822	41,556	38,484	46,301
November	41,772	29,144	40,818	40,000	44,137
December	40,995	37,097	40,207	41,151	43,912
Total	639,016	468,774	472,458	484,368	524,568

Pipe-line runs in Kentucky in 1912 and 1913, by districts and months, in barrels.

1912.

Month ending—	Cooper and Slickford.	Griffin (Denney).	Mount Pisgah (Sandusky).	Parmleysville.	Steubenville.	Total, Wayne County.	Beaver Creek.	Busseyville.	Campton.
Jan. 27	4,231	7,170	7,377	4,382	1,595	24,755	1,093		1,521
Feb. 24	4,125	9,023	7,390	4,096	2,147	26,781	904		1,024
Mar. 30	5,330	10,053	10,693	4,652	3,246	33,974	1,253		3,895
Apr. 27	4,388	8,994	7,518	3,991	1,890	26,781	844		2,570
May 25	4,278	10,920	6,980	4,057	2,630	28,865	751		3,144
June 29	4,687	16,004	8,453	4,616	2,839	36,599	1,367		3,185
July 27	3,793	14,380	5,805	3,589	2,028	29,595	1,017		2,281
Aug. 31	5,622	14,330	7,574	4,795	2,555	34,876	1,760		3,650
Sept. 28	3,653	11,149	4,507	2,818	1,950	24,077	1,514		2,443
Oct. 26	3,568	13,158	4,434	2,758	1,695	25,613	683	145	1,967
Nov. 30	4,436	15,793	5,227	3,941	2,299	31,696	1,589	1,173	2,953
Dec. 28	4,091	11,737	3,810	2,547	2,030	24,215	1,230	1,166	1,613
Total	52,202	142,711	79,768	46,242	26,904	347,827	14,005	2,484	30,246

Month ending—	Lewis.	Meadow Branch.	Page Hollow.	Ragland.	Stillwater.	Watson.	Williamsburg.	Total.
Jan. 27		223	831	2,634		622	404	32,083
Feb. 24		265	793	3,443		589	138	33,937
Mar. 30		353		4,533		262		44,270
Apr. 27		761		4,306		140		35,402
May 25		523		3,508		325		37,116
June 29		652	1,053	6,758		292	159	50,065
July 27		674		4,687		142	177	38,573
Aug. 31		448		4,558	558	517		46,367
Sept. 28		473		3,438	860			32,805
Oct. 26		564		4,583	917			34,472
Nov. 30	918	604		4,039	1,313	71	159	44,515
Dec. 28	1,698	511	835	4,274	625			36,167
Total	2,616	6,051	3,512	50,761	4,273	2,960	1,037	465,772

1913.

Month ending—	Cooper and Slickford.	Griffin (Denney).	Mount Pisgah (Sandusky).	Parmleysville.	Steubenville.	Total, Wayne County.	Beaver Creek.	Busseyville.	Campton.
Jan. 25	5,298	11,525	3,445	3,016	1,913	25,197	1,469	943	1,695
Feb. 22	4,964	10,815	3,654	2,543	1,824	23,800	1,517	929	2,324
Mar. 29	6,546	14,080	1,519	4,554	1,956	28,655	885	1,296	2,858
Apr. 26	4,324	11,732		5,159	2,239	23,454	1,507	1,170	3,098
May 31	6,663	14,662		7,100	3,295	31,720	1,279	1,229	3,410
June 28	4,675	12,019		4,863	2,482	24,039	970	975	1,978
July 26	5,022	15,479		4,580	2,244	27,325	1,072	957	2,706
Aug. 30	6,124	18,698		5,566	3,235	33,623	1,043	1,542	2,883
Sept. 27	5,109	13,936		4,016	2,525	25,586	1,131	645	2,821
Oct. 25	4,570	12,114		4,195	2,629	23,508	754	1,233	1,894
Nov. 29	6,181	13,708		5,557	2,764	28,210	1,585	1,250	3,035
Dec. 27	4,557	10,157		3,255	2,180	20,149	1,172	515	2,535
Total	64,033	158,925	8,618	54,404	29,286	315,266	14,384	12,684	31,237

Month ending—	Lewis.	Meadow Branch.	Page Hollow.	Ragland.	Stillwater.	Watson.	Williamsburg.	Total.
Jan. 25	1,080	776	572	4,325	712		145	36,914
Feb. 22	4,999	326		2,860	394	208	299	37,656
Mar. 29	3,616			6,100	701	279	298	44,688
Apr. 26	3,494			2,881	1,401		149	37,154
May 31	4,566			4,861	1,318		159	48,542
June 28	2,806			2,896	519		181	34,364
July 26	5,860			3,649	1,084		149	42,802
Aug. 30	11,852			4,232	781		148	56,104
Sept. 27	12,747			3,823	897		149	47,799
Oct. 25	9,401			3,033	1,227			41,050
Nov. 29	11,826			5,002	1,376			52,284
Dec. 27	8,272			3,157	914			36,714
Total	80,519	1,102	572	46,819	11,324	487	1,677	516,071

WELL RECORD.

In the following tables are given the well records for Kentucky from 1909 to 1913, inclusive:

Number of wells completed in Kentucky, 1909–1913, by counties.

County.	Oil.					Dry.					Total completed.[a]				
	1909	1910	1911	1912	1913	1909	1910	1911	1912	1913	1909	1910	1911	1912	1913
Allen	.....	.....	.....	.....	7	.....	.....	.....	.....	1	.....	.....	.....	.....	8
Barren	.....	.....	.....	.....	3	.....	.....	.....	.....	3	.....	.....	.....	.....	6
Cumberland	.....	.....	.....	1	.....	.....	.....	.....	.....	1	.....	.....	.....	1	2
Floyd	.....	.....	2	4	.....	1	.....	1	.....	1	1	.....	3	4	1
Lawrence	.....	2	.....	20	9	1	4	1	12	1	1	6	1	33	11
Logan	.....	7	1	.....	.....	.....	1	.....	.....	.....	.....	8	1	.....	.....
Meade	1	.....	.....	.....	.....	.....	1	.....	.....	.....	1	1	.....	.....	.....
Morgan	.....	.....	.....	.....	32	2	.....	.....	.....	13	2	.....	.....	.....	48
Wayne	86	61	94	75	67	71	38	27	44	31	157	99	121	119	98
Wolfe	5	.....	1	9	12	2	4	.....	2	10	7	4	2	11	22
Other	.....	.....	2	3	3	2	3	4	3	8	2	3	8	10	14
Total	92	70	100	112	133	[a] 79	[b] 51	[b] 33	[b] 61	[b] 69	171	121	136	178	210

[a] Including gas wells. [b] Not including gas wells.

Number of oil wells and dry holes drilled in Kentucky in 1913, by counties and months.

County.	Jan.		Feb.		Mar.		Apr.		May.		June.		July.		Aug.		Sept.		Oct.		Nov.		Dec.		Total, 1913.		Total, 1912.	
	Oil.	Dry.	Oil.	Dry.	Oil.	Dry.	Oil.	Dry.	Oil.	Dry.	Oil.	Dry.	Oil.	Dry.	Oil.	Dry.	Oil.	Dry.	Oil.	Dry.	Oil.	Dry.	Oil.	Dry.	Oil.	Dry.	Oil.	Dry.
Allen	...	..	2	1	...	..	...	..	2	..	...	..	...	..	...	..	...	..	2	..	1	..	...	..	7	1	....	....
Barren	...	..	...	..	...	1	...	..	...	..	1	..	...	..	...	..	...	..	...	..	2	..	...	2	3	3	....	....
Cumberland	...	..	...	..	...	..	...	..	...	..	...	..	...	1	...	..	...	..	...	..	...	..	...	..	....	1	1	....
Floyd	...	..	...	1	...	..	...	..	...	..	...	..	...	..	...	..	...	..	...	..	...	..	...	..	....	1	4	....
Lawrence	3	..	1	..	...	..	...	1	...	..	...	..	...	..	2	..	...	..	1	..	...	..	2	..	9	1	20	12
Morgan	1	1	1	2	1	..	3	1	...	1	5	..	1	2	3	2	7	2	4	1	1	..	5	1	32	13	....	....
Wayne	2	2	8	1	2	2	6	5	8	2	3	5	8	3	4	1	11	3	3	1	5	3	7	3	67	31	75	44
Wolfe	...	1	2	..	...	..	1	..	2	1	...	2	2	..	1	2	1	1	1	..	1	1	1	2	12	10	9	2
Other	...	..	1	2	1	1	1	2	...	..	...	..	...	..	...	..	...	1	...	..	...	..	...	2	3	8	3	3
Total	6	4	15	7	4	4	11	9	12	4	9	7	11	6	10	5	19	7	11	2	10	4	15	10	133	69	112	61

Number of oil wells drilled in Kentucky, 1909–1913, by months.

Year.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Total.
1909	10	9	9	12	13	11	8	8	3	3	2	4	92
1910	1	6	3	7	11	9	7	3	4	6	8	5	70
1911	6	14	7	6	11	10	9	8	4	10	9	6	100
1912	10	3	14	10	12	8	6	11	18	6	9	5	112
1913	6	15	4	11	12	9	11	10	19	11	10	15	133

Number of dry holes drilled in Kentucky, 1909–1913, by months.

Year.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Total.
1909	9	2	8	5	9	7	5	6	5	10	11	2	[a] 79
1910	3	4	......	4	2	9	10	6	5	5	1	2	[a] 51
1911	4	5	5	2	1	1	6	2	......	3	1	3	[b] 33
1912	3	1	5	1	3	7	2	7	17	4	7	4	[b] 61
1913	4	7	4	9	4	7	6	5	7	2	4	10	[b] 69

[a] Including gas wells. [b] Not including gas wells.

Total number of wells completed in Kentucky, 1909–1913, by months.[a]

Year.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Total.
1909	19	11	17	17	22	18	13	14	8	13	13	6	171
1910	4	10	3	11	13	18	17	9	9	11	9	7	121
1911	7	20	12	8	12	10	14	10	9	13	12	9	136
1912	13	6	19	11	16	15	8	18	37	10	16	9	178
1913	11	23	9	21	17	16	18	17	26	13	14	25	210

[a] Including gas wells.

Initial production of new wells completed in Kentucky in 1913, by counties and months, in barrels.

County.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Total, 1913.	Total, 1912.
Allen		45			22					22	25		114	
Barren						8					6		14	
Lawrence	31	10						11		5		8	65	148
Morgan	2	100	40	330	5	70	15	125	125	32	20	103	967	
Wayne	10	64	15	46	59	60	186	22	62	61	53	85	723	1,481
Wolfe		6		50	7		20	8	5	4	5	2	107	196
Other		100	50	75									225	118
Total	43	325	105	501	93	138	221	166	192	124	109	198	2,215	1,943

Total and average initial daily production of new wells in Kentucky, 1909–1913, by counties, in barrels.

County.	Total initial production.					Average initial production per well.				
	1909	1910	1911	1912	1913	1909	1910	1911	1912	1913
Allen					114					16.28
Barren					14					4.66
Cumberland				3					3.0	
Floyd			45	35				22.5	8.8	
Lawrence		17		148	65		8.5		7.4	7.22
Logan		65	10				9.3	10.0		
Meade	25					25.0				
Morgan					967					30.22
Wayne	2,111	747	1,729	1,481	723	24.5	12.2	18.4	19.7	10.79
Wolfe	50		25	196	107	10.0		25.0	21.8	8.92
Other			13	80	225			6.5	26.7	75.00
Total	2,186	829	1,822	1,943	2,215	23.8	11.8	18.2	17.3	16.65

Total initial daily production of new wells in Kentucky, 1909–1913, by months, in barrels.

Year.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Total.	Monthly average.
1909	214	128	215	100	277	177	155	502	78	10	105	225	2,186	182
1910	15	110	50	73	149	97	69	60	33	54	81	38	829	69
1911	17	93	101	167	176	89	195	227	358	129	125	145	1,822	152
1912	122	35	341	255	216	255	112	213	121	128	75	70	1,943	162
1913	43	325	105	501	93	138	221	166	192	124	109	198	2,215	185

TENNESSEE.

There was no commercial production of petroleum in Tennessee, but considerable interest in the prospects continued to be manifested in the neighborhood of Franklin. The conditions of occurrence of oil and gas in Tennessee are well described by George H. Ashley in "The Resources of Tennessee," vol. 2, No. 7.

OHIO.

DEVELOPMENT.

Interest in oil development in Ohio was almost entirely confined to the eastern and central parts of the State, where drilling was most active in Washington, Perry, Morgan, Licking, Monroe, Hocking, Ashland, and Noble counties. No considerable pools were developed, and in spite of a drilling campaign skillfully planned and carried out with great energy by the larger companies, the production declined from 8,969,007 barrels in 1912 to 8,781,468 barrels in 1913, or 2.09 per cent. Both the Lima district and the southeastern district shared the decline, which amounted to 48,685 barrels in the southeastern and to 138,854 barrels in the Lima district. The average price for the two districts increased from $1.35 in 1912 to $2 in 1913, and the value of the State's total product increased 45.1 per cent, or from $12,085,998 to $17,538,452.

Production of petroleum in Ohio in 1909–1913, by months and districts, in barrels.

Month.	Lima.				
	1909	1910	1911	1912	1913
January	520,146	430,261	395,132	254,382	336,665
February	469,111	389,171	364,706	245,764	275,831
March	566,455	488,017	413,321	316,946	279,117
April	524,356	444,837	380,434	366,846	349,204
May	518,656	443,865	405,705	380,394	333,866
June	515,396	436,721	393,385	354,165	317,476
July	512,017	416,649	367,216	365,227	327,556
August	488,034	436,568	383,440	358,260	319,486
September	470,970	407,103	365,586	322,245	319,443
October	467,788	400,640	376,118	353,881	332,992
November	457,845	397,553	330,800	313,361	296,090
December	404,583	402,751	360,032	[a] 324,426	329,317
Total	5,915,357	5,094,136	4,535,875	[a] 3,955,897	3,817,043

Month.	Southeastern Ohio.				
	1909	1910	1911	1912	1913
January	339,951	395,160	346,170	333,489	407,538
February	333,792	355,016	341,747	356,983	364,307
March	401,083	451,068	372,270	443,795	324,699
April	388,865	435,057	345,162	440,834	456,072
May	390,884	454,628	383,774	453,807	420,757
June	376,480	436,580	371,118	416,396	414,698
July	457,921	401,193	341,329	439,748	424,588
August	414,599	412,014	364,138	460,361	410,459
September	415,325	384,210	352,353	410,131	425,023
October	417,112	382,105	358,100	437,877	456,364
November	406,158	353,519	343,691	397,129	406,018
December	375,266	361,684	361,385	422,560	453,902
Total	4,717,436	4,822,234	4,281,237	5,018,110	4,964,425

Month.	Total.				
	1909	1910	1911	1912	1913
January	860,097	825,421	741,302	587,871	744,203
February	802,903	744 187	706,453	602,747	640,138
March	967,538	939,085	785,591	760,741	603,816
April	913,221	879,894	725,596	807,680	805,276
May	909,540	898,493	789,479	834,201	754,623
June	891,876	873,301	764,503	770,561	732,174
July	969,938	817,842	708,545	804,975	752,144
August	902,633	848,582	747,578	818,621	729,945
September	886,295	791,313	717,939	732,376	744,466
October	884,900	782,745	734,218	791,758	789,356
November	864,003	751,072	674,491	710,490	702,108
December	779,849	764,435	721,417	746,986	783,219
Total	10,632,793	9,916,370	8,817,112	8,969,007	8,781,468

[a] Includes production of Michigan.

The quantity and value of petroleum produced in Ohio from 1904 to 1913, inclusive, by districts, are shown in the following table:

Quantity, value, and average price per barrel of petroleum produced in Ohio, 1904–1913, by districts, in barrels.

Year.	Lima.		Average price per barrel.	Southeastern Ohio.		Average price per barrel.	Total.		Average price per barrel.
	Quantity.	Value.		Quantity.	Value.		Quantity.	Value.	
1904....	13,350,060	$14,735,129	$1.103	5,526,571	$8,995,386	$1.627	18,876,631	$23,730,515	$1.257
1905....	11,329,924	10,061,992	.888	5,016,736	6,992,885	1.393	16,346,660	17,054,877	1.043
1906....	9,881,184	9,157,641	.926	4,906,579	7,839,359	1.597	14,787,763	16,997,000	1.149
1907....	7,993,057	7,425,480	.929	4,214,391	7,344,408	1.742	12,207,448	14,769,888	1.209
1908....	6,748,676	6,861,885	1.016	4,110,121	7,316,617	1.780	10,858,797	14,178,502	1.305
1909....	5,915,357	5,451,497	.921	4,717,436	7,773,880	1.647	10,632,793	13,225,377	1.243
1910....	5,094,136	4,181,629	.821	4,822,234	6,469,939	1.341	9,916,370	10,651,568	1.074
1911....	4,535,875	3,888,119	.857	4,281,237	5,591,423	1.306	8,817,112	9,479,542	1.075
1912....	[a] 3,955,897	3,908,809	.988	5,013,110	8,177,189	1.628	8,969,007	12,085,998	1.347
1913....	3,817,043	5,308,842	1.391	4,964,425	12,229,610	2.463	8,781,468	17,538,452	1.997

[a] Includes production of Michigan.

WELL RECORD.

The increased drilling activity in 1913 was represented in central and southern Ohio by 2,191 wells completed, compared with 1,717 wells in 1912 and 1,680 wells in 1911. The proportion of producing wells to dry holes was satisfactory, but the initial daily production declined in 1913.

In the Lima region drilling was more active in all the larger counties, resulting in a total of 972 wells completed in 1913, against 551 in 1912. The initial production per well showed only a slight decline, and about equaled the average of the last five years.

Number of wells completed in central and southeastern Ohio, 1911–1913, by counties.

County.	Oil.			Dry.			Total completed.[a]		
	1911	1912	1913	1911	1912	1913	1911	1912	1913
Ashland	....	....	1	12	34	21	100	131	118
Athens	....	3	15	....	5	12	....	10	28
Belmont	....	9	21	....	3	29	....	13	58
Carroll	10	5	21	20	5	22	36	11	44
Columbiana	14	4	28	30	13	18	44	17	47
Coshocton	7	9	15	7	1	....	17	10	18
Cuyahoga	1	4	....	....	4	1	2	19	1
Delaware	....	....	....	1	....	....	1	....	....
Erie	....	....	....	....	....	....	1	....	....
Fairfield	57	25	44	35	19	28	115	60	91
Guernsey	....	....	11	....	....	22	....	....	33
Harrison	10	11	19	4	7	10	17	23	29
Hocking	38	74	178	12	12	30	92	129	137
Holmes	....	....	1	3	....	2	4	....	3
Jackson	....	....	....	1	....	....	1	....	....
Jefferson	28	30	60	31	19	22	79	57	83
Knox	....	....	1	11	12	8	44	53	24
Lake	....	....	....	....	....	....	....	1	....
Licking	6	37	38	34	35	26	164	169	144
Lorain	1	1	1	2	13	5	6	19	8
Madison	....	....	....	....	1	....	....	1	....
Medina	1	....	....	4	5	8	14	23	28
Monroe	43	70	100	42	24	31	98	102	137
Morgan	117	118	142	55	78	50	172	196	192
Muskingum	9	18	21	12	11	8	28	30	33
Noble	95	19	62	62	21	37	163	43	101
Perry	[b] 107	188	172	[b] 31	23	40	[b] 140	219	220

[a] Includes gas wells. [b] Includes Athens County.

Number of wells completed in central and southeastern Ohio, 1911–1913, by counties—Continued.

County.	Oil.			Dry.			Total completed.		
	1911	1912	1913	1911	1912	1913	1911	1912	1913
Richland				1	4	8	3	21	31
Ross	1						1		
Summit					2	2		3	2
Tuscarawas					2	1		2	1
Vinton	4	1		2	1		8	5	
Washington	215	206	370	98	94	151	324	303	533
Wayne	1	14	25	2	12	11	6	47	47
Total	765	846	1,246	512	460	603	1,080	1,717	2,191

Number of oil wells and dry holes drilled in central and southeastern Ohio in 1913, by counties and months.

County.	Jan.		Feb.		Mar.		Apr.		May.		June.		July.	
	Oil.	Dry.	Oil.	Dry.	Oil.	Dry.	Oil.	Dry.	Oil.	Dry.	Oil.	Dry.	Oil.	Dry.
Ashland (Ashland, Greene, Miflin, Milton, Montgomery, Perry, and Vermilion districts)		1		2						1		2		1
Athens	1				3			1			2			
Belmont	1	2	2	7	1	4	4	2	1		1	3	2	1
Carroll	2	3	2	3	2							1	1	
Columbiana (Alliance district)	1	2		2	1	3	2		3		8	5		
Coshocton (Bedford and Pike districts)											3		1	
Cuyahoga (Cleveland and Newburg districts)										1				
Fairfield (Berne, Liberty, Richland, and Walnut districts)	2	2	1	1	4	4	4	2	4	3			8	6
Guernsey										2	5	3	2	3
Harrison (Plum Run district)	2		1		2		1	1	2	2	2		2	4
Hocking (Falls, Gore, Greene, Good Hope, Laurel, Perry, Salt Creek, Starr, and Ward districts)	4	3	5	4	8		6		7	1	5		4	6
Holmes (Richland district)		1											1	1
Jefferson (Amsterdam and Steubenville districts)	3	1	1		8	1	7	6	6	2	1	2	5	2
Knox (Brown, Clay, Clinton, College, Jefferson, Morgan, Pleasant, and Pike districts)		3		3										
Licking (Bowling Green, Franklin, Granville, Hanover, Harrison, Hopewell, Liberty, McKean, Madison, Newark, Newton, Perry, St. Albans, Union, and Washington districts)	6	7	4	2		1	4		6	4	4	2	2	1
Lorain (Avon, Pittsfield, and Russia districts)		2		1	1									
Medina (Harrisville, Homer, Medina, Westfield, and York districts)				1		1		1						
Monroe (Graysville, Jackson Ridge, New Castle, Rinard Mills, Trail Run, and Woodsfield districts)	6		8	1	5	3	7	4	15	4	4	2	7	2
Morgan (Chester Hill district)	3	3	7	3	3	3	18	2	14	5	3	4	17	6
Muskingum (Bethlehem, Hopewell, Newton, and Washington districts)	1	1	4	3	3		1		3		1	1	2	1
Noble	1	1	5	1	5	3	8	7	5	2	12	3	1	2
Perry (Harrison, Madison, and Pike districts)	8	1	15	6	13	3	7	3	12	2	15	4	17	
Richland (Madison, Monroe, and Worthington districts)		3		2		1								
Summit (Franklin and Northfield districts)										2				
Tuscarawas (Rush district)										1				
Washington (Macksburg, Marietta, and New Matamoras districts)	24	8	20	9	34	8	24	15	44	11	43	17	26	14
Wayne (Baughman, Chester, Congress, Franklin, Green, Milton, and Wooster districts)	1	1	1		2	1	1		1	3	1		6	
Total	66	45	76	51	95	36	94	44	123	46	110	49	104	50

Number of oil wells and dry holes drilled in central and southeastern Ohio in 1913, by counties and months—Continued.

County.	Aug.		Sept.		Oct.		Nov.		Dec.		Total, 1913.		Total, 1912.	
	Oil.	Dry.	Oil.	Dry.	Oil.	Dry.	Oil.	Dry.	Oil.	Dry.	Oil.	Dry.	Oil.	Dry.
Ashland (Ashland, Greene, Miflin, Milton, Montgomery, Perry, and Vermilion districts)	....	3	....	4	....	....	....	5	1	2	1	21	....	34
Athens	3	1	4	2	....	2	1	2	1	4	15	12	3	5
Belmont	1	....	1	2	2	3	3	3	2	2	21	29	9	3
Carroll	5	3	2	5	1	4	2	2	4	1	21	22	5	5
Columbiana (Alliance district)	6	2	2	1	4	1	1	2	....	....	28	18	4	13
Coshocton (Bedford and Pike districts)	....	....	1	....	8	....	....	....	2	....	15	....	9	1
Cuyahoga (Cleveland and Newburg districts)	....	....	....	....	....	....	....	....	....	....	....	1	4	4
Fairfield (Berne, Liberty, Richland, and Walnut districts)	6	....	4	3	5	1	3	4	3	2	44	28	25	19
Guernsey	4	4	....	2	....	4	....	....	....	4	11	22	11	7
Harrison (Plum Run district)	....	....	2	1	3	1	2	....	....	1	19	10	74	12
Hocking (Falls, Gore, Greene, Good Hope, Laurel, Perry, Salt Creek, Starr, and Ward districts)	10	3	6	2	11	1	9	4	3	6	78	30	....	....
Holmes (Richland district)	....	....	....	....	....	....	....	....	....	....	1	2	....	....
Jefferson (Amsterdam and Steubenville districts)	6	....	7	4	3	2	5	....	8	2	60	22	30	19
Knox (Brown, Clay, Clinton, College, Jefferson, Morgan, Pleasant, and Pike districts)	....	1	....	....	....	1	....	....	1	....	1	8	....	12
Licking (Bowling Green, Franklin, Granville, Hanover, Harrison, Hopewell, Liberty, McKean, Madison, Newark, Newton, Perry, St. Albans, Union, and Washington districts)	4	2	1	1	1	....	4	3	2	3	38	26	37	35
Lorain (Avon, Pittsfield, and Russia districts)	....	1	....	....	....	1	....	....	....	....	1	5	1	13
Madison	....	....	....	....	....	....	....	....	....	....	....	....	....	1
Medina (Harrisville, Homer, Medina, Westfield, and York districts)	....	1	....	2	....	2	....	....	....	....	....	8	....	5
Monroe (Graysville, Jackson Ridge, New Castle, Rinard Mills, Trail Run, and Woodsfield districts)	11	6	7	2	12	3	11	....	7	4	100	31	70	24
Morgan (Chester Hill district)	10	5	23	6	16	3	8	3	20	7	142	50	118	78
Muskingum (Bethlehem, Hopewell, Newton, and Washington districts)	2	2	1	....	1	....	2	....	....	....	21	8	18	11
Noble	1	2	8	2	5	7	3	1	8	6	62	37	19	21
Perry (Harrison, Madison, and Pike districts)	18	5	20	3	15	5	19	6	13	2	172	40	188	23
Richland (Madison, Monroe, and Worthington districts)	....	....	....	1	....	....	....	1	....	....	....	8	....	
Summit (Franklin and Northfield districts)	....	....	....	....	....	....	....	....	....	....	....	2	....	2
Tuscarawas (Rush district)	....	....	....	....	....	....	....	....	....	....	....	1	....	2
Vinton	....	....	....	....	....	....	....	....	....	....	....	....	1	1
Washington (Macksburg, Marietta, and New Matamoras districts)	42	19	29	4	31	16	30	12	23	18	370	151	206	94
Wayne (Baughman, Chester, Congress, Franklin, Green, Milton, and Wooster districts)	2	1	4	2	2	....	2	1	2	2	25	11	14	12
Total	131	61	122	49	120	57	105	49	100	66	1,246	603	846	460

Number of oil wells drilled in central and southeastern Ohio, 1909–1913, by months.

Year.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Total.
1909	88	83	86	112	128	160	159	150	134	126	123	111	1,460
1910	62	71	93	86	89	108	96	76	85	58	71	58	953
1911	61	59	57	61	65	71	57	61	66	67	71	69	765
1912	45	49	48	65	79	89	86	81	71	94	65	74	846
1913	66	76	95	94	123	110	104	131	122	120	105	100	1,246

Number of dry holes drilled in central and southeastern Ohio, 1909–1913, by months.

Year.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Total.
1909	57	54	64	67	53	72	91	90	82	53	78	59	[a] 820
1910	43	33	49	57	53	67	54	44	79	62	59	95	[a] 686
1911	36	32	41	33	38	50	56	53	36	48	45	44	[b] 512
1912	31	17	28	26	33	32	50	49	65	51	41	37	[b] 460
1913	45	51	36	44	46	49	50	61	49	57	49	66	[b] 603

[a] Including gas wells. [b] Not including gas wells.

Total number of wells completed in central and southeastern Ohio, 1909–1913, by months.[a]

Year.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Total.
1909	145	137	150	179	181	232	250	240	216	179	201	170	2,280
1910	105	104	142	143	142	175	150	120	155	120	130	153	1,639
1911	138	121	121	114	129	151	149	133	144	162	172	146	1,680
1912	90	83	97	113	127	158	177	163	196	203	156	154	1,717
1913	140	165	151	148	184	172	174	227	200	224	200	206	2,191

[a] Including gas wells.

Initial daily production of new wells completed in central and southeastern Ohio in 1913, by counties and months, in barrels.

County.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Total, 1913.	Total 1912.
Ashland												20	20	
Athens	1		7			5		8	14		2	2	39	8
Belmont	150	25	2	121	75	5	45	2	60	87	126	12	710	553
Carroll	5	8	13				3	9	10	5	5	4	62	14
Columbiana	2		3	3	11	54		12	5	13	2		105	21
Coshocton						35	2		20	91		4	152	86
Cuyahoga														45
Fairfield	18	25	112	80	100		230	240	55	90	235	42	1,227	494
Guernsey						9	28	8					45	
Harrison	4	5	10	5	8	15	4		10	17	8		86	59
Hocking	125	310	420	275	195	150	215	408	310	655	480	95	3,638	2,986
Holmes							2						2	
Jefferson	12	2	26	23	20	2	14	22	27	9	24	37	218	135
Knox												10	10	
Licking	130	70		60	165	60	55	60	10	7	80	160	857	734
Lorain			15										15	10
Monroe	51	32	75	67	104	52	123	106	42	118	94	48	912	784
Morgan	17	44	11	57	36	9	68	30	44	37	36	65	454	781
Muskingum	20	32	7	2	7	5	7	13	1	1	12		107	393
Noble	1	31	87	50	33	31	2	5	21	11	7	39	318	93
Perry	168	411	272	145	352	623	348	397	663	795	465	146	4,785	15,117
Vinton														5
Washington	117	111	121	85	172	202	146	194	117	164	143	104	1,676	1,290
Wayne	50	10	60	50	50	25	215	95	150	59	65	35	864	585
Total	871	1,116	1,241	1,023	1,328	1,282	1,507	1,609	1,559	2,159	1,784	823	16,302	24,193

Total and average initial daily production of new wells in central and southeastern Ohio, 1911–1913, by counties, in barrels.

County.	Total initial production.			Average initial production per well.		
	1911	1912	1913	1911	1912	1913
Ashland	....	....	20	....	....	20.00
Athens	....	8	39	....	2.66	2.60
Belmont	....	553	710	....	61.44	33.81
Carroll	80	14	62	8.00	2.80	2.95
Columbiana	69	21	105	4.93	5.25	3.75
Coshocton	100	86	152	14.29	9.55	10.13
Cuyahoga	10	45	....	10.00	11.25	....
Fairfield	1,040	494	1,227	18.25	19.76	27.89
Guernsey	....	....	45	....	....	4.09
Harrison	35	59	86	3.50	5.36	4.53
Hocking	1,386	2,986	3,638	36.47	40.35	46.64
Holmes	....	....	2	....	....	2.00
Jefferson	91	135	218	3.25	4.50	3.63
Knox	....	....	10	....	....	10.00
Licking	143	734	857	2.38	19.84	22.55
Lorain	10	10	15	10.00	10.00	15.00
Medina	35	....	....	35.00	....	....
Monroe	393	784	912	9.14	11.20	9.12
Morgan	1,488	781	454	12.72	6.62	3.20
Muskingum	228	393	107	25.33	21.83	5.09
Noble	325	93	318	3.42	4.89	5.13
Perry	[a] 3,681	15,117	4,785	34.40	83.98	27.82
Ross	5	....	....	5.00	....	....
Summit	....	....	....	....	....	....
Vinton	77	5	....	19.25	5.00	....
Washington	1,702	1,290	1,676	7.91	6.26	4.53
Wayne	25	585	864	25.00	41.78	34.56
Total	10,923	24,193	16,302	14.28	28.60	13.08

[a] Includes Athens County.

Total initial daily production of new wells in central and southeastern Ohio, 1909–1913, by months, in barrels.

Year.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Total.	Monthly average.
1909	2,054	2,490	1,739	1,794	2,490	3,652	2,629	2,131	1,737	2,206	1,971	1,259	26,152	2,179
1910	1,319	1,440	2,388	2,747	2,314	2,065	1,296	872	1,055	1,195	783	642	18,116	1,510
1911	882	973	666	687	1,222	709	577	772	895	916	1,526	1,098	10,923	910
1912	1,737	3,577	1,992	1,944	2,309	2,067	2,077	2,518	1,039	2,199	1,006	1,728	24,193	2,016
1913	871	1,116	1,241	1,023	1,328	1,282	1,507	1,609	1,559	2,159	1,784	823	16,302	1,359

In the following tables are given the well records for the Lima (Ohio) oil field from 1909 to 1913, inclusive:

Number of wells completed in the Lima (Ohio) district, 1909–1913, by counties.

County.	Oil.					Dry.					Total completed.[a]				
	1909	1910	1911	1912	1913	1909	1910	1911	1912	1913	1909	1910	1911	1912	1913
Allen	75	12	21	54	138	4	1	.....	2	5	79	13	21	56	143
Auglaize	11	17	12	7	19	4	5	4	4	7	15	22	18	11	27
Hancock	106	114	104	101	172	5	8	2	7	20	111	125	113	116	193
Hardin	.....	2	2	.....	.....	.....	.....	.....	.....	.....	.....	5	2	.....	.....
Henry	1	.....	.....	.....	.....	.....	.....	.....	.....	.....	1	.....	.....	.....	.....
Lucas	21	7	21	18	29	.....	.....	1	2	8	21	7	22	21	37
Mercer	5	4	9	11	40	1	1	2	1	5	6	5	12	12	45
Ottawa	53	23	14	7	24	4	1	3	2	3	57	25	18	9	29
Putnam	.....	1	2	.....	2	.....	.....	.....	.....	.....	.....	1	2	.....	2
Sandusky	107	64	56	53	104	9	5	2	8	5	116	71	58	62	109
Seneca	71	47	35	29	35	12	7	8	9	7	83	54	44	40	43
Van Wert	75	18	23	19	38	8	2	1	1	4	83	20	24	21	42
Wood	253	189	179	177	271	29	26	9	18	23	282	217	191	196	298
Wyandot	9	3	2	4	1	.....	1	.....	.....	2	9	5	2	4	3
Miscellaneous	.....	.....	.....	2	.....	9	.....	.....	1	1	9	2	.....	3	1
Total	787	501	480	482	873	[a] 85	[b] 57	[b] 32	[b] 55	[b] 90	872	572	527	551	972

[a] Including gas wells. [b] Not including gas wells.

Number of oil wells and dry holes drilled in the Lima (Ohio) district in 1913, by counties and months.

County.	Jan.		Feb.		Mar.		Apr.		May.		June.		July.		Aug.		Sept.		Oct.		Nov.		Dec.		Total, 1913.		Total. 1912.	
	Oil.	Dry.	Oil.	Dry.	Oil.	Dry.	Oil.	Dry.	Oil.	Dry.	Oil.	Dry.	Oil.	Dry.	Oil.	Dry.	Oil.	Dry.	Oil.	Dry.	Oil.	Dry.	Oil.	Dry.	Oil.	Dry.	Oil.	Dry.
Allen	13	..	3	..	10	1	5	..	8	..	12	1	17	..	16	2	14	..	14	1	14	..	12	..	138	5	54	2
Auglaize	1	..	...	..	1	2	2	1	1	..	3	1	3	.	1	2	2	1	1	..	2	..	2	.	19	7	7	4
Hancock	10	..	8	1	7	3	9	3	14	..	15	1	17	1	24	1	14	5	18	3	18	..	18	2	172	20	101	7
Lucas	...	.	2	1	2	..	1	2	1	1	4	1	3	.	3	2	4	1	2	..	3	..	4	..	29	8	18	2
Mercer	2	1	2	..	1	1	1	2	2	1	5	..	6	..	5	.	5	..	4	..	3	..	4	..	40	5	11	1
Ottawa	...	..	1	..	1	..	...	..	4	..	3	..	2	1	5	1	2	..	1	..	3	1	2	..	24	3	7	2
Putnam	1	..	...	..	...	..	...	..	...	..	...	..	...	..	1	..	...	..	...	..	...	..	...	..	2	...	...	...
Sandusky	3	..	6	..	9	1	6	..	7	1	12	..	12	.	8	1	10	1	8	..	12	1	11	..	104	5	53	8
Seneca	4	..	2	..	3	..	3	2	2	1	2	..	4	1	4	3	2	..	3	..	4	..	2	..	35	7	29	9
Van Wert	2	..	1	.	4	..	1	..	7	.	...		4	2	3	.	4	1	6	1	4	.	2	.	38	4	19	1
Wood	12	2	14	1	19	..	13	..	24	3	17	2	29	1	32	4	26	4	31	3	23	2	31	1	271	23	177	18
Wyandot	...	1	...	..	...	..	...	..	...	..	...	..	1	..	...	..	...	..	...	..	...	..	...	1	1	2	4	...
Miscellaneous	...	..	...	..	...	..	...	..	...	1	...	..	...	..	...	..	...	..	...	..	...	..	...	.	...	1	2	1
Total	48	4	39	3	57	8	41	10	70	8	73	6	98	6	102	16	83	13	88	8	86	4	88	4	873	90	482	55

Number of oil wells drilled in Lima (Ohio) district, 1909–1913, by months.

Year.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Total.
1909	89	55	67	80	64	85	68	71	66	58	49	35	787
1910	24	24	26	40	46	50	52	51	48	38	63	39	501
1911	40	42	38	38	39	41	39	42	48	41	42	30	480
1912	15	17	22	31	43	44	43	46	54	43	62	62	482
1913	48	39	57	41	70	73	98	102	83	88	86	88	873

Number of dry holes drilled in the Lima (Ohio) district, 1909–1913, by months.

Year.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Total.
1909	9	4	11	6	6	7	4	7	5	6	14	6	[a] 85
1910	5	2	4	4	6	6	7	5	5	4	5	4	[b] 57
1911	3	4	1	......	4	5	4	3	......	2	4	2	[b] 32
1912	1	1	4	3	5	5	5	7	10	5	7	2	[b] 55
1913	4	3	8	10	8	6	6	16	13	8	4	4	[b] 90

[a] Including gas wells. [b] Not including gas wells.

Total number of wells completed in the Lima (Ohio) district, 1909–1913, by months. [a]

Year.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Total.
1909	98	59	78	86	70	92	72	78	71	64	63	41	872
1910	29	27	31	46	55	57	59	56	54	44	69	45	572
1911	45	48	40	40	44	48	42	46	50	44	47	33	527
1912	18	20	28	34	50	49	48	53	66	48	71	66	551
1913	53	43	65	52	78	80	107	119	96	96	90	93	972

[a] Including gas wells.

Initial daily production of new wells completed in the Lima (Ohio) district in 1913, by counties and months, in barrels.

County.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Total, 1913.	Total, 1912.
Allen	177	35	109	65	110	217	234	229	185	112	215	195	1,883	699
Auglaize	10	.....	10	20	3	22	12	5	6	15	24	15	142	47
Hancock	188	125	82	103	221	403	258	446	222	300	376	200	2,924	1,379
Lucas	.....	12	30	1	10	85	30	17	53	45	50	40	373	172
Mercer	10	45	10	20	70	40	75	90	63	40	35	75	573	111
Ottawa	.....	5	10	.....	22	25	25	21	10	5	18	7	148	36
Putnam	2	.....	.....	.....	.....	.....	.....	5	.....	.....	.....	.....	7	.....
Sandusky	20	28	48	46	52	56	59	30	77	46	86	77	625	266
Seneca	200	10	116	130	15	25	85	39	10	22	46	15	713	1,041
Van Wert	15	10	16	5	102	.....	30	55	33	40	58	15	379	272
Wood	87	169	168	242	266	333	425	477	239	298	314	386	3,404	3,153
Wyandot	.....	.....	.....	.....	.....	.....	10	.....	.....	.....	.....	.....	10	37
Miscellaneous	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	16
Total	709	439	599	632	871	1,206	1,243	1,414	898	923	1,222	1,025	11,181	7,229

Total and average initial daily production of new wells in the Lima (Ohio) district, 1909–1913, by counties, in barrels.

County.	Total initial production.					Average initial production per well.				
	1909	1910	1911	1912	1913	1909	1910	1911	1912	1913
Allen	708	110	171	699	1,883	9.4	9.2	8.1	12.9	13.6
Auglaize	138	306	174	47	142	12.5	18.0	14.5	6.7	7.5
Hancock	1,253	1,505	1,546	1,379	2,924	11.8	13.2	14.9	13.7	17.0
Hardin	....	13	25	....	....	....	6.5	12.5	....	....
Henry	5	....	....	....	....	5.0	....	....	....	....
Lucas	203	116	412	172	373	9.7	16.6	19.6	9.5	12.9
Mercer	35	65	60	111	573	7.0	16.3	6.7	10.1	14.4
Ottawa	450	183	108	36	148	8.5	8.0	7.7	5.1	6.2
Putnam	....	3	12	....	7	....	3.0	6.0	....	3.5
Sandusky	561	422	312	266	625	5.2	6.6	5.6	5.0	6.0
Seneca	582	737	341	1,041	713	8.2	15.7	9.7	35.9	20.4
Van Wert	639	192	369	272	379	8.5	10.7	16.0	14.3	10.0
Wood	3,423	3,003	2,836	3,153	3,404	13.5	15.9	15.8	17.8	12.6
Wyandot	121	90	15	37	10	13.4	30.0	7.5	9.3	10.0
Miscellaneous	....	....	....	16	....	....	....	....	8.0	....
Total	8,118	6,745	6,381	7,229	11,181	10.3	13.5	13.3	15.0	12.8

Total initial daily production of new wells in the Lima (Ohio) district, 1909–1913, by months, in barrels.

Year.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Total.	Monthly average.
1909	1,067	767	567	678	480	900	606	853	626	718	513	343	8,118	677
1910	377	425	500	530	565	447	684	735	794	441	723	524	6,745	562
1911	508	599	323	483	460	559	498	630	470	793	465	593	6,381	532
1912	192	221	983	440	619	767	643	781	743	463	839	538	7,229	602
1913	709	439	599	632	871	1,206	1,243	1,414	898	923	1,222	1,025	11,181	932

LIMA-INDIANA FIELD.

PRODUCTION.

Production has been declining in the Lima-Indiana field continuously since 1904. The rate of decline has varied within considerable limits, but in general it has been rapid. The decline in 1912 as compared with 1911 was 20.95 per cent. The general trend of higher prices for crude petroleum in the United States included the Lima-Indiana field, however, and raised the average price from $0.932 in 1912 to $1.38 in 1913. Naturally, this stimulated drilling to such an extent that the decline was almost halted, and amounted to only 3.1 per cent.

Production of petroleum in the Lima-Indiana field in 1912 and 1913, by months, in barrels.

Month.	1912			1913		
	Lima, Ohio.	Indiana.	Total.	Lima, Ohio.	Indiana.	Total.
January	254,382	64,403	318,785	336,665	73,237	409,902
February	245,764	62,991	308,755	275,831	70,336	346,167
March	316,946	81,148	398,094	279,117	57,204	336,321
April	366,846	92,965	459,811	349,204	78,764	427,768
May	380,394	101,102	481,496	333,866	77,379	411,245
June	354,165	85,819	439,984	317,476	73,056	390,532
July	365,227	90,011	455,238	327,556	73,838	401,394
August	358,260	86,492	444,752	319,486	72,467	391,953
September	322,245	78,432	400,677	319,443	81,462	400,905
October	353,881	83,634	437,515	332,992	91,368	424,560
November	313,361	69,733	383,094	296,090	98,444	394,534
December	[a] 324,426	73,279	397,705	329,317	108,540	437,857
Total	[a] 3,955,997	970,009	4,925,906	3,817,043	956,095	4,773,138

[a] Includes production of Michigan.

The history of the field is given in concise form in the following table, which shows that the field opened commercially in 1886 with a production of a little over 1,000,000 barrels, or 4 per cent of the total production of the United States. At one time (1896), by producing 25,000,000 barrels, the field contributed 41.43 per cent to the total production of the United States, but it has now fallen to 4,773,138 barrels, which is only 1.93 per cent of the total production.

The production of petroleum in the Lima-Indiana oil field from 1886 to 1913, inclusive, is given in the following table:

Production of petroleum in the Lima-Indiana field, 1886–1913, in barrels.

Year.	Production.	Percentage of total production.	Increase (+) or decrease (−) from preceding year.	Percentage of increase (+) or decrease (−)	Value.	Yearly average price per barrel.
1886	1,137,869	4.06			$444,198	$0.39
1887	4,650,375	16.44	+3,512,506	+308.69	953,327	.205
1888	9,682,683	35.07	+5,032,308	+108.21	1,452,402	.150
1889	12,186,564	34.66	+2,503,881	+ 25.86	1,833,859	.150
1890	15,078,378	32.91	+2,891,814	+ 23.73	4,536,927	.301
1891	17,452,612	32.15	+2,374,234	+ 15.75	5,333,797	.306
1892	15,867,575	31.41	−1,585,037	− 9.08	5,814,629	.366
1893	15,982,097	33.00	+ 114,522	+ .75	7,497,597	.469
1894	17,296,510	35.05	+1,314,413	+ 8.22	8,306,025	.480
1895	20,236,741	38.26	+2,940,231	+ 17.00	14,184,256	.700
1896	25,255,870	41.43	+5,019,129	+ 24.80	16,678,028	.660
1897	22,805,033	37.71	−2,450,837	− 9.70	10,848,097	.476
1898	20,321,323	36.71	−2,483,710	− 10.89	12,458,904	.613
1899	20,225,356	35.44	− 95,967	− .47	18,082,723	.894
1900	21,758,750	34.20	+1,533,394	+ 7.58	21,367,287	.982
1901	21,933,379	31.61	+ 174,629	+ .80	18,734,438	.854
1902	23,358,626	26.31	+1,425,247	+ 6.50	20,810,694	.890
1903	24,080,264	23.97	+ 721,638	+ 3.09	27,825,466	1.155
1904	24,689,184	21.09	+ 608,920	+ 2.53	26,970,803	1.092
1905	22,294,171	16.55	−2,395,013	− 9.70	19,466,901	.873
1906	17,554,661	13.88	−4,739,510	− 21.26	15,927,707	.907
1907	13,121,094	7.90	−4,433,567	− 25.26	11,962,410	.912
1908	10,032,305	5.62	−3,088,789	− 23.54	10,065,768	1.003
1909	8,211,443	4.48	−1,820,862	− 18.15	7,449,107	.907
1910	7,253,861	3.46	− 957,582	− 11.66	5,750,104	.793
1911	6,231,164	2.83	−1,022,697	− 14.10	5,116,954	.821
1912	[a] 4,925,906	2.21	−1,305,258	− 20.95	4,794,784	.932
1913	4,773,138	1.93	− 152,768	− 3.10	6,588,068	1.380
Total	428,396,932	13.96			311,255,260	.727

[a] Includes production of Michigan.

Production of petroleum in the Lima-Indiana field in 1912 and 1913, by States, showing decrease and percentage of decrease, in barrels.

District.	Production.			Percentage decrease.
	1912	1913	Decrease.	
North Lima	[a] 3,237,926	3,144,968	92,958	2.87
South Lima	717,971	672,075	45,896	6.39
Indiana	970,009	956,095	13,914	1.43
Total	4,925,906	4,773,138	152,768	3.10

[a] Includes production of Michigan.

Production, value, and average price per barrel of petroleum in the Lima-Indiana field, 1905–1913, in barrels.

Year.	North Lima, Ohio.		Average price per barrel.	South Lima, Ohio.		Average price per barrel.
	Quantity.	Value.		Quantity.	Value.	
1905	6,931,635	$6,290,459	$0.907	4,398,289	$3,771,533	$0.857
1906	6,859,669	6,479,607	.944	3,021,515	2,678,034	.886
1907	6,399,917	6,016,238	.940	1,593,140	1,409,242	.885
1908	5,430,124	5,574,400	1.027	1,318,552	1,287,485	.977
1909	4,761,065	4,434,277	.931	1,154,292	1,017,220	.881
1910	4,131,060	3,431,618	.831	963,076	750,011	.779
1911	3,676,397	3,221,308	.876	859,478	666,811	.776
1912	[a] 3,237,926	3,237,849	1.000	717,971	670,960	.934
1913	3,144,968	4,403,858	1.400	672,075	904,984	1.346

Year.	Indiana.		Average price per barrel.	Total.		Average price per barrel.
	Quantity.	Value.		Quantity.	Value.	
1905	10,964,247	$9,404,909	$0.858	22,294,171	$19,466,901	$0.873
1906	7,673,477	6,770,066	.882	17,554,661	15,927,707	.907
1907	5,128,037	4,536,930	.885	13,121,094	11,962,410	.912
1908	3,283,629	3,203,883	.976	10,032,305	10,065,768	1.003
1909	2,296,086	1,997,610	.870	8,211,443	7,449,107	.907
1910	2,159,725	1,568,475	.726	7,253,861	5,750,104	.793
1911	1,695,289	1,228,835	.725	6,231,164	5,116,954	.821
1912	970,009	885,975	.913	4,925,906	4,794,784	.932
1913	956,095	1,279,226	1.337	4,773,138	6,588,068	1.380

[a] Includes production of Michigan.

Production of petroleum in the Lima-Indiana field, 1909–1913, by months and years, in barrels.

Month.	1909	1910	1911	1912	1913
January	722,201	573,742	541,714	318,785	409,902
February	652,025	525,559	499,770	308,755	346,167
March	787,910	651,605	768,873	398,094	336,321
April	735,621	606,702	514,381	459,811	427,768
May	731,231	622,447	545,007	481,496	411,245
June	727,377	729,242	525,481	439,984	390,532
July	717,199	635,859	487,953	455,238	401,394
August	686,340	637,249	505,856	444,752	391,953
September	655,177	586,639	479,695	400,677	400,905
October	640,293	569,978	483,435	437,515	424,560
November	628,716	557,431	419,807	383,094	394,534
December	527,353	557,408	459,192	397,705	437,857
Total	8,211,443	7,253,861	6,231,164	4,925,906	4,773,138

Average daily production of petroleum in the Lima-Indiana field each month, 1909–1913, by months and years, in barrels.

Month.	1909	1910	1911	1912	1913
January	23,297	18,508	17,475	10,283	13,223
February	23,287	18,770	17,849	10,647	12,363
March	25,416	21,020	24,802	12,842	10,849
April	24,521	20,223	17,146	15,327	14,259
May	23,588	20,079	17,581	15,532	13,266
June	24,246	24,308	17,516	14,666	13,017
July	23,135	20,512	15,740	14,685	12,948
August	22,140	20,556	16,318	14,347	12,644
September	21,839	19,555	15,990	13,356	13,364
October	20,655	18,386	15,595	14,113	13,695
November	20,891	18,581	13,994	12,770	13,151
December	17,011	17,981	14,813	12,829	14,124
Average	22,497	19,874	17,072	13,459	13,077

PIPE-LINE RUNS IN LIMA-INDIANA OIL FIELD.

Pipe-line runs in the Lima-Indiana oil field in 1912 and 1913, by months, in barrels.

1912.

Month.	Buckeye pipe line.	Other Ohio.	Indiana pipe line.	Other Indiana.	Total.
January	188,717	65,665	45,355	19,048	318,785
February	182,946	62,818	41,879	21,112	308,755
March	229,845	87,101	59,056	22,092	398,094
April	262,325	104,521	71,417	21,548	459,811
May	276,078	104,316	78,666	22,436	481,496
June	252,928	101,237	66,980	18,839	439,984
July	263,981	101,246	71,335	18,676	455,238
August	257,578	100,682	67,069	19,423	444,752
September	231,015	91,230	62,649	15,783	400,677
October	254,144	99,737	66,222	17,412	437,515
November	220,209	93,152	54,426	15,307	383,094
December	225,146	[a] 99,980	54,868	18,411	397,705
Total	2,844,912	[a] 1,110,985	739,922	230,087	4,925,906

1913.

Month.	Buckeye pipe line.	Other Ohio.	Indiana pipe line.	Other Indiana.	Total.
January	234,428	102,237	56,477	16,760	409,902
February	191,841	83,990	55,024	15,312	346,167
March	191,646	87,471	39,137	18,067	336,321
April	244,764	104,440	59,179	19,385	427,768
May	233,760	100,106	59,636	17,743	411,245
June	220,054	97,422	54,643	18,413	390,532
July	229,084	98,472	55,947	17,891	401,394
August	223,957	95,529	51,136	21,331	391,953
September	225,303	94,140	49,574	31,888	400,905
October	239,187	93,805	49,423	42,145	424,560
November	207,835	88,255	44,873	53,571	394,534
December	232,531	96,786	50,055	58,485	437,857
Total	2,674,390	1,142,653	625,104	330,991	4,773,138

[a] Includes production of Michigan.

Pipe-line runs and deliveries of Lima-Indiana oil, by months, in barrels, in 1912 and 1913, and stocks at end of each month.

Month.	1912			1913		
	Runs.	Deliveries.	Stocks.	Runs.	Deliveries.	Stocks.
Dec. 31, 1911	....	....	3,194,985	....	....	....
January	318,785	503,806	3,009,964	409,902	374,280	2,455,163
February	308,755	292,617	3,026,102	346,167	442,569	2,358,761
March	398,094	377,539	3,046,657	336,321	439,064	2,256,018
April	459,811	435,192	3,071,276	427,768	330,353	2,353,433
May	481,496	997,635	2,555,137	411,245	694,753	2,169,925
June	439,984	407,254	2,587,867	390,532	480,573	2,079,884
July	455,238	809,024	2,234,081	401,394	325,058	2,156,220
August	444,752	281,357	2,397,476	391,953	481,723	2,067,450
September	400,677	261,603	2,536,550	400,905	317,730	2,150,625
October	437,515	737,646	2,236,419	424,560	673,064	1,902,121
November	383,094	372,827	2,246,686	394,534	428,586	1,768,069
December	[a] 397,705	224,850	2,419,541	437,857	458,571	1,746,355
Total	[a] 4,925,906	5,701,350	....	4,773,138	5,446,324	....

[a] Includes production of Michigan.

PRICES OF PETROLEUM IN LIMA-INDIANA FIELD.

In the following table are given the fluctuations in prices for the various grades of Lima and Indiana oil in 1911–1913. The dates are those on which changes in prices were made.

Fluctuations in prices of Lima (Ohio) and Indiana petroleum in 1911–1913, per barrel.

Date.	1911 North Lima.	1911 South Lima and Indiana.	1911 Princeton, Ind.
Jan. 1	$0.82	$0.77	$0.60
May 2	.82	.77	.63
June 14	.82	.77	.65
Sept. 15	.84	.79	.67

Date.	1912 North Lima.	1912 South Lima and Indiana.	1912 Princeton, Ind.
Jan. 1	$0.84	$0.79	$0.67
Jan. 2	.87	.82	.70
Jan. 6	.89	.84	.72
Jan. 24	.92	.87	....
Feb. 1	.95	.90	.75
Mar. 4	.98	.93	.81
Apr. 24	1.00	.95	.83
May 20	1.02	.97	....
May 24	....	....	.85
July 25	1.04	.99	.87
Oct. 28	1.07	1.02	....
Nov. 9	1.09	1.04	.89
Nov. 15	1.11	1.06	.91
Nov. 25	1.13	1.08	.93
Dec. 2	1.16	1.11	.96
Dec. 9	1.19	1.14	.99
Dec. 16	1.22	1.17	1.02
Dec. 23	1.25	1.20	1.05

Date.	1913 North Lima.	1913 South Lima and Indiana.	1913 Princeton, Ind.
Jan. 1	$1.25	$1.20	$1.05
Jan. 3	....	....	1.08
Jan. 6	1.28	1.23	....
Jan. 27	1.31	1.26	1.11
Feb. 1	1.34	1.29	1.14
Feb. 5	....	....	1.17
Feb. 6	1.37	1.32	1.20
Feb. 20	....	....	1.25
Apr. 16	1.39	1.34	1.30
Nov. 5	1.44	1.39	1.35
Nov. 22	1.49	1.44	....
Dec. 9	....	....	1.45

In the following table are given the average monthly prices of Lima (Ohio) and Indiana petroleum, per barrel of 42 gallons each, in 1911–1913:

Average monthly prices of Ohio and Indiana petroleum in 1911, 1912, and 1913, per barrel.

Month.	1911			1912			1913		
	North Lima.	South Lima and Indiana.	Princeton, Ind.	North Lima.	South Lima and Indiana.	Princeton, Ind.	North Lima.	South Lima and Indiana.	Princeton, Ind.
January	$0.82	$0.77	$0.60	$0.89	$0.84	$0.72	$1.28	$1.23	$1.08
February	.82	.77	.60	.95	.90	.75	1.36	1.31	1.21
March	.82	.77	.60	.98	.93	.80	1.37	1.32	1.25
April	.82	.77	.60	.98	.93	.81	1.38	1.33	1.28
May	.82	.77	.63	1.01	.96	.83	1.39	1.34	1.30
June	.82	.77	.64	1.02	.97	.85	1.39	1.34	1.30
July	.82	.77	.65	1.02	.97	.85	1.39	1.34	1.30
August	.82	.77	.65	1.04	.99	.87	1.39	1.34	1.30
September	.83	.78	.66	1.04	.99	.87	1.39	1.34	1.30
October	.84	.79	.67	1.04	.99	.87	1.39	1.34	1.30
November	.84	.79	.67	1.10	1.05	.90	1.45	1.41	1.34
December	.84	.79	.67	1.21	1.16	1.01	1.49	1.44	1.42
Average	.826	.776	.637	1.023	.973	.844	1.390	1.340	1.282
Average of North Lima, South Lima, and Indiana	.801			.998			1.375		

In the following table will be found the highest, lowest, and average prices of Lima (Ohio) oil for the last 10 years:

Highest, lowest, and average prices of Lima (Ohio) petroleum, 1904–1913, per barrel.

Year.	Highest.	Lowest.	Average.	Year.	Highest.	Lowest.	Average.
1904	[a] $1.36	[b] $0.95	$1.104	1909	[a] $1.04	[b] $0.79	$0.906
1905	[a] 1.01	[b] .81	.888	1910	[a] .84	[b] .77	.804
1906	[a] .98	[b] .85	.911	1911	[a] .84	[b] .77	.801
1907	[a] .94	[b] .85	.909	1912	[a] 1.25	[b] .79	.998
1908	[a] 1.04	[b] .89	1.001	1913	[a] 1.49	[b] 1.20	1.375

[a] North Lima. [b] South Lima.

WELL RECORD.

The rise in prices so stimulated the drilling in this field that 1,283 wells were completed as compared with just half that number (640) in 1912. The proportion of producing oil wells obtained by this drilling likewise was practically double that of 1912. The average initial production per well also increased from 15.2 to 17.1 barrels per well per day.

Number of wells completed in the Lima-Indiana field, 1909–1913, by districts.

District.	Oil.					Dry.					Total completed.[a]				
	1909	1910	1911	1912	1913	1909	1910	1911	1912	1913	1909	1910	1911	1912	1913
Lima, Ohio	787	501	480	482	873	[a] 85	57	32	55	90	872	572	527	551	972
Indiana	219	284	74	65	213	[a] 86	66	35	20	86	305	366	117	89	311
Total	1,006	785	554	547	1,086	[a] 171	123	67	75	176	1,177	938	644	640	1,283

[a] Including gas wells.

Number of oil wells and dry holes drilled in the Lima-Indiana field in 1913, by districts and months.

District.	Jan.		Feb.		Mar.		Apr.		May.		June.		July.		Aug.		Sept.		Oct.		Nov.		Dec.		Total, 1913.		Total, 1912.	
	Oil.	Dry.	Oil.	Dry.	Oil.	Dry.	Oil.	Dry.	Oil.	Dry.	Oil.	Dry.	Oil.	Dry.	Oil.	Dry.	Oil.	Dry.	Oil.	Dry.	Oil.	Dry.	Oil.	Dry.	Oil.	Dry.	Oil.	Dry.
Lima, Ohio..	48	4	39	3	57	8	41	10	70	8	73	6	98	6	102	16	83	13	88	8	86	4	88	4	873	90	482	55
Indiana......	3	2	9	..	13	3	4	..	17	2	16	5	14	7	28	6	18	15	27	15	34	11	30	20	213	86	65	20
Total..	51	6	48	3	70	11	45	10	87	10	89	11	112	13	130	22	101	28	115	23	120	15	118	24	1,086	176	547	75

Number of oil wells drilled in the Lima-Indiana field, 1909–1913, by months.

Year.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Total.
1909..............	110	64	83	100	83	112	87	92	79	74	60	62	1,006
1910..............	33	51	52	61	66	84	86	83	76	59	82	52	785
1911..............	50	48	47	43	45	48	45	49	53	45	45	36	554
1912..............	17	20	24	34	47	48	50	54	62	52	70	69	547
1913..............	51	48	70	45	87	89	112	130	101	115	120	118	1,086

Number of dry holes drilled in the Lima-Indiana field, 1909–1913, by months.

Year.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Total.
1909..............	18	11	13	10	13	16	12	13	11	19	19	16	[a] 171
1910..............	8	6	7	9	10	8	11	11	12	9	21	11	[b] 123
1911..............	7	7	2	3	6	7	9	7	2	4	11	2	[b] 67
1912..............	3	2	5	8	5	5	8	9	13	7	7	3	[b] 75
1913..............	6	3	11	10	10	11	13	22	28	23	15	24	[b] 176

[a] Including gas wells. [b] Not including gas wells.

Total number of wells completed in the Lima-Indiana field, 1909–1913, by months. [a]

Year.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Total.
1909..............	128	75	96	110	96	128	99	105	90	93	79	78	1,177
1910..............	47	60	60	73	80	95	97	97	89	70	105	65	938
1911..............	59	58	50	48	52	58	53	57	58	50	62	39	644
1912..............	23	25	31	42	54	54	58	63	77	60	79	74	640
1913..............	58	52	82	57	97	102	129	156	129	140	137	144	1,283

[a] Including gas wells.

Initial daily production of new wells completed in the Lima-Indiana field in 1913, by districts and months, in barrels.

District.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Total, 1913	Total, 1912
Lima, Ohio.	709	439	599	632	871	1,206	1,243	1,414	898	923	1,222	1,025	11,181	7,229
Indiana.....	65	271	327	223	555	467	384	437	756	1,466	1,430	1,012	7,393	1,083
Total..	774	710	926	855	1,426	1,673	1,627	1,851	1,654	2,389	2,652	2,037	18,574	8,312

Total and average initial daily production of new wells in the Lima-Indiana field, 1909–1913, by districts, in barrels.

District.	Total initial production.					Average initial production per well.				
	1909	1910	1911	1912	1913	1909	1910	1911	1912	1913
Lima, Ohio..................	8,118	6,745	6,381	7,229	11,181	10.3	13.5	13.3	15.0	12.8
Indiana.....................	3,863	8,664	1,096	1,083	7,393	17.6	30.5	14.8	16.7	34.7
Total.....................	11,981	15,409	7,477	8,312	18,574	11.9	19.6	13.5	15.2	17.1

Total initial daily production of new wells in the Lima-Indiana field, 1909–1913, by months, in barrels.

Year.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Total.	Monthly average.
1909	1,375	826	767	919	761	1,198	1,073	1,140	1,007	1,163	627	1,125	11,981	998
1910	865	1,310	1,320	1,244	1,311	2,192	1,360	1,894	1,194	921	1,013	785	15,409	1,284
1911	650	652	452	556	526	636	605	785	545	878	517	675	7,477	623
1912	267	281	1,013	490	704	824	690	863	891	635	1,026	628	8,312	693
1913	774	710	926	855	1,426	1,673	1,627	1,851	1,654	2,389	2,652	2,037	18,574	1,548

In the following tables are given the number of oil wells abandoned in the Lima-Indiana oil field from June, 1906, to December 31, 1913, inclusive:

Number of oil wells abandoned in Indiana and in the Lima (Ohio) oil field from June, 1906, to December, 1913, by months.

Month.	1906	1907	1908	1909	1910	1911	1912	1913	Total.
January	54	45	75	149	61	62	59	17	522
February	74	83	59	108	66	21	34	21	466
March	27	49	129	237	221	114	28	13	818
April	47	129	198	98	140	31	86	47	776
May	100	194	358	204	157	233	83	37	1,366
June	82	143	207	347	146	118	122	101	1,294
July	50	111	191	157	176	141	75	17	971
August	147	170	228	322	126	122	102	71	1,342
September	87	157	195	267	294	79	117	127	1,342
October	139	181	144	201	80	137	66	142	1,248
November	139	177	155	172	100	160	158	38	1,152
December	117	62	220	156	128	41	80	40	910
Total, Indiana	1,063	1,501	2,159	2,418	1,695	1,259	1,010	671	12,207
Total, Lima, Ohio	1,059	1,357	1,135	1,127	1,500	1,142	856	601	9,451
Total, Lima-Indiana	2,122	2,858	3,294	3,545	3,195	2,401	1,866	1,272	21,658

Number of oil wells abandoned in the Lima-Indiana oil field, June, 1905, to December 31, 1913, by counties.

Lima, Ohio.		Indiana.	
County.	Number of wells.	County.	Number of wells.
Allen	2,012	Adams	699
Auglaize	820	Blackford	1,290
Darke	4	Delaware	1,259
Hancock	1,243	Gibson	1
Lucas	377	Grant	3,785
Mercer	319	Hamilton	9
Ottawa	124	Huntington	771
Putnam	20	Jay	510
Sandusky	742	Knox	12
Seneca	117	Madison	87
Shelby	8	Marion	15
Van Wert	570	Miami	49
Wood	2,876	Randolph	206
Wyandot	219	Wabash	16
Total	9,451	Wells	3,498
		Total	12,207

INDIANA.

DEVELOPMENT.

The Indiana portion of the Lima-Indiana field fared somewhat better than the Ohio portion, inasmuch as the decline was only 1.43 per cent, while the value of the product increased 44.39 per cent, as shown in the following tables.

This checking of the usual rate of decline was effected chiefly by the development of the Sullivan County pool on the western border of the State. The finding of this new pool stimulated drilling so that 311 wells were drilled in the State, of which 132 were in Sullivan County. The average initial production for the new wells drilled in the State was 34.8 barrels, as compared with 16.7 in 1912.

PRODUCTION.

Production of petroleum in Indiana, 1909–1913, by months, in barrels.

Month.	1909	1910	1911	1912	1913
January	202,055	143,481	146,582	64,403	73,237
February	182,914	136,388	135,064	62,991	70,336
March	221,455	163,588	355,552	81,148	57,204
April	211,265	161,865	133,947	92,965	78,764
May	212,575	178,582	139,302	101,102	77,379
June	211,981	292,521	132,096	85,819	73,056
July	205,182	219,210	120,737	90,011	73,838
August	198,306	200,681	122,416	86,492	72,467
September	184,207	179,536	114,109	78,432	81,462
October	172,505	169,338	107,317	83,634	91,368
November	170,871	159,878	89,007	69,733	98,444
December	122,770	154,657	99,160	73,279	108,540
Total	2,296,086	2,159,725	1,695,289	970,009	956,095

WELL RECORD.

In the following tables are given the well record for Indiana from 1909 to 1913, inclusive:

Number of wells completed in Indiana, 1909–1913, by counties.

County.	Oil.					Dry.					Total completed.[a]				
	1909	1910	1911	1912	1913	1909	1910	1911	1912	1913	1909	1910	1911	1912	1913
Adams	11	12	1	6	8	3	1	1			14	13	2	6	8
Blackford	19	5	2	2	9	4	2		2	2	23	7	2	4	11
Cass	1					2					3				
Daviess	1	1		1	1			2			1	1	7	2	1
Delaware	8	9	10	15	47	5		5	7	8	13	10	15	22	55
Dubois		1					4					5			
Gibson	2	2			18	6	7	1		1	8	9	1		19
Grant	35	1		1	1	2	1		1	1	37	2		2	4
Huntington	12	3				3					15	3			
Jay	46	21	9	14	27	17	10	3	4	6	63	34	13	20	33
Knox		1	1	1			3	6	4	1		4	7	5	2
Madison	1							3			1		3		
Martin		1					1					2			
Miami						1				1	1				1
Pike	38	179	27	5	11	27	25	11	1	5	65	215	40	6	20
Pulaski	1					3					4				
Randolph	4	13	4	4	8	1	7			3	5	20	4	4	11
Sullivan		3		2	75					52		3		2	132
Vigo	1			1		1	1				2	1		1	
Warrick							3	1				3	1		
Wells	39	32	17	6	5					1	39	33	17	6	6
Miscellaneous			3	7	3	11	1	2	1	5	11	1	5	9	8
Total	219	284	74	65	213	[a] 86	[b] 66	[b] 35	[b] 20	[b] 86	305	366	117	89	311

[a] Including gas wells. [b] Not including gas wells.

Number of oil wells and dry holes drilled in Indiana in 1913, by counties and months.

County.	Jan.		Feb.		Mar.		Apr.		May.		June.		July.		Aug.		Sept.		Oct.		Nov.		Dec.		Total, 1913.		Total, 1912.	
	Oil.	Dry.	Oil.	Dry.	Oil.	Dry.	Oil.	Dry.	Oil.	Dry.	Oil.	Dry.	Oil.	Dry.	Oil.	Dry.	Oil.	Dry.	Oil.	Dry.	Oil.	Dry.	Oil.	Dry.	Oil.	Dry.	Oil.	Dry.
Adams	...	..	...	..	...	..	...	..	2	..	1	..	1	..	...	..	2	..	1	..	...	..	1	..	8	....	6	....
Blackford	...	..	1	..	...	..	1	..	...	..	1	..	1	1	1	1	1	..	2	..	...	..	1	..	9	2	2	2
Daviess	...	..	1	..	...	..	...	..	...	..	...	..	...	..	...	..	...	..	...	..	...	..	...	..	1	....	1	....
Delaware	...	1	6	..	5	..	1	..	9	1	8	2	7	1	2	1	4	2	3	..	2	..	...	..	47	8	15	7
Gibson	1	..	1	..	8	1	...	..	...	..	1	..	1	..	4	..	...	..	...	..	1	..	1	..	18	1	....	....
Grant	...	..	...	..	...	..	...	..	...	..	...	..	...	..	...	..	...	..	...	1	...	..	1	..	1	1	1	1
Jay	1	..	...	..	...	2	1	..	2	..	3	1	2	..	7	..	4	1	3	1	1	1	3	..	27	6	14	4
Knox	...	..	...	..	...	..	...	..	...	..	...	..	...	..	...	..	...	..	...	..	...	1	...	..	....	1	1	4
Miami	...	..	...	..	...	..	...	..	...	..	...	..	...	..	...	..	...	..	...	1	...	..	...	..	....	1	....	....
Pike	...	1	...	..	...	..	...	..	2	..	...	..	...	2	2	..	2	1	...	..	4	1	1	..	11	5	5	1
Randolph	...	..	...	..	...	..	...	..	1	..	...	..	2	1	2	..	1	2	1	..	1	..	...	..	8	3	4	....
Sullivan	...	..	...	..	...	..	...	..	...	..	...	..	...	..	8	4	4	8	17	12	24	8	22	20	75	52	2	....
Vigo	...	..	...	..	...	..	...	..	...	..	...	..	...	..	...	..	...	..	...	..	...	..	...	..	....	....	1	....
Wells	...	..	...	..	...	..	1	..	...	..	2	1	...	..	1	..	...	..	...	..	1	..	...	..	5	1	6	....
Miscellaneous	1	..	...	..	...	..	...	..	1	1	...	1	...	2	1	..	...	1	...	..	...	..	...	..	3	5	7	1
Total	3	2	9	..	13	3	4	..	17	2	16	5	14	7	28	6	18	15	27	15	34	11	30	20	213	86	65	20

Number of oil wells drilled in Indiana, 1909–1913, by months.

Year.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Total.
1909	21	9	16	20	19	27	19	21	13	16	11	27	219
1910	9	27	26	21	20	34	34	32	28	21	19	13	284
1911	10	6	9	5	6	7	6	7	5	4	3	6	74
1912	2	3	2	3	4	4	7	8	8	9	8	7	65
1913	3	9	13	4	17	16	14	28	18	27	34	30	213

Number of dry holes drilled in Indiana, 1909–1913, by months.

Year.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Total.
1909	9	7	2	4	7	9	8	6	6	13	5	10	[a] 86
1910	3	4	3	5	4	2	4	6	7	5	16	7	[b] 66
1911	4	3	1	3	2	2	5	4	2	2	7	......	[b] 35
1912	2	1	1	5	......	......	3	2	3	2	......	1	[b] 20
1913	2	......	3	......	2	5	7	6	15	15	11	20	[b] 86

[a] Including gas wells. [b] Not including gas wells.

Total number of wells completed in Indiana, 1909–1913, by months. [a]

Year.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Total.
1909	30	16	18	24	26	36	27	27	19	29	16	37	305
1910	18	33	29	27	25	38	38	41	35	26	36	20	366
1911	14	10	10	8	8	10	11	11	8	6	15	6	117
1912	5	5	3	8	4	5	10	10	11	12	8	8	89
1913	5	9	17	5	19	22	22	37	33	44	47	51	311

[a] Including gas wells.

Initial daily production of new wells completed in Indiana in 1913, by counties and months, in barrels.

County.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Total, 1913	Total, 1912
Adams	.....	.....	.....	.....	15	10	10	......	23	10	......	5	73	103
Blackford	.....	1	.....	8	......	5	4	5	2	6	......	15	46	7
Daviess	.....	10	.....	.....	......	......	......	......	......	......	......	......	10	10
Delaware	.....	245	100	150	345	390	230	35	160	55	55	......	1,765	425
Gibson	15	15	227	.....	......	15	10	42	......	......	5	3	332	......
Grant	.....	.....	.....	.....	......	......	......	......	......	......	......	5	5	5
Jay	20	.....	.....	50	28	32	10	88	80	70	15	30	423	204
Knox	.....	.....	.....	.....	......	......	......	......	......	......	......	......	......	3
Pike	.....	.....	.....	.....	42	......	......	29	16	......	65	50	202	150
Randolph	.....	.....	.....	.....	100	......	120	15	50	100	10	......	395	35
Sullivan	.....	.....	.....	.....	......	......	......	208	425	1,225	1,270	904	4,032	15
Vigo	.....	.....	.....	.....	......	......	......	......	......	......	......	......	......	30
Wells	.....	.....	.....	15	......	15	......	10	......	......	10	......	50	31
Miscellaneous	30	.....	.....	.....	25	......	......	5	......	......	......	......	60	65
Total	65	271	327	223	555	467	384	437	756	1,466	1,430	1,012	7,393	1,083

Total and average initial daily production of new wells in Indiana, 1909–1913, by counties, in barrels.

County.	Total initial production.					Average initial production per well.				
	1909	1910	1911	1912	1913	1909	1910	1911	1912	1913
Adams	58	73	10	103	73	5.3	6.1	10.0	17.2	9.1
Blackford	140	75	5	7	46	7.4	15.0	2.5	3.5	5.1
Cass	2	....	....	....	....	2.0	....	....	....	....
Daviess	20	5	....	10	10	20.0	5.0	....	10.0	10.0
Delaware	142	232	325	425	1,765	17.8	25.8	32.5	28.3	37.6
Dubois	....	15	....	....	....	....	15.0	....	....	....
Gibson	35	20	....	....	332	17.5	10.0	....	....	18.4
Grant	167	1	....	5	5	4.8	1.0	....	5.0	5.0
Huntington	77	40	....	....	....	6.4	13.3	....	....	....
Jay	378	203	90	204	423	8.2	9.7	10.0	14.6	15.7
Knox	....	10	5	3	....	....	10.0	5.0	3.0	....
Madison	40	....	....	....	....	40.0	....	....	....	....
Martin	....	5	....	....	....	....	5.0	....	....	....
Pike	2,385	7,453	439	150	202	62.7	41.6	16.3	30.0	18.4
Pulaski	5	....	....	....	....	5.0	....	....	....	....
Randolph	130	207	26	35	395	32.5	15.9	6.5	8.8	49.4
Sullivan	....	25	....	15	4,032	....	8.3	....	7.5	53.8
Vigo	20	....	....	30	....	20.0	....	....	30.0	....
Wells	264	300	181	31	50	6.8	9.4	10.6	5.2	10.0
Miscellaneous	....	....	15	65	60	....	....	5.0	9.3	20.0
Total	3,863	8,664	1,096	1,083	7,393	17.6	30.5	14.8	16.7	34.8

Total initial daily production of new wells in Indiana, 1909–1913, by months, in barrels.

Year.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Total.	Monthly average.
1909	308	59	200	241	281	298	467	287	381	445	114	782	3,863	322
1910	488	885	820	714	746	1,745	676	1,159	400	480	290	261	8,664	722
1911	142	53	129	73	66	77	107	155	75	85	52	82	1,096	91
1912	75	60	30	50	85	57	47	82	148	172	187	90	1,083	90
1913	65	271	327	223	555	467	384	437	756	1,466	1,430	1,012	7,393	616

ILLINOIS OIL FIELD.

GENERAL CONDITIONS.

This State showed the sharpest decline among the large fields. In 1912 the total output was 28,601,308 barrels—already a sharp decline from 33,143,362 barrels in 1910. In 1913 the total fell to 23,893,899 barrels, a decline of 16.45 per cent from 1912. Meanwhile the price per barrel increased 52 per cent, from $0.851 in 1912 to $1.296 in 1913, raising the total value from $24,332,605 in 1912 to $30,971,910 in 1913, a gain of 27.29 per cent.

The decline does not presage exhaustion of the Illinois field, but rather what may be considered settled production for a long time, unless the production should be increased again by the discovery of new oil pools. This is by no means unlikely in view of the great extent of territory which is good prospecting ground and which the energetic Illinois Geological Survey will be encouraged to examine thoroughly during the next few years; for the beneficial work of this organization in past years is well recognized by the oil fraternity.

The only regions that caused any drilling excitement in 1913 were localities in Lawrence County and the town-lot boom in Robinson, Crawford County.

The following description of the development of petroleum in Illinois in the last two years is taken from the advance Circular No. 8 published by the Illinois State Geological Survey.

> The sharp decline in State production, beginning in 1912, seems to correspond with the decrease in new development in the deep Lawrence County pools. The sands of this locality have a good staying quality and are expected to yield abundantly for many years. The present rapid drop in their production is normal; later, the decline should continue at a much lower rate. The opening of new fields would probably reverse the situation.
>
> The drain on stored oil in 1912 and 1913 kept pace with the decline in production. The surplus oil in Illinois fields began to accumulate in 1906 and reached the maximum amount about September 1, 1910, with stocks aggregating 29,289,164 barrels. The decline in stocks, until August 1, 1912, averaged about 19,500 barrels per day. From August, 1912, until February, 1913, the daily decline averaged about 23,400 barrels, and since that time about 16,000 barrels a day.
>
> A general advance in prices of Illinois oil has accompanied the decline in production and stocks. This has been due chiefly to the demand for motor fuels and to other prevailing economic conditions. The present price of $1.45 per barrel as against 67 cents, January 1, 1912, is a large inducement to extensive wildcat work in the effort to locate new fields. From January 1, 1908, to December 20, 1912, Illinois oil was graded and sold according to difference in specific gravity. Since then the grading has been abolished, and now all of the oil of the State commands one price.

SOUTHEASTERN ILLINOIS.

Shallow fields.—The Clark, Cumberland, Coles, and Edgar County fields (shallow oil-sand territory) showed a very low but steady yield of oil in 1912 and 1913. These pools produce from 1 to 3 barrels of oil per day per well and seem to be profitable in 1914 where a number of wells are pumped on one central power. Until very recently there has been but little active drilling. Several wells were drilled in the area in 1912 to a depth of about 2,500 feet, in which small quantities of high-grade sour oil were found. The producing zone is thought to correspond to the Trenton limestone. The expense of drilling with such small returns is almost prohibitive of extensive development to this horizon; but the presence of oil has induced some recent investigation of the Trenton northward along the La Salle anticline between Pesotum and Mahomet, where the depth is much less. Very recently a new shallow sand was discovered in Clark County, beneath the old productive sand, and is attracting considerable attention. The production from this pay is not as great as in the old sand, but its shallow depth makes it a profitable venture. The combined daily output of the shallow fields in 1913 was about 5,000 barrels as against 9,000 in 1910.

Crawford County.—Like the shallow fields, the Crawford County area, with its 900-foot sands, was rapidly developed and drained, and is now maintaining a low but steady yield. The average daily output in 1913 was about 15,000 barrels, as against 30,000 barrels in 1910 and 100,000 barrels in 1907. The two chief additions to the field in the last three years were the development of the New Hebron pool, and the deep sand, at 1,350 feet, north of Oblong. In 1912 and 1913, the drilling was for the most part confined to inside field locations which did not add materially to the general output. At the close of 1913 oil was found on a town lot in the north part of Robinson in Crawford County. Considerable excitement ensued, and now about 15 wells are drilling.

Lawrence County.—Lawrence County is the richest oil-producing area in the State. There are seven sands from 450 to 1,985 feet in depth that produce large quantities of high-grade oil. In order of depth they are: The Shallow sand, 450 feet (very limited in areal extent); the Bridgeport sand of three lenses, 750 to 1,000 feet; the Buchanan sand, 1,250 to 1,380 feet; the "Gas" sand, 1,200 to 1,300 feet; the Kirkwood sand, 1,320 to 1,985 feet (variableness of depth due to structure); the Tracy sand, 1,500 to 1,750 feet; and the McClosky limestone, 1,600 to 1,850 feet. These sands rank in production as follows: McClosky, Kirkwood, Buchanan, Bridgeport, Tracy, "Gas," and Shallow. The accumulation of oil in all of the sands is governed by a strong double-plunging anticline. Until late in 1912, the remarkably steady production of the Lawrence County sands did much to retard the decline of general production. Since this time, the initial high yield has given way to a rapid decline that has affected the State yield. In 1912, the drilling in the county was confined mostly inside of the oil fields and consisted of wells which tap the McClosky sand. Many of the new wells were reported with initial productions from 500 to 2,400 barrels a day and a large number of the oil wells drilled to shallower sands were deepened to the McClosky. Several isolated oil pools were opened in 1912 and 1913, near Lawrenceville. The largest lies just northwest of this place and produces from the Buchanan sand. Three smaller pools in the Kirkwood sand lie southeast of the town in sec. 8, 15, and 17, T. 3 N., R. 11 W. General drilling in the county was greatly handicapped in 1913, because of an extensive summer drought and a consequent shortage of water. The average daily output for the county was about 35,000 barrels as against 45,000 in 1912.

Wabash County.—A small pool of oil of about 37° Baumé gravity was discovered and defined in 1912, in secs. 3, 4, 9, and 10, T. 1 N., R. 12 W. It was named after the nearby town of Allendale. This pool was disappointing in areal extent. There are at present 36 producing wells with a daily production of about 700 barrels. The oil comes from a depth of about 1,480 to 1,550 feet in a sand which seems to correspond to the Kirkwood sand of Lawrence County. The governing structure of the pool has the appearance of an isolated shelf along the steep western limb of the La Salle anticline.

SOUTH-CENTRAL AND WESTERN ILLINOIS.

Clinton County.—The Carlyle pool, 3 miles northwest of Carlyle, has shown a steady decline in the last two years. There are at present 154 wells and a combined daily production of about 1,070 barrels as against 120 wells and 4,500 barrels at the close of 1911. Only 14 new wells were added to the field during 1913. Their combined initial yield was 134 barrels.

Marion County.—The Sandoval pool, just north of Sandoval, has 112 producing wells and a combined daily yield of about 875 barrels, as against 66 wells and 1,800 barrels in 1911. There were 23 new wells added to the field in 1913, with an initial production of 492 barrels. Both the Sandoval and the Carlyle pools have been profitable because of their continued yield. A small oil well of about 20 barrels initial yield was discovered a mile south of the old Brown well east of Centralia. The producing sand corresponds to the Benoist sand in the Sandoval pool.

Macoupin County.—The Carlinville pool, two miles south of Carlinville, now has six gas wells and eight oil wells. One of the oil wells is credited with an initial yield of 100 barrels of thick heavy oil, which characterized the field. The daily yield of the field is about 200 barrels. The oil comes from the Pottsville sandstone formation overlying the St. Louis limestone or "Big lime."

MISCELLANEOUS DRILLING.

In 1912, barren wells were drilled near Murphysboro, Ava, Grubbs, Denny, Nashville, O'Fallon, Virden, Watson, Camargo, Keensburg, Jacksonville, Edwardsville, and Villa Grove. In 1913, dry holes were drilled near Equality, Harrisburg, Duquoin, Murphysboro, Hoffman, Hoyleton, Edwardsville, Millstadt, Pinkstaff, Kinsman, Lexington, Dundas, Anna, Olive Branch, and Villa Grove. New drilling is going on or is contemplated near Allerton, Vandalia, Pesotum, Sadorus, Mahomet, Sorento, Birmingham, and Hillsboro.

The discovery of the Allendale pool and its rapid development in June and July, 1912, caused the average initial production to exceed that of any month in the last two years. The confinement of drilling to proved territory that had already suffered considerably drain is well shown by the difference in the total well completions, new production, and the average initial yield per producing well.

On January 1, 1913, it was estimated that 21,238 wells had been drilled in Illinois. Of these, 3,422, or 16.1 per cent, were barren. In 1913, 1,749 wells were drilled, of which 310, or 17.7 per cent, were barren. The total number up to January 1, 1914, is 22,987 wells drilled, of which 3,732, or 16.2 per cent, are dry.

PRODUCTION.

The production of petroleum in the Illinois field from 1889 to 1913, inclusive, is given in the following table:

Production of petroleum in Illinois, 1889–1913, in barrels.

Year.	Production.	Percentage of total production.	Increase (+) or decrease (−).	Percentage of increase (+) or decrease (−).	Value.	Yearly average price per barrel.
1889	1,460				$4,906	$3.360
1890	900		− 560	− 38.36	3,000	3.333
1891	675		− 225	− 25.00	2,363	3.500
1892	521		− 154	− 22.81	1,823	3.500
1893	400		− 121	− 23.22	1,400	3.500
1894	300		− 100	− 25.00	1,800	6.000
1895	200		− 100	− 33.33	1,200	6.000
1896	250		+ 50	+ 25.00	1,250	5.000
1897	500		+ 250	+ 100.00	2,000	4.000
1898	360		− 140	− 28.00	1,800	5.000
1899	360				1,800	5.000
1900	200		− 160	− 44.44	1,000	5.000
1901	250		+ 50	+ 25.00	1,250	5.000
1902	200		− 50	− 20.00	1,000	5.000
1903			− 200	− 100.00		
1904						
1905	181,084	0.13	+ 181,084		116,561	.644
1906	4,397,050	3.47	+ 4,215,966	+2,328.18	3,274,818	.745
1907	24,281,973	14.62	+19,884,923	+ 452.23	16,432,947	.677
1908	33,686,238	18.87	+ 9,404,265	+ 38.73	22,649,561	.672
1909	30,898,339	16.87	− 2,787,899	− 8.28	19,788,864	.640
1910	33,143,362	15.82	+ 2,244,923	+ 7.27	19,669,383	.593
1911	31,317,038	14.21	− 1,826,224	− 5.51	19,734,339	.630
1912	28,601,308	12.83	− 2,715,730	− 8.67	24,332,605	.851
1913	23,893,899	9.62	− 4,707,409	− 16.45	30,971,910	1.296
Total	210,406,867	6.85			156,997,580	.746

Production of petroleum in Illinois, 1909–1913, by months, in barrels.

Month.	1909	1910	1911	1912	1913
January	2,668,607	2,640,303	2,578,579	2,241,867	2,149,264
February	2,510,548	2,353,684	2,373,229	2,262,440	1,859,412
March	2,757,794	2,865,055	2,790,515	2,369,428	2,008,245
April	2,562,215	2,776,800	2,560,963	2,351,693	2,015,058
May	2,829,277	2,860,760	2,731,965	2,535,039	2,117,425
June	2,670,549	2,746,620	2,634,521	2,503,038	2,003,278
July	2,728,857	3,029,787	2,740,654	2,698,582	2,075,444
August	2,719,958	3,007,151	2,770,946	2,519,651	2,001,228
September	1,902,197	2,850,119	2,615,120	2,366,712	1,942,052
October	2,560,072	2,768,750	2,638,927	2,424,472	1,982,002
November	2,497,847	2,629,132	2,400,670	2,174,856	1,819,116
December	2,490,418	2,615,201	2,480,949	2,153,530	1,921,375
Total	30,898,339	33,143,362	31,317,038	28,601,308	23,893,899

Average daily production of petroleum in Illinois each month, 1909–1913, by months and years, in barrels.

Month.	1909	1910	1911	1912	1913
January	86,084	85,171	83,180	72,318	69,331
February	89,662	84,060	84,758	78,015	66,407
March	88,961	92,421	90,017	76,433	64,782
April	85,407	92,560	85,365	78,390	67,169
May	91,267	92,283	88,128	81,775	68,304
June	89,018	91,554	87,817	83,435	66,776
July	88,028	97,735	88,408	87,051	66,950
August	87,741	97,005	89,385	81,279	64,556
September	63,407	95,004	87,171	78,890	64,735
October	82,583	89,315	85,127	78,209	63,936
November	83,262	87,638	80,022	72,495	60,637
December	80,336	84,361	80,031	69,469	61,980
Average	84,653	90,804	85,800	78,146	65,463

Production and value of petroleum in Illinois, 1906–1913, in barrels.

Year.	Ohio Oil Co.	Other lines.	Total quantity.	Total value.
1906	4,385,471	11,579	4,397,050	$3,274,818
1907	23,733,790	548,183	24,281,973	16,432,947
1908	31,972,634	1,713,604	33,686,238	22,649,561
1909	27,640,773	3,257,566	30,898,339	19,788,864
1910	27,751,090	5,392,272	33,143,362	19,669,383
1911	25,987,480	5,329,558	31,317,038	19,734,339
1912	23,137,234	5,464,074	28,601,308	24,332,605
1913	17,585,155	6,308,744	23,893,899	30,971,910

PIPE-LINE RUNS, DELIVERIES, AND STOCKS.

Pipe-line runs and deliveries to trade of petroleum from Illinois, by months, in 1913, and stocks at end of each month, in barrels.

Month.	Runs.	Deliveries.	Stocks.[a]
Dec. 31, 1912			15,709,738
January	2,149,264	3,075,502	14,783,500
February	1,859,412	2,722,247	13,920,665
March	2,008,245	2,533,839	13,395,071
April	2,015,058	2,659,425	12,750,704
May	2,117,425	2,622,819	12,245,310
June	2,003,278	2,533,606	11,714,982
July	2,075,444	2,706,745	11,083,681
August	2,001,228	2,413,448	10,671,461
September	1,942,052	2,814,292	9,799,221
October	1,982,002	2,623,700	9,157,523
November	1,819,116	2,329,011	8,647,628
December	1,921,375	2,325,582	8,243,421
Total	23,893,899	31,360,216	

[a] Includes a small quantity of Indiana oil of Illinois grade.

The following tables show the runs, deliveries, and stocks of the Ohio Oil Co. during the years 1909–1913, by months:

Pipe-line runs, deliveries, and stocks of the Ohio Oil Co. in Illinois, 1909–1913, by months, in barrels.

PIPE-LINE RUNS.

Month.	1909	1910	1911	1912	1913
January	2,494,492	2,220,842	2,137,674	1,853,266	1,591,944
February	2,358,198	1,976,637	1,968,429	1,853,379	1,348,292
March	2,568,392	2,377,012	2,349,208	1,949,945	1,457,711
April	2,388,309	2,306,336	2,138,500	1,916,071	1,456,551
May	2,536,413	2,374,134	2,264,925	2,084,743	1,551,323
June	2,365,956	2,274,501	2,177,280	2,083,087	1,471,437
July	2,413,218	2,569,830	2,265,374	2,230,164	1,531,800
August	2,411,483	2,528,532	2,312,973	1,996,824	1,483,801
September	1,595,934	2,409,232	2,154,693	1,871,325	1,437,974
October	2,228,269	2,334,659	2,172,457	1,901,119	1,473,679
November	2,149,372	2,211,286	1,977,073	1,668,306	1,360,159
December	2,130,737	2,168,089	2,068,894	1,594,700	1,420,484
Total	27,640,773	27,751,090	25,987,480	23,002,929	17,585,155

Pipe-line runs, deliveries, and stocks of the Ohio Oil Co. in Illinois, 1909–1913, by months, in barrels—Continued.

DELIVERIES.[a]

Month.	1909	1910	1911	1912	1913
January	324,887	1,226,379	933,861	1,350,621	1,201,633
February	869,212	842,135	838,566	1,387,078	1,042,834
March	721,519	882,209	1,218,111	1,532,428	1,172,522
April	891,423	936,706	1,022,936	1,420,013	1,139,433
May	903,838	946,346	1,132,231	1,301,727	1,226,625
June	1,077,383	1,156,895	1,174,211	1,302,537	1,161,667
July	1,176,410	1,332,242	1,231,534	1,327,329	1,171,492
August	1,052,431	1,229,479	1,206,244	1,306,563	794,844
September	849,533	1,135,323	1,252,988	1,359,968	1,039.267
October	938,860	1,245,778	1,352,605	1,401,807	1,065,320
November	1,120,751	997,805	1,304,663	1,230,357	810,907
December	685,585	1,036,260	1,454,394	1,206,516	1,204,375
Total	10,611,832	12,967,557	14,122,344	16,126,944	13,030,919

STOCKS.[b]

Month.	1909	1910	1911	1912	1913
January	25,876,529	28,355,182	26,252,274	18,393,303	11,118,521
February	26,203,238	28,356,243	25,643,012	17,706,835	10,344,393
March	26,630,509	28,373,855	24,005,215	17,279,112	9,935,612
April	26,856,675	28,593,365	24,013,861	17,001,576	9,446,550
May	27,593,494	29,025,647	24,138,187	16,636,329	8,941,584
June	27,899,220	29,106,098	23,195,749	16,235,353	8,054,011
July	27,627,086	29,198,965	22,714,129	15,689,994	7,548,743
August	27,683,334	29,177,382	22,265,928	14,682,823	6,876,978
September	28,399,427	28,879,676	21,904,719	13,949,064	6,416,698
October	28,535,636	28,492,136	21,359,482	13,039,507	5,748,180
November	28,373,985	28,086,619	20,211,934	12,307,725	5,829,018
December	28,671,543	27,348,358	19,131,678	11,591,427	5,551,556

[a] These deliveries are to trade only. Deliveries to other pipe lines are also made.
[b] Stocks 1910, 1911, 1912, and 1913 include some Indiana petroleum of Illinois grade.

RAILROAD SHIPMENTS.

The following table shows the quantity of petroleum shipped by railroad from the Illinois oil field, 1907–1913, by months. The shipments were made by the Vandalia Railroad Co., the Baltimore & Ohio Southwestern Railroad Co., the Illinois Southern Railway Co., the Indianapolis Southern Railroad Co., and the Cleveland, Cincinnati, Chicago & St. Louis Railway from Lawrenceville, Flat Rock, Sparta, Stoy, Bridgeport, Robinson, Sandoval, and Casey stations.

Shipments of petroleum by railroad in tank cars from Illinois oil field, in barrels, 1907–1913, by months.

Month.	1907 [a]	1908 [a]	1909 [a]	1910 [a]	1911 [a]	1912 [a]	1913 [a]
January	8,701	91,807	144,511	220,856	228,404	232,522	192,735
February	14,598	71,170	111,407	217,917	224,836	172,106	167,632
March	23,947	132,300	152,056	263,056	254,927	216,156	176,028
April	42,249	118,074	109,872	257,292	347,530	211,809	135,341
May	158,227	84,290	157,783	283,285	333,324	232,043	226,364
June	166,644	122,317	183,432	285,095	329,621	214,860	224,614
July	322,622	107,688	158,642	276,533	311,681	211,025	272,536
August	223,134	70,171	166,943	277,317	297,784	281,991	264,424
September	70,555	83,042	173,509	253,788	238,917	210,974	271,709
October	56,570	102,163	200,067	213,217	292,004	249,263	299,451
November	56,080	138,147	198,044	287,750	263,627	222,866	291,287
December	66,692	126,967	185,166	234,819	285,082	219,034	298,227
Total	1,210,019	1,248,136	1,941,432	3,070,925	3,407,757	2,674,649	2,820,348

[a] Calculations made according to the specific gravity of the oil, ranging from 296.476 to 321.17 pounds to the barrel.

PRICES.

In the following table are given the dates of change and the changes in prices at wells of the different grades of petroleum produced in Illinois during the years 1911–1913:

Fluctuation in prices, per barrel, of Illinois petroleum in 1911–1913.

Date.	Above 30° B.	Below 30° B.	Date.	Above 30° B.	Below 30° B.	Date.	Above 30° B.	Below 30° B.
1911.			1912—Con.			1913.		
Jan. 1	$0.60	$0.52	May 24	$0.85	$0.75	Jan. 1	$1.08	$1.05
May 2	.63	.55	June 13	....	.77	Jan. 3	1.08	....
June 14	.65	.55	June 27	....	.79	Jan. 27	1.11	....
Sept. 15	.67	.55	July 25	.87	.82	Feb. 2	1.14	....
Sept. 19	.67	.57	Sept. 12	....	.84	Feb. 5	1.17	....
			Oct. 28	.90	.87	Feb. 6	1.20	....
1912.			Nov. 9	.92	.89	Feb. 20	1.25	....
Jan. 1	.67	.57	Nov. 15	.94	.91	Apr. 16	1.30	....
Jan. 2	.70	.60	Nov. 25	.96	.93	Nov. 5	1.35	....
Jan. 6	.72	.62	Dec. 2	.99	.96	Nov. 19	1.40	....
Jan. 24	.75	.65	Dec. 9	1.02	.99	Nov. 22	1.45	....
Feb. 1	.78	.68	Dec. 16	1.05	1.02			
Mar. 4	.81	.71	Dec. 20	....	1.05			
Apr. 24	.83	.73	Dec. 23	1.08	1.05			

In the following table are given the average monthly prices paid for Illinois petroleum at wells in Illinois from 1909 to 1913, inclusive:

Average monthly prices of Illinois petroleum, 1909–1913, per barrel.

Month.	1909		1910		1911		1912		1913
	Above 30° B.	Below 30° B.	Above 30° B.	Below 30° B.	Above 30° B.	Below 30° B.	Above 30° B.	Below 30° B.	
January	$0.68	$0.60	$0.60	$0.52	$0.60	$0.52	$0.72	$0.62	$1.09
February	.68	.60	.60	.52	.60	.52	.78	.68	1.21
March	.68	.60	.60	.52	.60	.52	.81	.71	1.25
April	.68	.60	.60	.52	.60	.52	.81	.71	1.28
May	.68	.60	.60	.52	.63	.55	.84	.74	1.30
June	.67½	.59½	.60	.52	.64	.55	.85	.76	1.30
July	.63⅜	.55⅜	.60	.52	.65	.55	.85	.80	1.30
August	.62	.54	.60	.52	.65	.55	.87	.82	1.30
September	.62	.54	.60	.52	.66	.56	.87	.83	1.30
October	.61¼	.53¼	.60	.52	.67	.57	.87	.84	1.30
November	.60	.52	.60	.52	.67	.57	.93	.90	1.38
December	.60	.52	.60	.52	.67	.57	1.04	1.02	1.45
Average	.646	.566	.60	.52	.637	.546	.853	.786	1.288

WELL RECORD.

In the following tables is given the well record for Illinois from 1909 to 1913, inclusive:

Number of wells completed in Illinois, 1909–1913, by counties.

County.	Oil.					Dry.					Total completed.[a]				
	1909	1910	1911	1912	1913	1909	1910	1911	1912	1913	1909	1910	1911	1912	1913
Bond	.....	1	.....	.....	.....	.....	5	9	.....	.....	.....	7	10	.....	.....
Clark	134	80	45	50	169	47	28	25	12	35	181	112	72	62	208
Clinton	.....	.....	123	35	14	.....	3	49	13	5	.....	3	172	48	19
Coles	9	4	2	1	3	3	1	.....	5	3	12	5	2	6	6
Crawford	1,738	950	369	310	540	355	214	93	96	110	2,093	1,210	481	414	669
Cumberland	23	13	6	42	49	10	2	7	8	11	33	17	13	50	61
Edgar	2	.....	.....	.....	.....	4	1	1	.....	.....	6	2	1	.....	.....
Hancock	.....	1	.....	.....	.....	.....	.....	.....	.....	.....	.....	1	.....	.....	.....
Jackson	1	.....	.....	1	.....	2	2	.....	4	2	3	2	.....	6	2
Jasper	7	4	3	.....	2	11	4	2	1	.....	18	8	5	1	2
Lawrence	668	594	466	495	538	56	79	38	77	69	724	689	523	586	663
Macoupin	1	.....	2	1	3	8	2	.....	.....	6	9	2	2	1	9
Madison	1	.....	.....	.....	.....	1	1	1	4	.....	2	1	1	4	.....
Marion	6	34	44	22	21	17	26	11	4	1	23	60	55	26	22
Randolph	2	.....	.....	.....	.....	10	.....	.....	1	.....	12	.....	.....	1	.....
Saline	1	.....	.....	.....	.....	1	1	.....	.....	2	2	1	.....	.....	2
Wabash	.....	.....	.....	22	24	.....	.....	.....	20	24	.....	.....	.....	42	48
Miscellaneous	.....	.....	1	1	.....	33	24	27	12	10	33	29	28	13	10
Total	2,593	1,681	1,061	980	1,363	[a]558	[b]393	[b]263	[b]257	[b]278	3,151	2,149	1,365	1,260	1,721

[a] Including gas wells. [b] Not including gas wells.

Number of oil wells and dry holes drilled in Illinois in 1913, by counties and months.

County.	Jan.		Feb.		Mar.		Apr.		May.		June.		July.		Aug.		Sept.		Oct.		Nov.		Dec.		Total,1913.		Total,1912.	
	Oil.	Dry.	Oil.	Dry.	Oil.	Dry.	Oil.	Dry.	Oil.	Dry.	Oil.	Dry.	Oil.	Dry.	Oil.	Dry.	Oil.	Dry.	Oil.	Dry.	Oil.	Dry.	Oil.	Dry.	Oil.	Dry.	Oil.	Dry.
Clark	3	1	5	..	8	4	7	..	17	1	17	6	12	8	22	6	18	3	13	2	29	3	18	1	169	35	50	12
Clinton	2	..	3	1	1	..	...	..	2	..	...	1	1	1	1	1	...	..	...	1	2	..	2	..	14	5	35	13
Coles	...	..	...	..	...	1	...	..	...	..	...	..	...	1	...	1	1	..	1	..	...	..	1	..	3	3	1	5
Crawford	39	7	24	6	28	3	27	6	52	8	39	9	56	8	41	21	65	9	67	11	34	12	68	10	540	110	310	96
Cumberland	5	..	5	..	2	..	3	1	8	2	7	7	10	1	1	..	4	..	1	..	...	..	3	..	49	11	42	8
Jackson	...	..	...	1	...	..	...	..	...	..	...	1	...	..	...	..	...	..	...	..	...	..	...	..	.....	2	1	4
Jasper	...	..	1	..	...	..	...	..	...	..	...	..	...	..	...	..	...	..	...	..	...	..	1	..	2	.....	.....	1
Lawrence	49	8	42	5	30	3	51	4	56	5	45	5	55	7	46	6	55	4	62	11	47	7	...	4	538	69	495	77
Macoupin	...	..	...	..	...	..	...	..	...	..	...	..	1	..	1	..	...	..	1	5	...	1	...	..	3	6	1	.....
Madison	...	..	...	..	...	..	...	..	...	..	...	..	...	..	...	..	...	..	...	..	...	..	...	..	.....	.....	.....	4
Marion	1	..	1	1	1	..	2	..	1	..	2	..	2	..	2	..	...	..	5	..	2	..	2	..	21	1	22	4
Randolph	...	..	...	..	...	..	...	..	...	..	...	..	...	..	...	..	...	..	...	..	...	..	...	..	.....	.....	.....	1
Saline	...	..	...	..	...	..	...	..	...	..	...	2	...	..	...	..	...	..	...	..	...	..	...	..	.....	2	.....	.....
Wabash	7	7	2	7	1	..	2	2	1	2	2	1	2	1	2	2	2	..	1	1	1	1	1	..	24	24	22	20
Miscellaneous	...	..	...	1	...	1	...	..	...	3	...	3	...	1	...	1	...	..	...	..	...	..	...	..	.....	10	1	12
Total.	106	23	83	22	71	12	92	13	137	21	112	35	139	28	116	38	145	16	151	31	115	24	96	15	1,363	278	980	257

Number of oil wells drilled in Illinois, 1909–1913, by months.

Year.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Total.
1909	172	177	171	225	276	289	296	246	232	192	173	144	2,593
1910	94	115	99	116	149	161	129	198	186	168	138	128	1,681
1911	83	65	56	66	85	105	97	119	101	91	104	89	1,061
1912	74	53	44	54	66	96	77	95	88	124	107	102	980
1913	106	83	71	92	137	112	139	116	145	151	115	96	1,363

Number of dry holes drilled in Illinois, 1909–1913, by months.

Year.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Total.
1909	41	47	45	38	45	53	50	57	50	48	52	32	[a] 558
1910	9	36	24	31	35	44	37	40	42	29	36	30	[b] 393
1911	16	16	10	13	31	37	24	25	34	16	23	18	[b] 263
1912	7	15	8	17	21	24	44	30	13	21	31	26	[b] 257
1913	23	22	12	13	21	35	28	38	16	31	24	15	[b] 278

[a] Including gas wells. [b] Not including gas wells.

Total number of wells completed in Illinois, 1909–1913, by months.[a]

Year.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Total.
1909	213	224	216	263	321	342	346	303	282	242	223	176	3,151
1910	111	158	128	157	192	211	172	245	234	198	177	166	2,149
1911	105	89	70	81	117	147	127	150	135	107	129	108	1,365
1912	81	71	54	74	91	122	123	126	104	146	139	129	1,260
1913	131	107	89	105	159	153	170	156	163	181	143	164	1,721

[a] Including gas wells.

Initial daily production of new wells completed in Illinois in 1913, by counties and months, in barrels.

County.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Total, 1913	Total, 1912
Clark	50	85	152	101	190	169	214	399	272	130	435	413	2,610	1,178
Clinton	15	18	20	.....	18	......	15	10	......	......	30	8	134	1,127
Coles	.....	.....	.....	.....	......	......	......	......	50	5	......	20	75	5
Crawford	855	855	464	413	732	668	1,067	776	988	1,332	860	980	9,990	7,175
Cumberland	60	80	41	25	95	81	151	3	22	10	......	27	595	800
Jackson	.....	.....	.....	.....	......	......	......	......	......	......	......	......	....	3
Jasper	.....	5	.....	.....	......	......	......	......	......	......	......	25	30	....
Lawrence	2,795	2,795	1,595	2,953	3,075	2,625	3,025	2,153	3,275	2,966	2,189	2,870	32,316	51,975
Macoupin	.....	.....	.....	.....	......	......	40	100	......	25	......	......	165	3
Madison	.....	.....	.....	.....	......	......	......	......	......	......	......	......	....	....
Marion	10	15	15	60	25	40	55	60	......	125	52	35	492	610
Randolph	.....	.....	.....	.....	......	......	......	......	......	......	......	......	....	....
Saline	.....	.....	.....	.....	......	......	......	......	......	......	......	......	....	....
Wabash	215	33	50	150	35	135	70	80	55	50	75	50	998	....
Miscellaneous	.....	.....	.....	.....	......	......	......	......	......	......	......	......	....	2,810
Total	4,000	3,886	2,337	3,702	4,170	3,718	4,637	3,581	4,662	4,643	3,641	4,428	47,405	65,686

Total and average initial daily production of new wells in Illinois, 1909–1913, by counties, in barrels.

County.	Total initial production.					Average initial production per well.				
	1909	1910	1911	1912	1913	1909	1910	1911	1912	1913
Bond	....	25	....	....	....	....	25.0	....	....	....
Clark	3,219	1,802	771	1,178	2,610	24.0	22.5	17.1	23.6	15.4
Clinton	....	....	11,681	1,127	134	....	....	95.0	32.2	9.6
Coles	95	65	10	5	75	10.6	16.3	5.0	5.0	25.0
Crawford	44,379	26,382	9,802	7,175	9,990	25.5	27.8	26.6	23.1	18.5
Cumberland	558	162	100	800	595	24.3	12.5	16.7	19.0	12.1
Edgar	10	....	....	....	....	5.0	....	....	....	....
Hancock	....	5	....	....	....	....	5.0	....	....	....
Jackson	3	....	....	3	....	3.0	....	....	3.0	....
Jasper	50	40	20	....	30	7.1	10.0	6.7	....	15.0
Lawrence	41,056	61,015	40,432	51,975	32,316	61.5	102.7	86.8	105.0	60.1
Macoupin	5	....	7	3	165	5.0	....	3.5	3.0	55.0
Madison	10	....	....	....	....	10.0	....	....	....	....
Marion	223	8,760	4,025	610	492	37.2	110.6	91.5	27.7	23.4
Randolph	145	....	....	....	....	72.5	....	....	....	....
Saline	3	....	....	....	....	3.0	....	....	....	....
Wabash	....	....	....	2,235	998	....	....	101.6	41.6	....
Miscellaneous	....	....	3	575	....	....	....	3.0	575.0	....
Total	89,756	93,256	66,851	65,686	47,405	34.6	55.5	63.0	67.0	34.8

Total initial daily production of new wells in Illinois, 1909–1913, by months, in barrels.

Year.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Total.	Monthly average.
1909	5,060	4,833	5,018	5,237	7,681	9,050	9,820	8,661	8,324	8,904	9,628	7,540	89,756	7,479
1910	5,331	6,840	5,593	7,260	8,091	9,267	6,386	10,042	8,419	10,133	8,832	7,062	93,256	7,771
1911	5,677	3,512	3,909	5,587	5,132	5,850	9,058	7,535	6,551	4,782	5,826	3,432	66,851	5,571
1912	3,894	4,367	2,232	3,768	4,013	10,761	6,879	6,114	4,679	7,367	7,104	4,508	65,686	5,474
1913	4,000	3,886	2,337	3,702	4,170	3,718	4,637	3,581	4,662	4,643	3,641	4,428	47,405	3,950

MID-CONTINENT OIL FIELD.

PRODUCTION.

For commercial purposes it is convenient to group under the title "Mid-Continent oil field" the oil pools of Kansas, Oklahoma, Caddo, De Soto, La., and northern Texas. In this grouping the only new additions are the De Soto field, south of Shreveport, La. and the Moran field in northern Texas. The De Soto production is included with the Caddo field, and Moran's production is included with Electra. The description of these new developments is given farther on under the appropriate States.

The Mid-Continent field declined in 1912 as compared with the production in 1911, owing to the decline in Oklahoma, which was not offset by increase in the other divisions of the field. In 1913 every division of the Mid-Continent field increased, with a resulting total production for the field of 84,920,225 barrels, as compared with 65,473,345 barrels in 1912. The greatest increase was in Oklahoma.

Production of petroleum in the Mid-Continent field in 1912 and 1913, by months, in barrels.

Month.	1912					1913				
	Kansas.	Oklahoma.	Northern Texas.	Caddo, La.	Total.	Kansas.	Oklahoma.	Northern Texas.	Caddo, La.	Total.
Jan.	100,228	3,992,225	312,319	550,691	4,955,463	160,899	5,003,741	563,629	542,905	6,271,174
Feb.	108,160	3,836,382	304,397	646,488	4,895,427	161,306	4,689,487	537,780	562,863	5,951,436
Mar.	115,833	4,075,506	383,966	583,518	5,158,823	176,134	5,200,619	626,642	717,963	6,721,358
Apr.	120,297	3,929,944	394,327	700,594	5,145,162	184,231	5,267,004	646,958	860,274	6,958,467
May	131,757	4,288,801	469,802	648,826	5,539,186	184,093	5,613,275	707,308	968,538	7,473,214
June	129,488	4,012,952	427,967	617,267	5,187,674	183,156	5,321,915	774,509	1,010,049	7,289,629
July	141,777	4,364,329	458,701	592,223	5,557,030	194,637	5,320,234	848,714	953,530	7,317,115
Aug.	148,783	4,619,251	454,533	583,805	5,806,372	200,304	5,050,977	863,157	802,200	6,916,638
Sept.	144,672	4,342,560	465,039	593,422	5,545,693	209,082	5,188,563	887,324	812,062	7,097,031
Oct.	152,915	4,861,929	535,919	562,616	6,113,379	217,392	5,558,189	936,438	905,558	7,617,577
Nov.	131,844	4,429,295	529,783	550,887	5,641,809	234,381	5,580,288	905,928	814,545	7,535,142
Dec.	167,042	4,673,897	538,776	547,612	5,927,327	269,414	5,785,092	885,865	831,073	7,771,444
Total.	1,592,793	51,427,071	5,275,529	7,177,949	65,473,345	2,375,029	63,579,384	9,184,252	9,781,560	84,920,225

Production of petroleum in the Mid-Continent field, 1889–1913, in barrels.

Year.	Production.	Percentage of total production.	Increase (+) or decrease (−).	Percentage of increase (+) or decrease (−).	Value.	Yearly average price per barrel.
1889	500	....	....	....	$2,500	$5.000
1890	1,200	....	+ 700	+140.00	8,400	7.000
1891	1,430	....	+ 230	+ 19.17	9,9[illegible]0	6.958
1892	5,080	....	+ 3,650	+255.24	5,480	1.079
1893	18,010	0.04	+ 12,930	+254.53	18,060	1.003
1894	40,130	.08	+ 22,120	+122.82	40,810	1.017
1895	44,467	.08	+ 4,337	+ 10.81	26,910	.605
1896	115,141	.19	+ 70,674	+158.93	52,587	.457
1897	147,648	.24	+ 32,507	+ 28.23	71,914	.487
1898	616,600	1.11	+ 468,952	+317.62	305,875	.496
1899	738,183	1.29	+ 121,583	+ 19.72	523,068	.709
1900	917,225	1.44	+ 179,042	+ 24.25	945,992	1.031
1901	989,696	1.43	+ 72,471	+ 7.90	778,096	.787
1902	986,720	1.12	− 2,976	− .30	745,803	.756
1903	1,573,085	1.57	+ 586,365	+ 59.42	1,645,936	1.046
1904	6,186,629	5.28	+ 4,613,544	+293.28	5,859,982	.947
1905	12,533,777	9.30	+ 6,347,148	+102.60	6,908,002	.551
1906	22,839,911	18.05	+10,306,134	+ 82.23	10,357,923	.454
1907	46,896,267	28.23	+24,056,356	+105.33	19,239,085	.410
1908	48,823,747	27.35	+ 1,927,480	+ 4.11	19,134,658	.392
1909	50,833,740	27.75	+ 2,009,993	+ 4.12	18,863,436	.371
1910	5[illegible],217,582	28.26	+ 8,383,842	+ 16.49	23,163,676	.391
1911	66,595,477	30.21	+ 7,377,895	+ 12.46	31,928,208	.479
1912	65,473,345	29.48	− 1,122,132	− 1.68	45,300,669	.692
1913	84,920,225	34.18	+19,446,880	+ 29.70	80,767,758	.951
Total	470,515,815	15.33	....	....	266,704,778	.567

Production of petroleum in the Mid-Continent field in 1912 and 1913, by States, showing increase and percentage of increase, in barrels.

State.	Production.		Increase.	Percentage increase.
	1912	1913		
Kansas	1,592,796	2,375,029	782,233	49.11
Oklahoma	51,427,071	63,579,384	12,152,313	23.63
Northern Texas	5,275,529	9,184,252	3,908,723	74.08
Caddo, La	7,177,949	9,781,560	2,603,611	36.27
Total	65,473,345	84,920,225	19,446,880	29.70

Production, value, and average price per barrel of petroleum in the Mid-Continent field, 1904–1913, by States, in barrels.

Year.	Kansas and Oklahoma.			Northern Texas.		
	Quantity.	Value.	Average price per barrel.	Quantity.	Value.	Average price per barrel.
1904	5,617,527	$5,447,622	$0.970	569,102	$412,360	$0.724
1905	12,013,495	6,546,398	.545	520,282	361,604	.695
1906	21,718,648	9,615,198	.443	1,117,905	740,542	.662
1907	45,933,649	18,478,658	.402	912,618	721,577	.791
1908	47,600,546	18,441,538	.387	723,264	479,072	.662
1909	49,122,982	17,920,623	.364	681,940	393,732	.577
1910	53,157,386	20,307,423	.383	969,403	505,396	.521
1911	57,348,456	27,060,523	.472	2,251,193	1,213,960	.539
1912	53,019,867	35,768,302	.674	5,275,529	4,112,826	.779
1913	65,954,413	61,830,231	.937	9,184,252	9,125,185	.992

Production, value, and average price per barrel of petroleum in the Mid-Continent field, 1904–1913, by States, in barrels—Continued.

Year.	Caddo, La.			Total.		
	Quantity.	Value.	Average price per barrel.	Quantity.	Value.	Average price per barrel.
1904				6,186,629	$5,859,982	$0.947
1905				12,533,777	6,908,002	.551
1906	3,358	$2,183	$0.650	22,839,911	10,357,923	.454
1907	50,000	38,850	.277	46,896,267	19,239,085	.410
1908	499,937	214,048	.428	48,823,747	19,134,658	.392
1909	1,028,818	549,081	.533	50,833,740	18,863,436	.371
1910	5,090,793	2,290,857		59,217,582	23,163,676	.391
1911	6,995,828	3,653,725	.522	66,595,477	31,928,208	.479
1912	7,177,949	5,419,541	.755	65,473,345	45,300,669	.692
1913	9,781,560	9,812,342	1.003	84,920,225	80,767,758	.951

Production of petroleum in the Mid-Continent oil field, 1909–1913, by months and years, in barrels.

Month.	1909	1910	1911	1912	1913
January	4,072,631	4,556,738	4,919,620	4,955,463	6,271,174
February	3,652,477	4,028,540	4,683,538	4,895,427	5,951,436
March	4,225,436	5,161,294	7,080,646	5,158,823	6,721,358
April	3,925,727	5,563,228	5,952,082	5,145,162	6,958,467
May	4,259,114	5,117,565	5,742,241	5,539,186	7,473,214
June	4,620,111	5,248,177	5,584,423	5,187,674	7,289,629
July	4,267,179	5,048,983	5,488,403	5,557,030	7,317,115
August	4,371,422	4,836,711	5,386,153	5,806,372	6,916,638
September	4,474,618	5,115,361	5,466,628	5,545,693	7,097,031
October	4,264,225	5,121,995	5,680,980	6,113,379	7,617,577
November	4,419,409	4,677,634	5,352,694	5,641,809	7,535,142
December	4,281,391	4,741,356	5,258,069	5,927,327	7,771,444
Total	50,833,740	59,217,582	66,595,477	65,473,345	84,920,225

Average daily production of petroleum in the Mid-Continent oil field each month, 1909–1913, by months and years, in barrels.

Month.	1909	1910	1911	1912	1913
January	131,375	146,992	158,697	159,208	202,296
February	130,466	143,876	167,269	168,808	212,551
March	136,304	166,493	228,408	166,414	216,818
April	130,858	185,441	198,403	171,505	231,949
May	137,391	165,083	185,234	178,683	241,071
June	154,004	174,939	186,147	172,932	242,988
July	149,264	162,870	177,045	179,259	236,036
August	141,013	156,023	173,747	187,302	223,117
September	149,154	170,512	182,221	184,856	236,568
October	137,556	165,226	183,257	197,206	245,728
November	147,314	155,931	178,423	188,060	251,171
December	138,109	152,947	169,615	191,204	250,692
Average	139,270	162,240	182,453	178,889	232,658

PIPE-LINE RUNS, DELIVERIES, AND STOCKS.

Pipe-line runs and deliveries to trade of petroleum from the Mid-Continent field, by months, in barrels, in 1913, and stocks at end of each month.

Month.	Runs.	Deliveries.	Stocks.
December 31, 1912			51,537,779
January	6,271,174	5,280,230	52,528,723
February	5,951,436	5,823,690	52,656,469
March	6,721,358	6,202,572	53,175,255
April	6,958,467	6,456,718	53,677,004
May	7,473,214	7,189,648	53,960,570
June	7,289,629	6,501,766	54,748,433
July	7,317,115	6,666,738	55,398,810
August	6,916,638	6,666,782	55,648,666
September	7,097,031	6,906,896	55,838,801
October	7,617,577	7,324,808	56,131,570
November	7,535,142	6,662,930	57,003,782
December	7,771,444	7,383,380	57,391,846
Total	84,920,225	79,066,158	

Plate IV shows the relations of the total production and stocks of oil in the Mid-Continent field to the prices for Kansas and Oklahoma oil from 1909 to 1913. The two lines for 1909 and part of 1910 show the prices for two grades of oil, the upper line being for oil with a gravity of 30° Baumé or lighter and the lower line for heavier oils.

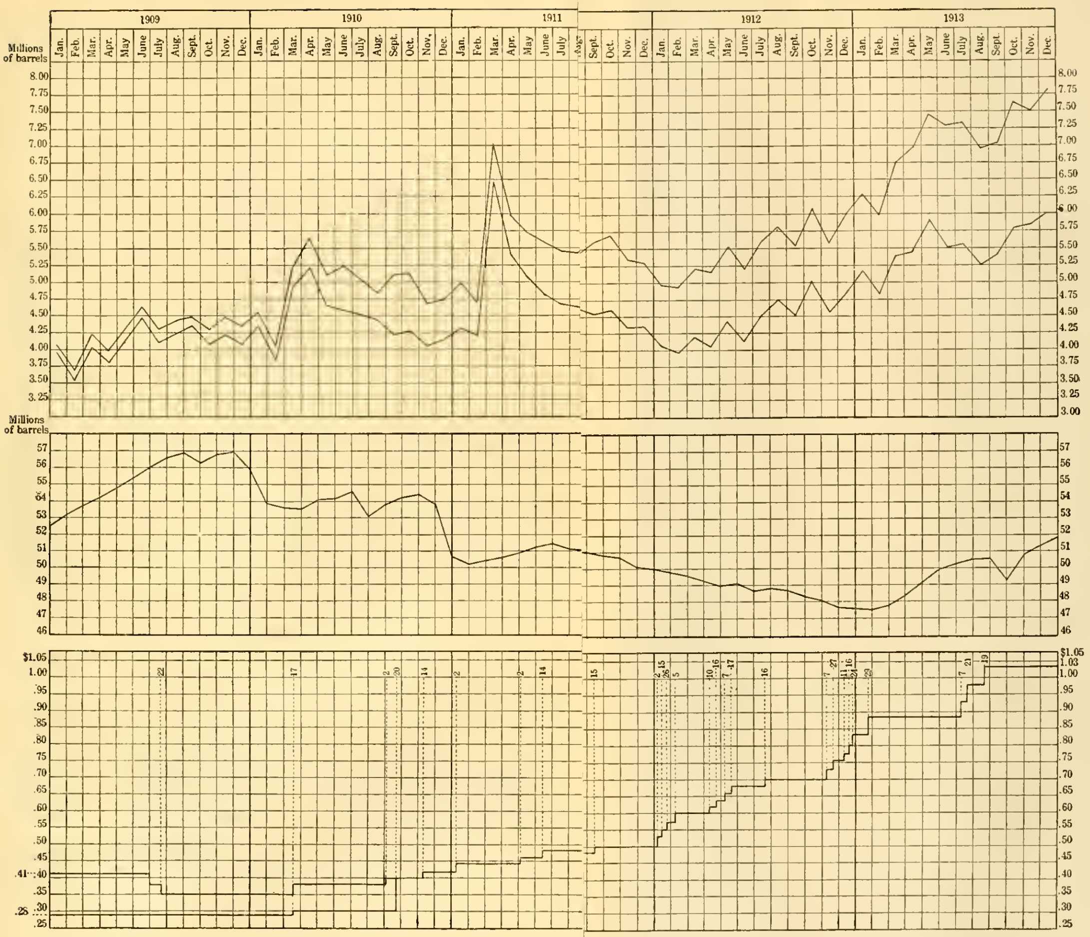
PRICES.

The following table shows the changes in prices of Mid-Continent oil per barrel in 1911, 1912, and 1913, with the dates on which the changes were made:

Prices paid for Mid-Continent oil per barrel in 1911–1913, with the dates on which the changes were made.

Date.	Kansas and Oklahoma.	Northern Texas.				Caddo, La.
		Corsicana (light).	Henrietta.	Powell (heavy).	Electra.	
1911.						
Jan. 1	$0.42	$0.58	$0.55	$0.50		$0.42
Jan. 2	.44					
Jan. 3						.44
Mar. 14						.44–.50
May 2	.46					
June 14	.48					.50–.60
Aug. 9						.40–.60
Sept. 15	.50					.40–.62
1912.						
Jan. 1	.50	.50	.50	.50	$0.50	.40–.62
Jan. 2	.53					
Jan. 4						.40–.65
Jan. 15	.55					
Jan. 18						.40–.67
Jan. 26	.57					
Jan. 27						.40–.69
Feb. 1		.55	.55		.55	
Feb. 2						.40–.72
Feb. 5	.60					
Mar. 1				.55		
Apr. 10	.62					
Apr. 16	.64	.60	.60		.60	
Apr. 17						.40–.75
May 7	.66					
May 17	.68					
May 20		.65	.65		.65	.40–.77
June 20						.55–.77
July 15						.55–.80
July 16	.70					

Date.	Kansas and Oklahoma.	Northern Texas.				Caddo, La.
		Corsicana (light).	Henrietta.	Powell (heavy).	Electra.	
1912.						
July 18		$0.70	$0.70		$0.70	
Sept. 10				$0.60		$0.60–$0.80
Oct. 25				.65		
Nov. 7	$0.73					
Nov. 9						.60– .83
Nov. 14		.75	.75		.75	
Nov. 27	.76					
Dec. 11	.78					
Dec. 12						.60– .88
Dec. 14		.80	.80	.70	.80	.60– .91
Dec. 16	.80					
Dec. 24	.83					
Dec. 26		.83	.88		.88	
1913.						
Jan. 1	.83	.83	.88	.70	.88	.60– .91
Jan. 7						.70– .93
Jan. 9		.90	.90		.90	
Jan. 10		.88	.88		.88	
Jan. 13		.90	.90		.90	
Jan. 29	.88	.95	.95		.95	
Feb. 1						.70– .98
Apr. 7				.80		
July 7	.93					.75– 1.00
July 21	.98					
July 24		1.00	1.00		1.00	
Aug. 19	1.03					
Aug. 22						.75– 1.05
Aug. 25		1.05	1.05		1.05	



PRODUCTION, STOCKS, AND PRICES OF PETROLEUM IN THE MID-CONTINENT FIELD, BY MONTHS, 1909-1913.

In the upper diagram the upper curve shows the production in Kansas, Oklahoma, northern Texas, and Caddo, La., and the lower curve shows the production in Kansas and Oklahoma. The middle diagram shows stocks of Kansas and Oklahoma oil at the end of each month. The lower diagram shows changes in price of Kansas and Oklahoma oil and dates on which changes were made. After September 20, 1910, price is same for all grades.

In the following table is given the average price per month of the different oils of the Mid-Continent field during the years 1912 and 1913:

Average monthly prices of Mid-Continent petroleum in 1912 and 1913; per barrel.

1912

Month.	Kansas and Oklahoma.	Northern Texas.				Caddo, La.
		Corsicana (light).	Henrietta.	Powell (heavy).	Electra.	
January	$0.54	$0.50	$0.50	$0.50	$0.50	$0.40 –$0.66
February	.60	.55	.55	.50	.55	.40 – .71
March	.60	.55	.55	.55	.55	.40 – .72
April	.62	.55	.55	.55	.55	.40 – .73
May	.67	.60	.60	.55	.60	.40 – .76
June	.68	.65	.65	.55	.65	.46 – .77
July	.69	.65	.65	.55	.65	.55 – .75
August	.70	.70	.70	.55	.70	.55 – .80
September	.70	.70	.70	.59	.70	.59 – .80
October	.70	.70	.70	.61	.70	.60 – .80
November	.73	.70	.70	.65	.70	.60 – .83
December	.79	.75	.75	.68	.75	.60 – .88
Average	.668	.634	.634	.569	.634	.496– .768

1913

Month.	Kansas and Oklahoma.	Corsicana (light).	Henrietta.	Powell (heavy).	Electra.	Caddo, La.
January	$0.83	$0.88	$0.88	$0.70	$0.88	$0.68 –$0.93
February	.88	.95	.95	.70	.95	.70 – .98
March	.88	.95	.95	.70	.95	.70 – .98
April	.88	.95	.95	.78	.95	.70 – .98
May	.88	.95	.95	.80	.95	.70 – .98
June	.88	.95	.95	.80	.95	.70 – .98
July	.92	.96	.96	.80	.96	.74 – .94
August	1.00	1.01	1.01	.80	1.01	.75 – 1.02
September	1.03	1.05	1.05	.80	1.05	.75 – 1.05
October	1.03	1.05	1.05	.80	1.05	.75 – 1.05
November	1.03	1.05	1.05	.80	1.05	.75 – 1.05
December	1.03	1.05	1.05	.80	1.05	.75 – 1.05
Average	.939	.983	.983	.773	.983	.723– .991

WELL RECORD.

Number of wells completed in the Mid-Continent field, 1909–1913, by districts.

District.	Oil.					Dry.					Total completed.[a]				
	1909	1910	1911	1912	1913	1909	1910	1911	1912	1913	1909	1910	1911	1912	1913
Kansas	69	85	172	536	1,422	106	82	96	160	260	558	428	418	949	2,016
Oklahoma	2,742	3,188	3,294	4,712	6,965	380	408	489	843	1,308	3,279	3,777	4,087	5,993	8,851
North Texas	116	108	84	299	581	45	[a] 82	38	124	208	175	190	126	434	799
Caddo, La[b]	69	124	246	239	356	33	54	63	62	92	121	[c] 226	341	353	518
Total	2,996	3,505	3,796	5,786	9,324	564	626	686	1,189	1,868	4,133	4,621	4,972	7,729	12,184

[a] Including gas wells.
[b] Includes in 1913 Bossier, De Soto, and Sabine parishes.
[c] Includes Marion County, Tex.

Number of oil wells and dry holes drilled in the Mid-Continent field in 1913, by districts and months.

District.	Jan.		Feb.		Mar.		Apr.		May.		June.		July.	
	Oil.	Dry.	Oil.	Dry.	Oil.	Dry.	Oil.	Dry.	Oil.	Dry.	Oil.	Dry.	Oil.	Dry.
Kansas	44	6	69	9	61	12	63	13	97	29	128	30	147	31
Oklahoma	375	69	433	61	401	67	470	46	624	111	664	135	647	180
North Texas	38	27	31	25	35	12	55	16	57	18	61	19	47	17
Caddo, La [a]	31	9	20	3	17	9	36	1	33	4	14	7	39	9
Total	488	111	553	98	514	100	624	76	811	162	867	191	880	237

District.	Aug.		Sept.		Oct.		Nov.		Dec.		Total, 1913.		Total, 1912.	
	Oil.	Dry.	Oil.	Dry.	Oil.	Dry.	Oil.	Dry.	Oil.	Dry.	Oil.	Dry.	Oil.	Dry.
Kansas	155	20	133	23	147	32	184	24	194	31	1,422	260	536	160
Oklahoma	691	130	626	97	656	125	669	122	709	165	6,965	1,308	4,712	843
North Texas	56	20	41	9	48	10	68	25	44	10	581	208	299	124
Caddo, La [a]	25	6	39	10	30	10	32	13	40	11	356	92	239	62
Total	927	176	839	139	881	177	953	184	987	217	9,324	1,868	5,786	1,189

[a] Includes in 1913 Bossier, De Soto, and Sabine parishes.

Number of oil wells drilled in the Mid-Continent field, 1909–1913, by months.

Year.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Total.
1909	274	265	307	343	339	246	225	211	196	182	170	164	[a] 2,996
1910	208	265	287	317	336	325	253	261	265	308	326	230	[b] 3,505
1911	254	290	349	413	378	279	254	243	262	249	317	262	[b] 3,796
1912	148	296	313	423	448	564	538	533	510	544	615	555	5,487
1913	493	558	525	633	817	876	892	939	843	885	955	989	9,405

[a] South Bosque, Tex., and Caddo, La., not given by months.
[b] Caddo, La., not given by months.

Number of dry holes drilled in the Mid-Continent field, 1909–1913, by months.

Year.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Total.
1909	53	32	49	62	63	61	44	39	27	34	44	36	[a] 578
1910	34	62	59	60	48	52	50	25	67	43	40	32	[b] 626
1911	45	29	39	71	68	74	57	47	34	39	61	59	[b] 686
1912	32	75	56	90	92	101	83	75	99	136	139	87	1,065
1913	114	105	100	91	163	201	243	180	141	178	185	224	1,925

[a] South Bosque, Tex., and Caddo, La., not given by months.
[b] Caddo, La., not given by months.

Total number of wells completed in the Mid-Continent field, 1909–1913, by months. [a]

Year.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Total.
1909	370	330	408	435	441	348	300	286	263	267	289	269	[b] 4,133
1910	307	387	386	417	426	427	332	306	357	384	383	283	[c] 4,621
1911	328	344	421	528	482	417	364	304	351	322	407	363	4,972
1912	203	420	406	571	604	745	674	676	679	767	848	702	7,295
1913	677	728	671	782	1,090	1,199	1,225	1,202	1,068	1,149	1,226	1,306	12,323

[a] Including gas wells.
[b] South Bosque, Tex., and Caddo, La., not given by months.
[c] Caddo, La., not given by months.

Initial daily production of new wells completed in the Mid-Continent field in 1913, by districts and months, in barrels.

District.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Total, 1913.	Total, 1912.
Kansas......	860	1,065	1,003	1,897	1,548	1,918	1,945	2,250	2,283	2,501	2,857	2,340	22,467	7,245
Oklahoma ..	19,220	19,505	21,615	29,847	27,139	32,192	26,071	27,897	27,267	30,953	29,211	43,133	334,050	228,886
North Texas	2,726	3,366	2,986	1,909	6,258	9,720	7,391	4,593	5,605	5,092	5,291	2,498	57,435	28,213
Caddo, La...	6,499	11,615	10,585	20,865	24,246	11,636	12,735	19,189	6,250	9,890	3,397	15,048	151,955	84,098
Total .	29,305	35,551	36,189	54,518	59,191	55,466	48,142	53,929	41,405	48,436	40,756	63,019	565,907	348,442

Total and average initial daily production of new wells in the Mid-Continent field, 1909–1913, by districts, in barrels.

District.	Total initial production.					Average initial production per well.				
	1909	1910	1911	1912	1913	1909	1910	1911	1912	1913
Kansas..............	1,309	1,897	3,271	7,245	22,467	19.0	22.3	19.0	13.5	15.8
Oklahoma............	206,454	226,638	262,333	228,886	334,050	75.3	71.1	79.6	48.6	48.0
North Texas.........	1,177	1,683	19,180	28,213	57,435	10.8	15.6	228.3	94.3	98.9
Caddo, La............	8,750	[a]139,945	169,123	84,098	[b]151,955	127.0	1,128.6	687.5	351.9	426.8
Total..........	217,690	370,163	453,907	348,442	565,907	72.7	105.6	119.6	60.2	60.7

[a] Includes Marion County, Tex. [b] Includes Bossier, De Soto, and Sabine parishes.

Total initial daily production of new wells in the Mid-Continent field, 1909–1913, by months, in barrels.

Year.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Total.	Monthly average.
1909.....	21,795	21,915	21,445	21,121	21,457	18,383	16,675	15,608	14,349	11,802	12,543	11,847	[a]217,690	18,141
1910.....	15,840	18,090	21,057	19,110	19,758	27,462	15,204	16,906	19,305	18,899	18,187	20,400	[a]370,163	30,847
1911.....	23,525	26,970	40,855	31,168	28,828	24,225	16,968	12,934	17,274	20,754	22,738	18,545	[a]453,907	37,826
1912.....	19,283	22,437	24,429	37,573	24,592	22,099	23,971	30,153	36,468	38,877	37,573	30,987	348,442	29,037
1913.....	29,305	35,551	36,189	54,518	59,191	55,466	48,142	53,929	41,405	48,436	40,756	63,019	565,907	47,159

[a] Caddo, La., not given by months.

KANSAS.

DEVELOPMENT.

The low cost of leases in Kansas as compared with Oklahoma led to the drilling of more than twice as many wells as were drilled in 1912 and four times the number drilled in 1911. The results were more than satisfactory, for the initial production increased from 13.5 barrels per well in 1912 to 15.8 barrels in 1913. Montgomery County led in drilling activity, obtaining 867 wells; 442 wells were obtained in Chautauqua County, and 316 in Neosho. The wildcatting showed a tendency to spread to counties farther west. As a general result Kansas showed a gain of 49.11 per cent in quantity and of 105.19 per cent in value of product; the quantity rose from 1,592,796 barrels in 1912 to 2,375,029 barrels in 1913, and the total value from $1,095,698 to $2,248,283.

PRODUCTION.

Production of petroleum in Kansas, 1909–1913, in barrels.

	1909	1910	1911	1912	1913
Quantity piped from wells in Kansas to refineries	466,298	388,013	307,750	367,878	456,633
Rail shipments in Kansas	52,261	21,590	28,122	6,624	27,744
Quantity piped from other wells in Kansas and sold	745,205	719,065	942,947	1,218,294	1,890,652
Total sales in Kansas	1,263,764	1,128,668	1,278,819	1,592,796	2,375,029
Total value	$491,633	$444,763	$608,756	$1,095,698	$2,248,283

WELL RECORD.

The following tables give the well record for Kansas from 1909 to 1913, inclusive:

Number of wells completed in Kansas, 1909–1913, by counties.

County.	Oil.					Dry.					Total completed.[a]				
	1909	1910	1911	1912	1913	1909	1910	1911	1912	1913	1909	1910	1911	1912	1913
Allen	16	13	30	50	154	35	14	10	6	11	151	78	59	58	171
Anderson	.....	.....	.....	.....	.....	.....	.....	.....	.....	....	1	.....	.....	.....	.....
Chautauqua	23	42	64	182	311	3	14	11	28	77	31	60	82	222	442
Elk	7	.....	.....	.....	.....	.....	.....	4	.....	.....	9	1	4	.....	.....
Franklin	.....	1	.....	18	54	1	.....	.....	.....	3	7	3	.....	18	58
Labette	.....	1	.....	2	.....	3	.....	.....	.....	.....	11	3	1	2	3
Montgomery	5	16	60	202	602	22	7	22	47	92	127	79	118	365	867
Neosho	18	9	16	62	257	17	17	22	23	22	100	87	59	115	316
Wilson	.....	1	2	18	40	24	27	27	52	45	113	108	94	156	139
Woodson	.....	.....	.....	1	2	.....	.....	.....	3	3	2	.....	.....	7	5
Miscellaneous	.....	2	.....	1	2	1	3	.....	1	2	6	9	1	6	15
Total	69	85	172	536	1,422	106	82	96	160	260	558	428	418	949	2,016

[a] Including gas wells.

Number of oil wells and dry holes drilled in Kansas in 1913, by counties, and months.

County.	Jan.		Feb.		Mar.		Apr.		May.		June.		July.		Aug.		Sept.		Oct.		Nov.		Dec.		Total, 1913.		Total, 1912.	
	Oil.	Dry.	Oil.	Dry.	Oil.	Dry.	Oil.	Dry.	Oil.	Dry.	Oil.	Dry.	Oil.	Dry.	Oil.	Dry.	Oil.	Dry.	Oil.	Dry.	Oil.	Dry.	Oil.	Dry.	Oil.	Dry.	Oil.	Dry.
Allen	4	1	5	2	3	..	10	..	5	1	13	..	12	..	17	1	16	..	18	4	26	..	25	3	154	11	50	6
Chautauqua	7	1	15	3	15	5	17	2	30	12	29	13	35	12	31	8	38	10	36	3	22	3	36	5	311	77	182	28
Franklin	2	..	4	..	4	..	2	..	3	1	3	..	4	..	12	..	2	..	3	1	7	1	8	..	54	3	18	....
Labette	...	..	...	..	...	..	...	..	...	..	...	..	...	..	...	..	...	..	...	..	...	..	...	..	.....	.....	2	....
Montgomery	21	3	33	4	25	3	11	5	37	9	56	14	75	7	47	6	52	7	55	11	89	11	101	12	602	92	202	47
Neosho	8	1	9	..	13	1	22	5	16	3	23	..	18	3	44	1	21	1	26	4	36	2	21	6	257	27	62	23
Wilson	2	..	3	..	1	3	1	1	6	3	3	2	3	9	4	5	4	5	7	7	4	6	2	4	40	45	18	52
Woodson	...	..	...	..	...	..	...	..	...	..	1	..	...	..	...	..	...	..	...	1	...	1	1	1	2	3	1	3
Miscellaneous	...	..	...	..	...	..	...	..	...	..	...	1	...	..	...	..	...	..	2	1	...	..	...	..	2	2	1	1
Total	44	6	69	9	61	12	63	13	97	29	128	30	147	31	155	20	133	23	147	32	184	24	194	31	1,422	260	536	160

Number of oil wells drilled in Kansas, 1909–1913, by months.

Year.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Total.
1909	3	3	11	9	12	8	5	2	4	5	3	4	69
1910	......	5	3	4	5	2	8	7	12	14	11	14	85
1911	7	5	16	7	21	14	22	23	13	20	11	13	172
1912	4	11	10	23	37	46	60	80	56	63	81	65	536
1913	44	69	61	63	97	128	147	155	133	147	184	194	1,422

Number of dry holes drilled in Kansas, 1909–1913, by months.

Year.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Total.
1909	14	8	11	7	6	8	9	7	6	13	12	5	106
1910	9	8	12	10	7	4	5	2	7	9	5	4	82
1911	8	5	7	7	10	10	9	9	2	7	15	7	96
1912	2	7	9	9	12	8	7	10	18	29	34	15	160
1913	6	9	12	13	29	30	31	20	23	32	24	31	260

Total number of wells completed in Kansas, 1909–1913, by months. [a]

Year.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Total.
1909	54	38	63	39	45	49	36	36	39	55	58	46	558
1919	45	48	42	40	34	29	36	25	30	47	28	24	428
1911	29	20	36	27	43	53	41	23	41	40	26	39	418
1912	9	27	27	46	75	72	77	115	106	138	155	102	919
1913	75	107	88	96	172	190	202	207	185	209	236	249	2,016

[a] Including gas wells.

Initial daily production of new wells completed in Kansas in 1913, by counties and months, in barrels.

County.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Total, 1913.	Total, 1912.
Allen	75	90	50	325	75	254	188	243	492	348	453	367	2,960	632
Chautauqua	295	330	280	475	553	632	691	772	749	885	878	818	7,358	2,963
Franklin	15	55	70	125	18	39	50	158	41	22	90	65	748	155
Montgomery	245	340	293	147	434	646	646	404	469	665	855	727	5,871	2,522
Neosho	220	220	295	800	435	307	335	612	500	530	564	350	5,168	693
Wilson	10	30	15	25	33	35	35	61	32	44	17	5	342	255
Woodson	.....	.....	.....	.....	......	5	......	......	......	......	......	8	13	5
Miscellaneous	.....	.....	.....	.....	......	......	......	......	......	7	......	......	7	20
Total	860	1,065	1,003	1,897	1,548	1,918	1,945	2,250	2,283	2,501	2,857	2,340	22,467	7,245

Total and average initial daily production of new wells in Kansas, 1909–1913, by counties, in barrels.

County.	Total initial production.					Average initial production per well.				
	1909	1910	1911	1912	1913	1909	1910	1911	1912	1913
Allen	251	210	353	632	2,960	15.7	16.2	11.8	12.6	19.2
Chautauqua	475	1,100	1,355	2,963	7,358	20.7	26.2	21.2	16.3	23.7
Elk	110	....	....	....	....	15.7	....	....	....	....
Franklin	....	5	....	155	748	....	5.0	....	8.6	13.9
Labette	....	20	....	15	....	....	20.0	....	7.5	....
Montgomery	113	382	1,300	2,522	5,871	22.6	23.9	21.7	12.5	9.8
Neosho	360	130	208	693	5,168	20.0	14.4	13.0	11.2	20.1
Wilson	....	10	55	255	342	....	10.0	27.5	14.2	8.6
Woodson	....	....	....	5	13	....	....	....	5.0	6.5
Miscellaneous	....	40	....	5	7	....	20.0	....	5.0	3.5
Total	1,309	1,897	3,271	7,245	22,467	19.0	22.3	19.0	13.5	15.8

Total initial daily production of new wells in Kansas, 1909–1913, by months, in barrels.

Year.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Total.	Monthly average.
1909	50	45	225	166	220	130	98	55	85	65	70	100	1,309	109
1910	......	95	65	95	170	40	235	200	257	305	210	225	1,897	158
1911	155	90	304	161	438	255	285	363	265	380	265	310	3,271	273
1912	65	173	213	390	352	714	834	940	507	842	1,185	1,030	7,245	604
1913	860	1,065	1,003	1,897	1,548	1,918	1,945	2,250	2,283	2,501	2,857	2,340	22,467	1,872

OKLAHOMA.

DEVELOPMENT.

The history of the production of petroleum in Oklahoma during 1913 is one of continuous increase at an increasing rate from the beginning to the end of the year. As a result, the production of 1912, which was 51,427,071 barrels, valued at $34,672,604, increased to 63,579,384 barrels, valued at $59,581,948, in 1913. The percentage of increase in quantity was 23.63 and in value 71.83.

Perhaps the most significant feature of development as bearing upon the ultimate value of the Oklahoma fields is the fact that this increase was not the result of a flood of oil from any new pool; it was due rather to the exceptional development within known limits, and to the desire to extend the edges and thus prove the limits of a great many pools already well known. It is true that the Cushing pool was an unusual element in the development, but this field was discovered in 1912 and had received quite considerable development before the beginning of 1913. In addition to the Cushing contribution, the new development in the Osage region; the extension of the Hogshooter pool to the east and of the Shallow fields to the west; the developments between Bartlesville and the old Dewey pool; the developments in the immediate neighborhood of Tulsa, and the development of the new Wicey pool near Mounds had each a decided influence in the record-breaking production.

Cushing.—Without doubt the one single factor of more interest than any other was the development in the Cushing pool. In the first week in January, 1913, the Cushing pool was yielding 11,000 barrels a day; but the consumption in Oklahoma was so great thatstocks were drawn upon during January. By the end of that month the Cushing pool had increased to 20,000 barrels a day from about 120 wells. Many of the wells declined rapidly and a short life for the field was the general prediction. In the month of February, in spite of bad weather, drilling resulted in 67 wells being developed in the Cushing field alone. There were 62 oil wells, 4 gas wells, and only 1 failure. As a result the rate of production in the Cushing field increased to 21,500 barrels a day by February 10, to 25,000 barrels a day by February 20, and to 28,000 barrels a day by the end of the month. The wells in the pool, as already noted, declined rapidly, so that by March 10 the daily yield was down to 25,000 barrels again, and to 23,000 barrels by March 18. This production and the rapid drilling in other parts of the State had led, however, to an increase in stocks instead of the decrease at the beginning of the year, and early in March 11,000 barrels a day were being added to storage. The decline in the Cushing pool continued in April down to 18,000 barrels a day and by June 10 the field only yielded 16,000 barrels a day. The gusher characteristics of the new wells did not equal the rapid decline in the old ones. In August rapid drilling operations brought the daily production up again to 25,000 barrels and by September 1 this had gone to 30,000 barrels, only to decline again by October 1 to 25,000 barrels, and by the end of October the daily rate was down to 23,000 barrels, again increasing in the following week, however. These fluctuations continued, the increase above the rate prevailing in the first half of the year being due to a northwestern extension in the pool, where wells showed greater staying powers than in the older portion.

December 9 brought a very decided change in the outlook for the Cushing pool. On that date the Prairie Oil & Gas Co. drilled a well in sec. 3, T. 17, R. 7, to the Bartlesville sand at a depth of 2,600 feet. This resulted in a very large gusher. It was the signal for general drilling to the Bartlesville sand, and the year for the Cushing pool closed with greater excitement in the extension of the pool than had been created by the discovery of the pool just a year before.

Healdton.—A second feature of greatest importance for the future of Oklahoma's oil production was the drilling of a well in the neighborhood of Healdton, Carter County, in September. On September 25, the Red River Oil Co. brought in a second well at a depth of 850 feet, a mile and a half north of Number One, which yielded 35 barrels a day. By November 1 this development had led to much excitement, involving the payment of large sums of money for leases in the Healdton region. Although the effect was not such as to increase the yield for 1913 to any great extent, the subsequent development in the Healdton field has been of the greatest importance in regard to conditions in 1914.

PRODUCTION.

The following table shows the production and sales of petroleum in Oklahoma from 1909 to 1913:

Production of petroleum in Oklahoma, 1909–1913, in barrels.

	1909	1910	1911	1912	1913
Quantity shipped from Glenn pool and sold.	18,946,740	19,236,914	13,880,118	10,405,518	9,469,870
Quantity piped from other wells in Oklahoma and sold	28,330,313	32,124,072	41,783,947	40,732,128	52,192,881
Rail shipments (outside Glenn pool) in Oklahoma	582,165	667,732	405,572	289,425	1,916,633
Total sales in Oklahoma	47,859,218	52,028,718	56,069,637	51,427,071	63,579,384
Total value	$17,428,990	$19,922,660	$26,451,767	$34,672,604	$59,581,948

Production of petroleum in Oklahoma in 1912 and 1913, by months, in barrels.

Month.	Runs from wells.		Shipped by rail and fuel consumption not included in pipe-line runs.	Total.
	Gulf, Prairie and Texas companies' pipe lines.	Alluwe, Chelsea, Cherokee, Muskogee, National Refining, Nowata, and other lines to refineries.		
1912.				
January	3,477,588	480,335	34,302	3,992,225
February	3,328,570	486,518	21,294	3,836,382
March	3,547,455	505,791	22,260	4,075,506
April	3,408,534	493,341	28,069	3,929,944
May	3,722,122	528,055	38,624	4,288,801
June	3,462,517	528,213	22,222	4,012,952
July	3,815,577	523,939	24,813	4,364,329
August	4,041,753	555,784	21,714	4,619,251
September	3,781,135	545,454	15,971	4,342,560
October	4,243,964	594,144	23,821	4,861,929
November	3,835,125	577,959	16,211	4,429,295
December	4,061,952	582,734	29,211	4,673,897
Total	44,726,292	[a] 6,402,267	298,512	51,427,071
1913.				
January	4,030,733	915,437	57,571	5,003,741
February	3,826,109	793,618	69,660	4,689,487
March	4,288,256	827,145	85,218	5,200,619
April	4,244,596	840,327	182,081	5,267,004
May	4,471,192	862,264	279,819	5,613,275
June	4,210,510	874,078	237,327	5,321,915
July	4,239,810	902,681	177,743	5,320,234
August	4,026,405	880,415	144,157	5,050,977
September	4,141,791	844,851	201,921	5,188,563
October	4,535,799	853,933	168,457	5,558,189
November	4,525,751	815,385	239,152	5,580,288
December	4,718,619	869,443	197,030	5,785,092
Total	51,259,571	[a] 10,279,577	2,040,236	63,579,384

[a] Quantity run by other lines averaged.

OSAGE COUNTY.

The following table gives a statement of the quantity of petroleum produced by the Indian Territory Illuminating Oil Co. and its sublessees from wells in Osage County from 1903 to 1913, inclusive:

Production of petroleum by the Indian Territory Illuminating Oil Co. and its sublessees from Jan. 1, 1903, to Dec. 31, 1913.

Year	Barrels.	Year	Barrels.
1903	56,905	1909	4,516,524
1904	652,479	1910	5,892,970
1905	3,421,478	1911	11,707,676
1906	5,219,106	1912	8,169,158
1907	5,143,971	1913	9,009,996
1908	4,961,147		

Total production and value of royalty oil and gas from wells in Osage County during the years 1912 and 1913.

1912.

Received by—	Total quantity produced.	Amount received by Osage Nation for royalty of one-eighth of production.
	Barrels.	
Prairie Oil & Gas Co	6,631,390	$550,162
Gulf Pipe Line Co	492,595	40,866
Uncle Sam Oil Co	94,714	7,858
Southwestern Refining Co	136,261	11,305
The Texas Co	809,501	67,158
Indian Territory Illuminating Oil Co	853	71
Barnsdall Oil Co	3,844	319
Total	8,169,158	677,739
Royalty received by Osage Nation for gas		3,895
Total amount received by Osage Nation for oil and gas		681,634

1913.

Received by—	Total quantity produced.	Amount received by Osage Nation for royalty of one-eighth of production.
	Barrels.	
Prairie Oil & Gas Co	7,611,686	$875,453
Gulf Pipe Line Co	464,772	53,050
Uncle Sam Oil Co	132,620	14,918
Southwestern Refining Co	244,853	26,649
Texas Co	546,709	62,403
Sold by lessees for fuel	9,356	1,057
Total	9,009,996	1,033,530
Royalty received by Osage Nation for gas		5,943
Total amount received by Osage Nation for oil and gas		1,039,473

In the following table is shown the number of wells owned in Osage County by the Indian Territory Illuminating Oil Co. and its sublessees from 1903 to 1913, inclusive:

Oil and gas wells in Osage County, 1903–1913.

Total wells to—	Completed.	Productive.	Gas.	Dry.[a]
Jan. 1, 1903	30	17	2	11
Dec. 31, 1904	361	243	21	97
June 10, 1905	544	355	34	155
Dec. 31, 1905	704	462	45	197
June 10, 1906	862	569	55	238
Dec. 31, 1906	1,080	716	66	298
June 30, 1907	1,155	779	67	309
Dec. 31, 1907	1,277	837	71	369
Dec. 31, 1908	1,422	936	78	408
Dec. 31, 1909	1,574	1,027	81	466
Dec. 31, 1910	1,735	1,175	82	478
Dec. 31, 1911	2,233	1,562	90	581
Dec. 31, 1912	2,682	1,887	112	683
Dec. 31, 1913	3,307	2,323	145	839

[a] Wells which have been exhausted and abandoned in addition to wells that were dry when drilled in.

GLENN POOL.

In the following table is given the production of petroleum in the Glenn pool (Creek County) for the last five years:

Estimated production and sales of petroleum from Glenn pool, 1909–1913, by months, in barrels.

Month.	1909	1910	1911	1912	1913
January	1,362,602	1,745,206	1,099,192	882,385	792,336
February	1,410,878	1,543,660	967,924	867,566	718,580
March	1,543,463	1,974,514	2,584,464	924,144	807,022
April	1,467,179	1,674,709	1,570,947	898,527	823,645
May	1,590,730	1,676,366	1,069,863	927,182	850,607
June	1,809,989	1,573,578	958,519	816,028	816,789
July	1,856,524	1,557,869	965,122	880,906	787,274
August	1,699,486	1,609,702	981,946	927,675	734,476
September	1,670,167	1,593,986	937,886	794,958	773,847
October	1,602,988	1,521,794	969,247	921,736	817,628
November	1,539,342	1,400,118	864,519	768,254	753,115
December	1,393,392	1,365,412	910,489	886,157	794,551
Total	18,946,740	19,236,914	13,880,118	10,495,518	9,469,870

WELL RECORD.

The following table gives the well record for Oklahoma for 1912 and 1913, by districts and pools:

Well record in Oklahoma in 1912 and 1913, by districts and pools.

District and pool.	1912					1913				
	Wells completed.			Initial daily production.		Wells completed.			Initial daily production.	
	Oil.	Dry.	Total.[a]	Total.	Average per well.	Oil.	Dry.	Total.[a]	Total.	Average per well.
				Barrels.	*Barrels.*				*Barrels.*	*Barrels.*
Cherokee deep sand:										
Bartlesville	499	45	584	11,716	23.5	} 829	75	948	19,412	28.4
Hogshooter	285	43	392	13,151	46.1	}				
Bird Creek	697	92	821	27,880	40.0	610	70	755	17,813	29.2
Copan-Ramsey	482	50	573	10,972	22.8	393	50	469	6,309	16.1
Collinsville	......	......	......	......	......	122	49	205	8,129	66.6
Dewey	481	26	536	12,306	25.6	770	55	872	15,842	20.6
Total	2,444	256	2,906	76,025	31.1	2,724	299	3,249	67,505	24.8
Cherokee, shallow sand:										
Alluwe	} 544	47	594	7,460	13.7	......	......	......	......	......
Chelsea	}									
Coody's Bluff	......	......	......	......	......	......	......	......	......	......
Delaware-Childers	209	21	236	3,355	16.1	......	......	......	......	......
Nowata	8	19	51	115	14.4	......	......	......	......	......
Total	761	87	881	10,930	14.4	[b]1,071	[b]139	[b]1,231	[b]17,672	16.5
Cleveland	196	46	253	33,903	173.0	187	68	262	15,787	84.4
Creek:										
Bald Hill	56	23	82	2,860	51.1	155	65	238	10,000	64.5
Beggs-Preston	36	27	67	4,860	135.0	75	51	145	14,163	188.8
Cushing	68	2	79	15,465	227.4	717	41	821	101,245	141.2
Glenn pool	159	41	228	9,815	61.7	}				
Taneha	91	19	112	2,609	28.7	} 740	186	989	31,595	426.9
Tulsa	174	76	310	11,360	65.3	}				
Morris-Okmulgee	122	74	219	15,056	123.4	336	130	491	19,335	57.5
Mounds	11	17	29	865	78.6	118	45	192	7,977	67.6
Muskogee	12	24	38	293	24.4	60	31	100	1,569	26.1
Sapulpa	33	11	48	1,495	45.3	(c)	(c)	(c)	(c)	......
Schulter	90	30	134	12,910	142.4	203	105	337	7,912	39.9
Total	852	344	1,346	77,588	91.1	2,404	654	3,313	193,796	80.6
Osage	417	54	489	25,400	60.9	506	69	620	34,856	68.8
Ponca City	31	20	58	4,790	154.5	29	23	55	2,964	102.2
Carter County	......	......	......	......	......	15	5	23	844	56.2
Miscellaneous	11	36	60	250	22.7	29	51	98	626	21.5
Grand total	4,712	843	5,993	228,886	48.6	6,965	1,308	8,851	334,050	47.9

[a] Including gas wells. [b] Not reported by districts. [c] Included in Glenn pool, Taneha, and Tulsa.

Number of wells completed in Oklahoma, 1909–1913, by districts.

District.	Oil.					Dry.					Total completed.[a]				
	1909	1910	1911	1912	1913	1909	1910	1911	1912	1913	1909	1910	1911	1912	1913
Cherokee, deep	519	627	806	2,444	2,724	62	61	114	256	299	652	802	1,074	2,906	3,249
Cherokee, shallow	1,535	1,665	1,381	761	1,071	169	152	109	87	139	1,724	1,830	1,576	881	1,231
Creek	582	657	536	852	2,404	114	142	175	344	654	733	837	746	1,346	3,313
Cleveland	23	10	129	196	187	3	2	31	46	68	28	13	165	253	262
Osage	75	206	438	417	506	15	25	40	54	69	108	239	494	489	620
Ponca City	.....	.....	.....	31	29	.....	.....	.....	20	23	.....	.....	.....	58	55
Carter County	.....	.....	.....	.....	15	.....	.....	.....	.....	5	.....	.....	.....	.....	23
Miscellaneous	8	23	4	11	29	17	26	20	36	51	34	56	32	60	98
Total	2,742	3,188	3,294	4,712	6,965	380	408	489	843	1,308	3,279	3,777	4,087	5,993	8,851

[a] Including gas wells.

Number of oil wells and dry holes drilled in Oklahoma in 1913, by districts and months.

District.	Jan.		Feb.		Mar.		Apr.		May.		June		July.	
	Oil.	Dry.	Oil.	Dry.	Oil.	Dry.	Oil.	Dry.	Oil.	Dry.	Oil.	Dry.	Oil.	Dry.
Cherokee, deep	168	17	184	12	159	16	180	13	300	25	311	24	267	38
Cherokee, shallow	42	14	65	5	62	3	70	5	68	11	104	14	116	21
Creek	124	29	150	30	137	30	157	21	198	59	187	72	207	91
Cleveland	16	4	13	4	11	6	16	1	21	8	29	11	16	5
Osage	23	2	20	8	30	9	42	4	35	3	30	4	40	8
Ponca City	2	3	1	....	2	1	5	....	....	3	....	....	....	11
Carter County	....	....	....	....	....	1	....	....	....	....	1	1	....	....
Miscellaneous	....	....	....	2	....	1	....	2	2	2	2	9	1	6
Total	375	69	433	61	401	67	470	46	624	111	664	135	647	180

District.	Aug.		Sept.		Oct.		Nov.		Dec.		Total, 1913.		Total, 1912.	
	Oil.	Dry.	Oil.	Dry.	Oil.	Dry.	Oil.	Dry.	Oil.	Dry.	Oil.	Dry.	Oil.	Dry.
Cherokee, deep	291	25	235	27	244	28	201	31	184	43	2,724	299	2,444	256
Cherokee, shallow	116	18	93	15	106	13	109	9	120	11	1,071	139	761	87
Creek	223	61	226	43	227	66	280	63	288	89	2,404	654	852	344
Cleveland	9	8	14	8	12	2	15	5	15	6	187	68	196	46
Osage	48	9	46	2	57	6	54	7	81	7	506	69	417	54
Ponca City	1	....	1	1	2	....	....	....	15	4	29	23	31	20
Carter County	1	....	3	....	3	....	3	1	4	2	15	5	......	......
Miscellaneous	2	9	8	1	5	10	7	6	2	3	29	51	11	36
Total	691	130	626	97	656	125	669	122	709	165	6,965	1,308	4,712	843

Number of oil wells drilled in Oklahoma in 1909–1913, by months.

Year.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Total.
1909	271	260	296	330	309	223	203	202	180	167	147	154	2,742
1910	208	240	271	293	321	311	237	248	242	292	310	215	3,188
1911	245	278	329	393	356	265	225	217	240	222	294	230	3,294
1912	135	269	288	388	386	495	458	430	427	456	506	474	4,712
1913	375	433	401	470	624	664	647	691	626	656	669	709	6,965

Number of dry holes drilled in Oklahoma, 1909–1913, by months.

Year.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Total.
1909	33	22	38	51	53	48	31	28	14	17	21	24	380
1910	25	48	41	41	36	40	31	17	50	28	28	23	408
1911	30	16	27	56	56	64	46	35	32	32	45	50	489
1912	28	61	46	77	77	86	70	62	70	97	100	69	843
1913	69	61	67	46	111	135	180	130	97	125	122	165	1,308

Total number of wells completed in Oklahoma, 1909–1913, by months. [a]

Year.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Total.
1909	310	288	345	388	374	279	243	239	205	198	200	210	3,279
1910	262	313	325	348	377	378	274	269	306	329	343	253	3,777
1911	290	309	375	479	436	364	313	275	301	275	367	303	4,087
1912	180	366	361	508	501	636	566	526	527	592	654	576	5,993
1913	483	520	492	548	793	885	884	864	775	830	846	931	8,851

[a] Including gas wells.

Initial daily production of new wells completed in Oklahoma in 1913, by districts and months, in barrels.

District.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Total, 1913.	Total, 1912.
Cherokee, deep	5,310	4,955	5,207	6,275	7,270	8,184	5,864	4,718	4,636	3,719	3,687	7,680	67,505	76,025
Cherokee, shallow	1,385	1,050	1,158	2,462	1,484	1,419	1,788	2,138	1,420	1,416	993	959	17,672	10,930
Creek	9,640	10,700	12,307	17,516	15,849	19,828	15,621	18,830	16,456	18,269	17,405	21,375	193,796	77,588
Cleveland	1,625	1,650	1,430	1,435	1,944	1,813	1,328	592	2,264	200	591	915	15,787	33,903
Osage	1,010	1,120	1,388	1,759	573	942	1,466	1,572	2,389	7,192	5,611	9,834	34,856	25,400
Ponca City	250	30	125	400	......	......	......	17	15	23	......	2,104	2,964	4,790
Carter County	......	......	......	......	......	2	......	15	45	48	480	254	844	......
Miscellaneous	......	......	......	......	19	4	4	15	42	86	444	12	626	250
Total	19,220	19,505	21,615	29,847	27,139	32,192	26,071	27,897	27,267	30,953	29,211	43,133	334,050	228,886

Total and average initial daily production of new wells in Oklahoma, 1909–1913, by districts, in barrels.

District.	Total initial production.					Average initial production per well.				
	1909	1910	1911	1912	1913	1909	1910	1911	1912	1913
Cherokee, deep	34,130	28,903	30,135	76,025	67,505	65.8	46.1	37.4	31.1	24.8
Cherokee, shallow	90,861	85,147	70,221	10,930	17,672	59.2	51.1	50.8	14.3	16.5
Creek	68,710	76,485	49,879	77,588	193,796	118.1	116.4	93.1	91.1	80.6
Cleveland	1,865	713	22,100	33,903	15,787	81.1	71.3	171.3	173.0	84.4
Osage	10,205	35,060	89,660	25,400	34,856	136.1	170.2	204.7	60.9	68.9
Ponca City	....	....	....	4,790	2,964	......	......	......	154.5	102.2
Carter County	....	....	....	....	844	......	......	......	......	56.3
Miscellaneous	680	330	338	250	626	85.0	14.3	84.5	22.7	21.6
Total	206,454	226,638	262,333	228,886	334,050	75.3	71.1	79.6	48.6	48.0

Total initial daily production of new wells in Oklahoma, 1909–1913, by months, in barrels.

Year.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Total.	Monthly average.
1909	21,745	21,820	21,220	20,910	21,020	18,120	16,350	15,480	14,190	11,683	12,225	11,691	206,454	17,205
1910	15,840	17,785	20,915	18,932	19,545	26,378	14,915	16,680	18,998	18,585	17,915	20,150	226,638	18,887
1911	23,366	23,615	40,539	30,440	28,190	23,970	16,255	12,121	14,709	18,165	17,223	13,740	262,333	21,861
1912	9,448	13,807	12,281	17,329	10,993	17,617	18,507	24,635	22,096	27,519	27,599	27,055	228,886	19,074
1913	19,220	19,505	21,615	29,847	27,139	32,192	26,071	27,897	27,267	30,953	29,211	43,133	334,050	27,838

GULF OIL FIELD.

GENERAL CONDITIONS.

This field includes the pools of southern Texas and southern Louisiana, because these oils are much alike in their composition and in the products which they yield. In fact, these oils, though occurring over a long stretch of territory, are more uniform in composition than those of the Mid-Continent field. The oil is an asphaltic oil, with some of the characteristics of the oil from Baku, Russia. The similarity of the oil in all the pools of the Gulf field is doubtless due to the fact that it all occurs under practically the same conditions in connection with salt domes, which are thus far peculiar to the Gulf region. This mode of accumulation is somewhat analogous to that of the pools associated with igneous masses near the Gulf coast in Mexico. This Gulf oil has been of great value from the time of its first discovery, serving first an important purpose in developing a cheap and very satisfactory fuel for railroads. It also developed manufacturing enterprises very rapidly in the Gulf region. Later it was found practicable to refine it, and also within recent years the asphalt itself has become valuable for roofing and street paving and the asphaltic oil as a binder in macadam roads. The heavier naphtha serves unusually well as a solvent, and the lubricants have obtained an enviable reputation for their excellence.

PRODUCTION.

This oil field entered into commerce in 1901, and reached its maximum in 1905 with 36,526,323 barrels for that year. Since that time it has declined, at first rapidly, then irregularly, until in 1913 it remained practically constant at 8,542,494 barrels. The price obtained in 1913 was the highest since this petroleum entered the general markets, amounting to $0.936 a barrel. The average price in 1901 was $0.175 a barrel. At the close of 1913 the tendency to drill deeper in connection with the various salt domes of the Gulf field had led to the finding of good gushers approaching in size those of the first days of the field and sufficient in number to increase production so as to reduce the price of crude oil and to indicate a return of the output in previous years. The number of oil wells drilled in the field has been remarkably constant since 1909, averaging slightly over 500 a year. The proportion of dry holes to productive wells was very large in 1913—312 dry holes were completed in that field.

Production of petroleum in the Gulf field in 1912 and 1913, by months, in barrels.

Month.	1912			1913		
	Coastal Texas.	Coastal Louisiana.	Total.	Coastal Texas.	Coastal Louisiana.	Total.
January	552,107	165,831	717,938	443,707	261,193	704,900
February	555,497	186,345	741,842	423,212	187,491	610,703
March	620,837	163,893	784,730	538,087	338,246	876,333
April	592,677	159,906	752,583	476,895	279,447	756,342
May	552,391	155,375	707,766	509,716	248,051	757,767
June	539,930	144,280	684,210	464,718	231,816	696,534
July	539,020	174,892	713,912	457,051	219,189	676,240
August	519,809	180,835	700,644	472,821	214,699	687,520
September	526,915	148,138	675,053	485,500	198,438	683,939
October	511,058	159,474	670,532	487,849	190,211	678,060
November	472,490	211,851	684,341	492,718	179,071	671,789
December	476,797	234,670	711,467	572,952	169,416	742,368
Total	6,459,528	2,085,490	8,545,018	5,825,226	2,717,268	8,542,494

Production of petroleum in the Gulf field, 1889–1913, in barrels.

Year.	Production.	Percentage of total production.	Increase (+) or decrease (−).	Percentage of increase (+) or decrease. (−)	Value.	Yearly average price per barrel.
1889	48				$340	$7.084
1890	54		+ 6	+ 12.50	229	4.204
1891	54				227	4.204
1892	45		− 9	− 16.67	225	5.000
1893	50		+ 5	+ 11.11	210	4.200
1894	60		+ 10	+ 20.00	300	5.000
1895	50		− 10	− 16.67	250	5.000
1896	50				250	5.000
1897	50				250	5.000
1898	1,450		+ 1,400	+2,800.00	7,250	5.000
1899	530		− 920	− 63.45	2,650	5.000
1900	0		− 530	− 100.00		
1901	3,593,113	5.18	+ 3,593,113		630,752	.175
1902	18,014,404	20.29	+14,421,291	+ 401.36	3,766,683	.209
1903	18,371,383	18.29	+ 356,979	+ 1.98	7,418,393	.411
1904	24,631,269	21.03	+ 6,259,886	+ 34.07	8,817,454	.357
1905	36,526,323	27.11	+11,895,054	+ 48.29	8,791,983	.240
1906	20,524,162	16.23	−16,002,161	− 43.81	9,380,691	.457
1907	16,360,299	9.85	− 4,163,863	− 20.29	13,704,469	.837
1908	15,772,137	8.83	− 588,162	− 3.60	9,511,007	.603
1909	10,883,240	5.94	− 4,888,897	− 30.00	7,872,686	.723
1910	9,680,465	4.62	− 1,202,775	− 11.05	7,383,571	.763
1911	10,999,873	4.99	+ 1,319,408	+ 13.63	7,355,681	.669
1912	8,545,018	3.83	− 2,454,855	− 22.32	6,344,173	.742
1913	8,542,494	3.44	− 2,524	− .03	7,993,997	.936
Total	202,446,620	6.60			98,193,619	.485

Production, value, and average price per barrel of petroleum produced in the Gulf field, 1904–1913, by years and States, in barrels.

Year.	Coastal Texas.			Coastal Louisiana.			Total.		
	Quantity.	Value.	Average price per barrel.	Quantity.	Value.	Average price per barrel.	Quantity.	Value.	Average price per barrel
1904....	21,672,311	$7,743,860	$0.357	2,958,958	$1,073,594	$0.363	24,631,269	$8,817,454	$0.357
1905....	27,615,907	7,190,658	.2603	8,910,416	1,601,325	.178	36,526,323	8,791,983	.240
1906....	11,449,992	5,825,036	.5087	9,074,170	3,555,655	.392	20,524,162	9,380,691	.457
1907....	11,410,078	9,680,286	.848	4,950,221	4,024,183	.813	16,360,299	13,704,469	.837
1908....	10,483,200	6,221,636	.593	5,288,937	3,289,371	.622	15,772,137	9,511,007	.603
1909....	8,852,527	6,399,318	.723	2,030,713	1,473,368	.725	10,883,240	7,872,686	.723
1910....	7,929,863	6,100,359	.769	1,750,602	1,283,212	.733	9,680,465	7,383,571	.763
1911....	7,275,281	5,340,592	.734	3,724,592	2,015,089	.541	10,999,873	7,355,681	.669
1912....	6,459,528	4,739,887	.734	2,085,490	1,604,286	.769	8,545,018	6,344,173	.742
1913....	5,825,226	5,550,408	.953	2,717,268	2,443,589	.899	8,542,494	7,993,997	.936

Production of petroleum in the Gulf field in 1912 and 1913, by States, showing increase or decrease and percentage of increase or decrease, in barrels.

State.	Production.		Increase.	Decrease.	Percentage.	
	1912	1913			Increase.	Decrease.
Coastal Texas	6,459,528	5,825,226		634,302		9.82
Coastal Louisiana	2,085,490	2,717,268	631,778		30.29	
Total	8,545,018	8,542,494		2,524		.03

Production of petroleum in the Gulf oil field, 1909–1913, by months and years, in barrels.

Month.	1909	1910	1911	1912	1913
January	1,095,522	776,908	1,080,926	717,938	704,900
February	982,903	711,583	1,280,144	741,842	610,703
March	1,014,107	790,178	1,283,975	784,730	876,333
April	900,502	746,059	1,004,704	752,583	756,342
May	933,618	771,995	985,075	707,766	757,767
June	873,221	757,875	848,610	684,210	696,534
July	900,630	814,933	822,501	713,912	676,240
August	866,806	844,980	777,506	700,644	687,520
September	816,868	803,947	750,862	675,053	683,938
October	825,307	864,183	758,321	670,532	678,060
November	833,310	847,080	671,778	684,341	671,789
December	840,446	950,744	735,471	711,467	742,368
Total	10,883,240	9,680,465	10,999,873	8,545,018	8,542,494

Average daily production of petroleum in the Gulf oil field each month, 1909–1913, by months and years, in barrels.

Month.	1909	1910	1911	1912	1913
January	35,339	25,062	34,869	23,159	22,739
February	35,104	25,414	45,719	25,581	21,811
March	32,714	25,490	41,419	25,314	28,269
April	30,017	24,869	33,490	25,086	25,211
May	30,117	24,903	31,777	22,831	24,445
June	29,107	25,263	28,287	22,807	23,218
July	29,053	26,288	26,532	23,029	21,814
August	27,961	27,257	25,081	22,601	22,178
September	27,229	26,798	25,029	22,502	22,798
October	26,623	27,877	24,462	21,630	21,873
November	27,777	28,236	22,393	22,811	22,393
December	27,111	30,669	23,725	22,951	23,947
Average	29,817	26,522	30,137	23,347	23,404

PIPE-LINE RUNS, DELIVERIES, AND STOCKS.

Pipe-line runs and deliveries of petroleum from the Gulf field, by months, in 1913, and stocks at end of each month, in barrels.

Month.	Runs.	Deliveries.	Stocks.
Dec 31, 1912	....	....	1,472,247
January	704,900	710,810	1,466,337
February	610,703	588,059	1,488,981
March	876,333	854,248	1,511,066
April	756,342	768,032	1,499,376
May	757,767	723,866	1,533,277
June	696,534	688,463	1,541,348
July	676,240	638,673	1,578,915
August	687,520	719,832	1,546,603
September	683,938	569,705	1,660,836
October	678,060	617,587	1,721,309
November	671,789	556,733	1,836,365
December	742,368	519,957	2,058,776
Total	8,542,494	7,955,965	....

PRICES.

The average monthly prices per barrel of petroleum at wells in the Gulf field in the years 1912 and 1913 were as follows:

Average monthly prices per barrel of petroleum in the Gulf field, 1912 and 1913.

1912.

Month.	Coastal Texas.			
	Batson.	Dayton.	Humble.	Saratoga.
January	$0.65-$0.72½	$0.67	$0.65 -$0.72½	$0.65-$0.72½
February	.70- .75	.70	.67½ - .75	.67½ - .75
March	.75	.70	.67 - 675	.67½ - .75
April	.75	.70	.67½ - .75	.67½ - .75
May	.75	.70	.67½ - .75	.67½ - .75
June	.75	.70	.67½ - .75	.67½ - .75
July	.75	.70	.75	.75
August	.75	.70	.75	.75
September	.75	.70	.75	.75
October	.75	....	.75	.75
November	.75	.70	.75	.75
December	.75	.70	.75	.75
Average	.741	.697	.718	.741

Month.	Coastal Texas.		Coastal Louisiana.	
	Sourlake.	Spindletop.	Jennings.	Vinton.
January	$0.65 -$0.67½	$0.70-$0.80	$0.625-$0.75	$0.500-$0.625
February	.67½- .72	.72- .80	.625- .80	.560- .625
March	.67½- .75	.75- .80	.625- .85	.560- .625
April	.67½- .75	.75- .80	.625- .85	.625- .650
May	.67½- .75	.80	.625- .85	.625- .650
June	.67½- .75	.80	.625- .90	.625- .700
July	.75	.80	.625- .90	.625- .700
August	.75	.80	.625- .90	.625- .700
September	.75	.80	.625- .90	.625- .750
October	.75	.80	.625- .92	.625- .750
November	.75	.80	.625- .92	.625- .750
December	.75	.80	.625- .92	.625- .750
Average	.745	.796	.876	.641

Average monthly prices per barrel of petroleum in the Gulf field, 1912 and 1913—Contd.

1913.

Month.	Coastal Texas.			
	Batson.	Dayton.	Humble.	Saratoga.
January	$0.75–$0.78	$0.75	$0.87½–$1.00	$0.87½–$1.00
February	.84	....	1.00	.96 – 1.00
March	.80– .87	.80	.95 – 1.00	.93 – 1.00
April	.80– .90	.80	.90 – 1.00	.90 – 1.00
May	.80– .91	.80	.90 – 1.00	.90 – 1.00
June	.80– .90	.80	.90 – 1.00	.90 – 1.00
July	.80– .94	.80	.90 – 1.00	.90 – 1.00
August	.80– .99	.80	.90 – 1.00	.90 – 1.00
September	.80– .99	.80	.90 – 1.00	.90 – 1.00
October	.80– .99	.80	.90 – 1.00	.90 – 1.00
November	.80– 1.00	.80	.90 – 1.00	.90 – 1.00
December	.80– 1.00	.80	.90 – 1.00	.90 – 1.00
Average	.904	.797	.965	.913

Month.	Coastal Texas.		Coastal Louisiana.	
	Sourlake.	Spindletop.	Jennings.	Vinton.
January	$0.87½–$1.08	$0.84–$0.92½	$0.78–$0.90	$0.73 –$0.90
February	1.00 – 1.08	.98– 1.05	.90– .95	.86 – .90
March	.95 – 1.08	1.00– 1.02	.90– 1.00	.86 – .90
April	.90 – 1.08	.95– 1.06	.90– 1.00	.87 – .90
May	.90 – 1.08	.95– 1.06	.90– 1.00	.87 – .90
June	.90 – 1.08	.95– 1.04	.90– 1.00	.87 – .90
July	.90 – 1.08	.95– 1.04	.90– 1.02	.87½– .90
August	.90 – 1.08	.95– 1.03	.90– 1.00	.87 – .90
September	.90 – 1.08	.95– 1.03	.90– 1.00	.88 – .90
October	.90 – 1.08	.95– 1.04	.90– 1.00	.87 – .90
November	.90 – 1.08	.95– 1.04	.90– 1.00	.87 – .90
December	.90 – 1.06	.95– 1.04	.90– 1.00	.88 – .90
Average	1.000	1.000	.974	.869

WELL RECORD.

Number of wells completed in the Gulf field, 1909–1913, by districts.

District.	Oil.					Dry.					Total completed.[a]				
	1909	1910	1911	1912	1913	1909	1910	1911	1912	1913	1909	1910	1911	1912	1913
Coastal Texas	368	365	352	353	325	161	116	117	109	255	538	481	502	462	592
Coastal Louisiana	34	32	63	59	81	28	10	32	25	57	62	42	112	84	139
Total	402	397	415	412	406	189	[a]126	149	134	312	600	523	614	546	731

[a] Including gas wells.

Number of oil wells and dry holes drilled in the Gulf field in 1913, by districts and months.

District.	Jan.		Feb.		Mar.		Apr.		May.		June.		July.		Aug.		Sept.		Oct.		Nov.		Dec.		Total, 1913.		Total, 1912.	
	Oil.	Dry.	Oil.	Dry.	Oil.	Dry.	Oil.	Dry.	Oil.	Dry.	Oil.	Dry.	Oil.	Dry.	Oil.	Dry.	Oil.	Dry.	Oil.	Dry.	Oil.	Dry.	Oil.	Dry.	Oil.	Dry.	Oil.	Dry.
Coastal Texas	26	6	25	18	32	16	33	30	20	15	31	31	36	27	31	30	25	20	23	21	19	16	24	25	325	255	353	109
Coastal Louisiana	5	3	5	7	11	..	9	15	6	1	9	10	12	6	12	4	4	2	4	1	2	1	2	7	81	57	59	25
Total	31	9	30	25	43	16	42	45	26	16	40	41	48	33	43	34	29	22	27	22	21	17	26	32	406	312	412	134

Number of oil wells drilled in the Gulf field, 1909–1913, by months.

Year.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Total.
1909	30	40	36	33	36	24	35	35	30	21	30	18	a 402
1910	41	22	43	29	30	26	35	28	25	29	31	26	a 397
1911	26	35	29	30	31	58	40	24	19	16	20	24	a 415
1912	16	44	39	47	29	30	28	35	34	40	43	27	412
1913	31	30	43	42	26	40	48	43	29	27	21	26	406

a Coastal Louisiana not given by months.

Number of dry holes drilled in the Gulf field, 1909–1913, by months.

Year.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Total.
1909	18	11	18	16	16	11	10	17	15	16	8	14	a 198
1910	14	16	9	11	20	11	11	10	7	1	3	3	a 126
1911	15	10	17	14	10	17	11	......	......	9	9	5	b 149
1912	8	9	8	15	14	14	9	12	14	13	8	10	c 134
1913	9	25	16	45	16	41	33	34	22	22	17	32	c 312

a Coastal Louisiana not given by months; including gas wells.
b Coastal Louisiana not given by months.
c Not including gas wells.

Total number of wells completed in the Gulf field, 1909–1913, by months. [a]

Year.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Total.
1909	48	51	54	49	52	35	45	52	45	37	38	32	b 600
1910	55	38	52	40	50	37	46	38	32	30	34	29	b 523
1911	41	46	46	44	41	76	51	41	33	25	29	29	b 614
1912	24	53	47	62	43	44	37	47	48	53	51	37	546
1913	42	56	60	90	46	84	81	77	51	49	37	58	731

a Including gas wells.
b Coastal Louisiana not given by months.

Initial daily production of new wells completed in the Gulf field in 1913, by districts and months, in barrels.

District.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug	Sept.	Oct.	Nov.	Dec.	Total, 1913.	Total, 1912.
Coastal Texas	1,147	3,652	10,936	2,305	5,595	3,195	1,335	1,147	1,757	2,186	1,016	4,707	38,978	33,082
Coastal Louisiana	14,565	795	16,635	7,995	2,740	2,330	2,940	3,437	330	1,273	50	2,650	55,740	25,520
Total	15,712	4,447	27,571	10,300	8,335	5,525	4,275	4,584	2,087	3,459	1,066	7,357	94,718	58,602

Total and average initial daily production of new wells in the Gulf field, 1909–1913, by districts, in barrels.

District.	Total initial production.					Average initial production per well.				
	1909	1910	1911	1912	1913	1909	1910	1911	1912	1913
Coastal Texas	33,300	63,283	32,740	33,082	38,978	89.7	173.5	93.0	93.7	119.9
Coastal Louisiana	12,700	15,230	74,145	25,520	55,740	373.5	475.9	1,176.9	432.5	618.1
Total	46,000	78,513	106,885	58,602	94,718	114.4	197.8	257.6	142.2	233.3

Total initial daily production of new wells in the Gulf field, 1909–1913, by months, in barrels.

Year.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Total.	Monthly average.
1909	2,180	4,160	3,155	2,577	3,090	2,520	4,615	3,285	2,955	1,459	2,334	970	a46,000	3,833
1910	3,048	3,135	1,150	5,540	2,935	4,457	8,570	3,940	3,500	4,590	13,835	8,583	a78,513	6,543
1911	5,970	5,890	2,115	6,380	1,561	3,455	2,708	935	1,355	772	619	980	a106,885	8,907
1912	2,670	5,690	4,679	3,885	2,030	2,575	7,475	3,313	12,045	1,170	7,779	5,291	58,602	4,884
1913	15,712	4,447	27,571	10,300	8,335	5,525	4,275	4,584	2,087	3,459	1,066	7,357	94,718	7,893

a Coastal Louisiana not given by months.

TEXAS.

DEVELOPMENT.

Two new fields were opened up during the year. One at Moran, Shackelford County, in the northern Texas oil region, and the other in the Gulf region in Orange County.

Electra.—There was considerable extension of the Electra field to the southeast and considerable successful drilling in the neighborhood of Burkburnett in the same county, and also patient prospecting over rather large areas in the old Petrolia region. As a result, the production in the northern Texas field increased very steadily and resulted in a total yield for the State of 15,009,478 barrels, an increase of 3,274,421 barrels over 1912.

Moran.—The existence of natural gas in paying quantities has been known in Shackelford County for years. At the beginning of the year 1913, the Texas Co. was drilling several tests in the neighborhood of Moran, including No. 1 Blackstock, a short distance northeast of Moran, in sec. 56; No. 1 Wild in sec. 65, 1 mile south of Moran; No. 2 Elliott, 2 miles south of Moran; and No. 1 Freeman, about 1 mile south of Moran.

In January, the Texas Co. brought in a gas well yielding 4,000,000 cubic feet in the southwestern part of Throckmorton County, 15 miles north of Albany and at a depth reported as 1,060 feet. This well is located on a lease of some 80,000 acres. Similar leases chiefly controlled by the larger companies characterize the region, which will therefore probably be drilled carefully and with the view to the greatest conservation of the oil and gas. With gas thus found in the neighborhood of Moran and 35 miles to the northwest, a considerable inducement was offered for further wildcatting, although the wells in the neighborhood of Moran required drilling to below 2,000 feet.

The well referred to above as No. 1 Wild, sec. 65, came in making 20 to 30 barrels of oil a day, which quantity gradually increased to 40 and 50 barrels, with the result that all land in this neighborhood was leased with very considerable bonuses. A second well, the No. 1 Edward, yielded 100 to 200 barrels of the light oil (35° B. gravity) characteristic of northern Texas, at a depth of over 2,500 feet. The excitement continued and active drilling in the region extended to Stephens County. At the end of the year it was evident that a new oil field had been developed.

Orange County.—Seepages of natural gas in the Cow Bayou region of Orange County near the Louisiana line have attracted the attention of drillers for several years, and in January, 1913, the Terry Oil Co. drilled 6 miles west of Terry, Orange County, 2,000 feet; at that depth the well was lost after having shown much natural gas. No. 2 was drilled 400 feet away and by June had begun to show much gas at 800 feet. In the meantime the Rio Bravo Oil Co. acquired a leasehold and, after persistent drilling, obtained a good well of the usual character of the Gulf oil, at a depth of over 3,000 feet. It started at 180 barrels a day and settled to 100 barrels. The considerable depth of the wells rendered drilling slow, but it is evident that a field will eventually be developed.

Sourlake.—At the beginning of March, 1913, the Texas Co.'s well No. 196, about the center of the field, which had been a small producer in the sand at 900 feet, was deepened to 1,200 feet and immediately increased its production to 6,000 barrels a day. This declined to a final yield of 900 barrels at the end of the month. Drilling, of course, became active in all the Gulf pools with such generally successful results as to increase the supply of Gulf oil and to decrease the price of oil.

Toyah.—Drilling was active in the region west of Pecos River in Reeves County three years ago and developed the fact that, although very small wells of thick petroleum can be obtained at a depth of less than 200 feet on the Ross property, some 17 miles west of north of Toyah station, the efforts to secure oil at a greater depth were only successful in one well, in which oil slightly lighter in gravity and containing more sulphur was found by the Producers Oil Co. None of the wells drilled in this region succeeded in getting through the thick beds of gypsum and certainly did not reach the cavernous limestone which outcrops a few miles west of Rustler Springs in Culberson County. During the year 1913, one deep well was drilled near Pedrigan Springs, 9 miles west of Toyah station. The drilling was chiefly in gypsum, but shale is reported in the gypsum at the bottom of the well, and from this shale some oil seeps in. Other deep-drilling tests have encouraged the reexamination of the field by the Producers Oil Co. and others, so that the leasing has been very active, and it is probable that the field will receive a thorough test during 1914. Many of these leases are located on land concerning which the mineral title was in doubt. During the year suit was brought in the Texas Supreme Court against the Texas Land Commissioner by owners of the surface rights in the Toyah region to mandamus the land commissioner to release the minerals to the owner of the surface rights, upon such land as had been patented by the State since the passage of the act of 1907, under which the mineral rights had been reserved to the State on a large portion of the land in West Texas. The position of the State of Texas was sustained as to the reservation of the mineral rights. While this was a disappointment to the holders of surface rights, it has not deterred the investment of both California and eastern capital in lands between the oil seepages in Reeves County and the outcrops of oil-bearing limestone in Culberson County.

PRODUCTION.

The production of petroleum in Texas from 1904 to 1913, inclusive, has been as follows:

Production of petroleum in Texas, 1904–1913, by districts, in barrels.

Year.	Northern Texas.						Coastal Texas.			
	Corsicana.	Henrietta.	Powell.	Marion County.	Electra.	Total.[a]	Batson.	Dayton.	Goose Creek.	Humble.
1904...	374,318	65,455	129,329			569,252	10,904,737			
1905...	311,554	75,592	132,866			520,282	3,774,841	60,294		15,594,310
1906...	332,622	111,072	673,221			1,117,905	2,289,507	92,850		3,571,445
1907...	226,311	83,260	596,897			912,618	2,164,453	108,038		2,929,640
1908...	211,117	85,963	421,659			723,264	1,593,570	39,901		3,778,521
1909...	180,764	113,485	383,137			681,940	1,206,214	17,647		3,237,060
1910...	137,331	126,531	450,188	251,717		969,403	1,113,767	9,582		2,495,511
1911...	128,526	168,965	373,055	677,689	899,579	2,251,193	1,023,493	4,344		2,426,220
1912...	233,282	197,421	251,240	362,870	4,227,104	5,275,529	844,563	12,151	43,898	1,829,923
1913...	158,830	344,868	282,476	262,392	8,131,624	9,184,252	741,350	13,329	249,641	1,504,880

Year.	Coastal Texas—Continued.							Total.
	Matagorda County.	Orange County.	Saratoga.	Sourlake.	Spindletop.	Other.	Total.	
1904....	151,936		739,239	6,442,357	3,433,842	[b] 50	21,672,161	22,241,413
1905....	46,471		3,125,028	3,362,153	1,652,780	[b] 30	27,615,907	28,136,189
1906....	3,600		2,182,057	2,156,010	1,077,492	77,031	11,449,992	12,567,897
1907....	1,573		2,130,928	2,353,940	1,699,943	21,563	11,410,078	12,322,696
1908....	62,640		1,634,786	1,595,060	1,747,537	31,185	10,483,200	11,206,464
1909....	29,103		1,183,559	1,703,798	1,388,107	87,039	8,852,527	9,534,467
1910....	455,999		1,024,348	1,518,723	1,182,436	129,497	7,929,863	8,899,266
1911....	561,828		925,777	1,364,880	965,939	2,800	7,275,281	9,526,474
1912....	613,292		1,116,655	1,175,108	822,916	1,022	6,459,528	11,735,057
1913....	294,553	17,706	937,720	1,348,053	716,374	1,620	5,825,226	15,009,478

[a] Includes other districts of northern Texas. [b] Bexar County.

Production and value of petroleum in northern and coastal Texas, 1904–1913, in barrels.

Year.	Northern Texas.		Coastal Texas.		Total.	
	Quantity.	Value.	Quantity.	Value.	Quantity.	Value.
1904	569,102	$412,360	21,672,311	$7,743,860	22,241,413	$8,152,220
1905	520,282	361,604	27,615,907	7,190,658	28,136,187	7,552,262
1906	1,117,905	740,542	11,449,992	5,825,036	12,567,897	6,565,578
1907	912,618	721,577	11,410,078	9,680,286	12,322,696	10,401,863
1908	723,264	479,072	10,483,200	6,221,636	11,206,464	6,700,708
1909	681,940	393,732	8,852,527	6,399,318	9,534,467	6,793,050
1910	969,403	505,396	7,929,863	6,100,359	8,899,266	6,605,755
1911	2,251,193	1,213,960	7,275,281	5,340,592	9,526,474	6,554,552
1912	5,275,529	4,112,826	6,459,528	4,739,887	11,735,057	8,852,713
1913	9,184,252	9,125,185	5,825,226	5,550,408	15,009,478	14,675,593

The following table gives a statement of the production and value of petroleum at wells in Texas in 1912 and 1913, by districts:

Production and value of petroleum in Texas in 1912 and 1913, by districts, in barrels, with increase or decrease, in barrels, and percentage of increase or decrease.

	1912			1913			Increase (+) or decrease (−).	Percentage of increase (+) or decrease (−).
	Quantity.	Value.	Average price per barrel.	Quantity.	Value.	Average price per barrel.		
Northern Texas:								
Corsicana	233,282	$149,393	$0.640	158,830	$156,844	$0.987	− 74,452	− 31.92
Henrietta	197,421	134,681	.682	344,868	342,783	.994	+ 147,447	+ 74.69
Powell	251,240	193,439	.769	282,476	216,402	.766	+ 31,236	+ 12.43
Electra	4,227,104	3,340,828	.790	8,131,624	8,142,797	1.001	+3,904,520	+ 92.37
Marion County	362,870	290,974	.802	262,392	261,965	.998	− 100,478	− 27.69
Other	3,612	3,511	.972	4,062	4,394	1.081	+ 450	+ 12.40
Total	5,275,529	4,112,826	.779	9,184,252	9,125,185	.994	+3,908,723	+ 74.08
Coastal Texas:								
Batson	844,563	625,812	.741	741,350	670,323	.904	− 103,213	− 12.22
Dayton	12,151	8,473	.697	13,329	10,633	.797	+ 1,178	+ 9.69
Goose Creek	43,898	27,791	.633	249,641	206,311	.826	+ 205,743	+468.68
Humble	1,829,923	1,313,229	.718	1,504,880	1,453,158	.965	− 325,043	− 17.76
Matagorda County	613,292	406,032	.662	294,553	266,338	.904	− 318,739	− 51.97
Orange County	....	....	....	17,706	19,123	1.080	+ 17,706	....
Saratoga	1,116,655	827,847	.741	937,720	855,935	.913	− 178,935	− 16.02
Sourlake	1,175,108	874,897	.745	1,348,053	1,350,379	1.000	+ 172,945	+ 14.72
Spindletop	822,916	654,778	.796	716,374	716,993	1.000	− 106,542	− 12.95
Other	1,022	1,028	1.000	1,620	1,215	.75	+ 598	+ 58.51
Total	6,459,528	4,739,887	.934	5,825,226	5,550,408	.953	− 634,302	− 9.82
Total Texas	11,735,057	8,852,713	.754	15,009,478	14,675,593	.978	+3,274,421	+ 27.90

In the following table will be found the production of petroleum in Texas, by districts and months, for the years 1912 and 1913:

Production of petroleum in Texas, 1912–1913, by districts and months, in barrels.

1912.

Month.	Northern Texas.							Coastal Texas.
	Corsicana.	Henrietta.	Powell.	Electra.	Marion County.	Other.[a]	Total.	Batson.
January	16,473	12,758	21,826	225,264	35,724	274	312,319	77,397
February	30,088	12,213	20,770	206,340	34,685	301	304,397	69,976
March	22,277	13,999	21,393	290,415	35,580	302	383,966	78,339
April	24,040	14,275	21,713	300,154	33,839	306	394,327	76,695
May	20,309	16,689	21,892	377,143	33,467	302	469,802	71,527
June	17,545	16,929	20,146	342,186	30,859	302	427,967	73,095
July	20,944	16,210	22,584	369,575	29,084	304	458,701	66,654
August	17,652	15,840	19,944	373,123	27,669	305	454,533	70,107
September	16,143	18,157	19,991	384,807	25,639	302	465,039	67,929
October	17,034	21,679	20,306	450,549	26,046	305	535,919	68,409
November	15,286	18,362	19,876	450,856	25,098	305	529,783	62,671
December	15,491	20,310	20,799	456,692	25,180	304	538,776	61,764
Total	233,282	197,421	251,240	4,227,104	362,870	3,612	5,275,529	844,563

[a] Includes small production in South Bosque, and Brown, McCulloch, and McMullen counties.

Production of petroleum in Texas, 1912–1913, by districts and months, in barrels—Con.

1912—Continued.

Month.	Coastal Texas.							Total.
	Humble.	Matagorda County.	Saratoga.	Sour-lake.	Spindle-top.	Other.[a]	Total.	
January	180,417	32,393	88,474	107,228	61,176	5,022	552,107	864,426
February	164,522	68,813	90,019	95,330	61,939	4,898	555,497	859,894
March	186,815	89,844	92,735	104,015	64,029	5,060	620,837	1,004,803
April	166,953	80,890	85,886	102,972	74,861	4,420	592,677	987,004
May	174,039	52,862	87,067	98,812	63,420	4,664	552,391	1,022,193
June	156,489	59,212	87,628	90,352	68,212	4,942	539,930	967,897
July	168,763	48,948	80,163	99,949	70,004	4,539	539,020	997,721
August	147,353	40,446	94,133	96,481	66,317	4,972	519,809	974,342
September	132,775	37,663	118,046	96,650	68,921	4,931	526,915	991,954
October	122,828	38,057	109,382	96,087	72,431	3,864	511,058	1,046,977
November	115,014	30,868	92,093	92,060	74,127	5,657	472,490	1,002,273
December	113,955	33,296	91,029	95,172	77,479	4,102	476,797	1,015,573
Total	1,829,923	613,292	1,116,655	1,175,108	822,916	57,071	6,459,528	11,735,057

[a] Includes Dayton, Goose Creek, and Duval and Brewster counties.

1913.

Month.	Northern Texas.							Coastal Texas.	
	Corsicana.	Henrietta.	Powell.	Electra.	Marion County.	Other.[a]	Total.	Batson.	Goose Creek.
January	13,889	21,479	22,649	482,240	23,035	337	563,629	58,910	17,655
February	13,288	20,305	21,763	460,133	21,954	337	537,780	56,856	14,184
March	14,662	30,059	23,409	535,524	22,651	337	626,642	62,157	15,857
April	14,243	27,693	23,797	557,094	23,794	337	646,958	61,136	16,341
May	13,779	32,626	24,156	613,602	22,808	337	707,308	64,101	27,341
June	16,788	28,187	23,791	682,831	22,570	342	774,509	59,889	23,275
July	12,873	30,027	24,415	759,961	21,095	343	848,714	60,370	20,120
August	12,942	30,660	23,868	771,300	24,050	337	863,157	67,842	22,832
September	11,707	34,428	24,336	796,213	20,302	338	887,324	64,575	21,987
October	15,185	32,424	23,692	844,934	19,864	339	936,438	59,565	23,592
November	9,119	29,108	25,019	820,887	21,456	339	905,928	64,343	24,084
December	10,355	27,872	21,581	806,905	18,813	339	885,865	61,606	22,373
Total	158,830	344,868	282,476	8,131,624	262,392	4,062	9,184,252	741,350	249,641

Month.	Coastal Texas.								Total.
	Humble.	Matagorda County.[b]	Orange County.	Saratoga.	Sour-lake.	Spindle-top.	Other.[c]	Total.	
January	109,033	32,489	....	83,260	69,207	72,623	530	443,707	1,007,336
February	100,245	27,004	....	72,611	86,503	65,674	135	423,212	960,992
March	112,188	30,142	....	80,724	165,667	70,669	683	538,087	1,164,729
April	114,376	30,334	....	79,582	107,113	66,847	1,166	476,895	1,123,853
May	110,053	30,085	....	83,124	130,661	63,123	1,228	509,716	1,217,024
June	119,628	24,594	....	78,324	100,079	58,483	446	464,718	1,239,227
July	115,553	23,526	....	79,914	97,125	59,976	467	457,051	1,305,765
August	120,080	21,478	1,848	79,633	101,322	56,685	1,101	472,821	1,335,978
September	133,172	20,984	3,013	76,768	115,488	46,297	3,216	485,500	1,372,824
October	135,214	18,766	2,578	78,547	116,143	51,196	2,248	487,849	1,424,281
November	136,405	17,572	6,694	73,851	116,350	51,773	1,646	492,718	1,398,646
December	198,933	17,579	3,573	71,382	142,395	53,028	2,083	572,925	1,458,817
Total	1,504,880	294,553	17,706	937,720	1,348,053	716,374	14,949	5,825,226	15,009,478

[a] Includes Archer, Coleman, Brown, McCulloch, and McLennan counties.
[b] Markham and Big Hill.
[c] Includes Duval County and Dayton.

RAILROAD SHIPMENTS.

In the following table is given the shipments of petroleum by railroad in tank cars from the different stations of Texas during the years 1912 and 1913:

Quantity of petroleum shipped by railroad in tank cars from the oil fields of Texas, at the stations named, by months, during the years 1912 and 1913, in barrels.

1912.

Month.	Electra.	Beaumont, Guffey.	Corsicana.	Danbury, Markham, Christine, Noledo.	Houston (Trice).	Humble.	Saratoga.	Sour-lake.	Petrolia.	Total.
January	35,712	158,269	4,905	12,206	129,446	109,715	1,396	9,440	7,345	468,434
February	24,324	95,118	4,905	22,940	107,094	51,579	450	15,358	8,540	330,308
March	59,464	113,527	4,905	24,309	71,185	60,943	1,673	7,830	9,049	352,885
April	35,560	109,308	4,905	27,860	50,072	60,356	450	18,941	3,938	311,390
May	98,265	136,840	4,905	16,792	61,616	50,737	450	32,191	3,105	404,901
June	35,063	122,149	4,905	29,095	90,889	53,337	....	29,854	300	365,592
July	21,959	105,453	4,905	17,360	118,665	54,635	676	23,239	....	346,892
August	14,439	101,445	4,906	10,680	111,970	60,333	1,351	....	....	305,124
September	17,164	69,808	4,906	13,928	115,122	45,744	2,252	8,305	....	227,229
October	18,570	130,320	4,906	12,384	104,225	50,156	1,126	15,212	....	336,899
November	13,115	57,840	4,906	7,588	85,200	44,385	1,802	71,007	....	285,843
December	19,029	59,513	4,906	8,480	82,323	18,300	1,808	110,090	....	304,449
Total	392,664	1,259,590	58,865	203,622	1,127,807	660,220	13,434	341,467	32,277	4,089,946

1913.

Month.	Electra, Iowa Park, Petrolia.	Beaumont, Guffey.	Corsicana.[a]	Markham, Noledo.	Houston (Trice).	Humble.	Saratoga.	Sour-lake.	Total.
January	18,706	46,527	6,962	4,420	44,263	16,735	1,834	10,587	150,034
February	32,748	70,830	6,962	5,571	10,143	45,155	450	19,540	191,399
March	24,436	14,748	6,962	3,095	10,100	24,585	225	12,638	96,789
April	42,708	22,348	6,962	4,670	10,479	22,722	679	23,398	133,966
May	57,919	19,557	6,962	8,048	19,545	24,821	1,350	77,144	215,346
June	40,602	43,141	6,962	11,122	22,420	17,608	....	29,720	171,575
July	31,601	10,476	6,962	6,810	44,327	19,221	....	32,740	152,137
August	27,352	7,349	6,962	5,571	71,358	11,307	....	15,240	145,139
September	36,181	5,594	6,963	4,454	58,094	7,135	....	31,327	149,748
October	57,302	27,729	6,963	6,345	44,256	7,461	....	22,771	172,827
November	99,071	20,916	6,963	4,952	50,464	8,779	1,125	29,863	222,133
December	84,299	36,576	6,963	3,250	56,982	8,323	....	5,977	202,370
Total	552,925	325,791	83,548	68,308	442,431	213,852	5,663	310,945	2,003,463

[a] Averaged.

WELL RECORD.

Drilling was unusually active in 50 counties of Texas. In all 1,391 wells were drilled, 592 in the Gulf region and 799 in northern Texas. In the Electra field, 311 oil wells were obtained and only 63 dry holes; at Burkburnett 89 wells were drilled, 24 of which were dry. In Clay County, out of 171 wells 45 were dry. Outside of Wichita, Clay, Navarro, and Marion Counties, drilling in northern Texas was practically all of the wildcat order, that is, of the 166 wells drilled, 156 were dry and only 5 oil wells and 5 gas wells were obtained. In northern Texas this wildcatting was carried on in the following counties: Archer, Baylor, Brown, Callahan, Coleman, Hall, Jack, McCulloch, Shackelford, Stephens, Throckmorton, Titus, Wilbarger, Wilson, Wise, and Young. In coastal Texas, drilling was also very active, and fairly satisfactory results were obtained in the old fields; but from 62 wells drilled in wildcat territory only 5 oil wells and 5 gas wells were obtained. Besides various attempts at wildcatting in other regions, wells were actually completed in the following counties of coastal Texas: Angelina, Atascosa, Bee, Bexar, Brazoria, Brazos, Brown, Chambers, Comanche, Eastland, Erath, Franklin, Freestone, Gonzales, Hardin, Harris, Houston, Jefferson, Liberty, Limestone, Madison, Matagorda, Montgomery, Orange, Polk, Sabine, Shelby, Tyler, and Willacy.

WELL RECORD IN NORTHERN TEXAS.

The following tables give the well record in northern Texas from 1909 to 1913, inclusive:

Number of wells completed in northern Texas, 1909–1913, by districts.

District.	Oil.					Dry.					Total completed.[a]				
	1909	1910	1911	1912	1913	1909	1910	1911	1912	1913	1909	1910	1911	1912	1913
Corsicana	4	17	20	17	3	1	10	19	7	1	5	27	39	24	4
Electra	.....	.....	51	259	[b]435	.....	.....	1	66	[b]125	.....	.....	53	326	[b]561
Henrietta	20	35	7	6	122	15	37	9	10	45	46	72	19	20	171
Marion County	.....	.....	6	3	16	.....	.....	9	7	6	.....	.....	15	10	22
Powell	87	56	.....	.....	.....	28	35	.....	.....	.....	118	91	.....	.....	.....
South Bosque	1	.....	.....	.....	.....	1	.....	.....	.....	.....	2	.....	.....	.....	.....
Other	4	.....	.....	14	5	.....	.....	.....	34	31	4	.....	.....	54	41
Total	116	108	84	299	581	45	[a]82	38	124	208	175	190	126	434	799
Coastal Texas	368	365	352	353	325	161	116	117	109	255	538	481	502	462	592
Total Texas	484	473	436	652	906	206	198	155	233	463	713	671	628	896	1,391

[a] Including gas wells. [b] Including other districts in Wichita County.

Number of oil wells and dry holes drilled in northern Texas in 1913, by districts and months.

District.	Jan.		Feb.		Mar.		Apr.		May.		June.		July.		Aug.		Sept.		Oct.		Nov.		Dec.		Total, 1913.		Total, 1912.	
	Oil.	Dry.	Oil.	Dry.	Oil.	Dry.	Oil.	Dry.	Oil.	Dry.	Oil.	Dry.	Oil.	Dry.	Oil.	Dry.	Oil.	Dry.	Oil.	Dry.	Oil.	Dry.	Oil.	Dry.	Oil.	Dry.	Oil.	Dry.
Corsicana	3	1	...	..	...	..	...	..	...	..	...	..	...	..	...	..	...	..	...	..	...	..	...	..	3	1	17	7
Electra [a]	29	16	23	17	22	6	28	7	33	8	30	8	30	9	47	7	41	9	44	9	65	22	43	7	435	125	259	66
Henrietta	5	1	8	5	11	5	25	6	24	7	21	7	15	6	8	5	...	..	3	..	1	1	1	2	122	45	6	10
Marion County	...	..	...	..	1	..	...	..	...	..	10	2	2	..	1	1	...	..	1	1	1	1	...	1	16	6	3	7
Other	1	9	...	3	1	1	2	3	...	3	...	2	...	2	...	7	...	..	...	..	1	1	...	..	5	31	14	34
Total	38	27	31	25	35	12	55	16	57	18	61	19	47	17	56	20	41	9	48	10	68	25	44	10	581	208	299	124
Coastal Texas	26	6	25	18	32	16	33	30	20	15	31	31	36	27	31	30	25	20	23	21	19	16	24	25	325	255	353	109
Total Texas	64	33	56	43	67	28	88	46	77	33	92	50	83	44	87	50	66	29	71	31	87	41	68	35	906	463	652	233

[a] Includes in 1913 other districts in Wichita County.

Number of oil wells drilled in northern Texas, 1909–1913, by months.

Year.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Total.
1909	......	2	......	4	18	15	17	7	12	10	20	6	[a]116
1910	([b])	20	13	20	10	12	8	6	11	2	5	1	108
1911	2	7	4	13	1	......	7	3	9	7	12	19	84
1912	4	21	22	33	38	12	20	34	22	44	22	27	299
1913	38	31	35	55	57	61	47	56	41	48	68	44	581

[a] South Bosque not reported by months. [b] No record.

Number of dry holes drilled in northern Texas, 1909–1913, by months.

Year.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Total.
1909	6	2	......	4	4	5	4	4	7	4	11	7	[b] 59
1910	([a])	6	6	9	5	8	14	6	10	6	7	5	[b] 82
1911	7	8	5	8	2	......	2	3	......	......	1	2	[c] 38
1912	......	3	8	8	11	19	12	18	8	10	19	8	[c] 124
1913	27	25	12	16	18	19	17	20	9	10	25	10	[c] 208

[a] No record. [b] Including gas wells. [c] Not including gas wells.

Total number of wells completed in northern Texas, 1909–1913, by months.

Year.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Total.
1909	6	4	......	8	22	20	21	11	19	14	31	13	[a] 175
1910	([b])	26	19	29	15	20	22	12	21	8	12	6	190
1911	9	15	10	22	3	......	10	6	9	7	14	21	126
1912	4	24	31	44	49	31	32	53	32	55	42	37	434
1913	66	57	47	73	76	80	66	77	50	59	93	55	799

[a] South Bosque not reported by months. [b] No record.

Initial daily production of new wells completed in northern Texas in 1913, by districts and months, in barrels.

District.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Total, 1913.	Total, 1912.
Corsicana	12	......	......	......	......	......	......	......	......	......	......	......	12	108
Electra [a]	2,662	3,076	2,702	1,800	5,585	5,428	6,282	4,482	5,605	4,740	4,436	2,488	49,286	26,932
Henrietta	47	290	252	105	673	122	349	26	......	302	500	10	2,676	315
Marion County	......	......	30	......	......	4,170	760	85	......	50	155	......	5,250	198
Other	5	......	2	4	......	......	......	......	......	......	200	......	211	660
Total	2,726	3,366	2,986	1,909	6,258	9,720	7,391	4,593	5,605	5,092	5,291	2,498	57,435	28,213
Coastal Texas	1,147	3,652	10,936	2,305	5,595	3,195	1,335	1,147	1,757	2,186	1,016	4,707	38,978	33,082
Total Texas	3,873	7,018	13,922	4,214	11,853	12,915	8,726	5,740	7,362	7,278	6,307	7,205	96,413	61,295

[a] Includes in 1913 other districts in Wichita County.

Total and average initial daily production of new wells in northern Texas, 1909–1913, by districts, in barrels.

District.	Total initial production.					Average initial production per well.				
	1909	1910	1911	1912	1913	1909	1910	1911	1912	1913
Corsicana	25	54	107	108	12	6.2	3.2	5.4	6.4	4.0
Electra	......	......	15,550	26,932	[a]49,286	......	......	304.9	104.0	113.3
Henrietta	484	1,331	69	315	2,676	24.2	38.0	9.9	52.5	21.9
Marion County	......	......	3,454	198	5,250	......	......	575.7	66.0	328.1
Powell	668	298	......	......	......	7.8	5.3	......	......	......
Other	......	......	......	660	211	......	......	......	47.1	42.2
Total	1,177	1,683	19,180	28,213	57,435	10.8	15.6	228.3	94.3	98.9
Coastal Texas	33,300	63,283	32,740	33,082	38,978	89.7	173.5	93.0	93.7	119.9
Total Texas	34,477	64,966	51,920	61,295	96,413	71.2	137.3	119.1	94.0	106.4

[a] Includes other districts in Wichita County.

Total initial daily production of new wells in northern Texas, 1909–1913, by months, in barrels.

Year.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Total.	Monthly average.
1909	0	50	0	45	117	133	227	73	74	154	248	56	1,177	98
1910	(a)	210	77	83	43	1,044	54	26	50	9	62	25	1,683	140
1911	4	3,265	12	567	200	......	428	450	2,300	2,209	5,250	4,495	19,180	1,598
1912	650	3,395	3,185	2,004	2,955	955	1,909	2,462	2,250	5,006	1,678	1,764	28,213	2,351
1913	2,726	3,366	2,986	1,909	6,258	9,720	7,391	4,593	5,605	5,092	5,291	2,498	57,435	4,786

a No record.

WELL RECORD IN COASTAL TEXAS.

The following tables give the well record in coastal Texas from 1909 to 1913, inclusive:

Number of wells completed in coastal Texas, 1909–1913, by districts.

District.	Oil.					Dry.					Total completed.[a]				
	1909	1910	1911	1912	1913	1909	1910	1911	1912	1913	1909	1910	1911	1912	1913
Batson	40	51	23	23	51	11	14	10	7	16	51	65	36	30	69
Dayton	0	....	....	....	....	4	....	....	....	....	4	....	....	....	....
Goose Creek	5	1	1	17	27	2	2	4	9	24	7	3	5	26	51
Hoskins Mound [b]	1	2	....	....	....	1	2	....	....	....	2	4	....	....	....
Humble	129	115	122	90	89	64	45	40	27	54	201	160	170	117	144
Markham	2	9	27	31	8	....	7	9	17	13	2	16	41	48	21
Piedras Pintas	2	1	....	....	....	10	....	....	....	....	12	1	....	....	....
Saratoga	27	30	45	91	49	4	7	10	11	28	31	37	56	102	78
Sourlake	116	83	76	54	64	29	12	21	8	18	146	95	101	62	85
Spindletop	46	73	58	47	29	36	27	23	30	40	82	100	93	77	69
Miscellaneous	....	....	....	....	8	....	....	....	....	62	....	....	....	....	75
Total	368	365	352	353	325	161	116	117	109	255	538	481	502	462	592
Northern Texas	116	108	84	299	581	45	a82	38	124	208	175	190	126	434	799
Total Texas	484	473	436	652	906	206	198	155	233	463	713	671	628	896	1,391

a Including gas wells. b Includes West Columbia.

Number of oil wells and dry-holes drilled in coastal Texas in 1913, by districts and months

District.	Jan.		Feb.		Mar.		Apr.		May.		June.		July.		Aug.		Sept.		Oct.		Nov.		Dec.		Total, 1913.		Total, 1912.	
	Oil.	Dry.	Oil.	Dry.	Oil.	Dry.	Oil.	Dry.	Oil.	Dry.	Oil.	Dry.	Oil.	Dry.	Oil.	Dry.	Oil.	Dry.	Oil.	Dry.	Oil.	Dry.	Oil.	Dry.	Oil.	Dry.	Oil.	Dry.
Batson	3	1	3	1	4	..	6	..	1	..	4	1	7	3	4	3	7	..	5	5	5	1	2	1	51	16	23	7
Goose Creek	2	..	4	..	2	4	...	2	4	1	1	2	4	1	1	7	1	3	3	3	1	1	4	..	27	24	17	9
Humble	3	1	4	2	6	4	9	2	5	2	9	4	17	4	7	9	6	12	5	3	6	6	12	5	89	54	90	27
Markham	...	..	1	..	1	..	5	1	...	2	...	2	...	2	...	1	1	..	...	2	...	3	...	..	8	13	31	17
Saratoga	9	4	6	2	10	4	4	9	6	..	5	6	1	1	6	1	1	1	1	..	...	..	...	..	49	28	91	11
Sourlake	4	..	2	1	6	1	7	2	2	1	10	1	2	5	6	2	7	1	7	1	5	..	6	3	64	18	54	8
Spindletop	5	..	5	3	3	1	2	5	2	6	2	12	2	5	3	4	1	2	2	..	2	1	...	1	29	40	47	30
Miscellaneous	...	..	...	9	...	2	...	9	...	3	...	3	3	6	4	3	1	1	...	7	...	4	...	15	8	62	....	....
Total	26	6	25	18	32	16	33	30	20	15	31	31	36	27	31	30	25	20	23	21	19	16	24	25	325	255	353	109
Northern Texas	38	27	31	25	35	12	55	16	57	18	61	19	47	17	56	20	41	9	48	10	68	25	44	10	581	208	299	124
Total Texas	64	33	56	43	67	28	88	46	77	33	92	50	83	44	87	50	66	29	71	31	87	41	68	35	906	463	652	233

Number of oil wells drilled in coastal Texas, 1909–1913, by months.

Year.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Total.
1909	30	40	36	33	36	24	35	35	30	21	30	18	368
1910	41	22	43	29	30	26	35	28	25	29	31	26	365
1911	26	35	29	30	31	58	40	24	19	16	20	24	352
1912	13	41	35	45	24	25	23	30	27	38	34	18	353
1913	26	25	32	33	20	31	36	31	25	23	19	24	325

Number of dry holes drilled in coastal Texas, 1909–1913, by months.

Year.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Total.
1909	18	11	18	16	16	11	10	17	15	16	8	14	[a] 170
1910	14	16	9	11	20	11	11	10	7	1	3	3	[a] 116
1911	15	10	17	14	10	17	11	......	......	9	9	5	[b] 117
1912	8	8	8	13	13	10	8	9	10	8	5	9	[b] 109
1913	6	18	16	30	15	31	27	30	20	21	16	25	[b] 255

[a] Including gas wells. [b] Not including gas wells.

Total number of wells completed in coastal Texas, 1909–1913, by months.[a]

Year.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Total.
1909	48	51	54	49	52	35	45	52	45	37	38	32	538
1910	55	38	52	40	50	37	46	38	32	30	34	29	481
1911	41	46	46	44	41	76	51	41	33	25	29	29	502
1912	21	49	43	58	37	35	31	39	37	46	39	27	462
1913	34	43	49	66	38	65	63	61	45	44	35	49	592

[a] Including gas wells.

Initial daily production of new wells completed in coastal Texas in 1913, by districts and months, in barrels.

District.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Total, 1913.	Total, 1912.
Batson	85	165	188	100	3,000	1,620	270	227	157	78	53	37	5,980	829
Goose Creek	145	140	950	......	935	20	350	50	60	220	100	160	3,130	3,005
Humble	32	72	275	415	1,340	225	535	290	205	775	280	3,675	8,119	5,615
Markham	.....	45	90	230	......	......	......	......	15	......	......	......	380	10,040
Saratoga	295	2,895	2,873	1,160	110	345	25	150	15	15	......	......	7,883	9,350
Sourlake	145	60	6,225	235	50	935	20	160	1,285	1,080	413	835	11,443	1,530
Spindletop	445	275	335	165	160	50	85	60	15	18	170	......	1,778	2,713
Miscellaneous	.....	......	......	......	......	......	50	210	5	......	......	......	265	......
Total	1,147	3,652	10,936	2,305	5,595	3,195	1,335	1,147	1,757	2,186	1,016	4,707	38,978	33,082
Northern Texas	2,726	3,366	2,986	1,909	6,258	9,720	7,391	4,593	5,605	5,092	5,291	2,498	57,435	28,213
Total Texa	3,873	7,018	13,922	4,214	11,853	12,915	8,726	5,740	7,362	7,278	6,307	7,205	96,413	61,295

Total and average initial daily production of new wells in coastal Texas, 1909–1913, by districts, in barrels.

District.	Total initial production.					Average initial production per well.				
	1909	1910	1911	1912	1913	1909	1910	1911	1912	1913
Batson	2,179	2,328	606	829	5,980	54.0	45.6	26.3	36.0	117.3
Goose Creek	54	100	250	3,005	3,130	11.0	100.0	250.0	176.8	115.9
Hoskins Mound	20	4,500	....	....	....	20.0	2,250.0	....	....	....
Humble	8,645	7,502	4,597	5,615	8,119	67.0	65.2	37.6	62.3	91.2
Markham	175	22,100	13,275	10,040	380	87.0	2,455.5	491.7	323.8	47.5
Piedras Pintas	175	150	....	....	....	87.0	150.0	....	....	....
Saratoga	3,590	2,137	2,309	9,350	7,883	13.3	71.2	51.3	102.7	160.9
Sourlake	12,737	16,388	4,463	1,530	11,443	11.0	197.4	58.7	28.3	178.8
Spindletop	5,725	8,078	7,240	2,713	1,778	12.4	110.7	124.8	57.7	61.3
Miscellaneous	....	....	....	....	265	....	....	....	....	33.1
Total	33,300	63,283	32,740	33,082	38,978	89.7	173.5	93.0	93.7	119.9
Northern Texas	1,177	1,683	19,180	28,213	57,435	10.8	15.6	228.3	94.3	98.9
Total Texas	34,477	64,966	51,920	61,295	96,413	71.2	137.3	119.1	94.0	106.4

Total initial daily production of new wells in coastal Texas, 1909–1913, by months, in barrels.

Year.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Total.	Monthly average.
1909	2,180	4,160	3,155	2,577	3,090	2,520	4,615	3,285	2,955	1,459	2,334	970	33,300	2,775
1910	3,048	3,135	1,150	5,540	2,935	4,457	8,570	3,940	3,500	4,590	13,835	8,583	63,283	5,274
1911	5,970	5,890	2,115	6,380	1,561	3,455	2,708	935	1,355	772	619	980	32,740	2,728
1912	935	5,495	3,359	3,435	875	1,805	5,265	2,038	6,055	1,080	1,259	1,481	33,082	2,757
1913	1,147	3,652	10,936	2,305	5,595	3,195	1,335	1,147	1,757	2,186	1,016	4,707	38,978	3,248

LOUISIANA.

DEVELOPMENT.

Caddo.—The development in the Caddo field continued in the characteristically erratic manner during 1913 and resulted in a very great output from perhaps a larger number of gushers yielding 1,000 barrels or more each than had been the case in 1912. The following table gives the list of the principal gushers developed in the field during 1913:

Principal wells developed in Caddo field, La., in 1913

Date.	Location.	Owner.	Capacity.	Depth.
			Barrels.	*Feet.*
Apr. 17	No. 1, sec. 19, T. 20, R. 15	South Western Gas & Electric Co.	1,800	....
May 8	No. 1, Stoakley	Phœnix Oil Co	3,500	....
May 16	No. 1, Noel, Mooringsport	Atlas Oil Co	3,000	....
May 22	At Mooringsport	Azel Ford Co	1,300	....
May 29	No. 96, W. P. Stiles, sec. 28, T. 21, R. 16, Trees city.	Standard Oil Co. of La	18,000	....
29	No. 3, Pitts, sec. 19, T. 20, R. 15	Producers Oil Co	8,000	....
July 17	No. 1, sec. 21, T. 20, R. 15	Gulf Refining Co	1,800	2,239
17	No. 4, Brown lease, sec. 19, T. 20, R. 15	Producers Oil Co	3,000	....
July 24	Sec. 19, T. 20, R. 15	Higgins Oil Co	7,000	....
Aug. 21	Leonard lease, Caddo city, sec. 35, T. 21, R. 16	Richardson Oil Co	3,000	....
Aug. 28	Loucks	Star Oil Co	4,700	....
Sept. 25	106 Stiles, sec. 21, T. 21, R. 16	Standard Oil Co. of La	1,800	....
Oct. 23	No. 1, Stiles, sec. 15, T. 21, R. 16	Gulf Refining Co	6,000	....

The year 1913 was characterized by some of the most disastrous fires that have ever been known in the oil industry. The phenomenal success in extinguishing them has added much to the ability to control such catastrophes in the future.

De Soto Parish.—A feature of great importance to the State was the development near Mansfield in De Soto Parish. On May 10, 1913, the Gulf Refining Co.'s well No. 2 on the Jenkins lease, 1 mile northeast of Naborton, De Soto Parish, came in unexpectedly at a depth of about 2,400 feet. At first the well showed chiefly gas, but by the next day it began yielding oil and was closed in pending the erection of proper storage. At first the well flowed at the rate of over 1,000 barrels a day, and then settled down to 500 barrels. Sufficient interest had been aroused by the discovery of oil in small quantities with the shallow gas near Mansfield to maintain considerable wildcatting in all directions; a well 8 miles southeast of Naborton had attracted some attention from the showings of oil; the Gulf Co. had drilled Jenkins No. 1, 5 miles east of Mansfield; but the drilling of Jenkins No. 2 made it evident that a valuable oil sand had been found. Hence even before the well was tested the excitement to get leases was unusually great, and conditions were complicated by the fact that many leases had been allowed to lapse.

As soon as the Jenkins No. 2 was drilled a 6-inch pipe line was laid to a loading rack at the railroad at Mansfield. The oil is similar to Caddo crude. By August drilling by all the large companies interested in northern Louisiana was very active. In October the eccentricity of this field was shown by the finding of a gas well of great volume—40,000,000 to 60,000,000 cubic feet a day—with very high pressure at the unusually great depth of 2,800 feet. By the end of the year several good oil producers had been developed with the prospect of considerable extension of the field. The oil-bearing sand is found at from 2,400 to 2,900 feet.

The excitement caused by these developments was tempered by the appearance of water from a sand below, but the efforts to bring in further wells continued with more careful and conservative drilling methods. Just about the close of the year a series of good wells were drilling 6 miles northeast of the De Soto pool proper, and had it not been for the heavy rains which delayed drilling, the production would have increased still more. These developments have sufficed to cause leasing even in remote parts of the State and also an unusual amount of wildcatting.

PRODUCTION.

Production of petroleum in Louisiana, 1904–1913, by districts, in barrels.

Year.	Coastal Louisiana.				Caddo.	Total.
	Jennings.	Welsh.	Anse la Butte.	Vinton.		
1904	2,923,066	35,892				2,958,958
1905	8,891,416	10,000	9,000			8,910,416
1906	9,025,174	23,996	25,000		3,358	9,077,528
1907	4,842,520	47,316	60,385		50,000	5,000,221
1908	5,111,577	31,555	145,805		499,937	5,788,874
1909	1,966,614	26,169	37,930		1,028,818	3,059,531
1910	1,625,159	54,724	44,018	26,701	5,090,793	6,841,395
1911	1,180,177	27,901	62,411	2,454,103	6,995,828	10,720,420
1912	1,105,711	22,140	25,000	932,639	7,177,949	9,263,439
1913	790,648	31,144	6,612	1,888,864	9,781,560	12,498,828

The following table shows the production of petroleum in Louisiana in 1912 and 1913, by districts and months:

Production of petroleum in Louisiana in 1912 and 1913, by districts and months, in barrels.

1912.

Month.	Jennings.	Welsh.	Anse la Butte.	Caddo.	Vinton.	Total.
January	89,226	1,845	1,700	550,691	73,060	716,522
February	117,952	1,845	2,109	646,488	64,439	832,833
March	94,049	1,845	2,119	583,518	65,880	747,411
April	97,033	1,845	2,119	700,594	58,909	860,500
May	80,738	1,845	2,119	648,826	70,673	804,201
June	87,809	1,845	2,119	617,267	52,507	761,547
July	102,816	1,845	2,119	592,223	68,112	767,115
August	101,254	1,845	2,119	583,805	75,617	764,640
September	85,510	1,845	2,119	593,422	58,664	741,560
October	84,102	1,845	2,119	562,616	71,408	722,090
November	83,449	1,845	2,119	550,887	124,438	762,738
December	81,773	1,845	2,120	547,612	148,932	782,282
Total	1,105,711	22,140	25,000	7,177,949	932,639	9,263,439

1913.

Month.	Jennings.	Welsh.	Anse la Butte.	Caddo.	Vinton.	Total.
January	78,215	3,257	155	542,905	179,566	804,098
February	76,100	2,430		562,863	108,961	750,354
March	79,670	2,360	310	717,963	255,906	1,056,209
April	84,923	2,428	306	860,274	191,790	1,139,721
May	74,877	2,840	1,621	968,538	168,713	1,216,589
June	66,839	2,459	3,446	1,010,049	159,072	1,241,865
July	64,190	3,265	774	953,530	150,960	1,172,719
August	53,899	2,798		802,200	158,002	1,016,899
September	54,960	2,488		812,062	140,990	1,010,500
October	57,891	2,157		905,558	130,163	1,095,769
November	51,852	2,124		814,545	125,095	993,616
December	47,232	2,538		831,073	119,646	1,000,489
Total	790,648	31,144	6,612	9,781,560	1,888,864	12,498,828

The following table gives a statement of the production and value of petroleum at wells in Louisiana in 1912 and 1913, by districts:

Production and value of petroleum in Louisiana in 1912 and 1913, by districts, in barrels, with increase or decrease in barrels and percentage of increase and decrease.

District	1912			1913			Increase (+) or decrease (−).	Percentage of increase (+) or decrease (−).
	Quantity.	Value.	Average price per barrel.	Quantity.	Value.	Average price per barrel.		
Caddo	7,177,949	$5,419,541	$0.755	9,781,560	$9,812,342	1.003	+2,603,611	+ 36.27
Jennings	1,105,711	968,393	.876	790,648	769,917	.974	− 315,063	− 28.49
Welsh	22,140	18,655	.843	31,144	26,745	.859	+ 9,004	+ 40.67
Anse la Butte	25,000	19,605	.784	6,612	5,290	.800	− 18,388	− 73.55
Vinton	932,639	597,633	.641	1,888,864	1,641,637	.869	+ 956,225	+102.53
Total	9,263,439	7,023,827	.758	12,498,828	12,255,931	.981	+3,235,389	+ 34.93

Production, value, and average price per barrel of petroleum in the Caddo field, 1906–1913, in barrels.

Year.	Caddo, La.			Marion County, Tex.			Total.		
	Quantity.	Value.	Average price per barrel.	Quantity.	Value.	Average price per barrel.	Quantity.	Value.	Average price per barrel.
1906	3,358	$2,183	$0.650				3,358	$2,183	$0.650
1907	50,000	38,863	.777				50,000	38,863	.777
1908	499,937	214,048	.428				499,937	214,048	.428
1909	1,028,818	549,081	.533				1,028,818	549,081	.533
1910	5,090,793	2,292,349	.451	251,717	$102,842	$0.409	5,342,510	2,395,191	.448
1911	6,995,828	3,653,725	.522	677,689	365,067	.539	7,673,517	4,018,792	.524
1912	7,177,949	5,419,541	.755	362,870	290,974	.802	7,540,819	5,710,515	.757
1913	9,781,560	9,812,342	1.003	262,392	261,965	.998	10,043,952	10,074,307	1.003
Total	30,628,243	21,982,132	.718	1,554,668	1,020,848	.657	32,132,911	23,002,980	.716

Production of petroleum in Caddo field, 1906–1913, by districts, with increase or decrease and percentage of increase or decrease, in barrels.

Year.	Caddo, La.			Marion County, Tex.			Total.		
	Quantity.	Increase (+) or decrease (−).	Percentage of increase (+) or decrease (−).	Quantity.	Increase (+) or decrease (−).	Percentage of increase (+) or decrease (−).	Quantity.	Increase (+) or decrease (−).	Percentage of increase (+) or decrease (−).
1906	3,358						3,358		
1907	50,000	+ 46,642	+1,388.98				50,000	+ 46,642	+1,388.98
1908	499,937	+ 449,937	+ 899.87				499,937	+ 449,937	+ 899.87
1909	1,028,818	+ 528,881	+ 105.79				1,028,818	+ 528,881	+ 105.79
1910	5,090,793	+4,061,975	+ 394.8	251,717			5,342,510	+4,313,692	+ 419.29
1911	6,995,828	+1,905,035	+ 37.42	677,689	+ 425,972	+ 169.22	7,673,517	+2,331,007	+ 43.63
1912	7,177,949	+ 182,121	+ 2.60	362,870	− 314,819	− 46.45	7,540,819	− 132,698	− 1.76
1913	9,781,560	+2,603,611	+ 36.27	262,392	− 100,478	− 3.12	10,043,952	+2,503,133	+ 3.61
Total	30,628,243			1,554,668			32,132,911		

RAILROAD SHIPMENTS.

The following table gives a statement of shipments of petroleum from stations on the line of the Louisiana Western Railroad and of the Kansas City Southern Railway in Louisiana during the years 1912 and 1913, by months:

Rail shipments of petroleum from stations on the lines of the Louisiana Western Railroad and the Kansas City Southern Railway in Louisiana in 1912 and 1913, by months, in barrels.

1912.[a]

Month.	Anse la Butte.	Caddo oil.				Jennings oil.			Vinton.	Total.
		Lewis.	Mooringsport.	Oil City.	Vivian.	Egan.	Jennings.	Mermentau.		
January	....	46,986	6,437	68,266	15,306	2,786	2,816	3,173	....	145,770
February	....	42,973	71,754	57,430	9,550	774	6,878	995	....	190,354
March	465	47,097	3,319	105,162	10,610	3,405	11,520	727	25,386	207,691
April	....	38,086	6,205	68,467	12,062	3,250	6,262	943	40,410	175,685
May	1,210	37,763	235	44,299	6,551	4,798	4,873	1,715	32,909	134,353
June	2,017	29,006	....	42,335	4,394	2,012	1,398	677	28,030	109,869
July	1,776	36,830	380	61,218	3,980	8,927	2,150	2,046	35,010	152,317
August	....	55,644	190	60,645	4,157	12,387	1,850	4,593	27,942	167,408
September	611	37,148	....	26,538	4,843	17,662	3,302	1,987	28,111	120,202
October	1,043	53,275	190	33,504	3,509	10,209	4,613	1,851	27,092	135,286
November	464	51,100	....	28,323	2,346	2,756	2,800	3,410	19,919	111,118
December	....	61,216	374	50,414	854	6,456	1,304	4,199	27,958	152,775
Total	7,586	537,124	89,084	646,601	78,162	75,422	49,766	26,316	292,767	1,802,828

[a] These are the official figures, calculation being made on the basis of 310.8 pounds of crude petroleum to a barrel of 42 gallons.

1913.

Month.	Anse la Butte.	Caddo oil.					Jennings oil.			Vinton.	Total.
		Lewis.	Mooringsport.	Oil City.	Vivian.	Mansfield.	Egan.	Jennings.	Mermentau.		
January	155	10,384	567	39,303	7,161	694	3,163	13,858	10,177	27,938	113,400
February	....	11,431	8,448	40,709	1,403	967	2,719	19,203	4,798	19,645	109,323
March	310	17,564	23,205	40,436	1,513	194	7,779	24,101	848	17,100	133,050
April	306	17,869	55,372	29,765	5,407	....	5,401	55,422	5,888	8,161	183,591
May	1,621	23,282	41,415	43,096	2,628	....	8,251	69,024	15,773	974	206,064
June	3,446	22,229	....	49,684	1,210	1,921	9,045	27,722	15,282	....	130,539
July	774	24,306	....	49,706	1,537	19,970	5,926	22,144	13,722	....	138,085
August	....	43,173	....	60,203	2,471	13,847	2,895	17,114	15,334	....	155,037
September	....	15,941	....	53,845	3,203	16,788	8,126	31,038	27,856	....	156,797
October	....	4,905	....	43,073	2,664	19,810	2,179	26,480	8,158	....	107,269
November	....	14,942	....	50,802	3,446	16,383	1,393	21,062	15,600	....	123,628
December	....	5,117	....	49,129	2,233	62,809	2,106	25,956	6,285	....	153,635
Total	6,612	211,143	129,007	549,751	34,876	153,383	58,983	353,124	139,721	73,818	1,710,418

WELL RECORD.

In the following tables are given the well record for Louisiana for the years 1909 to 1913, inclusive:

Number of wells completed in Louisiana, 1909–1913, by districts.

District.	Oil.					Dry.					Total completed.[a]				
	1909	1910	1911	1912	1913	1909	1910	1911	1912	1913	1909	1910	1911	1912	1913
Caddo	69	124	246	239	356	33	54	63	62	92	121	[b]226	341	353	[c]518
Coastal Louisiana:															
Anse la Butte	5	3	.....	3	5	4	1	1	4	1	9	4	1	7	6
Calcasieu	.....	.....	.....	.....	4	.....	.....	.....	.....	1	.....	.....	.....	.....	5
Cameron	.....	.....	.....	.....	.....	.....	.....	.....	.....	2	.....	.....	.....	.....	2
Evangeline	.....	.....	.....	.....	.....	.....	.....	.....	.....	1	.....	.....	.....	.....	1
Jennings	28	16	4	24	19	23	6	1	9	9	51	22	5	33	28
Pine Prairie	.....	.....	.....	1	2	.....	.....	.....	5	4	.....	.....	.....	6	6
Rapides	.....	.....	.....	.....	.....	.....	.....	.....	.....	1	.....	.....	.....	.....	1
Terrebonne	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	1
Vinton	.....	8	54	31	45	.....	3	27	7	34	.....	11	96	38	79
Welsh	1	5	5	.....	6	1	.....	3	.....	4	2	5	10	.....	10
Total	103	156	309	298	437	61	64	95	87	149	183	268	453	437	657

[a] Including gas wells.
[b] Including Marion County, Tex.
[c] Including Bosseir, De Soto, and Sabine parishes.

Number of oil wells and dry holes drilled in Louisiana in 1913, by districts and months.

District.	Jan.		Feb.		Mar.		Apr.		May.		June.		July.		Aug.		Sept.		Oct.		Nov.		Dec.		Total, 1913.		Total, 1912.	
	Oil.	Dry.	Oil.	Dry.	Oil.	Dry.	Oil.	Dry.	Oil.	Dry.	Oil.	Dry.	Oil.	Dry.	Oil.	Dry.	Oil.	Dry.	Oil.	Dry.	Oil.	Dry.	Oil.	Dry.	Oil.	Dry.	Oil.	Dry.
Caddo[a]	31	9	20	3	17	9	36	1	33	4	14	7	39	9	25	6	39	10	30	10	32	13	40	11	356	92	239	62
Coastal Louisiana:																												
Anse la Butte	...	..	...	1	1	..	...	..	1	..	1	..	...	..	1	..	...	..	...	..	...	..	1	..	5	1	3	4
Calcasieu	...	..	...	..	...	..	...	..	...	..	...	..	...	..	1	..	2	1	1	..	...	..	...	..	4	1	...	...
Cameron	...	..	...	..	...	..	...	1	...	..	...	..	...	..	...	1	...	..	...	..	...	..	...	..	...	2	...	...
Evangeline	...	..	...	..	...	..	...	..	...	..	...	..	...	..	...	..	...	..	...	..	...	1	...	..	...	1	...	...
Jennings	3	2	1	1	2	..	4	..	1	..	3	2	2	1	1	..	1	..	...	1	...	..	...	2	19	9	24	9
Pine Prairie	...	..	1	..	...	..	...	3	...	..	...	..	...	..	1	1	...	..	...	..	...	..	...	..	2	4	1	5
Rapides	...	..	...	..	...	..	...	1	...	..	...	..	...	..	...	..	...	..	...	..	...	..	...	..	...	1	...	...
Vinton	2	1	3	4	8	..	4	9	4	1	5	7	9	5	6	1	1	1	...	..	2	..	1	5	45	34	31	7
Welsh	...	..	...	1	...	..	1	1	...	..	...	1	1	..	2	1	...	..	2	..	...	..	...	..	6	4	...	...
Total	36	12	25	10	28	9	45	16	39	5	23	17	51	15	37	10	43	12	34	11	34	14	42	18	437	149	298	87

[a] Includes in 1913 Bossier, De Soto, and Sabine parishes.

Number of oil wells drilled in Louisiana, 1909–1913, by months.

Year.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Total.
1909	14	5	13	8	13	9	12	9	5	4	6	5	103
1910	7	4	8	5	12	16	20	19	17	15	16	17	156
1911	20	33	49	26	39	29	27	18	21	14	16	17	309
1912	12	19	19	14	30	28	25	28	34	27	37	25	298
1913	36	25	28	45	39	23	51	37	43	34	34	42	437

Number of dry holes drilled in Louisiana, 1909–1913, by months.

Year.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Total.
1909	6	8	6	9	7	6	15	2	10	2	4	5	80
1910	9	10	14	19	6	6	1	14	9	......	9	15	64
1911	12	15	12	6	9	6	9	8	3	4	5	6	95
1912	2	8	1	6	4	11	7	6	15	15	8	4	87
1913	12	10	9	16	5	17	15	10	12	11	14	18	149

Total number of wells completed in Louisiana, 1909–1913, by months.[a]

Year.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Total.
1909	20	13	19	17	20	15	27	11	15	6	10	10	183
1910	16	14	22	24	18	22	21	33	26	15	25	32	268
1911	32	51	64	33	52	38	39	42	32	20	25	25	453
1912	17	31	22	21	34	46	37	43	57	44	51	34	437
1913	53	44	44	65	49	44	73	54	58	51	51	71	657

[a] Including gas wells.

Initial daily production of new wells completed in Louisiana in 1913, by districts and months, in barrels.

District.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Total, 1913.	Total, 1912.
Caddo [a]	6,499	11,615	10,585	20,865	24,246	11,636	12,735	19,189	6,250	9,890	3,397	15,048	151,955	84,098
Coastal Louisiana:														
Anse la Butte	......	......	125	......	2,000	75	......	12	......	......	......	150	2,362	590
Calcasieu	......	......	......	......	......	......	......	600	80	1,100	......	2,500	1,780	......
Jennings	440	375	550	2,665	30	105	240	100	150	158	......	......	4,813	5,905
Pine Prairie	......	60	......	......	......	......	......	20	......	......	......	......	80	1,050
Vinton	14,125	360	15,960	5,300	710	2,150	2,675	2,675	100	......	50	......	46,605	17,975
Welsh	......	......	......	30	......	......	25	30	......	15	......	......	100	......
Total	21,064	12,410	27,220	28,860	26,986	13,966	15,675	22,626	6,580	11,163	3,447	17,698	207,695	109,618

[a] Includes in 1913 Bossier, De Soto, and Sabine parishes.

Total and average initial daily production of new wells in Louisiana, 1909–1913, by districts, in barrels.

District.	Total initial production.					Average initial production per well.				
	1909	1910	1911	1912	1913	1909	1910	1911	1912	1913
Caddo	8,750	[a]139,945	169,123	84,098	[b]151,955	127.0	1,128.6	687.5	351.9	426.8
Coastal Louisiana:										
Anse la Butte	955	735	....	590	2,362	191.0	245.0	....	196.7	472.4
Calcasieu	....	....	....	....	1,780	....	....	....	....	445.0
Jennings	11,745	3,230	480	5,905	4,813	419.0	201.9	120.0	246.0	253.3
Pine Prairie	....	....	....	1,050	80	....	....	....	1,050.0	40.0
Vinton	....	11,100	73,550	17,975	46,605	....	1,387.5	1,362.0	579.8	1,035.7
Welsh	....	165	115	....	100	....	33.0	23.0	....	16.7
Total	21,450	155,175	243,268	109,618	207,695	210.3	994.7	787.3	432.5	475.3

[a] Includes Marion County, Tex.
[b] Includes Bossier, De Soto, and Sabine parishes.

Total initial daily production of new wells in Louisiana, 1909–1913, by months, in barrels.

Year.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Total.	Monthly average.
1909.......	3,900	865	2,260	4,730	1,250	1,560	1,720	570	640	160	2,625	1,170	21,450	1,788
1910.......	1,750	1,345	5,320	3,520	11,040	20,650	8,270	12,245	33,560	30,840	16,215	10,420	155,175	12,931
1911.......	35,275	29,325	17,110	38,595	62,150	6,980	5,405	4,505	23,465	4,886	5,292	10,280	243,268	20,272
1912.......	10,855	5,257	10,070	18,300	11,447	3,583	4,931	3,391	17,605	5,600	13,631	4,948	109,618	9,135
1913.......	21,064	12,410	27,220	28,860	26,986	13,966	15,675	22,626	6,580	11,163	3,447	17,698	207,695	17,308

CALIFORNIA OIL FIELD.

GENERAL CONDITIONS.

Although the production of oil in California increased to almost 100,000,000 barrels (97,788,525) in 1913, and although the gusher development in the Midway field in the lower end of the Sunset field, and in the Fullerton field, showed that no forecast can yet be made as to what maximum the California production may reach, there was, nevertheless, a great steadying tendency evident throughout the State. In 1912 began the passing of the stage of fraudulent companies, characteristic of every oil development. The completion of this was aided in 1913 by legal enactment providing for the scrutiny of oil corporations. Another steadying influence during the year was the increased development of refining facilities at Port Costa and elsewhere on San Francisco Bay, at El Segundo in Los Angeles County, and at Port Harford in San Luis Obispo County, as well as the development of a definite policy among the producing companies to introduce topping plants. In consequence the quantity of crude petroleum sold for fuel was considerably decreased. The reduced material has a better flash point and in general is safer for fuel purposes, and the tops are salable to the refining companies. The fact that the oil produced is changing in character, being progressively lighter in specific gravity and containing more gasoline and kerosene, is a feature of great significance for the oil trade in 1914.

At the beginning of the year 1913, the producers of heavy oil (oil with Baumé gravity of 18° or lower) were unable to dispose of their output to the Standard Oil Co. of California and temporarily closed in a production amounting to about 25,000 barrels a day pending arrangements for disposing of it at a satisfactory price. This storing, together with a steady consumption brought about a condition of about equal production and consumption at the beginning of the year.

After efforts to find independent markets for the heavy oil, the producers of this grade gradually turned it over to the Independent Agency which had begun to draw upon its stocks.

Early in the year the Sunset field was extended southeast by the drilling of large wells on the Maricopa flats. With their yield production again began to exceed consumption, so that by the end of the year the production had reached almost 98,000,000 barrels, against 87,272,593 barrels in 1912, and oil was again going into storage.

The fact that this great increase involved no discovery of new oil pools and merely the extension of the Sunset pools southeast is significant as to the conditions of the occurrence of oil in California. The increase was due to the opening of gushers of large capacity during the course of ordinary developments within well-known oil pools. In fact, the reason for the increase in production is well epitomized by the following table showing the development during the year of gushers which had an initial production of 1,000 barrels, or more, a day:

List of wells completed in California fields during 1913 with estimated daily output of 1,000 barrels or more, by months.

Month.	District.	Location. S.	T.	R.	Depth. Feet.	Daily capacity.	Gravity (°B.).
January:							
Lakeview No. 2 Oil Co	Maricopa	4	11	23	2,635	1,500	25.5
Kern Trading & Oil Co	do	5	11	23	2,496	1,800	26.8
Union Oil Co	Coyote	13	3	10	3,193	1,350	23.0
February:							
Maricopa Queen Oil Co	Maricopa	32	12	23	2,405	4,000	23.5
Pacific Crude Oil Co	Midway	32	31	23	3,160	1,200	25.5
Associated Oil Co	do	34	31	23	3,237	3,300	23.5
Kern Trading & Oil Co	do	1	32	23	2,500	1,000	29.4
Amalgamated Oil Co	Coyote	13	3	10	3,245	1,500	22.4
Orange Oil Co	Fullerton					1,400	
March:							
Mays Consolidated Oil Co	Midway	28	31	23	3,000	2,500	26.8
Honolulu Cons. Oil Co	do	6	32	24	2,473	2,000	27.4
Kern Trading & Oil Co	do	11	32	24	3,203	1,600	26.8
Amalgamated Oil Co	Coyote	13	3	10	3,258	1,200	23.0
Universal Oil Co	Lost Hills	32	26	21		1,500	
Union Oil Co	Sunset-Midway	34	31	23		5,000	
April:							
General Petroleum Co	Lost Hills	4	27	21	1,600	1,000	34.6
Standard Oil Co	Sunset-Midway	36	31	23	2,500	20,000	
Union Oil Co	do	34	31	28		7,000	
Standard Oil Co	Lost Hills	4	27	21	1,720	1,200	
May:							
California Oil Fields (Ltd.)	Coalinga	34	19	15	2,722	1,000	24.3
Miocene Oil Co	Maricopa	32	12	23	2,523	1,000	21.6
Amalgamated Oil Co	Fullerton					1,900	
Maricopa Queen Oil Co	Sunset-Midway	32	12	23		6,000	
June:							
Turner Oil Co	Coalinga	22	19	15	3,512	2,700	31.0
Midway Northern Oil Co	Maricopa	32	12	23	2,565	2,000	23.0
Standard Oil Co	Midway	10	32	23	3,229	1,000	26.4
Standard Oil Co	do	36	31	23	2,500	1,000	26.9
General Petroleum Co	do	32	32	24	2,522	1,400	17.5
General Petroleum Co	do	32	31	24	3,350	2,200	26.8
Amalgamated Oil Co	Fullerton					2,000	
July:							
Turner Oil Co	Coalinga	22	19	15	4,020	2,500	30.5
Standard Oil Co	Midway	36	31	23	2,480	10,000	22.5
Union Oil Co	Santa Maria	Newlove.			3,250	1,200	30.0
Standard Oil Co	Coyote	14	3	11	3,500	3,400	26.0
August:							
Pacific Crude Oil Co	Midway	32	31	23	3,178	1,200	25.0
September:							
Standard Oil Co	Coyote	14	3	11	3,590	2,000	26.0
October:							
Kern Trading & Oil Co	Coalinga	35	19	15	3,729	2,100	30.0
Caribou Oil & Mining Co	Midway	28	31	23	3,050	1,200	26.0
Standard Oil Co	Coyote	14	3	11	3,425	10,000	31.6
November:							
Mays Consolidated Oil Co	Midway	28	31	23	2,730	1,200	27.7
Kern Trading & Oil Co	do	3	32	23	3,415	1,000	28.2
Murphy Oil Co	Coyote	18	3	10	3,555	1,500	28.0
Monte Cristo Oil Co	Sunset				2,750	10,000	
December:							
Obispo Oil Co	Maricopa	32	12	24	2,565	10,000	25.2
Union Oil Co	Midway	34	31	23	3,282	1,200	23.0
Union Oil Co	do	34	31	23	3,190	10,000	23.0
Kern Trading & Oil Co	do	1	32	23	3,284	3,400	29.0
Northern Exploration Co	do	22	31	23		3,000	

It will be seen that these gushers were well scattered over the producing regions of California, but that the large gushers were particularly important as to number or size in the Maricopa, Midway, Sunset, and Fullerton fields.

A feature of especial importance was the drilling by the Kern Trading & Oil Co. of a gusher yielding an initial production of 1,800 barrels a day out on the Maricopa Flats at the southeastern end of the Sunset fields (sec. 5, T. 11 N., R. 23) at about 2,500 feet. This was followed by a gusher of 1,800 barrels by the Lakeview Number Two Oil Co. on adjoining sec. 4. Several other wells yielding more than 1,000 barrels a day were drilled during the year, and added materially to the production.

A table following, page 1069, shows the production in the different fields in 1913 as compared with 1912. The table gives evidence of a declining production in the Kern River field, but it should be noted that there is possibility of extending this field to the northwest if the conditions of demand should justify it.

In the Coalinga district the year produced many eventful features, including extensions of territory to the east and the discovery of additional deep sands that yielded petroleum containing paraffin and larger proportions of light oils. The value of the field was indicated by the sale late in the year of the California Oil Fields (Ltd.) to the Shell Trading & Transportation Co., an ally of the Royal Dutch Syndicate.

The Santa Maria field benefited by advances in technologic methods by which the oils were topped and dehydrated with markedly greater efficiency. These developments included the successful introduction of the Cottrell electric dehydration process. The adoption of the Trumble and the Dyer topping and dehydrating processes and the great advance in methods for obtaining gasoline from natural gas were among the striking achievements of the year; but although less spectacular, the economies effected by many minor improvements in the great refineries at Point Richmond, Oleum, and El Segundo contributed perhaps equally to the general problem of efficient refining.

In transportation the new pipe line of the General Petroleum Co. over Tehachapi Pass effected cheaper transportation to the south, and the natural-gas line to Los Angeles was equally advantageous. Meanwhile, several new tank oil carriers and oil-burning steamships were added to the Pacific coast trade and aided in increasing consumption.

TRANSPORTATION.

PIPE-LINE TRANSPORTATION.

The following table gives the approximate capacity of the pipe lines of California. It has been stated that an 8-inch pipe line is capable of delivering 30,000 barrels a day of California oil. This possibly has been done with the light oils of California when heated to a high temperature; but this quantity is ordinarily in considerable excess of the possibilities, and the capacity of the oil pipe lines of the State is due to the fact that there are many loops in them which increase their capacity, as is clear from the following description:

Pipe lines of the San Joaquin Valley.

STANDARD OIL CO.

	Estimated daily capacity in barrels.
Two 8-inch trunk lines 280 miles long from Kern River district to San Francisco Bay, with 115 miles of 12-inch loop; two 8-inch branch lines 32 miles long from Kern River to Midway, with 14 miles of 12-inch loop	65,000
One 8-inch branch line 29 miles long from Coalinga to Mendota, with 20 miles of 6-inch loop	28,000
One 8-inch branch line 20 miles long from Lost Hills to Pond	20,000

SOUTHERN PACIFIC RAILROAD.

Associated Pipe Line Co.:	
One 8-inch trunk line 284 miles long from Kern River to San Francisco Bay	14,000
One 8-inch trunk line 279 miles long from Sunset district to San Francisco Bay	30,000
One 6-inch trunk line 110 miles long from Coalinga district to Monterey Bay	12,000

UNION OIL CO.

Producers' Transportation Co.:	
Two 8-inch trunk lines 70 miles long from Junction to Port Harford	40,000
Five 8-inch branch lines to Coalinga, Kern River, Sunset, Midway, and Lost Hills	23,000

GENERAL PETROLEUM CO.

General Pipe Line Co.: This company has one 8-inch pipe line from Midway district to Los Angeles Harbor, a distance of 154 miles, the estimated daily capacity of which is about 30,000 barrels. A branch 8-inch line 52 miles long runs from Lebec station to Mohave, where the oil is topped before shipping by rail to south and east of Mohave.

Pipe lines of the Santa Maria and Santa Clara districts.

STANDARD OIL CO.

	Estimated daily capacity in barrels.
One 8-inch line 32 miles long from Orcutt to Port San Luis, estimated capacity	30,000
One 8-inch line 33 miles long from Orcutt to Port Harford (idle), belonging to Refining & Producing Oil Co	20,000

UNION OIL CO.

This company, through its subsidiaries, controls—	
One 8-inch and one 6-inch line 34 miles long from Santa Maria to Port Harford, estimated capacity	30,000

OTHER COMPANIES.

Pinal-Dome Oil Co.:

One 4-inch line from Santa Maria field to a topping plant at Bettaravia for crude.

One 2-inch line from Santa Maria field to a topping plant at Bettaravia for gasoline.

Pipe lines from the Santa Clara Valley.

STANDARD OIL CO.

One 2-inch and 3-inch, 44 miles long from Newhall field through Santa Clara Valley fields to Ventura, estimated daily capacity	1,500

UNION OIL CO.

One 2-inch, 3-inch, and 4-inch line 35 miles long from Torrey Canyon to Ventura, estimated daily capacity	2,000

Pipe lines from Los Angeles to Puente Hills.

STANDARD OIL CO.

This company owns one 6-inch and one 8-inch line, 23 miles long, connecting the Puente Hills district to the refinery at El Segundo, near the coast, about 15 miles southwest of Los Angeles. This line has an estimated capacity of 27,000 barrels a day.

SOUTHERN PACIFIC RAILROAD CO.

Amalgamated Oil Co.: The Los Angeles fields are connected to a refinery near the city of Los Angeles by a pipe line having an estimated capacity of 28,800 barrels a day.

The total pipe-line carrying capacity in California at the end of 1913 was as follows:

	Barrels.
Daily carrying capacity of San Joaquin Valley	191,000
Daily carrying capacity of Santa Maria system of pipe lines	100,000
Daily carrying capacity of Santa Clara Valley system of pipe lines to Ventura	3,500
Daily carrying capacity of pipe lines from Los Angeles and Puente Hills districts to Los Angeles city and harbor	106,800
Daily carrying capacity of all lines in California	401,300

RAILROAD TRANSPORTATION.

The Standard Oil Co. leases from the Union Tank Line Co. 12,400 cars; the Southern Pacific Co. is equipped with about 2,850 cars; the Atchison, Topeka & Santa Fe Railway with 2,566 cars; the San Pedro, Los Angeles & Salt Lake Railroad with 205 cars. The Associated Oil Co. has about 340 cars, the Union Oil Co. about 112, and the Western Pacific Railway Co. about 170. These cars have a capacity of between 200 and 300 barrels.

TANK-STEAMER TRANSPORTATION.

The tank steamers owned by the principal oil companies of California and used in transporting crude oil and residues from California ports to Oregon, Washington, Canada, Hawaii, Japan, and other foreign countries are shown in the following table:

Number and capacity of tank steamers transporting crude oil and residues from California in 1913.

Company.	Number.	Capacity, (barrels of 42 gallons.)
Standard Oil Co	26	431,785
Union Oil Co	24	666,905
Associated Oil Co	14	302,403
General Petroleum Co	12	378,119
Total	76	1,779,212

PRODUCTION.

The production of petroleum in California from 1876 to 1913, inclusive, is given in the following table:

Production of petroleum in California, 1876–1913, in barrels.

Year.	Production.	Percentage of total production.	Increase (+) or decrease (−).	Percentage of increase (+) or decrease (−).	Value.	Yearly average price per barrel.
1876	12,000	0.13	....	....	$30,000	$2.50
1877	13,000	.10	+ 1,000	+ 8.33	32,500	2.50
1878	15,227	.10	+ 2,227	+ 17.13	35,174	2.309
1879	19,858	.10	+ 4,631	+ 30.41	45,872	2.31
1880	40,552	.15	+ 20,694	+104.21	93,675	2.309
1881	99,862	.36	+ 59,310	+146.26	230,727	2.31
1882	128,636	.42	+ 28,774	+ 28.81	297,149	2.309
1883	142,857	.61	+ 14,221	+ 11.06	330,000	2.31
1884	262,000	1.08	+ 119,143	+ 83.40	605,220	2.31
1885	325,000	1.49	+ 63,000	+ 24.46	750,750	2.31
1886	377,145	1.34	+ 52,145	+ 16.05	870,205	2.307
1887	678,572	2.39	+ 301,427	+ 79.92	1,567,501	2.31
1888	690,333	2.50	+ 11,761	+ 1.73	1,390,666	2.01
1889	303,220	.86	− 387,113	− 56.08	356,048	1.174
1890	307,360	.67	+ 4,140	+ 1.37	384,200	1.25
1891	323,600	.59	+ 16,240	+ 5.28	401,264	1.24
1892	385,049	.76	+ 61,449	+ 18.99	561,333	1.45
1893	470,179	.97	+ 85,130	+ 22.11	608,092	1.29
1894	705,969	1.43	+ 235,790	+ 50.15	823,423	1.16
1895	1,208,482	2.28	+ 502,513	+ 71.18	849,082	.70
1896	1,252,777	2.05	+ 44,295	+ 3.67	1,240,990	.99
1897	1,903,411	3.15	+ 650,634	+ 51.93	1,713,102	.90
1898	2,257,207	4.08	+ 353,796	+ 18.59	1,917,596	.85
1899	2,642,095	4.63	+ 384,888	+ 15.67	2,508,751	.95
1900	4,324,484	6.80	+ 1,682,389	+ 63.67	4,076,975	.943
1901	8,786,330	12.66	+ 4,461,846	+103.17	4,974,540	.566
1902	13,984,268	15.75	+ 5,197,938	+ 59.16	4,873,617	.348
1903	24,382,472	24.27	+10,398,204	+ 74.36	7,399,349	.303
1904	29,649,434	25.33	+ 5,266,962	+ 21.60	8,265,434	.279
1905	33,427,473	24.81	+ 3,778,939	+ 12.74	8,201,846	.245
1906	33,098,598	26.17	− 328,875	− .98	9,553,430	.289
1907	39,748,375	23.93	+ 6,649,777	+ 20.09	14,699,956	.370
1908	44,854,737	25.13	+ 5,106,362	+ 12.87	23,433,502	.523
1909	55,471,601	30.29	+10,616,864	+ 23.67	30,756,713	.554
1910	73,010,560	34.84	+17,538,959	+ 31.62	35,749,473	.490
1911	81,134,391	36.80	+ 8,123,831	+ 11.13	38,719,080	.477
1912	[a] 87,272,593	39.152	+ 6,138,202	+ 7.57	39,624,501	.454
1913	97,788,525	39.356	+10,515,932	+ 12.05	45,709,400	.467
Total	641,498,232	20.90	....	....	293,681,136	.458

[a] Includes small quantity from Alaska.

The following table shows the production and value of petroleum in California in 1912 and 1913, by districts and counties:

Production and value of petroleum in California in 1912 and 1913, by districts and counties, in barrels.

District and county.	1912			1913		
	Quantity.	Value.	Price per barrel.	Quantity.	Value.	Price per barrel.
Coastal and southern:						
Los Angeles County—						
Los Angeles city	344,789	$211,896	$0.615	320,804	$176,398	$0.550
Newhall; Puente; Salt Lake-Sherman; Whittier; Orange County—Fullerton; Ventura County—Santa Paula; Santa Barbara County—Lompoc; Santa Maria	a16,685,230	a10,186,018	.615	19,777,885	11,027,878	.557
Summerland	65,376	44,295	.677	66,000	44,150	.669
San Luis Obispo County; Santa Clara County	20,123	11,977	.595	42,216	25,368	.601
San Joaquin Valley:						
Fresno County—						
Coalinga	19,911,820	8,768,303	.441	19,302,654	8,507,714	.442
Kern County—						
Lost Hills	1,367,359	652,927	.477	3,440,595	2,209,909	.642
Kern River	12,558,439	5,399,914	.422	9,885,380	3,917,273	.396
McKittrick	5,881,996	2,350,096	.399	6,391,716	2,485,492	.389
Midway	23,928,368	9,713,362	.405	30,000,336	14,075,950	.469
Sunset	6,509,093	2,285,713	.351	8,560,939	3,238,268	.378
Total	50,245,255	20,402,012	.406	58,278,966	25,929,892	.445
Grand total	87,272,593	39,624,501	.454	97,788,525	45,709,400	.467

a Includes small quantity from Alaska.

The following table shows the production of petroleum in California, by counties, from 1904 to 1913, inclusive:

Production of petroleum in California, 1904–1913, by counties, in barrels.

Year.	Fresno.	Kern.	Los Angeles.	Orange.	Santa Barbara.	Ventura.	San Mateo.	Santa Clara.	Total.
1904	5,114,958	19,608,045	2,102,892	1,473,335	789,006	517,770	1,500	41,928	29,649,434
1905	10,967,015	14,487,967	3,469,433	1,429,688	2,684,837	337,970	50,563		33,427,473
1906	7,991,039	14,520,854	3,449,119	2,032,637	4,774,361	299,124	a 31,464		33,098,598
1907	8,871,723	15,652,156	3,477,235	2,604,982	8,708,077	357,094	a 77,108		39,748,375
1908	10,386,168	18,132,893	4,692,495	3,358,714	7,816,682	379,044	a 88,741		44,854,737
1909	14,795,459	23,831,768	16,774,195				a 70,179		55,471,601
1910	18,387,750	37,896,727	16,665,678				b 60,405		73,010,560
1911	18,483,751	45,921,712	16,708,466				b 20,462		81,134,391
1912	19,911,820	50,245,255	c 17,095,395				b 20,123		87,272,593
1913	19,302,654	58,278,966					b 42,216		97,788,525

a Includes oil produced in San Luis Obispo County.
b Production of Santa Clara and San Luis Obispo counties.
c Includes small quantity from Alaska.

Production of petroleum in California in 1912 and 1913, by districts and counties, with increase or decrease and percentage thereof, in barrels.

District and county.	1912	1913	Increase.	Decrease.	Per centage.	
					Increase.	Decrease.
Coastal and southern:						
Los Angeles County—						
Los Angeles city	344,789	320,804		23,985		7.48
Newhall						
Puente						
Salt Lake-Sherman						
Whittier						
Orange County—						
Fullerton	a16,685,230	19,777,885	3,192,655		19.67	
Ventura County—						
Santa Paula						
Santa Barbara County—						
Lompoc						
Santa Maria						
Summerland	65,376	66,000	624		.95	
San Luis Obispo County	20,123	42,216	22,093		109.79	
Santa Clara County						
San Joaquin Valley:						
Fresno County—						
Coalinga	19,911,820	19,302,654		609,166		3.06
Kern County—						
Lost Hills	1,367,359	3,440,595	2,073,236		151.62	
Kern River	12,558,439	9,885,380		2,673,059		21.28
McKittrick	5,881,996	6,391,716	509,720		8.66	
Midway	23,928,368	30,000,336	6,071,968		25.38	
Sunset	6,509,093	8,560,939	2,051,846		31.52	
Total	50,245,255	58,278,966	8,033,711		15.99	
Grand total	87,272,593	97,788,525	10,515,932		12.05	

a Includes small quantity from Alaska.

Production, value, and average price per barrel of petroleum in California, 1904–1913, by districts, in barrels.

Year.	Coastal and southern.			San Joaquin Valley.			Total.		
	Quantity.	Value.	Average price per barrel.	Quantity.	Value.	Average price per barrel.	Quantity.	Value.	Average price per barrel.
1904	24,723,003	$4,952,255	$0.2003	4,926,431	$3,313,179	$0.672	29,647,434	$8,265,434	$0.279
1905	25,454,982	5,351,572	.2102	7,972,491	2,850,274	.357	33,427,473	8,201,846	.245
1906	22,511,893	5,191,060	.231	10,586,705	4,362,370	.412	33,098,598	9,553,430	.289
1907	24,523,879	7,393,036	.301	15,224,496	7,306,920	.4799	39,748,375	14,699,956	.370
1908	16,335,676	9,296,743	.569	28,519,061	14,136,759	.4956	44,854,737	23,433,502	.523
1909	16,844,374	9,737,616	.578	38,627,227	21,019,097	.544	55,471,601	30,756,713	.554
1910	16,726,083	10,532,080	.629	56,284,477	25,217,393	.448	73,010,560	35,749,473	.490
1911	16,728,928	10,607,280	.904	64,405,463	28,111,800	.436	81,134,391	38,719,080	.477
1912	a17,115,518	a10,454,186	.615	70,157,075	29,170,315	.416	87,272,593	39,624,501	.454
1913	20,206,905	11,293,794	.557	77,581,620	34,435,606	.444	97,788,525	45,709,400	.467

a Includes small quantity from Alaska.

FIELD REPORT.

The field report for California for 1912 and 1913 is shown in the following table:

Field report for California in 1912 and 1913, by counties and districts.

1912.

County and district.	Wells.					Acreage.		
	Productive Jan. 1.	Completed. Oil.	Completed. Dry.	Abandoned.	Productive Dec. 31.	Fee.	Lease.	Total.
Fresno County	956	142	11	56	1,042	63,137	13,032	76,169
Kern County:								
Lost Hills	20	51	4	15	56	17,521	2,280	19,801
Kern River	1,787	94	1	68	1,813	12,162	3,737	15,899
McKittrick	246	71	16	20	297	38,811	1,878	40,689
Midway	692	202	20	92	802	23,865	27,351	51,216
Sunset	330	82	6	32	380	16,033	11,855	27,888
Los Angeles County:								
Los Angeles City	413	1	......	19	395	505	426	931
Newhall-Puente	133	......	1	31	102	4,981	4,015	8,996
Salt Lake-Sherman	288	21	3	5	304	12,634	4,057	16,691
Whittier	109	13	1	4	118	5,566	184	5,750
Orange County	290	19	1	11	298	11,324	10,816	22,140
San Luis Obispo County	3	1	2	....	4	13,524	1,178	14,702
San Mateo County	4	......	......	....	4	....	....	....
Santa Clara County	4	......	......	....	4	50	6,000	6,050
Santa Barabra County:								
Lompoc-Santa Maria	255	23	2	29	249	82,708	34,696	117,404
Summerland	161	......	......	9	152	11	20	31
Ventura County	255	55	......	11	299	27,118	78,546	105,664
Miscellaneous	1	1	3	....	2	4,952	8,855	13,807
Total	5,947	776	71	402	6,321	334,902	208,926	543,828

1913.

County and district.	Productive Jan. 1.	Completed. Oil.	Completed. Dry.	Abandoned.	Productive Dec. 31.	Fee.	Lease.	Total.
Fresno County	1,042	91	16	47	1,086	47,201	12,644	59,845
Kern County:								
Lost Hills	56	83	2	3	136	12,664	5,570	18,234
Kern River	1,813	70	1	105	1,778	12,088	2,790	14,878
McKittrick	297	64	12	18	343	37,717	1,188	38,905
Midway	802	242	15	33	1,011	24,898	23,738	47,636
Sunset	380	63	6	11	432	10,317	13,829	24,146
Los Angeles County:								
Los Angeles city	395	......	......	9	386	406	341	747
Newhall-Puente	102	19	......	6	115	6,975	298	7,273
Salt Lake-Sherman	304	12	2	9	307	11,677	3,476	15,153
Whittier	118	6	......	2	122	2,999	1,368	4,367
Orange County	298	39	4	2	335	9,989	13,526	23,515
San Luis Obispo County	4	......	......	3	1	160	718	878
San Mateo County	4	......	......	....	4	....	600	600
Santa Clara County	4	......	......	1	3	....	6,115	6,115
Santa Barbara County:								
Lompoc-Santa Maria	249	40	4	....	289	94,489	31,050	125,539
Summerland	152	2	......	20	134	54	....	54
Ventura County	299	58	3	23	334	20,898	90,720	111,618
Miscellaneous	2	......	2	1	1	800	1,640	2,440
Total	6,321	789	67	293	6,817	293,332	209,611	502,943

COLORADO OIL FIELD.

GENERAL CONDITIONS.

Production of petroleum in Colorado has been declining continuously for five years, and the yield in 1913 amounted to only 188,799 barrels. The wells of the Florence field are unusually steady producers. The Oil and Gas Journal reports a well which has been pumped for 23 years and has yielded over 600,000 barrels.

There is oil awaiting transportation facilities in the Rangely field in Rio Blanco County, and oil and gas have been found near De Beque in Mesa County.

DE BEQUE.

After several unsuccessful attempts in drilling for oil at and near De Beque in the period since 1900, the Grand River Valley Oil & Gas Co. drilled a well in 1913 a short distance west of the town and found a good sand at 1,135 feet. The casing collapsed, but the gas pressure is sufficient to throw water intermittently to a height of 100 feet. Oil of 42° B. gravity was obtained as well as gas. A second test in 1914 reports a well of 100 barrels a day at 1900 feet, but it is troubled with water. The results have stimulated much leasing in the neighborhood, and a thorough test will be given.

OIL SHALES IN COLORADO AND UTAH.

In the field season of 1912 E. G. Woodruff, then of the United States Geological Survey, noted the presence of oil-bearing shales over large areas in the middle portion of the Green River formation in northwestern Colorado and northeastern Utah. He was directed to examine the economic possibilities of these shales during the summer of 1913. Many of these beds were measured and sampled, and the shales were distilled in lots of 100 or more pounds in a still operated at the deposits. The samples of oil and shale obtained were further tested by D. T. Day in the petroleum laboratory of the Survey. The results showed 10 to 68 gallons of crude oil to the ton of shale, with a probable average for better grades of shale of one barrel of oil to the ton. However, this average may not hold for extensive deposits of the rock. No tonnage estimate of the bituminous shales was attempted, but observations were made of their occurrence in various localities in Colorado and Utah and also in Wyoming and Nevada. It is known their acreage is very great, and in many places beds of notable thickness have been found. The latent possibilities of these resources are fully realized. The lands have not been withdrawn from entry, as the Secretary of the Interior deems it wise to avoid placing any hindrance in the way of private enterprise at the initial stage of development and to favor utilization by offering to real producers every premium the present law affords.

The Survey will make a more detailed examination of the Colorado and Utah shales, and the Bureau of Mines will probably take up the technologic study relating to their utilization. The shales yield, besides oil and large quantities of fixed gases, the usual ammonia characteristic of all such shales.

It will be remembered that oil was extracted from bituminous shales in the United States in the early days of the oil industry; in fact, in 1860 there were more than 20 shale-treating plants in operation, which were put out of business by the low price of petroleum at that time.

Although the shale-oil industry long since ceased in the United States, it has persisted and apparently flourished in Great Britain and France. In 1904, the production of oil shale in Scotland amounted to 2,709,840 tons with a content of 63,000,000 gallons of crude oil, yielding marketable products of 2,517,296 gallons of naphtha, 16,991,748 gallons of burning oil, 37,997 tons of gas oil, 39,487 tons of lubricating oil, 22,476 tons of paraffin wax, and 49,600 tons of ammonia salts. In 1913 the production of oil shale in Scotland was 3,150,000 tons, from which about 65,000,000 gallons of oil was obtained and also a large quantity of ammonium sulphate. This yield of 20 gallons of oil to the ton of shale may be contrasted with the assumed average yield of 40 gallons from the Colorado and Utah shales. The cost of mining and treating the shale in Scotland for both oil and by-products is said to be about $1.85 a ton.

PRODUCTION.

In the following table is given the production of petroleum in Colorado, by fields and months, in 1912 and 1913:

Production of petroleum in Colorado in 1912 and 1913, by fields and months, in barrels.

Month.	1912				1913			
	Boulder.	Florence.	Other.[a]	Total.	Boulder.	Florence.	Other.[a]	Total.
January	1,430	13,398	20	14,848	1,269	17,464	25	18,758
February	865	14,425	20	15,310	1,273	14,795	25	16,093
March	1,740	15,410	21	17,171	1,570	15,708	26	17,304
April	967	16,723	21	17,711	1,318	14,099	26	15,443
May	1,586	16,401	21	18,008	1,315	14,811	26	16,152
June	1,126	15,151	21	16,298	1,141	14,752	26	15,919
July	1,509	17,638	21	19,168	914	14,993	26	15,933
August	1,267	16,215	21	17,503	314	14,203	26	14,543
September	1,109	16,423	21	17,553	575	14,307	26	14,908
October	1,306	16,266	21	17,593	1,007	14,153	26	15,186
November	1,154	15,944	21	17,119	704	13,687	26	14,417
December	1,245	16,504	21	17,770	396	13,721	26	14,143
Total	15,304	190,498	250	206,052	11,796	176,693	310	188,799

[a] Averaged.

The following table gives the production of petroleum in Colorado from 1887 to 1913, inclusive:

Production, value, average price per barrel of petroleum in Colorado, 1887–1913, with the increase or decrease for each year, in barrels.

Year.	Production.	Percentage of total production.	Increase (+) or decrease (−).	Percentage of increase (+) or decrease (−).	Value.	Average yearly price per barrel.
1887	76,295	0.27			$76,295	$1.000
1888	297,612	1.07	+ 221,317	+ 29.01	267,851	.900
1889	316,476	.90	+ 18,864	+ 6.34	280,240	.885
1890	368,842	.80	+ 52,366	+ 16.54	309,827	.84
1891	665,482	1.22	+ 296,640	+ 89.42	559,005	.84
1892	824,000	1.63	+ 158,518	+ 23.82	692,160	.84
1893	594,390	1.22	− 229,610	− 27.86	497,581	.838
1894	515,746	1.05	− 78,644	− 13.23	303,652	.589
1895	438,232	.83	− 77,514	− 15.02	336,010	.767
1896	361,450	.59	− 76,782	− 17.52	318,977	.883
1897	384,934	.64	+ 23,484	+ 6.50	332,122	.86
1898	444,383	.80	+ 59,449	+ 15.44	367,447	.827
1899	390,278	.69	− 54,105	− 12.18	404,110	1.035
1900	317,385	.50	− 72,893	− 18.67	323,434	1.019
1901	460,520	.66	+ 143,135	+ 45.09	461,031	1.000
1902	396,901	.45	− 63,619	− 13.81	484,683	1.220
1903	483,925	.48	+ 87,024	+ 21.93	431,723	.892
1904	501,763	.43	+ 17,838	+ 3.67	578,035	1.152
1905	376,238	.28	− 125,525	− 25.02	337,606	.897
1906	327,582	.26	− 48,656	− 12.93	262,675	.802
1907	331,851	.20	+ 4,269	+ 1.30	272,813	.822
1908	379,653	.21	+ 47,802	+ 14.40	346,403	.913
1909	310,861	.17	− 68,792	− 18.12	318,162	1.023
1910	239,794	.12	− 71,067	− 22.86	243,402	1.015
1911	226,926	.10	− 12,868	− 5.37	228,104	1.005
1912	206,052	.09	− 20,874	− 9.20	199,661	.973
1913	188,799	.07	− 17,253	− 8.37	174,779	.926
Total	10,426,370	.34			9,411,788	.903

Production of petroleum in Colorado in 1912 and 1913, by districts, showing increase or decrease and percentage of increase or decrease, in barrels.

District.	Production.		Increase.	Decrease.	Percentage.	
	1912	1913			Increase.	Decrease.
Boulder	15,304	11,796		3,508		22.92
Florence	190,498	176,693		13,805		7.25
Other districts	250	310	60		24.00	
Total	206,052	188,799		17,253		8.37

In the following table will be found the production and value of petroleum in the Boulder and Florence fields in Colorado from 1904 to 1913, inclusive:

Production, value, and average price per barrel of petroleum in Colorado, 1904–1913, by districts, in barrels.

Year.	Boulder.			Florence.			Total.		
	Quantity.	Value.	Average price per barrel.	Quantity.	Value.	Average price per barrel.	Quantity.	Value.	Average price per barrel.
1904	18,167	$20,034	$1.103	483,596	$558,001	$1.153	501,763	$578,035	$1.152
1905	10,502	11,502	1.095	365,736	326,104	.892	376,238	337,606	.897
1906	48,952	53,847	1.0999	278,630	208,828	.7495	327,582	262,675	.802
1907	68,353	75,188	1.0999	263,498	197,625	.750	331,851	272,813	.822
1908	84,174	124,794	1.482	295,479	221,609	.750	379,653	346,403	.913
1909	85,709	129,812	1.514	225,062	187,900	.834	[a] 310,861	318,162	1.023
1910	42,186	63,420	1.503	193,482	174,332	.901	[b] 239,794	243,402	1.015
1911	37,973	50,393	1.327	187,341	175,763	.938	[b] 226,926	228,104	1.005
1912	15,304	19,130	1.250	190,498	180,281	.946	[c] 206,052	199,661	.973
1913	11,796	15,366	1.303	176,693	159,413	.902	[c] 188,799	174,779	.926

[a] Includes a small production in Garfield County.
[b] Includes production of Garfield and Rio Blanco counties.
[c] Includes production of Rio Blanco County.

FIELD REPORT.

Field report for Colorado in 1912 and 1913, by counties.

County.	Wells.									Acreage.					
	1912					1913				1912			1913		
	Productive, Jan. 1.	Completed. Oil.	Completed. Dry.	Abandoned.	Productive, Dec. 31.	Completed. Oil.	Completed. Dry.	Abandoned.	Productive, Dec. 31.	Fee.	Lease.	Total.	Fee.	Lease.	Total.
Boulder	26	....	....	7	19	2	....	3	18	2,978	745	3,723	2,567	445	3,012
Crowley	....	....	....	....	....	....	1	....	....	......	......	......	......	2,500	2,500
Fremont	54	11	13	15	50	4	12	3	51	2,326	1,780	4,106	2,366	1,820	4,186
Rio Blanco	39	4	....	1	42	2	....	21	23	4,000	8,800	12,800	4,800	800	5,600
Other	1	....	....	....	1	....	....	....	1	100	40	140	......	40	40
Total	120	15	13	23	112	8	13	27	93	9,404	11,365	20,769	9,733	5,605	15,338

UTAH.

DEVELOPMENT.

Although no production is reported for Utah in 1913, more or less prospecting was carried on, especially in Uinta County, and an interesting well was being drilled north of Ogden.

FIELD REPORT.

The field report for Utah in 1912 and 1913 is shown in the following table:

Field report for Utah in 1912 and 1913, by counties.

County.	Wells.									Acreage.					
	1912					1913				1912			1913		
	Productive Jan. 1.	Completed. Oil.	Completed. Dry.	Abandoned.	Productive Dec. 31.	Completed. Oil.	Completed. Dry.	Abandoned.	Productive Dec. 31.	Fee.	Lease.	Total.	Fee.	Lease.	Total.
Emery	....	....	....	....	....	....	2	....	....	....	....	....	2,560	......	2,560
Grand	....	....	....	....	....	....	1	....	....	....	....	....	5,000	......	5,000
San Juan	9	....	1	....	9	....	4	4	5	12,917	160	13,077	13,737	......	13,737
Uinta	2	....	....	1	1	....	1	....	1	200	1,000	1,200	1,300	......	1,300
Washington	6	....	....	3	3	....	....	....	3	600	....	600	600	......	600
Wayne	....	....	....	....	....	....	1	....	....	....	....	....	....	......	....
Total	17	....	1	4	13	....	9	4	9	13,717	1,160	14,877	23,197	......	23,197

WYOMING.

DEVELOPMENT.

Increased transportation and refining facilities, affiliation of several companies, and satisfactory marketing contracts following the assurance of a large supply of crude oil, all combined to establish the petroleum industry on a permanent basis in the Salt Creek field tributary to Casper, in Natrona County, Wyo. Further the waning production in the Evanston region is offset by promising conditions at the opposite side of the State in the Big Horn country. All this has encouraged prospecting wherever oil has been found or wherever indications are promising in the State. Production increased from 1,572,306 barrels in 1912 to 2,406,522 barrels in 1913, and the total value increased from $798,470 to $1,187,232.

Negotiations begun in Paris early in the year and concluded in New York in March affiliated the Franco-Wyoming Oil Co., the Natrona Pipe Line & Refining Co., and the Dutch Maatschappij Salt Creek Petroleum Co., and formed the Franco Petroleum Co. under the laws of Wyoming.

Pipe-line shipments from the Salt Creek field to the Casper refineries increased from 6,000 barrels a day early in the year to double that quantity at the close, when the refining capacity at Casper had been greatly increased and included a motor spirit plant of the Standard Oil Co. of Indiana. The Burlington locomotives on the Casper division have been changed to oil burners.

PRODUCTION.

The following table gives the production of petroleum in Wyoming from 1894 to 1913, inclusive:

Production, value, and average price per barrel of petroleum in Wyoming, 1894–1913, with the increase or decrease for each year, in barrels.

Year.	Production.	Percentage of total production.	Increase (+) or decrease (−).	Percentage of increase (+) or decrease (−).	Value.	Average yearly value per barrel.
1894	2,369				$15,920	$6.720
1895	3,455		+ 1,086	+ 45.84	27,640	8.000
1896	2,878		− 577	− 16.70	23,024	8.000
1897	3,650		+ 772	+ 26.82	29,200	8.000
1898	5,475		+ 1,825	+ 50.00	38,325	7.000
1899	5,560		+ 85	+ 1.55	38,920	7.000
1900	5,450		− 110	− 1.98	38,150	7.000
1901	5,400		− 50	− .92	37,800	7.000
1902	6,253		+ 853	+ 15.74	43,771	7.000
1903	8,960		+ 2,707	+ 40.29	62,720	7.000
1904	11,542		+ 2,582	+ 28.82	80,794	7.000
1905	8,454		− 3,088	− 26.75	51,545	6.100
1906	[a] 7,000		− 1,454	− 17.20	49,000	7.000
1907	[b] 9,339	0.005	+ 2,339	+ 33.41	21,883	2.343
1908	[b] 17,775	.01	+ 8,436	+ 90.33	27,920	1.570
1909	[b] 20,056	.01	+ 2,281	+ 12.83	34,456	1.718
1910	[b] 115,430	.05	+ 95,374	+475.54	93,536	.810
1911	[b] 186,695	.085	+ 71,265	+ 61.74	124,037	.664
1912	1,572,306	.71	+1,385,611	+742.18	798,470	.507
1913	2,406,522	.97	+ 834,216	+ 53.06	1,187,232	.493
Total	4,404,569	.14			2,824,343	.641

[a] Estimated. [b] Includes Utah.

FIELD REPORT.

The field report for Wyoming in 1912 and 1913 is shown in the following table:

Field report for Wyoming in 1912 and 1913, by counties.

WELLS.

County.	1912					1913			
	Productive Jan. 1.	Completed.		Abandoned.	Productive Dec. 31.	Completed.		Abandoned.	Productive Dec. 31.
		Oil.	Dry.			Oil.	Dry.		
Bighorn	16	1	6	1	16				16
Converse	5	2			7	6		4	9
Crook	11		2	1	10	2	2		12
Fremont	37	4		10	31		1	10	21
Johnson	1				1			1	
Lincoln							1		
Natrona	65	50	16	15	100	7	7	10	97
Uinta	25	2		3	24	19	5		43
Total	160	59	24	30	189	34	16	25	198

Field report for Wyoming in 1912 and 1913, by counties—Continued.

ACREAGE.

County.	1912			1913		
	Fee.	Lease.	Total.	Fee.	Lease.	Total.
Bighorn	2,360	3,190	5,550	532	2,190	2,722
Converse	468	400	868	468	2,240	2,708
Crook	1,880	160	2,040	1,880	....	1,880
Fremont	2,776	10,376	13,152	1,260	5,320	6,580
Johnson	160	....	160	160	....	160
Natrona	2,020	18,340	20,360	4,840	14,480	19,320
Uinta	10,480	12,200	22,680	9,080	11,000	20,080
Total	20,144	44,666	64,810	18,220	35,230	53,450

MISSOURI.

DEVELOPMENT.

The discovery of oil at shallow depths at Swart in Vernon County, Mo., in 1913, led to some excitement and the drilling of two shallow wells without effective results up to the close of the year. A shallow well was drilled in Adair County which yielded a showing of oil, but no production.

PRODUCTION.

The production of petroleum in Missouri from 1889 to 1913, inclusive, is given in the following table:

Production of petroleum in Missouri, 1889–1913, in barrels.

Year.	Production.	Percentage of total production.	Increase (+) or decrease (−).	Percentage of increase (+) or decrease (−).	Value.	Average yearly value per barrel.
1889	20	....	....	....	$40	$2.00
1890	278	....	+ 258	+1,290.00	556	2.00
1891	25	....	− 253	− 91.01	84	3.39
1892	10	....	− 15	− 60.00	40	4.00
1893	50	....	+ 40	+ 400.00	154	3.08
1894	8	....	− 42	− 84.00	40	5.00
1895	10	....	+ 2	+ 25.00	50	5.00
1896	43	....	+ 33	+ 330.00	185	4.30
1897	19	....	− 24	− 55.81	174	9.16
1898	10	....	− 9	− 47.37	105	10.50
1899	132	....	+ 122	+1,220.00	205	1.553
1900	[a] 1,602	....	+ 1,470	+1,113.64	1,177	.735
1901	[a] 2,335	....	+ 733	+ 45.76	2,600	1.114
1902	[a] 757	....	− 1,578	− 67.58	1,066	1.41
1903	[a] 3,000	....	+ 2,243	+ 296.30	4,650	1.55
1904	[a] 2,572	....	− 428	− 14.27	4,769	1.854
1905	[a] 3,100	....	+ 528	+ 20.53	3,320	1.071
1906	[a] 3,500	....	+ 400	+ 12.90	4,890	1.397
1907	[a] 4,000	....	+ 500	+ 14.28	6,500	1.625
1908	[a] 15,246	....	+11,246	+ 281.15	22,345	1.466
1909	[a] 5,750	....	− 9,496	− 62.28	7,830	1.362
1910	[a] 3,615	....	− 2,135	− 37.13	4,794	1.326
1911	[a] 7,995	....	+ 4,380	+ 121.2	7,995	1.000
1912	([b])	....	....	....	....	....
1913	[c] 10,843	.004	+10,843	....	19,263	1.777
Total	64,920	....	....	....	92,832	1.430

[a] Includes Michigan.
[b] No production for Missouri; Michigan included in Lima, Ohio.
[c] Includes Alaska, Michigan, and New Mexico.

MICHIGAN.

There was the usual slight production in 1913 from the small wells in St. Clair County. In 1912 oil was struck in the city of Saginaw, Saginaw County, and the usual drilling excitement ensued. The subsequent wells were failures, and the enterprise was abandoned in 1913.

ARKANSAS.

In four counties in Arkansas five wells were drilled in 1913 in search of petroleum, but with no result except dry holes.

Nearly 600,000 acres of leases are involved in the lands where these dry holes were drilled.

NEW MEXICO.

In 1912 the old Brown well, 2½ miles northeast of Dayton, in Eddy County, which had been yielding three barrels a day, was improved by setting a packer between the oil sand and the artesian water stratum which lies 100 feet above. The well then yielded some 50 barrels of oil a day after the packer had been reset, successfully shutting off the water. In 1913 the Pecos Valley Oil & Gas Co. began drilling a test on the Martin farm, 1 mile southwest of the Brown well, in the direction of Dayton. The Belt well, due east of Dayton, was deepened and the Seven Rivers Oil Co. began drilling about 15 miles southwest of Dayton. A deep well test was also made in this same region by the Dayton Petroleum Co., headed by California capital, about three-fourths mile south of the Brown well. Five other companies secured acreage in this region and prepared to drill. About 4 miles north of Roswell a well was drilled under the encouragement of the Roswell Chamber of Commerce.

All of this development work was somewhat discouraged by the fact that by the close of the year the California interests abandoned their deep-well test. Later in the year wells were started by companies which operated one to the east and the other to the west of Carlsbad, in Eddy County.

WASHINGTON.

The wildcatting for oil which has been carried on for a year or two in the region of Forks, Clallam County, Wash., resulted in 1913 in finding small quantities of oil. This discovery, in connection with the natural seepages between Forks and the mouth of Hoh River, led to the leasing of large tracts of land, covering most of the territory between the region of Forks, Clallam County, and Moclips, in Chehalis County. Near Taholah, at the mouth of Queniult River, the Jefferson Oil Co. began the exploration of the gas indications of that region, and obtained a small quantity of oil and considerable gas at a depth of less than 350 feet. Inasmuch as the region is largely covered by the Queniult and other Indian reservations, C. T. Lupton, of the Geological Survey, made a field examination of the oil and gas prospects on the Pacific slope of the Olympic Peninsula. The investigation, which was a reconnaissance, was made by the United States Geological Survey on behalf of the Office of Indian

Affairs and has been the subject of a report recently issued.[1] Mr. Lupton reports that the main surface showings of oil in the region are situated 15 to 20 miles north of the Queniult Reservation, near Hoh River. Two prospect holes about 18 feet in depth have been dug in this locality, one in sec. 12, T. 26 N., R. 14 W., and the other in sec. 11, T. 26 N., R. 13 W., Willamette principal meridian, about 5 miles farther east. The former is known as the Jefferson Oil Co.'s seep, and the latter as the Lacey seep.

Analyses of the samples of oil collected at these prospects by Mr. Lupton show a paraffin oil of very high grade, containing no asphaltum. Near the Jefferson Oil Co.'s prospect a well has been drilled to a depth of about 800 feet, and near Forks another well has been drilled to a depth of 1,400 feet or more. In both of these wells, the drilling of which is still in progress, some gas and traces of oil have been encountered, though they have not yet been found in sufficient quantities to be of economic importance.

Near Taholah, at the mouth of Queniult River, is a mound about 50 feet in height and 300 to 400 feet in diameter at the base, with a small opening at the apex from which gas and mud issue. This mound, which is locally known as the Garfield gas mound, has undoubtedly been built up by mud carried up by the gas and deposited around the opening. The adjacent spruce trees indicate that the mound is hundreds of years old, some trees with trunks 3 or 4 feet in diameter being located within 6 or 8 feet of the top of the mound. The gas issuing from this opening contains about 95 per cent of methane and only small amounts of nitrogen and carbon dioxide.

At a distance of 125 feet from the apex of this mound a well is now being drilled for oil, by means of a rotary outfit, the depth so far reached being about 350 feet.

Another prominent gas vent was examined by Mr. Lupton on Hoh River, about 25 miles above its mouth, near Spruce post office. At this place the gas is escaping from a funnel-shaped hole which is full of water. The vent is known locally as the Devils Mush Pot, and the gas is apparently of the same quality as that collected in Taholah.

Other places within the general region were visited, at which outcrops of sandy clay gave the odor of gas and oil, the clay having long been referred to by the Indians as "smell mud." A few anticlines, which may serve as reservoirs for oil and gas, cross the region, mainly in a northeast-southwest direction. These features are described and mapped in Mr. Lupton's report.

The seeps and the gas vents encourage a reasonable expectation that petroleum and natural gas may be present in paying quantities, but their existence in this locality can be proved only by drilling.

IMPORTS.

For many years occasional importations of crude petroleum, and, more frequently, of some special product have been received in the United States, but without any particular bearing upon the trade. The first significant imports were those of gasoline from Borneo to the Pacific coast to supply the deficiency which then existed for gasoline for the growing automobile consumption. The low price now

[1] Lupton, C. T., Oil and gas in the western part of the Olympic Peninsula, Washington: U. S. Geol. Survey Bull. 581, 59 pp., 1914.

ruling for gasoline on the Pacific coast and the considerable supply now attainable of lighter oils, of which the supply is rapidly increasing in California, will, without doubt, stop these imports of gasoline.

In 1911 the importation of crude petroleum from Mexico began to assume significant proportions and rapidly increased in 1912 and in 1913, so that in the last year 17,869,082 barrels of crude petroleum were imported almost entirely from Mexico. This amounted to over two-thirds of the total production of petroleum in Mexico, with the probability of considerable extension of this trade from year to year.

Quantity and value of petroleum, paraffin oil, and ozokerite and paraffin wax imported for consumption into the United States, 1909–1913.

Year.	Petroleum.		Paraffin oil.		Ozokerite and paraffin wax.		Total value.
	Quantity.	Value.	Quantity.	Value.	Quantity.	Value.	
	Barrels.		*Barrels.*		*Pounds.*		
1909	69,614	$197,023	38,926	$79,438	10,152,913	$699,243	$975,704
1910	557,181	1,398,861	2,952	39,748	15,971,672	986,081	2,424,690
1911	1,709,932	2,410,884	4,019	43,343	12,699,459	749,475	3,203,702
1912	7,383,229	6,082,881	2,571	32,565	17,617,068	985,959	7,101,405
1913	17,869,082	12,947,280	2,676	49,458	16,051,322	932,894	13,929,632

EXPORTS.

TERRITORIAL SHIPMENTS.

Alaska.—In the following table are given the shipments of petroleum products to Alaska from 1906 to 1913, inclusive:

Shipments of petroleum products to Alaska from other parts of the United States, 1906–1913.

Year.	Crude.		Naphtha.		Illuminating.		Lubricating.	
	Quantity.	Value.	Quantity.	Value.	Quantity.	Value.	Quantity.	Value.
	Barrels.		*Gallons.*		*Gallons.*		*Gallons.*	
1906	63,526	$38,409	580,978	$100,694	568,033	$109,964	83,992	$32,854
1907	216,769	143,506	636,881	119,345	510,145	99,342	100,145	37,929
1908	283,128	176,483	939,424	147,104	566,598	102,567	94,542	36,423
1909	334,164	334,258	746,930	118,810	531,727	98,786	85,687	35,882
1910	448,468	477,673	788,154	136,569	626,972	95,483	104,512	38,625
1911	431,961	406,400	1,238,865	167,915	423,750	57,896	100,141	34,048
1912	79,144	64,866	2,736,739	344,739	672,176	100,722	154,565	60,949
1913	4,727	4,723	1,735,658	272,661	661,656	106,603	150,918	61,966

Hawaiian Islands, Philippine Islands, and Porto Rico.—In the following table are given the shipments of petroleum products to the Hawaiian Islands, Philippine Islands, and Porto Rico from 1907 to 1913, inclusive:

Shipments of petroleum products to Hawaii, the Philippines, and Porto Rico, 1907–1913.

Year.	Crude.		Naphtha.		Illuminating.		Lubricating.	
	Quantity.	Value.	Quantity.	Value.	Quantity.	Value.	Quantity.	Value.
HAWAII.	*Barrels.*		*Gallons.*		*Gallons.*		*Gallons.*	
1907	926,581	$581,905	484,435	$73,405	1,441,637	$230,968	355,451	$104,930
1908	1,136,188	802,325	648,310	91,851	1,143,591	179,507	358,262	140,157
1909	1,039,083	845,805	804,169	127,076	1,401,381	232,340	367,831	121,282
1910	1,288,502	1,061,060	974,268	160,700	1,359,671	226,481	359,528	133,968
1911	1,114,084	917,763	1,329,589	203,052	1,587,873	220,505	466,826	138,927
1912	917,838	861,080	2,501,938	343,062	1,817,718	190,939	477,012	165,993
1913	772,493	598,980	2,058,091	315,333	1,807,288	210,997	456,477	145,455
PHILIPPINES.								
1907	....	....	79,560	12,930	8,218,400	842,111	181,504	32,598
1908	109	322	140,550	21,775	9,234,263	957,284	257,800	61,571
1909	368	1,014	184,390	23,428	5,995,090	558,642	362,068	81,278
1910	320	1,098	318,070	42,058	10,643,804	862,496	432,867	95,213
1911	131	376	1,074,615	158,592	11,653,570	913,760	470,832	107,499
1912	543	476	1,326,040	216,810	12,634,519	1,094,596	487,607	121,999
1913	....	....	1,414,225	280,690	12,091,810	1,142,403	517,494	105,001
PORTO RICO.								
1907	....	....	219,691	38,003	1,700,838	176,808	223,389	53,599
1908	593	2,100	285,188	45,479	1,623,477	189,021	264,012	65,776
1909	121	340	495,367	93,649	1,931,676	216,316	218,829	78,963
1910	208	499	874,814	135,290	1,973,369	222,108	283,935	91,356
1911	1,229	2,899	1,106,327	133,470	2,323,401	207,804	479,579	117,034
1912	60	278	1,470,105	223,325	2,168,105	212,043	471,596	134,882
1913	35	117	1,580,772	303,012	2,381,187	246,137	507,412	120,007

FOREIGN SHIPMENTS.

GENERAL CONDITIONS.

Practically all forms of petroleum products, from crude oil to paraffin wax, form part of the export trade of the United States, and petroleum products in one form or another, especially kerosene, reach all parts of the world.

Between 4,000,000 and 5,000,000 barrels of crude oil are exported each year; and in 1913 about 200,000,000 gallons of gasoline and naphtha, slightly over 1,000,000,000 gallons of illuminating oil, over 200,000,000 gallons of lubricants, and over 300,000,000 gallons of gas oils, and more than 27,000,000 barrels of residuum were exported. In all, reduced to barrels, the exports amounted to 50,868,231 barrels in 1913, or 20.5 per cent of the total production.

This trade, which represents essentially the overflow of products beyond the consumptive requirements of the United States, is capable of an enormous expansion, if one considers the following interesting table recently compiled by Sir Boverton Redwood, which shows the consumption of kerosene per head of population in various countries in 1911.

Consumption of kerosene during 1911 per head of population, by countries.

Country	Gallons.	Country	Gallons.
United States	7.3	Roumania	1.8
Canada	4.0	Austria	1.8
England	3.9	Japan	1.6
Germany	3.6	Brazil	1.2
Australia	3.4	Italy	1.0
France	2.5	Mexico	.7
Russia	2.0	India	.6
South Africa	2.0	Spain	.5
Egypt	1.9	China	.4

In spite of the use of electricity and gas for illumination in the United States, the use of kerosene is shown by this table to amount to 7.3 gallons per year for every person in the United States. The quantity used in other countries is in every case less; four gallons per capita in Canada comes next to the United States, and England requires practically the same quantity.

There is a marked decline of the per capita used in other countries, and when one considers that China with its enormous population only consumes 0.4 of a gallon per capita, the quantity of kerosene which might be sold before the total Chinese consumption per capita would be brought up to the level of that of the United States would equal 11,000,000,000 gallons per annum, or ten times the quantity now exported from the United States, or about three times as much kerosene as is yielded by the total quantity of crude oil produced in the United States. In spite of our rapidly increasing production petroleum must be recognized as a limited mineral resource in the world, and the responsibilities for properly conserving the supply are evident from these considerations.

EXPORTS BY FISCAL YEARS.

In the following table is given a statement showing the foreign markets for oil in the four fiscal years ending June 30, 1913:

Exports of petroleum in its various forms from the United States for the fiscal years 1910 to 1913, by countries and kinds.

Country and kind.	Year ending June 30— 1910	1911	1912	1913
CRUDE.				
Europe:	*Barrels.*	*Barrels.*	*Barrels.*	*Barrels.*
Belgium	3		54	131
France	311,607	520,092	880,808	584,092
Germany		417	275	238
Spain	230,744	276,588	224,561	307,202
United Kingdom		5	96,864	26,589
Other Europe			23,810	476
	542,354	797,102	1,226,372	918,728
North America:				
Mexico	981,019	580,913	541,728	384,260
Cuba	112,228	124,485	109,364	127,656
Dominion of Canada	933,858	1,244,306	1,817,256	2,969,525
Panama	633,283	927,572	668,688	107
Other North America	95,344	72,681	46,336	419
	2,755,732	2,949,957	3,183,372	3,481,967
South America	722,706	661,764	543,794	255,177
All other countries	731	481	1,471	2,293
Total crude	4,021,523	4,409,304	4,955,009	4,658,165

Exports of petroleum in its various forms from the United States for the fiscal years 1910 to 1913, by countries and kinds—Continued.

Country and kind.	Year ending June 30— 1910	1911	1912	1913
REFINED.				
Gasoline.[a]				
Europe:	*Gallons.*	*Gallons.*	*Gallons.*	*Gallons.*
France				3,494,604
Germany				1,942,746
Netherlands				4,007,592
United Kingdom				6,049,646
Other Europe				2,048,357
				17,542,945
North America				51,932,234
South America				8,652,143
Africa				1,614,794
Asia and Oceania				1,956,801
Total gasoline				81,698,917
Naphtha.				
Europe:				
France	6,583,437	8,570,396	25,626,916	16,491,593
Germany	11,394,253	7,668,059	15,317,517	12,926,229
Sweden	522,680	702,010	1,283,881	1,471,525
United Kingdom	16,924,159	28,332,440	26,820,738	13,426,820
Other Europe	12,419,372	20,487,537	30,877,612	22,046,570
	47,843,901	65,760,442	99,926,664	66,362,737
North America	17,320,657	24,173,133	35,213,601	4,118,900
West Indies	320,160	539,065	856,510	265,424
South America	5,785,161	11,047,387	18,933,132	15,360,440
Asia and Oceania	5,210,862	8,339,291	13,707,125	11,766,558
Africa	1,170,182	2,138,942	2,403,118	3,947,513
	29,807,022	46,237,818	71,113,486	35,458,835
Total naphtha	77,650,923	111,998,260	171,040,150	101,821,572
Illuminating.				
Europe:				
Belgium	41,287,412	51,194,876	47,032,277	58,881,411
Denmark	20,238,497	23,494,756	29,966,403	30,104,209
France	46,924,343	45,322,937	37,702,251	52,953,474
Germany	151,890,625	106,405,766	92,289,677	103,983,882
Italy	26,057,918	23,915,541	30,469,655	21,182,834
Netherlands	121,808,987	102,904,032	112,747,606	134,204,916
Sweden and Norway	37,187,417	43,055,097	39,681,488	43,376,319
United Kingdom	194,226,610	164,599,861	166,215,650	169,288,659
Portugal	5,751,226	3,958,728	6,710,191	6,640,313
Other Europe	4,191,054	3,952,915	7,180,070	5,633,149
	649,564,089	568,804,509	569,995,268	626,249,166
North America:				
British North America	10,201,902	11,257,460	15,605,516	18,226,258
Central America	2,590,238	3,413,245	2,494,184	4,086,746
Mexico	740,615	200,252	165,396	1,225,289
West Indies—				
British	3,002,377	3,164,058	3,538,767	3,184,152
Other	3,447,741	4,031,921	2,960,860	5,318,112
Other North America	669,073	836,597	911,203	1,004,131
	20,651,946	22,903,533	25,675,926	33,044,688
South America:				
Argentina	18,490,512	15,723,182	28,449,374	21,367,616
Brazil	29,874,870	30,846,695	37,491,101	32,828,176
Chile	8,059,982	7,123,137	7,361,898	7,961,224
Uruguay	7,009,158	6,140,675	6,675,489	8,561,419
Venezuela	1,444,847	1,449,897	1,511,255	1,552,294
Other South America	3,546,848	3,270,171	2,961,441	2,790,195
	68,426,217	64,553,757	84,450,558	75,060,924

[a] Included with naphtha prior to 1913.

Exports of petroleum in its various forms from the United States for the fiscal years 1910 to 1913, by countries and kinds—Continued.

Country and kind.	Year ending June 30— 1910	1911	1912	1913
REFINED—continued.				
Illuminating—Continued.				
Asia:	*Gallons.*	*Gallons.*	*Gallons.*	*Gallons.*
Chinese Empire	65,817,980	107,167,449	68,164,997	79,015,610
Hongkong	12,692,037	12,074,776	14,794,710	7,767,090
East Indies—				
British	37,545,823	51,735,360	57,390,564	36,171,967
Dutch	12,572,121	19,235,260	14,370,190	13,417,693
Other East Indies	4,707,640	6,185,050	7,246,805	4,700,340
Japan	58,067,925	57,750,354	109,215,587	85,399,913
Other Asia	11,596,113	19,887,195	15,101,190	22,891,700
	202,999,639	274,035,444	286,284,043	249,364,313
Oceania:				
British	26,452,025	29,478,944	32,077,747	25,635,287
Philippine Islands	6,265,167	9,887,437	14,054,707	13,073,752
Other Oceania	10,880	17,084	18,417	44,904
	32,728,072	39,383,465	46,150,871	38,753,943
British Africa	18,135,570	16,604,729	14,961,057	14,449,160
Other Africa	12,522,003	36,025,605	16,532,125	11,972,103
	30,657,573	52,630,334	31,493,182	26,421,263
Total illuminating	1,005,027,536	1,022,311,042	1,044,049,848	1,048,894,297
Lubricating.				
Europe:				
Belgium	10,671,107	10,229,815	11,806,155	13,782,639
France	20,653,620	19,449,734	25,575,537	26,136,545
Germany	20,533,022	20,450,031	24,308,176	26,418,269
Italy	7,606,839	8,323,598	9,283,969	7,637,394
Netherlands	9,571,203	10,488,285	11,396,618	12,174,926
United Kingdom	54,748,608	53,573,129	62,886,561	61,412,294
Other Europe	7,986,759	9,026,568	11,189,030	13,243,346
	131,771,158	131,541,160	156,446,046	160,805,513
North America	6,095,575	7,064,255	7,587,478	9,846,385
West Indies	1,380,979	1,505,270	1,717,456	1,881,707
South America	7,494,903	7,843,115	10,162,069	11,504,006
Asia and Oceania	17,047,643	18,752,639	20,859,871	23,248,022
Africa	6,640,019	6,936,056	5,352,277	6,385,866
	38,659,119	42,101,335	45,679,151	52,865,986
Total lubricating	170,430,277	173,642,495	202,125,197	213,671,499
Gas and fuel oil.[a]				
Europe				152,327,387
North America				100,101,349
South America				66,883,260
Oceania				38,213
Africa				1,179,716
Total gas and fuel				320,529,925
Residuum.	*Barrels.*	*Barrels.*	*Barrels.*	*Barrels.*
Europe	112,792,362	102,430,883	111,321,764	146,037
North America	10,742,492	15,708,381	30,443,892	2,169,607
All other countries	520,409	5,258,924	26,573,822	25,197,924
Total residuum	124,055,263	123,398,188	168,339,478	27,513,568

[a] Included with residuum prior to 1913.

EXPORTS BY CALENDAR YEARS.

The following tables, compiled by the Bureau of Foreign and Domestic Commerce of the Department of Commerce, show the quantity and value of petroleum and its products (mineral oils) exported from ports and districts in the United States for the years ending December 31, 1912 and 1913:

Exports of mineral oils from the United States in the calendar years 1912 and 1913, by kind and port.

Kind and port.	1912		1913	
	Quantity.	Value.	Quantity.	Value.
CRUDE.	*Barrels.*		*Barrels.*	
New York	970,926	$2,399,698	1,174,017	$3,957,755
Philadelphia	37	138	6	38
Galveston	381	480	495	1,503
Other districts	3,521,785	4,370,168	3,455,712	4,488,998
Total	4,493,129	6,770,484	4,630,230	8,448,294
NAPHTHA.	*Gallons.*		*Gallons.*	
Baltimore	40,274	5,843	62,965	11,617
Boston and Charlestown	80,648	11,721	44,381	8,585
New York	105,423,206	11,933,874	102,869,333	16,872,213
Philadelphia	16,999,114	1,853,716	23,053,365	3,348,437
Galveston	30,485	3,273	35,911	5,346
Other districts	63,426,367	6,650,951	61,977,424	7,845,410
Total	186,000,094	20,459,378	188,043,379	28,091,608
ILLUMINATING.				
Baltimore	64,762	5,489	139,282	14,199
Boston and Charlestown	162,801	15,994	108,963	11,668
New York	566,796,456	37,834,220	538,619,277	40,100,916
Philadelphia	257,075,383	14,099,765	229,282,278	13,890,288
Galveston	....	....	165	20
Other districts	202,038,837	10,128,554	351,291,278	18,025,016
Total	1,026,138,239	62,084,022	1,119,441,243	72,042,107
LUBRICATING AND PARAFFIN.				
Baltimore	11,753,631	1,445,574	12,115,947	1,648,470
Boston and Charlestown	105,537	19,776	94,506	18,972
New York	144,934,778	19,657,690	138,778,365	20,227,289
Philadelphia	47,255,283	5,348,763	43,095,432	5,243,542
Galveston	679,010	137,002	552,276	114,154
Other districts	11,664,967	1,688,662	13,002,566	2,356,122
Total	216,393,206	28,297,467	207,639,092	29,608,549
RESIDUUM.				
Baltimore	21,801	1,740	....	....
Boston and Charlestown	159,557	9,988	2,505	263
New York	51,578,976	1,621,150	37,109,808	1,428,062
Philadelphia	32,425,934	671,617	20,220,194	742,123
Galveston	270	41	252	72
Other districts	182,050,400	4,294,495	369,539,614	8,955,331
Total	266,236,938	6,599,031	426,872,373	11,125,851
Grand total	1,883,479,897	124,210,382	2,136,465,721	149,316,409

RECAPITULATION BY KINDS.

Crude ....gallons..	188,711,420	$6,770,484	194,469,634	$8,448,294
Naphtha ....do....	186,000,094	20,459,378	188,043,379	28,091,608
Illuminating ....do....	1,026,138,239	62,084,022	1,119,441,243	72,042,107
Lubricating and paraffin ....do....	216,393,206	28,297,467	207,639,092	29,608,549
Residuum ....do....	266,236,938	6,599,031	426,872,373	11,125,851
Total	1,883,479,897	124,210,382	2,136,465,721	149,316,409

Exports of mineral oils from the United States in the calendar years 1912 and 1913, by kind and port—Continued.

RECAPITULATION BY PORTS, IN GALLONS.

Kind and port.	1912		1913	
	Quantity.	Value.	Quantity.	Value.
CRUDE.	*Barrels.*		*Barrels.*	
Baltimore	11,880,468	$1,458,646	12,318,194	$1,674,286
Boston and Charlestown	508,543	57,479	250,355	39,488
New York	909,512,304	73,446,632	866,685,489	82,586,235
Philadelphia	353,757,246	21,973,999	315,651,519	23,224,428
Galveston	725,765	140,796	609,374	121,095
Other districts	607,095,571	27,132,830	940,950,790	41,670,877
Total	1,883,479,897	124,210,382	2,136,465,721	149,316,409

Exports of mineral oils from the United States in 1912 and 1913, by months, in gallons.

Month.	1912		1913	
	Quantity.	Value.	Quantity.	Value.
January	132,160,209	$7,901,326	168,170,286	$11,176,786
February	110,618,086	6,864,817	129,026,557	9,650,639
March	122,254,481	8,037,325	148,935,705	10,854,484
April	163,206,438	10,619,283	171,498,655	13,152,384
May	195,734,654	13,171,878	174,851,170	12,786,745
June	147,859,275	10,573,393	185,643,586	12,574,364
July	186,196,374	11,913,785	176,685,335	12,520,886
August	166,618,226	11,677,602	182,584,132	12,482,146
September	182,896,451	12,235,747	191,555,641	13,277,685
October	148,863,918	9,538,976	219,474,668	15,147,538
November	181,012,206	11,882,373	171,537,378	11,887,420
December	146,059,579	9,793,877	216,502,608	13,805,332
Total	1,883,479,897	124,210,382	2,136,465,721	149,316,409

The following tables, furnished by the Bureau of Foreign and Domestic Commerce, Department of Commerce, give the exports of crude petroleum and its products from Texas, by months and kinds and by customs districts during 1912 and 1913:

Exports to foreign countries of crude and refined petroleum from all ports of Texas in calendar year 1912, by months.

Month.	Crude.			Naphtha.		Illuminating.	
	Quantity.		Value.	Quantity.	Value.	Quantity.	Value.
	Barrels.	*Gallons.*		*Gallons.*		*Gallons.*	
January	14,825	622,691	$15,101	1,097,921	$133,104	7,522,107	$443,654
February	322	13,500	270	171,246	28,174	5,536,320	337,417
March	4	150	8	9,348	1,045	6,915,316	336,275
April	5,708	239,720	20,365	995,048	70,977	2,714,857	190,429
May	39,670	1,666,139	54,157	2,250,321	165,564	13,102,353	708,009
June	2,478	104,076	2,304	1,114,595	103,684	9,362,613	503,347
July	8	350	14	7,545	996	5,577,996	270,641
August	320	13,458	269	1,865,764	174,940	6,887,311	421,475
September	381	16,000	480	69,035	10,716	3,787,339	238,648
October	22,618	949,939	34,647	165,100	12,663	3,885,041	159,799
November	....	....	....	103,021	16,415	2,682,067	188,436
December	476	20,000	950	650,901	103,381	4,919,090	307,577
Total	86,810	3,646,023	128,565	8,499,935	821,659	72,892,410	4,105,707

Exports to foreign countries of crude and refined petroleum from all ports of Texas in calendar year 1912, by months—Continued.

Month.	Lubricating and paraffin.		Residuum.		Total.	
	Quantity.	Value.	Quantity.	Value.	Quantity.	Value.
	Gallons.		*Gallons.*		*Gallons.*	
January	72,689	$15,264	2,947,512	$99,061	12,262,920	$706,184
February	90,115	18,103	2,874,936	106,493	8,686,117	490,457
March	83,920	16,064	2,696,108	94,404	9,704,842	447,796
April	91,675	18,619	3,675,459	127,118	7,716,759	427,508
May	102,550	21,368	5,500,776	192,527	22,622,139	1,141,625
June	105,846	21,693	3,197,470	109,055	13,884,600	740,083
July	105,019	20,721	6,811,539	231,173	12,502,449	523,545
August	119,107	24,357	3,524,452	122,060	12,410,092	743,101
September	209,196	41,710	6,972,043	233,994	11,053,613	525,548
October	140,546	28,036	4,548,133	143,586	9,688,759	378,731
November	88,316	18,782	5,926,507	192,214	8,799,911	415,847
December	78,512	15,201	8,061,966	268,834	13,730,559	695,943
Total	1,287,491	259,918	56,736,901	1,920,519	143,062,760	7,236,368

Exports to foreign countries of crude and refined petroleum from all ports of Texas in calendar year 1913, by months.

Month.	Crude.			Naphtha.		Illuminating.	
	Quantity.		Value.	Quantity.	Value.	Quantity.	Value.
	Barrels.	*Gallons.*		*Gallons.*		*Gallons.*	
January	17	730	$30	2,791	$437	4,692,255	$220,543
February	21,872	918,656	32,057	2,112,992	178,202	4,597,760	290,373
March				2,077	279	4,011,913	185,700
April				2,273,505	232,742	11,048,049	719,760
May	4,512	189,510	16,264	2,067,508	195,044	9,586,779	568,817
June				475,075	116,180	15,680,497	935,074
July	19	806	29	302,445	42,273	11,838,645	874,044
August	3,877	162,878	15,478	2,092,477	240,398	14,930,530	788,680
September	18,787	789,061	18,908	57,514	9,458	7,163,617	422,400
October	27	1,145	42	728,631	55,422	13,702,416	732,398
November	79,121	3,323,120	117,478	238,956	17,184	11,869,053	667,231
December	444	18,479	427	623,222	99,320	12,529,774	666,938
Total	128,676	5,404,385	200,713	10,977,193	1,186,939	121,651,288	7,071,958

Month.	Lubricating and paraffin.		Residuum.		Total.	
	Quantity.	Value.	Quantity.	Value.	Quantity.	Value.
	Gallons.		*Gallons.*		*Gallons.*	
January	54,916	$10,506	8,107,199	$276,571	12,857,891	$508,087
February	132,820	27,328	4,353,404	154,865	12,115,632	682,825
March	40,234	7,435	7,285,601	246,283	11,339,825	439,697
April	111,551	23,090	3,570,363	124,962	17,003,468	1,100,554
May	54,009	11,089	7,958,931	266,266	19,856,737	1,057,480
June	396,467	79,789	10,963,638	391,176	27,515,677	1,522,219
July	2,749	795	9,178,753	312,925	21,323,398	1,230,066
August	168,617	33,809	11,350,660	369,235	28,705,162	1,447,600
September	47,663	9,720	8,247,131	286,940	16,304,986	747,426
October	142,510	28,295	10,953,119	357,261	25,527,821	1,173,418
November	17,771	4,279	7,918,435	261,329	23,367,335	1,067,501
December	212,193	45,584	12,570,033	424,959	25,953,701	1,237,228
Total	1,381,500	281,719	102,457,267	3,472,772	241,871,633	12,214,101

Exports of crude and refined petroleum from Texas, by customs districts, in calendar year 1912.

Customs district.	Crude, including all natural oils.			Naphtha.		Illuminating.	
	Quantity.		Value.	Quantity.	Value.	Quantity.	Value.
	Barrels.	*Gallons.*		*Gallons.*		*Gallons.*	
Corpus Christi	853	35,825	$1,193	28,178	$2,752	34	$2
Brazos de Santiago	....	....	....	3,534	630	393	40
Galveston	381	16,000	480	30,485	3,273	....	....
Sabine	85,573	3,594,048	126,884	8,382,773	807,496	72,821,829	4,095,861
Paso del Norte	3	150	8	47,643	6,393	46,791	5,454
Saluria	....	....	....	7,322	1,115	23,363	4,350
Total	86,810	3,646,023	128,565	8,499,935	821,659	72,892,410	4,105,707

Customs district.	Lubricating and heavy paraffin.		Residuum.		Total.	
	Quantity.	Value.	Quantity.	Value.	Quantity.	Value.
	Gallons.		*Gallons.*		*Gallons.*	
Corpus Christi	72,990	$9,569	38,702	$1,004	175,729	$14,520
Brazos de Santiago	4,565	1,598	....	....	8,492	2,268
Galveston	679,010	137,002	270	41	725,765	140,796
Sabine	415,986	82,903	56,693,479	1,919,081	141,908,115	7,032,225
Paso del Norte	18,761	5,836	....	....	113,345	17,691
Saluria	96,179	23,010	4,450	393	131,314	28,868
Total	1,287,491	259,918	56,736,901	1,920,519	143,062,760	7,236,368

Exports of crude and refined petroleum from Texas, by customs districts, in calendar year 1913.

Customs district.	Crude, including all natural oils.			Naphtha.		Illuminating.	
	Quantity.		Value.	Quantity.	Value.	Quantity.	Value.
	Barrels.	*Gallons.*		*Gallons.*		*Gallons.*	
Laredo	203	8,513	$324	6,041	$994	17,927	$1,659
Galveston	494	20,770	1,503	35,911	5,346	165	20
Sabine	127,464	5,353,482	198,269	10,893,581	1,171,952	121,555,683	7,056,324
El Paso	....	....	....	19,825	3,959	23,249	2,604
Eagle Pass	515	21,620	617	21,835	4,688	54,264	11,351
Total	128,676	5,404,385	200,713	10,977,193	1,186,939	121,651,288	7,071,958

Customs district.	Lubricating and heavy paraffin.		Residuum.		Total.	
	Quantity.	Value.	Quantity.	Value.	Quantity.	Value.
	Gallons.		*Gallons.*		*Gallons.*	
Laredo	22,480	$3,233	247	$50	55,208	$6,260
Galveston	552,276	114,154	252	72	609,374	121,095
Sabine	773,481	156,528	102,456,668	3,472,633	241,032,895	12,055,706
El Paso	11,228	2,807	....	....	54,302	9,370
Eagle Pass	22,035	4,997	100	17	119,854	21,670
Total	1,381,500	281,719	102,457,267	3,472,772	241,871,633	12,214,101

Exports of crude petroleum, including shipments to noncontiguous territories, from Pacific ports, 1911–1913, in barrels.

Customs district.	1911		1912		1913	
	Quantity.	Value.	Quantity.	Value.	Quantity.	Value.
From—						
Alaska	16	$66				
Southern California	116,056	98,301	209,374	$181,024	294,327	$230,713
Washington	363,829	374,318	985,244	1,043,653	1,475,823	1,281,185
Oregon					2	3
San Francisco	2,882,714	2,110,692	1,213,988	996,789	580,164	445,494
Total	3,362,615	2,583,377	2,408,606	2,221,466	2,350,316	1,957,395
To—						
Alaska	431,961	406,400	79,144	64,866	4,727	4,723
Canada	366,934	373,114	973,170	1,030,508	1,471,098	1,276,465
Chile	463,190	292,200	144,003	86,405	98,000	73,500
Guatemala	26,000	15,600	45,000	27,000		
Hawaii	1,114,085	917,763	917,238	861,080	772,493	598,980
Mexico	14,062	11,467	10,874	8,424	3,827	3,213
Panama	874,640	524,784	239,000	142,800		
Peru	71,436	41,367				
Salvador	111	240	42	49	12	12
Other	196	442	135	334	159	502
Total	3,362,615	2,583,377	2,408,606	2,221,466	2,350,316	1,957,395

The following table exhibits the total production of petroleum from 1904 to 1913, in barrels and in gallons, also the separate derivatives exported and their value, together with their sum and value:

Quantity of petroleum produced in, and quantities and values of petroleum products exported from, the United States during each of the calendar years from 1904 to 1913, inclusive, in gallons.

Year.	Production.		Exports.			
					Mineral, refined, or manufactured.	
	Barrels of 42 gallons.	Gallons.	Mineral, crude (including all natural oils, without regard to gravity).		Naphtha, benzine, gasoline, etc.	
			Quantity.	*Value.*	*Quantity.*	*Value.*
1904	117,080,960	4,917,400,320	111,176,476	$6,350,682	24,989,422	$2,321,714
1905	134,717,580	5,658,138,360	126,185,187	6,085,592	28,419,930	2,214,609
1906	126,493,936	5,312,745,312	148,045,315	7,731,226	27,544,939	2,488,401
1907	166,095,335	6,976,004,070	126,306,549	6,333,715	34,625,525	3,676,206
1908	178,527,355	7,498,148,910	149,190,017	6,519,849	43,887,044	4,542,551
1909	183,170,874	7,693,176,708	170,337,773	6,027,588	68,758,675	5,799,994
1910	209,559,248	8,801,404,416	180,111,166	5,404,253	100,695,382	8,407,102
1911	220,449,391	9,258,874,422	201,843,355	6,165,403	137,294,606	11,482,761
1912	222,935,044	9,363,271,848	188,711,420	6,770,484	186,000,094	20,459,378
1913	248,446,230	10,434,741,660	194,469,634	8,448,294	188,057,107	28,092,580

Quantity of petroleum produced in, and quantities and values of petroleum products exported from, the United States during each of the calendar years from 1904 to 1913, inclusive, in gallons—Continued.

Year.	Exports.							
	Mineral, refined or manufactured.				Residuum (tar, pitch, and all other, from which the light bodies have been distilled).		Total exports.	
	Illuminating.		Lubricating (heavy paraffin, etc.).					
	Quantity.	*Value.*	*Quantity.*	*Value.*	*Quantity.*	*Value.*	*Quantity.*	*Value.*
1904...	761,358,155	$58,384,273	89,688,123	$12,393,382	34,904,100	$1,174,156	1,022,116,276	$80,624,207
1905...	881,450,388	54,900,649	113,730,205	14,312,383	70,727,877	2,127,696	1,220,513,587	79,640,929
1906...	878,274,104	54,858,312	151,268,522	18,689,622	64,644,765	1,971,305	1,269,777,645	85,738,866
1907...	905,924,296	59,635,208	152,028,855	19,210,353	75,774,754	2,527,582	1,294,659,979	91,383,064
1908...	1,129,004,833	75,988,256	147,769,024	18,971,436	77,551,683	2,793,363	1,547,402,601	108,815,455
1909...	1,046,401,072	67,814,406	161,639,609	20,016,107	121,966,249	4,180,495	1,569,103,378	103,838,590
1910...	940,247,039	55,642,368	163,832,544	20,921,103	117,605,802	3,732,196	1,502,491,933	94,107,022
1911...	1,112,295,006	61,055,095	183,319,645	23,337,126	133,979,087	3,882,463	1,768,731,699	105,922,848
1912...	1,026,138,239	62,084,022	216,393,206	28,207,467	266,236,938	6,599,031	1,883,479,897	124,210,382
1913...	1,119,441,243	72,042,107	207,639,092	29,608,549	426,858,645	11,124,879	2,136,465,721	149,316,409

PRICES.

The exports of kerosene given in the preceding tables are the dominant factor in the fluctuation of New York and Philadelphia prices for that product. The following quotations obtained from New York trade journals are therefore for oil with a flash of 70° C., by Abel closed cup, that is, for the principal brand for export. The rise in price was continuous in 1913.

Weekly prices of refined petroleum in the United States in 1913 at New York, in cents per gallon.

Week ending—	Refined oil.			Week ending—	Refined oil.		
	Bulk.	Cases.	Barrels.		Bulk.	Cases.	Barrels.
Jan. 4	4.80	10.80	8.50	July 12	5.00	11.00	8.70
11	4.80	10.80	8.50	19	5.00	11.00	8.70
18	4.80	10.80	8.50	26	5.00	11.00	8.70
25	4.80	10.80	8.50	Aug. 2	5.00	11.00	8.70
Feb. 1	4.80	10.80	8.50	9	5.00	11.00	8.70
8	4.80	10.80	8.50	16	5.00	11.00	8.70
15	4.80	10.80	8.50	23	5.00	11.00	8.70
22	4.80	10.80	8.50	30	5.00	11.00	8.70
Mar. 1	4.80	10.80	8.50	Sept. 6	5.00	11.00	8.70
8	4.80	10.80	8.50	13	5.00	11.00	8.70
15	4.80	10.80	8.50	20	5.00	11.00	8.70
22	4.80	10.80	8.50	27	5.00	11.00	8.70
29	4.80	10.80	8.50	Oct. 4	5.00	11.00	8.70
Apr. 5	4.80	10.80	8.50	11	5.00	11.00	8.70
12	4.80	10.80	8.50	18	5.00	11.00	8.70
19	4.80	10.80	8.50	25	5.25	11.75	8.75
26	4.80	10.80	8.50	Nov. 1	5.25	11.75	8.75
May 3	4.80	10.80	8.50	8	5.25	11.75	8.75
10	4.80	10.80	8.50	15	5.25	11.75	8.75
17	5.00	11.00	8.70	22	5.25	11.75	8.75
24	5.00	11.00	8.70	29	5.25	11.75	8.75
June 7	5.00	11.00	8.70	Dec. 6	5.25	11.75	8.75
14	5.00	11.00	8.70	13	5.25	11.75	8.75
21	5.00	11.00	8.70	20	5.25	11.75	8.75
28	5.00	11.00	8.70	27	5.25	11.75	8.75
July 5	5.00	11.00	8.70				

Wholesale prices of refined petroleum at New York at the first of each month, 1909–1913.

Month.	1909			1910			1911			1912			1913		
	Date.	Cents per gallon. In barrels.	Cents per gallon. In cases.	Date.	Cents per gallon. In barrels.	Cents per gallon. In cases.	Date.	Cents per gallon. In barrels.	Cents per gallon. In cases.	Date.	Cents per gallon. In barrels.	Cents per gallon. In cases.	Date.	Cents per gallon. In barrels.	Cents per gallon. In cases.
January	2	8.50	10.90	1	8.05	10.45	7	7.40	8.90	6	7.50	9.00	4	8.50	10.80
February	6	8.50	10.90	5	7.90	10.30	4	7.40	8.90	3	8.10	9.90	1	8.50	10.80
March	6	8.50	10.90	5	7.90	10.30	4	7.40	8.90	2	8.10	9.90	1	8.50	10.80
April	3	8.50	10.90	2	7.90	10.30	1	7.40	8.90	6	8.20	10.10	5	8.50	10.80
May	1	8.50	10.90	7	7.75	10.15	6	7.25	8.75	4	8.60	10.50	3	8.50	10.80
June	5	8.50	10.90	4	7.75	10.15	3	7.25	8.75	1	8.60	10.50	7	8.70	11.00
July	3	8.40	10.80	2	7.65	10.05	1	7.25	8.75	6	8.60	10.50	5	8.70	11.00
August	7	8.25	10.65	6	7.65	10.05	5	7.25	8.75	3	8.35	10.25	2	8.70	11.00
September	4	8.25	10.65	3	7.50	9.90	2	7.25	8.75	7	8.35	10.25	6	8.70	11.00
October	2	8.25	10.65	1	7.50	9.90	7	7.35	8.85	5	8.35	10.25	4	8.70	11.00
November	6	8.15	10.55	5	7.40	8.90	4	7.35	8.85	2	8.35	10.25	1	8.75	11.75
December	4	8.05	10.45	3	7.40	8.90	2	7.35	8.85	7	8.50	10.40	6	8.75	11.75

Monthly average prices, in cents per gallon, of petroleum exported from the United States in bulk, 1910–1913.

Month.	1910		1911		1912		1913	
	Crude.	Refined, illuminating.	Crude.	Refined, illuminating.	Crude.	Refined, illuminating.	Crude.	Refined, illuminating.
January	2.9	6.5	3.1	5.3	3.3	5.6	4.3	6.3
February	2.7	6.0	3.5	5.3	2.5	5.6	3.0	6.4
March	2.7	5.9	2.4	5.6	3.2	5.9	3.9	6.2
April	3.4	6.1	2.8	5.5	3.7	5.9	3.6	7.0
May	3.0	6.1	2.8	5.6	4.0	6.4	4.2	6.7
June	3.6	6.0	3.1	5.4	3.6	6.4	4.4	6.8
July	2.5	6.3	2.8	5.4	3.3	6.2	4.7	6.6
August	2.3	6.1	3.2	5.6	3.4	6.2	4.7	6.2
September	3.4	5.9	2.4	5.4	3.9	6.3	4.8	6.1
October	3.0	5.7	3.6	5.5	3.7	5.9	4.4	6.3
November	3.2	5.0	3.9	5.7	4.1	5.8	4.8	6.6
December	2.9	5.5	3.2	5.4	4.0	6.0	5.1	6.3

FOREIGN OIL FIELDS.

CANADA.

PRODUCTION.

The reports of the Canada Geological Survey show that the decline in production, which has been notable since 1907, continued during 1913, from both the oil wells in Ontario and the newer developments in New Brunswick.

In the following table is given the total production of petroleum in Canada from 1904 to 1913, inclusive, as reported by the Canada Geological Survey:

Production of petroleum in Canada, 1904–1913.

Year.	Quantity.	Value.	Average price per barrel.
	Barrels.a		
1904	552,575	$984,310	$1.780
1905	634,095	856,028	1.350
1906	569,753	761,760	1.337
1907	788,872	1,057,088	1.340
1908	527,987	747,102	1.415
1909	420,755	559,604	1.330
1910	315,895	388,550	1.230
1911	291,096	357,073	1.227
1912	243,336	345,050	1.418
1913	228,080	406,439	1.782

a Barrels of 35 imperial gallons. The Canadian barrel of 35 imperial gallons is the practical equivalent of the United States barrel of 42 gallons, the difference being less than 0.03 per cent.

Production of petroleum in Ontario and New Brunswick, 1909–1913, by districts, in barrels.

District.	1909	1910	1911	1912	1913
Bothwell	38,092	36,998	35,244	34,486	34,349
Dutton	9,513	7,752	6,732	4,335	4,610
Lambton	243,123	205,456	184,450	150,272	155,747
Leamington	5,929	141	} 13,501	7,115	4,172
Onondaga (Brant County)	....	1,005			
Tilbury and Romney	124,003	63,058	48,708	44,727	26,824
Belle River	....	....	....	....	464
Total Ontario	420,660	314,410	288,635	240,935	226,166
New Brunswick	95	1,485	2,461	2,679	2,111
Total Canada	420,755	315,895	291,096	243,614	228,277

PRICES.

The average monthly prices per barrel from 1909 to 1913, inclusive, are given in the following table:

Average monthly prices per barrel for crude oil at Petrolia, 1909–1913.

Month.	1909	1910	1911	1912	1913	Month.	1909	1910	1911	1912	1913
January	$1.44	$1.24	$1.22	$1.26	$1.681	August	$1.26	$1.22	$1.22	$1.44	$1.790
February	1.44	1.24	1.22	1.35	1.738	September	1.26	1.22	1.24	1.44	1.790
March	1.44	1.24	1.22	1.38	1.761	October	1.25	1.22	1.24	1.44	1.790
April	1.44	1.24	1.22	1.38	1.780	November	1.24	1.22	1.24	1.48	1.831
May	1.36	1.24	1.22	1.40	1.790	December	1.24	1.22	1.24	1.59	1.856
June	1.33	1.23	1.22	1.42	1.790						
July	1.27	1.22	1.22	1.42	1.790	The year	1.33	1.23	1.22⅔	1.42	1.782

WESTERN CANADIAN PROVINCES.

Vigorous efforts were made in 1913 to develop petroleum and natural gas in the western Provinces of Canada.

MANITOBA.

In Manitoba considerable exploration was made for petroleum and natural gas in Pembina valley, 9 miles south of Manitoba, but sufficient time has not elapsed for reports of definite results. In Saskatchewan drilling was commenced in August, 1911, and by the end of 1913 the well was 1,600 feet deep and no flow of oil or gas had been struck, though the hole passed through shale which showed gas and also contained salt water. A dark oil-bearing shale 14 feet thick was noted. At 300 feet a flow of pure water showing 100 pounds pressure was struck.

ALBERTA.

The successful development of large supplies of natural gas at Medicine Hat and Bow Island has been described in previous reports of this series.

Recent reports on the oil developments of this region have been made by the Canada Geological Survey, and a comprehensive report of the entire Canadian oil fields is being prepared by the Canada Bureau of Mines under the authorship of F. G. Clapp, of Pittsburgh. In brief, these reports show that north of Athabasca Landing in Alberta the oil from the Dakota limestones has saturated the overlying sandstones over an area of many square miles. The limestones dip to the south and at Calgary would probably not be reached at a depth less than 5,000 feet. To the west, between the line connecting Calgary and Edmonton and the outcrop of the probable oil-bearing formations to the west, there is a narrow belt in which many small occurrences of oil will probably be noted in the minor anticlines, which are clearly observable throughout the region.

In October, 1913, a small quantity of oil having a gravity of 64° Baumé, consisting largely of gasoline, and accompanied by considerable natural gas, was noted in a well drilled about 27 miles southwest of Calgary, known as the Dingman well. This discovery created a great rush for oil property. In order to keep it within reasonable bounds a circular was signed by Mayor H. A. Sinnott, of Calgary, by J. W. Campbell for the board of trade, and by O. G. Devenish for the industrial bureau to the following effect:

> Attention having been directed from many parts of the world to the reported discovery of crude petroleum in the vicinity of Calgary, it seems expedient that some announcement should be made on the subject with the purpose of preventing any false or harmful statements being circulated with respect to the result of the oil-boring operations in this territory.
>
> After several months of boring, crude petroleum of a limited quantity was struck on October 7, at a depth of 1,562 feet in the Dingman well upon the property of the Calgary Petroleum Products Co. (Ltd.), located in sec. 6, T. 20, R. 2, west of the fifth meridian.
>
> Boring continued with some promise of ultimate success; but until oil has been struck in volume, the public is warned against placing too great confidence in circulated reports and is particularly urged to exercise care in investments in oil leases or in syndicates which may have been formed for oil exploitations.

In spite of such warnings practically all of the territory for many miles around this well has been leased and many companies have been formed, several of which are drilling.

In the hope of a more generous yield, the well was continued and at 2,700 feet still more oil of the same character was found in quantity sufficient to fill the hole for a distance of a thousand feet or more. In spite of the warnings issued by the Canadian authorities and the indications of a small yield given by the character of the oil, the hysterical speculative features of the old times have been repeated in the Calgary field, although the Canada Geological Survey has repeatedly warned the public against overconfidence in the field and especially against investment in the stock companies depending upon public subscription. The Port Arthur News, commenting on the new oil discoveries in Alberta Province, gives the following timely advice:

> Financial journals that have investigated the oil-producing opportunities in Alberta are outspoken in their warnings to the public against investing real money in ventures that have yet to be proved worth while. Particularly it is urged on behalf of the little fellow, the man on salary, to keep out of oil speculations whose promoters offer to sell stock at a few cents per share.
>
> In the case of Alberta it is claimed by some writers that even if the bubble turned out to be substantially productive of oil, not one quarter of the companies with stock for sale could expect to yield their stockholders a cent's worth of profit in return for the risks they have taken.

It may be reasonably expected that with this great excitement, after the usual disappointments and the many unreasonable high hopes, the region will settle down as a small field of high-grade oil. In the meantime, the prospects for greater yields are good in the Athabasca territory.

Drilling excitement has also extended to British Columbia, where in the Pitt River valley many wells drilled years ago and abandoned are being reopened, and there is prospect of a yield of oil where the territory is not too broken. According to Consul General R. E. Mansfield, of Vancouver, a company composed of Vancouver citizens, which has been drilling for some time in the Pitt River region, recently found a limited flow of oil which was abandoned because of a strong flow of water in two wells. Drilling is continued. Wells will also be drilled in the Revelstoke region.

MEXICO.

Development work in Mexico was remarkably active during 1913, considering the unsettled conditions of the country. It resulted in the development of several large wells distributed over such a wide extent of territory as to assure a permanent large supply of oil. Up to the present time the supply of oil from Mexico has been furnished by a very few wells of phenomenally large size. One of these, owned by American interests, has furnished over 30,000,000 barrels of oil, and another, of English ownership, has furnished almost as great a quantity. Development of other large gushers, not only in the neighborhood of those referred to above but at considerable distance, and active prospecting has given evidence of the intention on the part of the principal producers to develop the fields rapidly. The prospect is that a very large trade in fuel oil will be developed not only in Europe but along the east coast of the United States and will make use of the fleet of about 40 large tank steamers which will soon be available. The market which can easily be supplied by this fleet of tank steamers is sufficiently great to justify a large increase in the production of Mexican oil without decrease in the price. Rather, it is probable that the price of Mexican oil will increase as the trade becomes firmly established. The pipe-line systems connected with the Mexican oil fields were extended during the year, and the fact that several oil companies began erection of refineries near Tampico evinces the general policy of sending out products rather than crude oil. The number of companies approaching the stage of actual production of oil is increasing rapidly. There are now 160 companies engaged in actual exploration of the Mexican field, although not all are actual producers.

A very comprehensive history of the Mexican oil field was published in the leading oil journals by E. De Golyer at the close of 1913. A complete list of the oil companies in the Mexican fields, including lists of their directors, is given in the Mexican Yearbook, 1914, together with a detailed description of the developments of the field. The following statistics show the production of petroleum in Mexico, by years, since it first came to have industrial importance.

From the best information available the production of petroleum in Mexico from 1907 to 1913 is as follows:

Production of petroleum in Mexico, 1907–1913.

1907	barrels..	1,717,690
1908	do....	3,481,410
1909	do....	2,488,742
1910	do....	3,332,807
1911	do....	14,051,643
1912	do....	16,558,215
1913	do....	25,696,291

The following table shows the quantity of crude petroleum, naphtha, and illuminating oil imported from the United States into Mexico in 1911, 1912, and 1913:

Imports of petroleum and specified products into Mexico from the United States, years ending June 30, 1911, 1912, and 1913.

Kind of oil.	1911		1912		1913	
	Quantity.	Value.	Quantity.	Value.	Quantity.	Value.
	Gallons.		*Gallons.*		*Gallons.*	
Crude	24,398,337	$814,298	22,752,588	$884,320	16,138,930	$590,098
Naphtha	363,101	41,890	314,667	37,373	168,809	27,187
Illuminating	200,252	26,734	165,396	20,607	1,225,289	95,668
Lubricating	1,308,964	253,608	1,060,745	194,270	889,577	211,729
Residuum	1,023,559	27,555	118,758	6,984	15,572	706
Total	27,294,213	1,164,085	24,412,154	1,143,554	18,438,177	925,388

Quantity and value of mineral oils imported into Mexico from the United States, 1904–1913.

Year ending June 30—	Mineral.					
	Crude.		Refined, including residuum.		Total.	
	Quantity.	Value.	Quantity.	Value.	Quantity.	Value.
	Gallons.		*Gallons.*		*Gallons.*	
1904	10,938,448	$663,575	1,179,894	$222,005	12,118,342	$885,580
1905	14,036,517	786,613	1,216,421	224,061	15,252,938	1,010,674
1906	14,366,495	766,353	3,295,325	616,479	17,661,820	1,382,832
1907	19,992,434	1,037,226	3,906,472	511,990	23,898,906	1,549,216
1908	17,523,440	901,115	1,839,803	320,235	19,363,243	1,221,350
1909	27,554,581	1,184,398	1,979,093	306,579	29,533,674	1,490,977
1910	41,202,786	1,428,632	2,333,558	357,258	43,536,344	1,785,890
1911	24,398,337	814,298	2,895,876	349,787	27,294,213	1,164,085
1912	22,752,588	884,320	1,659,566	259,234	24,412,154	1,143,554
1913	16,138,930	590,098	2,299,247	335,290	18,438,177	925,388

TRINIDAD.

The production of petroleum in Trinidad has increased in spite of the difficulties in managing drilling operations referred to in the last report of this series. Shipments of crude oil have increased from 183,000 barrels in 1911 to 323,000 barrels in 1913. The production in 1912 amounted to 461,986 barrels; this increased in 1913 to 503,616 barrels. Drilling was active during the year and the total number of wells thus far obtained aggregates 150. In May a gusher of 40,000 barrels capacity was obtained by the American Co., but it soon declined, owing probably to sand heaving.

The official report of Archibald G. Bell, inspector of mines in Trinidad, covering the fiscal year 1912–1913 is quoted as follows:

We are now in the position of knowing that at least three powerful corporations will soon be operating independently in the development of the oil fields of Trinidad, and we shall, therefore, shortly know what position it is going to take in the world.

Taken on the whole, the actual drilling work done by most of the companies can not be said to have been satisfactory. The majority of them seem not to have had sufficient working capital, and, consequently, have not been able to prove properly the oil-bearing prospects of the lands upon which they have been working. Yet, though a great amount of drilling has not been done, several of the wells drilled have proved that the oil sands in certain districts hold large quantities of oil, and that at no great depths. This has been proved at Guapo, and also at the Union Estate, Brighton. Wells were drilled at both places into sands containing large quantities of oil with high gas pressures, and in both cases the production was large and the wells flowed for several weeks. On cessation of gas pressure, the wells continued to give a fair production by pumping and bailing.

Eleven of the companies reported on in my last annual report carried on drilling operations during the year, and four have now closed down. Two new companies started work during the year.

The General Petroleum Properties of Trinidad Limited, did not resume operations at either Aripero or Guayaguayare during the year.

The Trinidad Lake Petroleum Co. (Ltd.) has carried out some very important work in the period under review. It has now practically concentrated work on its Union Estate at Brighton, and has drilled several wells, which have given a very large production. In this field a great amount of additional plant, in the shape of large boiler stations, pumping stations, pipe lines, etc., has been provided to deal with the production and to pump the oil won to the large storage tanks at Brighton. Large earthen storage reservoirs have been dug, large dams built, and additional lengths of asphalt road have been made. Though the company has had a fairly large production, shipments have been comparatively small.

The Trinidad Oilfields (Ltd.), at Point Fortin, has continued to open up the Crown lands held by it under the lease, and it has also continued the drilling operations on its private lands. The chief constructional work, apart from drilling, has been the laying down of large central steam plants, a considerable extension of its light railway, and the laying down of additional pipe lines.

A considerable amount of drilling has been done on its private lands with fair results. On Crown lands, the indications which I mentioned in my last report have been fulfilled, and several successful wells have been drilled. A small experimental refinery was erected during the year, and at the time of writing a larger one has been erected and is working.

The Trinidad Petroleum Options (Ltd.) was in negotiation with the Government during a large part of last year regarding the issue to it of a mining lease, and also the transfer of additional areas under prospecting license. A road was made into its Crown lands, and a bungalow was erected for the accommodation of the staff. A large Galician rig was partially erected, but no drilling was done.

No work has been done by the Trinidad Western Oilfields (Ltd.) during the year, and the prospecting license which it held has now expired.

The Trinidad Cedros Oil Co. (Ltd.) continued boring operations during the first part of the year, and then closed down. Since then no further work has been done.

The Guapo (Trinidad) Oil Co. (Ltd.) during the first half of the year continued its drilling work; since then little has been done with the exception of the extraction of a small quantity of oil.

During the early part of the year C. C. Stollmeyer continued prospecting work on his Perseverance Estate at Guapo. In June a well was drilled into an exceedingly prolific oil sand. This flowed for nearly two months, and a very large quantity of oil was produced, but, owing to the lack of storage arrangements, a great proportion of this oil flowed down the ravines into the sea and was lost. Since then the work has mainly been in building earthen storage reservoirs and laying pipe lines to convey the oil to the shipping place.

The Trinidad Central Oilfields (Ltd.) has continued the development of the lands held by it under prospecting license at Tabaquite. A number of small wells have been drilled, and in most of them a small production of very high-grade petroleum has been obtained. The refinery was working during the year, and the petrol obtained has been sold locally. The chief work, apart from drilling, has been the erection of further accommodations for the staff, the provision of a multiple pumping station for the wells, stores, and some additional steel storage tanks.

The South Naparima (Trinidad) Oil Co. (Ltd.) closed down work at the end of last financial year. During the latter half of this year, the Venezuelan Oilfield Exploration Co. (Ltd.) took over the wells and part of the properties belonging to it. This company then continued drilling operations during the rest of the year, and has provided steel storage tanks, additional accommodations for the staff, store sheds, etc.

The Tobago Oil Syndicate (Ltd.) continued drilling operations until June, and work was then abandoned.

The Consolidated Oilfields of Trinidad (Ltd.) continued work during the greater part of the year, and then suspended operations. Apart from drilling, little work was done in the field.

During the year Icacos (Trinidad) Development Co. (Ltd.) and the Trinidad Petroleum Developments (Ltd.) started drilling on private lands. Two shallow wells were also drilled with a hand boring machine by a cocoa proprietor at Erin.

Regular inspections of the oil fields have been made during the year, and in most cases the ordinances have been satisfactorily followed. In one case the department took proceedings against an oil-field manager for a breach of the law, and was successful. In addition to the regular inspections in connection with work under leases and licenses, and for the purpose of ascertaining if the ordinances are being followed, numerous special inspections have been made in connection with refineries, dams, roads, etc.

Total number of persons employed in the Trinidad petroleum industry was 801—799 males and 2 females.

GUATEMALA.

Mr. Manuel Lemut, who is engaged in deep drilling for water in Guatemala, reports that up to the close of 1913 no petroleum wells had been obtained, but that surface indications lead to the belief that such deposits may possibly be discovered in the Departments of San Marcos and Huehuetenango, and also in the northern and northeastern parts of the Departments of Quiche, Alta Verapaz, and Izabal. Preparations are being made to explore these deposits.

CENTRAL AMERICA AND THE WEST INDIES.

Interest was shown in the possibility of finding oil in Panama, Costa Rica, Honduras, and Nicaragua, but sufficient time had not elapsed at the end of the year for definitely locating any oil deposits in these countries.

In the islands of the West Indies, prospecting for petroleum was active in Haiti, where a small well was drilled near Azua. In Cuba drilling was resumed near Habana, Cardenas, and Motembo. Explorations for oil were also active in Barbados.

A specimen of manjac obtained from the Bureau of Foreign and Domestic Commerce, Department of Commerce, was examined in the Geological Survey. After finely powdering, five samples of 2 grams each were weighed off and treated with 10 c. c. of the following solvents: Chloroform, carbon bisulphide, carbon tetrachloride, ether, and carefully refined gasoline, boiling between 65° and 95° C., so-called normal benzine. After adding the solvent and heating to boiling for a few minutes the samples were allowed to stand for 24 hours. They were then filtered, and each was washed with a small quantity of its solvent. This showed the manjac to be soluble in the various solvents in the following proportions: Chloroform, 90.5 pre cent; carbon bisulphide, 87.1 per cent; carbon tetrachloride, 84.6 per cent; gasoline, 23.15 per cent. In general the solubility of manjac thus resembles gilsonite rather than albertite, grahamite, or elaterite.

A sample of crude petroleum sent by the Consular Service with the sample of manjac showed a gravity of 19.2° Baumé at 60° F., or 0.9383 specific gravity at 15.5° C. The oil was dark brown in color and perfectly sweet in odor, like Pennsylvania petroleum. It contained 11.5 per cent of unsaturated hydrocarbons, which also allies it with the heavier grades of Pennsylvania petroleum such as the natural lubricating oils found at Franklin, Pa. The sample was not large enough for complete examination. The samples are on file in the Bureau of Foreign and Domestic Commerce.

VENEZUELA.

Venezuela is still in the prospecting stage, as described in the report for 1912. After the end of the year 1913 a small yield of oil was obtained near Maracaibo in connection with the asphalt deposits of that region. The well was drilled by the Caribbean Petroleum Co. on the eastern coast of Lake Maracaibo. Oil was struck at a depth of 390 feet and the output was approximately 10 barrels a day. Other wells are being drilled in the neighborhood. The quality of the oil is reported to be of high grade. Two other companies are preparing for development work.

COLOMBIA.

English, American, and Canadian oil interests were concerned in 1913 with concessions for the development of large areas where seepages of oil and asphalt are so significant as to lead to the hope of a large addition to the world's supply of fuel oil. No large wells have yet been developed. The English interests withdrew from Colombia in the latter part of the year. Action of the Colombian legislature developed the policy of disposing of Colombian oil lands by the denouncement method rather than by the concession method.

ECUADOR.

During 1913 negotiations were actively in progress between rival British and American companies with a view to securing a concession from the Government for exploiting both the regions in Ecuador, where the existence of petroleum is probable, as well as the old fields near the coast, which have yielded a small production from time to time. The contract for such concession, which was under consideration between the English company and the Government, and which received the Government's approval, was a very clear proposition, designed to develop the oil resources of Ecuador rapidly.

There is a growing disposition on the part of South American Governments, however, to substitute the method of denouncement by which small tracts of land are outlined by the prospector and are turned over to him by the Government in payment for a small sum covering the right to exploit the region outlined for oil. Such a method of disposing of oil lands is practiced in Cuba and, recently, in Panama, Costa Rica, and Colombia.

BOLIVIA.

In addition to the statements concerning the occurrence of petroleum in Bolivia which were given in the report of this series for 1912, a report now in the hands of Director General Barrett, of the Pan American Union, states that the Espejos (mirror) spring, 12 leagues (about 36 miles) from Santa Cruz, in Bolivia, is a fair sample of the character and kind of petroleum surface manifestations found in the region extending from the northern boundary of Argentina to Madre de Dios River. This river is close to the southern boundary of western Brazil, and with the Beni into which it runs, finally joins Mamore River, to form Madeira River. The Espejos spring yields petroleum on its surface, an analysis of which shows a content of 78.2 per cent of kerosene, 17.5 per cent of lubricating oil, and 4.3 per cent of coke. Petroleum in paying quantities will probably be found in other localities as well as in the neighborhood of Santa Cruz.

PERU.

GENERAL CONDITIONS.

The year 1913 was one of the greatest prosperity and the greatest production in the history of the Peruvian fields, owing largely to deeper drilling. The industry is making rapid progress.

In Negritos deep drilling led to developing wells which yielded 300 barrels each a day—some wells more. The limits of one area are fairly well understood; the other area is still undefined but gives promise of good results. As the average total yield per well has in the past not exceeded 20,000 barrels, the great gains within the last few months have caused considerable interest in Peru, and negotiations have begun by English and American companies for the purchase of drilling rights in the fields. Drilling in Negritos is very easy and cheap; even wells 2,500 feet deep require only three months of work.

The Lobitos field is also prosperous, but the ultimate outcome depends upon a program of far more liberal drilling. Wells nearly 3,000 feet deep have given good production, and development is proceeding southward toward the Negritos field, that is, the Parinas Valley north of Talara.

Fair wells have also been developed at Punta Rusten near Cape Blanco. According to A. Beeby Thompson, who has kindly furnished much of the information given herein, there are hundreds of square miles of Tertiary beds in Peru where oil exists in paying quantities. The geology has now been worked out, and it is quite likely that these areas will be developed in the near future. All the fields are cut up by faults along a regular monocline, and there are no anticlines as they are usually interpreted, although, of course, the region of elevation where the oil beds are exposed is a wide fold which might be given this name by a stretch of the term.

Local use of oil as fuel was stimulated by the introduction of Diesel engines in many localities.

PRODUCTION.

The production of petroleum in Peru in recent years is shown in the following tables:

Production of petroleum in Peru, 1904–1913, in tons and barrels.

Year.	Production.	
	Metric tons.[a]	Barrels.
1904	38,683	290,123
1905	59,720	447,880
1906	71,506	536,294
1907	100,830	756,226
1908	134,824	1,011,180
1909	175,482	1,316,118
1910	177,347	1,330,105
1911	182,436	1,368,274
1912	233,486	1,751,143
1913	247,647	1,857,355

[a] One metric ton=7.5 barrels.

Production of petroleum in Peru, 1905–1913, by districts, in barrels.

Year.	Lobitos.	Negritos.	Zorritos.	Lake Titicaca (Huancane).	Total.
1905	[a] 75,000	335,160	37,720	....	447,880
1906	162,000	330,510	42,419	1,365	536,294
1907	279,000	396,750	65,476	15,000	756,226
1908	319,898	543,750	71,429	[a] 76,103	1,011,180
1909	429,195	740,070	70,750	[a] 76,103	1,316,118
1910	400,080	773,025	107,000	[a] 50,000	1,330,105
1911	391,290	882,698	64,286	[a] 30,000	1,368,274
1912	587,048	1,071,000	78,095	[a] 15,000	1,751,143
1913	557,355	[a] 1,200,000	[a] 90,000	[a] 10,000	1,857,355

[a] Estimated.

In the following table are given, so far as can now be ascertained, the production, shipments, and stocks of petroleum and the number of producing wells in the Lobitos oil field of Peru in the years 1905 to 1913, inclusive:

Production, shipments, and stocks of petroleum and number of producing wells in Lobitos oil field, 1905–1913.

Year.	Production.		Shipments.	Stock Dec. 31.	Producing wells Jan. 1.
	Metric tons.	*Barrels.*	*Metric tons.*	*Metric tons.*	
1905	[a] 10,000	75,000	....	....	....
1906	[a] 21,600	162,000	17,576	....	....
1907	[a] 37,200	279,000	25,821	4,816	....
1908	42,653	319,898	36,131	8,869	26
1909	57,226	429,195	54,289	11,797	62
1910	53,344	400,080	....	....	....
1911	52,172	391,290	....	....	92
1912	78,273	587,048	....	....	105
1913[a]	74,314	557,355	....	....	110

[a] Estimated.

The following table gives the production of petroleum in the Negritos oil field of Peru from 1904 to 1913, in tons and barrels:

Production of petroleum in Negritos oil field, Peru, 1904–1913.

Year.	Production.	
	Metric tons.	Barrels.
1904	39,508	296,310
1905	44,688	335,160
1906	44,068	330,510
1907	52,900	396,750
1908	72,500	543,750
1909	98,676	740,070
1910	103,070	773,025
1911	117,693	882,698
1912	142,800	1,071,000
1913[a]	160,000	1,200,000

[a] Estimated.

Production of petroleum in Zorritos oil field of Peru, 1904–1913, in gallons.

Year.	Crude petroleum.	Refined.[a]	Gasoline.	Benzine.
1904	2,080,000	365,000	46,200	
1905	1,584,242	300,000	29,570	
1906	1,781,600	350,000	54,000	10,000
1907	2,750,000	420,000	101,000	20,000
1908	3,000,000	500,000	150,000	30,000
1909	2,971,510	469,610	96,520	....
1910	4,494,000	....	....	....
1911	[b] 2,700,000	650,000	....	200,000
1912	3,280,000	476,620	226,440	....
1913	[c] 3,780,000	....	....	....

[a] Kerosene. [b] 64,286 barrels. [c] Estimated.

ARGENTINA.

The report of this series for 1912 gave a description of the petroleum resources of Argentina, including the deposit at Comodoro Rivadavia, which continues to be the only developed field, with very limited production in comparison with its capacity.

A Government commission is exploiting the reserved producing region, and a careful study is being made of the best methods for securing the greatest benefit to the State from the petroleum resources.

CHILE.

For many years emanations of inflammable gases have been observed in the neighborhood of Punta Arenas and in Tierra del Fuego. These gaseous emanations led to several drilling enterprises in search of petroleum which were without result. In October of 1912 a considerable volume of natural gas was found at the depth of 300 feet, about 1 mile west of Punta Arenas, near Minas River. Films of oil were also noticed on the water brought up by the pumps from this well. On the strength of these discoveries the minister of industry and public works commissioned Prof. E. Miers and Dr. Johannes Felsch, geologist to the minister of industry and public works, to make a geologic study of the region. The following is a résumé of the results obtained in this work: Inflammable gases are found in Quemas Malas; on Tres Brazos River, from lower Tertiary clays; on Minas River; near Cape Boqueron in Tres Puentes River; at Pecket Harbor, from sands of the upper Tertiary, and from Otway Gulf. The strata holding the gases are of different ages, but all lie in or below the Tertiary.

In the valleys of Tres Puentes River and of Tres Brazos River and at Cape Boqueron seepages of gas are found in connection with petroliferous rocks, in the immediate vicinity of Tres Brazos River, of Tres Minas, and of Tres Puentes River. In these regions faults have been noted. They probably exist also near Cape Boqueron and Pecket Harbor. Anticlines are found at Quemas Malas and to the north of Cape Yartau in Whiteside Channel. It is also believed that the petroleum will be found in the Cretaceous beds or in still older rocks.

The existence of petroleum has been definitely shown near Punta Arenas and northwest of Tierra del Fuego. The frequency of the emanations of natural gas makes it probable that the petroliferous deposits are large. The geologists have indicated to certain proposed drilling companies the most appropriate places for drilling. The State takes no part in actual drilling, but will continue to further scientific explorations with a view to giving all aid to the search for petroleum.

RUSSIA.

GENERAL CONDITIONS.

The declining condition of the older Russian petroleum localities noted in the previous reports of this series continued in 1913. It was not compensated by increase in the new districts, which include Emba for the first time as a commercial factor. The outlook for the future of Russian production is brightened by the prospecting which has progressed rapidly in the Ural-Caspian region, north of Gurief. The field is reached by steamers to the north shore of the Caspian Sea. About 30 miles from the shore large wells have already been obtained at Dossor, and pipe lines are laid to Gurief, where barges can be loaded and then towed up the Volga without the reloading which is necessary with shipments from Baku. Oil from Baku destined for the Volga River trade arrives at Astrakhan in steamers too deep for the river and is then transferred to barges. Exploration in this Ural-Caspian field has been extended many miles north of the present developments. Prospecting is impracticable in winter, but in summer it can be prosecuted with success in spite of the lack of water, the available supply of which is derived principally from snow scraped up in winter and stored in pits. The inhabitants of the region are nomads living in tents. They are peaceful and disposed to aid exploration.

On June 14, 1913, the first cargo of oil left Dossor for Astrakhan, 130,000 poods on a barge towed by the steamer Carthage. In July Dossor produced 700,000 poods, half from two gushers. Part of it went to Baku and part up the Volga.

Some 500 certificates have been issued for petroleum exploitation in the Kirghiz Steppes in Astrakhan Province. The region is being investigated by Government geologists.

Uchta.—The Russian Government has carried on systematic investigation of the Uchta region since 1909. The exploration is attended with much difficulty from lack of transportation facilities. Four wells have been drilled, the deepest to 1,050 feet. Two oil sands were found 10 to 35 feet thick. The wells are producing 4 to 6 barrels a day. That from the central part of the anticline is black and heavy—specific gravity 0.920 and smelling of hydrogen sulphide. The oil on the slopes is considerably lighter—0.876 specific gravity and without sulphur; it yields 4 per cent gasoline and 30 per cent kerosene. The region is Paleozoic. The ultimate development waits on better transportation facilities. There is, according to the reports, an outlook for a large number of small wells of very moderate depth, 400 to 600 feet.

PRODUCTION.

The usual tables of production, refining, and shipment follow:

Production of petroleum in Russia, 1904–1913, by fields.

Year.	Baku.		Grosny.		Maikop.	
	Poods.[a]	Barrels of 42 galians.	Poods.	Barrels of 42 gallons.	Poods.	Barrels of 42 gallons.
1904	614,115,445	73,723,290	40,095,331	4,813,365		
1905	414,762,000	49,791,356	43,057,052	5,168,914		
1906	447,520,000	53,723,889	38,373,603	4,606,675		
1907	476,002,000	57,143,097	39,214,612	4,707,637		
1908	465,343,000	55,863,504	52,058,895	6,249,567		
1909	492,500,000	59,123,650	57,033,015	6,846,700		
1910	497,842,212	59,764,971	74,048,358	8,889,359	1,304,800	156,640
1911	434,310,329	52,138,095	75,189,591	9,026,361	7,933,936	952,453
1912	429,300,000	51,536,615	65,400,000	7,851,140	9,200,000	1,104,442
1913	344,538,000	48,563,985	73,659,265	8,842,649	4,802,300	576,507

Year.	Other.		Total.	
	Poods.	Barrels of 42 gallons.	Poods.	Barrels of 42 gallons.
1904			654,210,776	78,536,655
1905			457,819,052	54,960,270
1906	[b] 4,721,000	566,747	490,614,603	58,897,311
1907			515,216,612	61,850,734
1908	[c] 611,221	73,376	518,013,116	62,186,447
1909			549,533,015	65,970,350
1910	[d] 12,708,290	1,525,604	585,903,660	70,336,574
1911	[e] 33,876,295	4,066,782	551,310,151	66,183,691
1912	[f] 62,700,000	7,527,011	566,600,000	68,019,208
1913	[g] 24,593,000	2,952,341	447,592,565	60,935,482

[a] 61.05 poods=1 metric ton crude; 8.33 poods crude=1 United States barrel of 42 gallons; 8 poods illuminating oil=1 United States barrel of 42 gallons; 8.18 poods lubricating oil=1 United States barrel of 42 gallons; 9 poods residuum=1 United States barrel of 42 gallons; 7.50 poods naphtha=1 United States barrel of 42 gallons; 8.3775 poods other products=1 United States barrel of 42 gallons, estimated; 1 pood=36.112 pounds; 1 kopeck=0.515 cents.

[b] Produced in Bereki and Tchimion oil fields.

[c] Produced in Surakhany.

[d] Includes 10,613,909 poods produced in Surakhany, 1,392,306 poods produced in Sviatoi, 610,500 poods produced in Ferghana, and 91,575 poods produced in Taman.

[e] Includes 19,896,524 poods produced in Surakhany, 2,515,363 poods produced in Sviatoi, 10,205,740 poods produced in Tcheleken, and 610,500 poods produced in Ferghana.

[f] Includes 43,900,000 poods produced in Surakhany, 3,300,000 poods produced in Sviatoi, 13,300,000 poods produced in Tcheleken, and 2,200,000 poods produced in Ferghana.

[g] Includes 4,733,000 poods produced in Sviatoi, 13,860,000 poods produced in Balakany, and 6,000,000 poods produced along Trans-Caucasian Railway.

Baku field.—The total production of crude petroleum on the Apsheron Peninsula or Baku field and the shipments of the chief petroleum products from Baku to all points from 1904 to 1913 are shown in the table following:

Total production of crude petroleum on the Apsheron Peninsula and shipments of petroleum products from Baku, 1904–1913, in barrels.

Year.	Production.	Shipments from Baku.					
		Illuminating.	Lubricating.	Other products.	Residuum.	Crude oil.	Total.
1904	73,723,290	19,205,250	1,896,455	159,355	33,622,111	2,249,340	57,132,511
1905	49,791,356	9,209,125	1,303,912	159,045	29,555,777	2,897,359	43,116,218
1906	53,723,889	8,941,125	1,847,799	179,289	22,697,667	4,001,441	37,667,321
1907	57,143,097	11,450,019	1,724,664	565,689	27,833,892	4,290,500	45,864,764
1908	55,863,504	10,682,750	1,754,034	105,163	23,989,778	5,398,200	41,929,925
1909	59,123,650	8,261,368	1,728,833	1,087,115	23,404,954	6,182,973	40,665,243
1910	59,764,971	9,978,406	1,892,046	1,381,921	24,414,210	6,207,278	43,873,861
1911	52,138,095	10,406,454	1,999,503	1,388,776	26,091,096	5,713,538	45,599,367
1912	51,536,615	10,639,886	2,372,605	1,875,209	21,961,469	6,054,524	42,903,693
1913	48,563,985	10,380,813	2,326,931	1,196,169	22,227,408	6,974,106	43,105,427

The division of the production among the districts of the Apsheron Peninsula or Baku field is as follows:

Production of the several districts of the Apsheron Peninsula, 1904–1913, in barrels.

Year.	Balakhani.	Sabunchi.	Romani.	Bibi-Eibat.	Binagadi.	Total.
1904	9,848,380	26,029,292	16,063,505	21,745,618	36,495	73,723,290
1905	6,866,747	16,494,310	11,230,732	15,175,558	24,009	49,791,356
1906	8,142,017	18,739,015	11,489,796	15,317,647	35,414	53,723,889
1907	8,594,118	22,036,734	10,750,901	15,761,344	....	57,143,097
1908	8,363,860	23,727,367	9,392,557	14,379,720	....	55,863,504
1909	8,763,505	24,873,950	10,492,198	14,753,901	a 240,096	59,123,650
1910	8,228,392	23,379,366	11,532,820	14,265,551	b 2,358,842	59,764,971
1911	7,661,934	21,121,650	9,977,837	12,304,431	c 1,072,243	52,138,095
1912	7,839,136	20,480,192	9,459,784	12,533,013	1,224,490	51,536,615
1913	7,878,872	19,273,469	8,467,107	11,186,074	1,758,463	48,563,985

a Other. b Includes 1,286,599 barrels in other districts. c 1910.

Production of petroleum from pumping and flowing wells in the Baku field, 1904–1913, by districts, in barrels.

Year.	Balakhani.	Sabunchi.	Romani.	Bibi-Eibat.	Binagadi.	Total.
PUMPING.						
1904	9,848,380	25,384,514	15,043,217	19,061,944	36,495	69,374,550
1905	6,866,747	16,265,306	9,927,971	14,861,945	24,009	47,945,978
1906	8,142,017	18,513,445	10,436,615	15,282,113	35,414	52,409,604
1907	8,594,118	21,676,950	10,353,782	15,137,215	....	55,762,065
1908	8,363,860	23,585,230	9,250,060	13,529,900	....	54,729,050
1909	8,763,505	24,849,940	9,843,938	12,953,181	a 192,077	56,602,641
1910	8,228,392	23,267,266	10,456,391	13,612,313	b 1,323,713	56,888,075
1911	7,661,934	21,086,257	9,774,918	11,306,740	c 1,072,243	50,902,092
1912	7,839,136	20,456,182	9,183,674	11,236,494	60,024	48,775,510
1913	7,878,872	19,273,469	8,282,713	10,587,635	1,638,415	47,661,104
FLOWING.						
1904	....	644,778	1,020,288	2,683,674	....	4,348,740
1905	....	229,004	1,302,761	313,613	....	1,845,378
1906	....	225,570	1,053,181	35,534	....	1,314,285
1907	....	359,784	397,119	624,129	....	1,381,032
1908	....	142,137	142,497	849,820	....	1,134,454
1909	....	24,010	648,260	1,800,720	a 48,019	2,521,009
1910	....	112,100	1,076,429	653,238	a 1,035,129	2,876,896
1911	....	35,393	202,919	997,691	....	1,236,003
1912	....	24,010	276,110	1,296,519	1,164,466	2,761,105
1913	....	....	184,394	598,439	120,048	902,881

a Other. b Includes 251,470 barrels in other districts. c 1910.

Number and condition of wells in the Baku fields in years ending Dec. 31, 1912 and 1913.

Condition of wells.	Balakhani.		Sabunchi.		Romani.		Bibi-Eibat.		Total.	
	1912	1913	1912	1913	1912	1913	1912	1913	1912	1913
Completed	60	68	111	112	39	23	17	22	227	225
Producing, Dec. 31	888	934	1,118	1,288	282	290	300	331	2,588	2,843
Trial pumping, Dec. 31	9	12	29	25	1	3	13	1	52	41
Drilling, Dec. 31	41	73	72	107	33	40	37	66	183	286
Drilling deeper, Dec. 31	16	20	25	22	12	13	19	17	72	72
Cleaning out and repairing	6	32	26	107	15	61	11	57	58	257
Standing idle	335	394	608	616	220	231	158	157	1,321	1,398
Rigs up, ready for drilling	24	45	60	75	6	8	20	12	52	140
New wells sunk	79	100	119	143	33	30	21	46	110	319
Length of wells drilled, in feet	92,743	115,269	172,739	198,184	64,134	56,595	45,255	83,902	374,871	453,950

The stocks of petroleum and petroleum products in the Baku field at the close of the year from 1909 to 1913 were as follows:

Stocks of petroleum in Baku, Dec. 31, 1909–1913, in barrels.

	1909	1910	1911	1912	1913
At oil wells: Crude	1,080,432	938,391	906,625	952,676	1,068,427
At refineries:					
Crude	2,495,087	3,073,853	1,887,270	2,551,577	2,081,428
Illuminating	938,971	947,024	1,028,885	1,268,626	1,144,663
Lubricating	247,358	272,017	272,170	260,397	260,599
Residuals	4,703,372	5,647,526	3,195,771	3,396,775	2,817,656
Other products	234,048	224,240	306,825	443,643	374,909
Total	9,699,268	11,103,051	7,597,546	8,873,694	7,747,682

Grosny field.—The following tables show the production in the Grosny field from 1909 to 1913:

Production of petroleum in the Grosny oil field, 1909–1913, in poods and barrels.

Year.	Pumping.		Flowing.		Total.	
	Poods.	*Barrels.*	*Poods.*	*Barrels.*	*Poods.*	*Barrels.*
1909	50,997,451	6,122,143	6,035,564	724,557	57,033,015	6,846,700
1910	58,097,733	6,974,518	15,950,625	1,914,841	74,048,358	8,889,359
1911	71,481,505	8,581,213	3,708,086	445,148	75,189,591	9,026,361
1912	65,319,687	7,841,499	109,920	13,196	65,429,607	7,854,695
1913	68,643,505	8,240,517	5,015,760	602,132	73,659,265	8,842,649

Well record in the Grosny field in 1909–1913.

Year.	Number of plots.		Total wells.	Producing, Dec. 31.	Boring and deepening, Dec. 31.	Average depth of wells.	Total sum of depth of producing wells.	Total length of wells drilled in the year.
	Producing.	Being exploited.						
						Feet.	*Feet.*	*Feet.*
1909	....	....	320	182	58	1,458.1	250,831	82,537
1910	44	71	343	234	67	1,557	....	87,836
1911	80	195	358	195	61	1,670	....	72,933
1912	....	223	402	264	71	1,752	....	119,165
1913	83	280	554	352	116	1,798	....	201,867

Crude petroleum on hand in Grosny field Jan. 1, 1910, 285,829 barrels; Dec. 31, 1910, 787,949 barrels; Dec. 31, 1911, 141,649 barrels; Dec. 31, 1912, 245,583 barrels.

Novorossisk.—The following tables show the shipments of petroleum and its products from Novorossisk from 1907 to 1912, and stocks on December 31, 1912 and 1913:

Shipments of petroleum from Novorossisk, 1907–1913, in metric tons.

Year.	Crude oil.	Illuminating.[a]	Benzine.	Residuals.	Total.
1907	....	34,414	31,543	24,922	90,879
1908	....	15,824	38,690	18,112	72,626
1909	....	23,248	54,800	49,920	127,968
1910	6,025	32,187	63,232	67,973	169,417
1911	18,690	62,044	65,520	76,092	222,346
1912	....	90,444	123,098	24,817	238,359
1913	....	69,216	120,000	20,973	210,189

[a] Refined.

Stocks of petroleum at Novorossisk, Dec. 31, 1911, 1912, and 1913.

	1911		1912		1913	
	Poods.	Barrels.	Poods.	Barrels.	Poods.	Barrels.
Crude	179,800	21,585	72,000	8,643	100,600	12,077
Illuminating oils	317,600	39,700	443,400	55,425	738,100	92,263
Astatki	282,000	31,333	230,000	25,555	839,000	93,222
Other products	1,361,000	162,459	1,073,900	127,845	1,736,500	207,281
Total	2,140,400	255,077	1,819,300	217,468	3,414,200	404,843

Batum.—The following table shows the shipments of petroleum products from Batum from 1909 to 1913:

Shipments of petroleum from Batum, 1909–1913.

Year.	Refined petroleum.	Lubricating.	Residuals.	Total.
	Metric tons.	*Metric tons.*	*Metric tons.*	*Metric tons.*
1909	405,857	164,840	78,839	649,536
1910	423,993	157,608	45,811	627,412
1911	353,518	171,725	57,282	582,525
1912	327,338	188,894	53,300	569,532
1913	454,165	183,180	62,594	699,939

The following were the stocks of petroleum products held at Batum at the close of the year from 1909 to 1913, in poods and barrels:

Stocks of petroleum at Batum, Dec. 31, 1909–1913.

	1909		1910		1911		1912		1913	
	Poods.	*Barrels.*	*Poods.*	*Barrels.*	*Poods.*	*Barrels.*	*Poods.*	*Barrels.*	*Poods.*	*Barrels.*
Illuminating...	2,700,000	350,000	2,590,778	323,847	2,216,007	278,251	3,384,654	423,082	1,777,723	222,215
Lubricating....	972,000	118,826	1,092,431	133,670	888,605	108,631	2,009,475	245,657	1,458,001	178,240
Solar oil........	24,000	3,000	} 522,032	60,000						
Vaseline........	158,000	18,860			300,585	35,880	963,794	107,088	1,063,459	118,162
Residuals......	577,000	64,111								
Total....	4,431,000	554,797	4,205,241	517,517	3,405,197	422,762	6,357,923	775,827	4,299,183	518,617

AUSTRIA-HUNGARY.

GALICIA.

Production.—Production in Galicia has been declining continuously since 1909 at the rate of about 2,000,000 barrels a year. In 1913, however, the decline was less than 1,000,000 barrels or from 8,535,174 barrels of 42 gallons each in 1912 to 7,818,130 barrels in 1913. The decline came altogether from Tustanowice, the dominating field of Galicia. In the other districts, Boryslaw and West Galicia, an increase was shown. There was a considerable decline in the amount of oil exported from Austria-Hungary and a large increase in the imports.

The Austrian railways have partly abandoned the use of oil on their northwestern lines and have reintroduced coal as fuel

Oil production from hand-dug wells has entirely ceased in Galicia, the number of such hand-dug wells having been reduced to 15, and on these no work was done during the year. Forty-three producing wells were worked by hand pumps, 914 by steam, 620 by gas motors, and 18 were flowing wells. There are also 861 wells which were not productive. Of the wells in the Boryslaw-Tustanowice area 252 exceeded 4,000 feet, the deepest having reached 5,400 feet, or over one mile.

The Canadian pole system of drilling is used almost entirely, the hydraulic system being forbidden by the authorities who have the questionable belief that this method is apt to drown out the oil strata.

A union formed among the producers in Galicia is devoting every possible effort to the discovery of new oil territory with good prospects of success.

Production of petroleum in Galicia, 1904–1913.

Year.	Metric centners.[a]	Barrels of 42 gallons.	Year.	Metric centners.[a]	Barrels of 42 gallons.
1904	8,271,167	5,947,383	1909	20,767,400	14,932,799
1905	8,017,964	5,765,317	1910	17,625,600	12,673,688
1906	7,604,432	5,467,967	1911	14,629,400	10,519,270
1907	11,759,740	8,455,841	1912	11,870,070	8,535,174
1908	17,540,220	12,612,295	1913	110,872,860	7,818,130

[a] 1 metric centner or quintal=100 kilograms (220.462 pounds); 1 metric centner or quintal of crude petroleum=0.71905 barrel of 42 gallons.

In the following table is given the production of petroleum in Galicia in 1909 to 1913, inclusive, by fields, in tons:

Production of petroleum in Galicia, 1909–1913, by fields, in metric tons. [a]

Field.	1909	1910	1911	1912	1913
East Galicia:					
Tustanowice	1,706,435	1,404,320	1,105,420	856,440	691,382
Boryslaw	231,195	209,300	197,320	170,500	205,904
Schodnica	34,860	32,860	} 160,200 (Schodnica to Libusza, etc.)	} 160,067 (Schodnica to Libusza, etc.)	} 190,000 (Schodnica to Libusza, etc.)
Urycz, Mraznica, Other fields	28,110	38,170			
West Galicia:					
Potok	11,370	13,010			
Rogi, Rowne	9,540	8,200			
Krosno	20,690	25,200			
Tarnawa-Wielopole-Zagorz	6,770	2,700			
Kobylanka, Kryg, Zalawie, Lipinki, Libusza, etc	27,770	28,800			
Total	2,076,740	1,762,560	1,462,940	1,187,007	1,087,286

[a] 1 metric ton=7.1905 barrels of crude petroleum of 42 gallons=2,204.62 pounds.

Deliveries of Galician petroleum to refineries, 1908–1912, in metric tons.

	1908	1909	1910	1911	1912
Deliveries to refineries:					
In Galicia and Bucovina	457,020	451,290	362,160	392,020	533,500
In the rest of Austria	540,820	672,970	547,950	488,770	535,160
In Hungary	338,720	384,090	319,380	347,550	313,930
To the State refinery in Drohobycz	....	....	208,760	337,340	372,270
Total	1,336,560	1,508,350	1,438,250	1,565,680	1,754,860
Exported	....	41,920	3,280	840	1,010
Used as fuel	....	120,000	97,430	90,120	33,910
Stocks in Government reservoirs	....	406,470	819,700	[a] 871,330	[b] 512,540
Total	....	2,076,740	2,358,660	2,527,970	2,302,320

[a] Does not include producers' storage, which decreased from 858,490 tons to 605,280 tons.
[b] Does not include producers' storage, which decreased to 280,510 tons.

Imports and exports.—In the following table are given the imports and exports of petroleum products into and from Austria-Hungary in 1910–1913:

Imports and exports of petroleum into and from Austria-Hungary in 1910–1913, in metric tons.

Kind.	1910		1911		1912		1913	
	Imports.	Exports.	Imports.	Exports.	Imports.	Exports.	Imports.	Exports.
Illuminating oils	1,460	266,739	1,517	265,378	1,377	383,183	1,868	285,445
Lubricating and other oils	15,358	139,071	18,213	91,065	19,687	155,583	27,037	155,907
Benzine	40	39,320	10	41,904	89	68,698	2,683	49,773
Paraffin	455	44,432	631	37,940	546	51,594	300	43,101
Crude petroleum	18,967	5,472	19,020	610	17,873	1,660	19,134	1,112
Ozokerite	....	....	....	....	150	2,525	146	2,275
Ceresin	....	....	....	....	39	1,712	16	1,550
Total	36,280	495,034	39,391	436,467	39,761	664,955	51,184	539,163

The conditions of oil refining in Galicia are well described by Dr. A. Guiselin, secretary of the International Petroleum Commission.[1]

ROUMANIA.

GENERAL CONDITIONS.

In spite of the Balkan war, with its depressing effects upon all industries, and of two unusually disastrous fires in the oil fields, the Roumanian producers succeeded in increasing, though very slightly, the total production of crude petroleum as is shown in the following tables, which give also valuable data as to the total yield of the chief products of the refineries.

In spite of the mobilization of the Roumanian Army in June and the consequent loss of workmen and drillers, exploitation increased as to both drilled and hand-dug wells. A gusher drilled in January, known as well No. 79 of the Columbia Co., at Gropi, opened new territory connected with Chiciura. In February the Astra-Romana Co. struck a gusher at Staropoleos-Moreni which added new territory west of previous developments in the Moreni field. In March the Romana-Americana Co.'s well No. 2 Fierbatori (Baicoi) proved a violent gusher and also opened new territory. In March also came a great fire at Moreni-Bana, caused by an oil well explosion, of which Harold Masterson, engineer of the Roumanian Consolidated Oil Fields, was a victim. The Steaua Romana obtained in this month its first well at Runcu, opening territory between the Bordeni and the Chiciura pools. In July the conclusion of peace in the Balkan States and the demobilization of the army in August caused considerable increase in oil operations. Several wells were drilled to the north of Mislishoara, adding new territory to that important region. But the industry received a serious setback in October by a well explosion and fire lasting 14 days, in which 17 wells were destroyed, among them the great gusher Columbia No. 1, which had yielded in all about 2,600,000 barrels of oil. Important progress was made in the construction of the pipe line from the oil fields to Constantza, on the Black Sea.

An invitation was extended early in the year for a general session at Bucharest of the International Petroleum Commission, but this was withdrawn in August. Meantime the minister of industries decided to found an International Petroleum Institute with headquarters in Bucharest. The organization of this institute was completed in December, and all nations were invited to join in it. Meanwhile the International Petroleum Commission also took into consideration the transformation of the commission into an international institute, and correspondence was active with a view to harmonizing the two propositions.

About 12,000 persons are employed in the oil-producing industry, 94 per cent of them Roumanians. Over 4,000 tank cars were in service in Roumania in 1913, consuming 1,500,000 barrels of oil. This was 64 per cent of the total fuel burned in the 780 locomotives. The remaining fuel was chiefly Roumanian coal; 8 per cent was wood.

[1] Bulletin mensuel de l'Association amicale: L'Ecole de physique et de chimie industrielles, Paris, May, 1912.

The crude oil, residues, etc., transported amounted to 675,615 metric tons; refined products aggregated 523,809 tons. The average revenue per ton of oil transported was $1.

Production of petroleum in Roumania in 1912 and 1913, by districts and months, in metric tons. [a]

1912.

Month.	District Prahova.					Dambovitza.	Buzeu.	Bacau.	Total.
	Bustenari-Calinet-Bordeni.	Campina Poiana.	Moreni.	Other.	Total.				
January	22,380	28,563	50,444	10,564	111,951	9,105	4,260	2,332	127,648
February	21,702	33,582	60,010	9,816	125,110	11,965	5,616	2,950	145,641
March	23,935	27,984	60,286	10,091	122,296	10,385	5,537	1,394	139,612
April	26,959	24,254	66,749	9,680	127,642	6,677	6,693	2,261	143,273
May	28,784	24,089	63,371	11,402	127,646	5,523	8,124	3,408	144,701
June	27,815	22,978	81,357	12,136	144,286	5,232	8,807	3,305	161,630
July	25,535	23,242	93,566	11,900	154,243	5,175	7,014	2,959	169,391
August	26,476	22,599	75,167	10,624	134,866	4,914	6,450	2,399	148,629
September	24,767	20,880	90,471	15,182	151,300	3,726	7,614	1,699	161,339
October	24,854	21,415	87,375	13,208	146,852	4,124	8,999	1,971	161,946
November	22,769	21,507	71,798	12,563	128,637	3,806	7,954	1,901	142,298
December	25,655	24,312	77,507	12,398	139,872	3,684	10,203	1,894	155,653
Total	301,631	295,405	878,101	139,564	1,614,701	74,316	87,271	28,473	1,804,761

1913.

Month.	Bustenari-Calinet-Bordeni.	Campina Poiana.	Moreni.	Other.	Total.	Dambovitza.	Buzeu.	Bacau.	Total.
January	30,869	22,285	85,485	12,465	151,104	3,356	9,602	2,103	166,165
February	25,265	21,595	76,685	10,396	133,941	2,838	8,512	2,462	147,753
March	25,149	23,151	78,637	15,991	142,828	2,710	10,217	2,767	158,522
April	23,988	21,298	88,087	12,952	146,325	2,734	10,107	4,517	163,683
May	24,786	22,160	84,617	12,178	143,741	3,499	10,162	4,014	161,416
June	26,115	21,327	88,862	10,996	147,300	3,874	10,075	3,798	165,047
July	25,094	20,881	84,481	10,786	141,242	3,739	8,880	2,365	156,226
August	21,333	19,219	88,167	9,506	138,225	3,540	9,167	2,733	153,665
September	20,809	17,536	82,979	13,575	134,999	3,455	11,306	3,637	153,397
October	28,946	18,948	86,717	14,287	148,898	3,532	12,054	3,776	168,260
November	26,904	17,962	61,766	12,617	119,249	3,782	12,002	4,021	139,054
December	24,356	17,353	75,470	12,728	129,907	4,524	13,638	3,968	152,037
Total	303,614	243,715	981,953	148,477	1,677,759	41,583	125,722	40,161	1,885,225

[a] 1 metric ton=7.19 barrels of 42 gallons.

The following table gives the statistics of the production of petroleum in Roumania in 1909–1913:

Roumanian petroleum industry, 1909–1913, in metric tons.

	1909	1910	1911	1912	1913
Crude-oil production	1,297,257	1,352,407	1,544,847	1,804,761	1,885,225
Crude oil treated at refineries	1,107,825	1,215,299	1,404,403	1,668,389	1,787,245
Output of refineries:					
Benzine	201,253	230,703	260,653	352,492	422,019
Illuminating oil	263,998	272,222	312,711	345,802	380,074
Lubricating oil	43,446	25,064	24,703	43,438	48,416
Residuals	576,600	667,260	783,136	898,011	906,735
Home consumption:					
Benzine	14,041	20,314	24,450	30,656	30,131
Illuminating oil	39,451	41,849	43,941	49,941	51,396
Lubricating oil	15,698	17,544	22,401	28,997	33,725
Residuals	366,703	360,551	434,094	540,383	560,492
Fuel at the refineries	109,077	108,314	123,029	140,590	135,728
Exports:					
Benzine	108,218	125,751	124,384	173,817	237,168
Illuminating oil and distillate	261,637	339,282	318,441	353,563	418,622
Crude, residuals, etc	49,715	116,223	233,895	318,443	380,077
Paraffin	545	285	476	600	579
Stocks on Dec. 31:					
Benzine	40,071	29,006	51,862	60,647	66,746
Illuminating oil	79,613	56,557	73,908	126,009	145,466
Lubricating oil and residuals	157,204	270,493	248,375	227,140	79,766

The percentage of the total production furnished by each of the departments of Roumania is given in the following table:

Percentage of production of petroleum in Roumania, 1909–1913, by departments.

Department.	1909	1910	1911	1912	1913
Prahova	94.23	92.10	89.67	89.51	89.00
Dambovitza	2.33	3.20	4.47	4.11	2.21
Buzeu	1.96	2.94	4.08	4.83	6.66
Bacau	1.48	1.76	1.78	1.55	2.13
Total	100.00	100.00	100.00	100.00	100.00

Percentage of refined products from Roumanian crude petroleum, 1909–1913.

Product.	1909	1910	1911	1912	1913
Crude benzine	18.1	19.0	18.6	21.2	23.6
Illuminating oil	23.8	22.4	22.3	20.7	21.3
Lubricating oil	3.9	2.0	1.8	2.6	2.7
Residue	52.0	54.9	55.8	53.8	50.7
Loss	2.2	1.7	1.5	1.7	1.7

The production of petroleum in Roumania in the last 10 years has been as follows:

Production of petroleum in Roumania, 1904–1913, in barrels.

Year.	Quantity.	Year.	Quantity.
1904	3,599,026	1909	9,327,278
1905	4,420,987	1910	9,723,806
1906	6,378,184	1911	11,107,450
1907	8,118,207	1912	12,976,232
1908	8,252,157	1913	13,554,768

WELL RECORD.

The well record in Roumania in 1913 is shown in the following table:

Well record in Roumania in 1913, by districts.

District.	Jan. 1, 1913.						Dec. 31, 1913.					
	Bore holes.			Hand wells.			Bore holes.			Hand wells.		
	Producing.	Drilling.	Abandoned.	Producing.	Drilling.	Abandoned.	Producing.	Drilling.	Abandoned.	Producing.	Drilling.	Abandoned.
Prahova	740	259	460	104	92	299	761	359	495	99	86	271
Dambovitza	18	21	19	61	11	138	24	8	23	58	7	148
Buzeu	48	43	23	44	2	59	72	33	27	52	2	50
Bacau	55	17	40	283	86	435	87	11	15	328	22	462
Putna	......	1	....	....	....	....	......	......	1	......	......	....
Total	861	341	542	492	191	931	944	411	561	537	117	931

EXPORTS.

In the following table are given the exports of petroleum products from Roumania in the years 1909–1913, in tons:

Exports of petroleum products from Roumania in 1909–1913, in metric tons.

Kind.	1909	1910	1911	1912	1913
Crude oil, gas oil, lubricating oil, and residuals	49,715	116,223	124,384	173,817	237,168
Illuminating oil	261,637	339,282	318,441	353,563	418,622
Benzine	108,218	125,751	233,895	318,443	380,077
Paraffin scale	545	285	476	600	579
Total	420,115	581,541	677,196	846,423	1,036,446

GERMANY.

In the following table are shown the quantity and value of petroleum produced in the German Empire, by States, from 1904 to 1913, inclusive:

Production of petroleum in the German Empire, 1904–1913, by States.

Year.	Alsace-Lorraine.	Prussia and Bavaria.	Total.		Total value.	
	Quantity.	Quantity.	Quantity.			
	Metric tons.	*Metric tons.*	*Metric tons.*	*Barrels (42 gallons).*	*Marks.*	*Dollars.*
1904	22,016	67,604	89,620	637,431	5,805,000	1,381,590
1905	21,128	57,741	78,869	560,963	5,207,000	1,239,266
1906	a 22,154	59,196	81,350	578,610	5,036,000	1,198,568
1907	a 26,124	80,255	106,379	756,631	7,056,000	1,679,328
1908	a 28,898	113,002	141,900	1,009,278	9,942,000	2,366,196
1909	a 29,726	113,518	143,244	1,018,837	10,118,000	2,408,084
1910			145,168	1,032,522	10,146,000	2,414,748
1911			142,992	1,017,045	10,045,000	2,390,710
1912			144,961	1,031,050	10,190,000	2,425,220
1913			b 140,000	995,764	9,790,285	2,330,088

a Includes Bavaria. b Estimated.

1 metric ton, crude=7.1126 barrels.

GREAT BRITAIN.

Oil shale.—In the following table is shown the production of oil shale in Great Britain in 1904 to 1913, taken from the Mineral Statistics of the United Kingdom:

Quantity and value of oil shale produced in Great Britain, 1904–1913, in long tons.

Year.	England.		Scotland.		Wales.		Total.	
	Quantity.	Value.	Quantity.	Value.	Quantity.	Value.	Quantity.	Value.
1904			2,331,885	$2,695,578	1,177	$2,146	2,333,062	$2,697,725
1905	2,000	$2,920	2,493,081	2,881,343	1,704	2,890	2,496,785	2,887,153
1906			2,545,724	3,200,449	798	1,358	2,546,522	3,201,807
1907			2,690,028	3,923,971			2,690,028	3,923,971
1908			2,892,039	3,870,118			2,892,039	3,870,118
1909	40	34	2,967,017	3,970,723			2,967,057	3,970,757
1910			3,130,280	4,189,114			3,130,280	4,189,114
1911			3,116,803	4,171,174			3,116,803	4,171,174
1912			3,184,826	3,726,425			3,184,826	3,726,425
1913 a			3,000,000	3,700,000			3,000,000	3,700,000

a Estimated.

NEW SOUTH WALES.

Quantity and value of oil shale produced in New South Wales, 1902–1913, in long tons.

Year.	Quantity.	Value.
1902	62,880	$290,613
1903	34,776	139,265
1904	37,871	130,276
1905	38,226	103,399
1906	32,446	138,549
1907	47,331	154,996
1908	46,303	126,855
1909	48,718	114,932
1910	68,293	164,955
1911	75,104	179,965
1912	[a] 75,000	180,000
1913	[a] 75,000	180,000

[a] Estimated.

ITALY.

In the following table will be found the production of petroleum in Italy from 1904 to 1913. This table is taken from the volumes of the Rivista del Servizio Minerario:

Production of petroleum in Italy, 1904–1913.

Year.	Number of wells in operation.	Quantity.		Value.	
		Metric tons.	United States barrels.	Lire.[a]	Dollars.
1904	10	3,543	25,476	1,053,294	203,286
1905	9	6,123	44,027	1,826,802	352,573
1906	12	7,451	53,577	2,226,559	429,726
1907	13	8,327	59,875	1,663,300	321,017
1908	14	7,088	50,966	1,415,640	273,219
1909	12	5,895	42,388	1,178,660	227,481
1910	9	7,069	50,830	1,413,800	272,863
1911	9	10,390	74,709	1,454,600	280,737
1912	9	7,479	53,778	1,196,640	230,952
1913 [b]	9	7,000	50,334	1,000,000	193,000

[a] Lira=$0.193. 1 metric ton, crude=7.1905 barrels. [b] Estimated.

BRITISH INDIA.

The following table gives the production of petroleum in India from 1904 to 1913 in imperial gallons reduced to barrels of 42 gallons and in rupees reduced to dollars:

Production and value of petroleum in India, 1904–1913.

Year.	Quantity.		Value.	
	Imperial gallons.	Barrels (42 United States gallons).	Rupees.[a]	Dollars.
1904	118,491,382	3,385,468	7,109,566	2,303,499
1905	144,798,444	4,137,098	9,063,051	2,936,429
1906	140,553,122	4,015,803	8,613,576	2,790,799
1907	152,045,677	4,344,162	9,150,225	2,968,637
1908	176,646,320	5,047,038	10,530,135	3,416,327
1909	233,678,087	6,676,517	13,652,580	4,429,352
1910	214,829,647	6,137,990	12,538,905	4,068,039
1911	225,792,094	6,451,203	13,265,970	4,303,923
1912	249,083,518	7,116,672	14,629,170	4,746,190
1913	277,555,225	7,930,149	15,518,790	5,035,803

[a] The value of the rupee is taken as 32.44⅓ cents; 15 rupees=£1.

Production of petroleum in India, 1908–1913, by Provinces, in imperial gallons.

Province.	1908	1909	1910	1911	1912	1913
Burma	173,402,790	230,396,617	211,507,903	222,225,531	245,335,209	272,865,397
Eastern Bengal and Assam	3,243,110	3,280,750	3,320,680	3,565,163	3,747,359	4,688,628
Punjab	420	720	1,064	1,400	950	1,200
Total	176,646,320	233,678,087	214,829,647	225,792,094	249,083,518	277,555,225

DUTCH EAST INDIES.

In the following table is given the production of petroleum in the Dutch East Indies during the years 1904 to 1913, inclusive:

Production of petroleum in Dutch East Indies, 1904–1913.

Year.	Borneo.		Java.		Sumatra.		Total.		
	Metric tons.	Liters.	Metric tons.	Liters.	Metric tons.	Liters.	Metric tons.	Liters.	Barrels.
1904	215,109	238,327,180	110,053	127,692,388	542,936	668,731,900	868,098	1,034,751,468	6,508,485
1905	439,487	486,924,000	110,711	128,456,000	513,630	632,635,700	1,063,828	1,248,015,700	7,849,896
1906	387,455	429,275,398	111,378	129,229,083	602,501	742,097,300	1,101,334	1,300,601,781	8,180,657
1907	489,151	541,948,068	142,983	165,900,000	713,841	879,235,063	1,345,975	1,587,083,131	9,982,597
1908	511,049	566,209,890	137,013	158,974,000	738,588	909,715,827	1,386,650	1,634,899,717	10,283,357
1909	411,506	455,922,397	140,351	162,846,428	922,894	1,136,720,015	1,474,751	1,755,488,840	11,041,852
1910	633,472	701,853,114	142,503	165,344,877	719,740	886,505,130	1,495,715	1,753,703,121	11,030,620
1911	814,707	902,654,621	172,438	190,766,435	683,523	841,895,279	1,670,668	1,935,316,335	12,172,949
1912	671,662	744,167,950	184,989	214,641,699	621,481	765,481,929	1,478,132	1,724,291,578	10,845,624
1913	797,059	883,061,666	207,135	366,608,237	529,947	652,735,720	[a]1,534,223	1,902,550,755	11,966,857

[a] Includes 82 metric tons produced in Ceram.

1 gallon Borneo crude=7.5322 pounds.
1 gallon Java crude=7.1924 pounds.
1 gallon Sumatra crude=6.7754 pounds.
1 United States barrel=158.985 liters; 1 liter=1.0567 quarts.

TIMOR.

Consul General George E. Anderson, of Hongkong, gives the following information concerning the occurrence of oil on the island of Timor.[1]

Timor is an island about 263 miles long and 60 miles wide at its greatest breadth, 2,100 miles from Hongkong and 436 miles from Port Darwin, the nearest important port. The eastern half, where the oil fields are being developed, belongs to Portugal, and the western part to the Netherlands. The climate is considered good.

There are 4 principal oil concerns—1 of Hongkong, 1 of England, and 2 of Sydney, Australia. The fields of the Hongkong company are near the seacoast at an elevation of 200 to 300 feet above the sea, which permits the transportation of oil by pipe line and gravity. Operations here are conducted with American machinery and along the lines followed in California and similar fields. The English company must transport its supplies and machinery over a mountain range and for a considerable distance in the undeveloped interior. The work of this company so far has, therefore, consisted largely in road building and other preliminary arrangements, but the concern is now ready for boring. Both the Australian companies are using more or less American machinery.

Experts report prospects of a considerable supply of oil from Timor in the near future, a strong flow being expected at a depth of 1,200 to 1,500 feet. The oil yields a high-grade kerosene. Tested by the Hongkong Government, oil obtained on the property of the Hongkong company showed a flashing point (Abel close test) of 112°

[1] Daily Cons. Repts., Jan. 9, 1914.

F. and had a specific gravity of 0.8403. British tests of oil from other concessions have shown 64.6 per cent of kerosene and about 30 per cent of intermediate lubricating oils. Pools of black viscid oil found on the surface of the island have given oil suitable for fuel, and on much of the island limestone coated with bitumen and ozokerite is found on the surface which yields 24 per cent, by weight, of crude, heavy oil.

Work has been greatly interfered with by a recent rebellion of natives, which has now been subdued. Ordinarily labor is abundant and cheap, 10 cents gold per day for unskilled labor being the customary wage. The natives are more Papuan than Malay, and are fair workmen; but they are divided into numberless small tribes, which are constantly at war with one another.

Concessions from the Portuguese Government are usually in lots of 1,250 acres. The laws are fairly liberal, customs duties and moderate license fees being the chief charges. Development is retarded chiefly by expensive transportation and the necessity of importing from Hongkong or Australia nearly all supplies needed for Europeans.

CHINA.

Petroleum is produced in China in the Province of Szechwan, in the neighborhood of the village of Lou Tcheou, where the industry is of great antiquity. The production in this Province amounts at present to about 30,000 barrels a year. Oil is also produced in the neighborhood of Yenan Fu, in the Province of Shensi. There are indications of oil in many other localities in Kansu and Chili.

About the end of the year 1913 the Standard Oil Co., of New York, it is reported, entered into an agreement with the Chinese Government by which the exclusive privilege is given to that company of studying the oil indications of China with a view to selecting oil fields in such Provinces as prove attractive; this study is to be carried out at the joint expense of the Standard Oil Co., of New York, and the Chinese Government. If the results are favorable a Sino-American company will be formed to exploit the fields.

JAPAN.

During 1913 about 50 rotary drilling rigs were introduced into Japan and have been sufficiently successful to result in an increase in the total production. Production increased in Formosa also.

The rotary system is to be credited with drilling in the first Japanese gusher, on May 22, 1914, near Akita. It gave several thousand barrels a day from a sand 54 feet thick found at a depth of about 1,400 feet and well covered by shales. No water was found with the oil.

According to Consul General George H. Scidmore, of Yokohama, the Nippon and the Hoden oil companies have contracted to supply the Japanese Navy with 10,500 tons of petroleum for one year. He states also that the press of Japan has been publishing glowing reports of sudden alleged enormous output of petroleum in Akita Ken. A clipping from the Japan Mail gives particulars in this connection:

> As a result of the extraordinary gush of oil in Akita prefecture Japanese shipping circles will derive beneficial effects after the Panama Canal is opened. The authorities are under this belief and state that Japan imported oil in 1913 to the value of $6,000,000 gold. If the well in the prefecture yields oil at its present rate its value will be $600,000 in one month. If the oil company will equip suitable receptacles it will not only stop further import of oil but will amply supply it to foreign markets. In consequence, a majority of oil-burning vessels coming to the Pacific through the canal will stop in Japan to take liquid fuel. The number of foreign ships coming to Japan in this way will greatly increase, which will directly or indirectly benefit this country.

Mr. K. Ito, superintendent of the investigation department of the Nippon Oil Co., states: "Work begun on the new well in April. On May 25 the rotary drill at 1,368 feet struck an extraordinary deposit. It is also extraordinary that the company's other five wells in the district, which had required suction pumps, have also begun flowing of their own accord. Many reservoirs have been constructed, into which the flow was directed. The new well was sunk with an 8-inch casing, which has been capped with a 4-way head, thereby controlling the flow. The output has thus been reduced from 480,000 gallons to 120,000 gallons per 24 hours, and when the additional reservoir is filled will again be reduced. In the meantime the other five wells have been checked entirely.

The Japan Gazette, however, expresses some doubt as to the exact truth of these reports and counsels caution in receiving them, pending official and expert confirmation.

In the following table is given the production of petroleum in Japan from 1904 to 1913, inclusive:

Production of petroleum in Japan, 1904–1913.[a]

[Barrels of 42 gallons.]

Year.	Crude.	
	Koku.	*Barrels.*
1904	1,249,536	1,419,473
1905	1,296,482	1,472,804
1906	1,501,563	1,705,776
1907	1,755,464	1,994,207
1908	1,815,001	2,061,841
1909	1,657,036	1,882,393
1910	1,520,458	1,727,240
1911	1,529,593	1,737,618
1912	1,458,290	1,656,617
1913	1,693,582	1,923,909

[a] Exclusive of the island of Formosa.

1 koku=39.7 English gallons=47.46 United States gallons=1.136 United States barrels.

In the following table is given a statement of the production of petroleum in Japan, 1905–1913, by fields, as reported by the mining bureau of the department of agriculture and commerce, Tokyo:

Production of petroleum in Japan, 1905–1913, inclusive.

Field.	1905	1906	1907	1908
NIIGATA PREFECTURE.				
Echigo:	*Koku.*	*Koku.*	*Koku.*	*Koku.*
Higashiyama	273,844	304,847	342,042	263,667
Nishiyama	271,495	294,277	360,115	492,393
Niitsu	634,704	808,655	970,556	807,002
Kubiki	97,075	76,578	63,572	62,938
Amaze	5,220	7,262	12,447	
Ojiya	14,180	9,964	6,732	7,097
Others (except Formosa)				6,450
Total quantity	1,296,482	1,501,563	1,755,464	1,639,547
Total value				$3,225,153

Production of petroleum in Japan, 1905–1913, inclusive—Continued.

Field.	1909	1910	1911	1912	1913
	Koku.	*Koku.*	*Koku.*	*Koku.*	*Koku.*
Akita	3,194	12,924	25,090	31,365	76,830
Hokkaido	2,169	1,892	1,358	5,038	4,218
Nagano	64	61	55		
Niigata	1,648,678	1,502,807	1,500,482	1,419,539	1,610,117
Shizuoka	2,931	2,637	2,229	2,030	1,983
Yamagata		135	356	205	336
Kagoshima			23		
Others				113	98
Total	1,657,036	1,520,458	1,529,593	1,458,290	1,693,582
Formosa	5,664	3,208	1,442	3,040	15,933
Total	1,662,700	1,523,664	1,531,035	1,461,330	1,709,515

Production of petroleum in Japan and Formosa, 1906–1913.

Year.	Japan.		Formosa.		Total.	
	Koku.	*Barrels.*	*Koku.*	*Barrels.*	*Koku.*	*Barrels.*
1906	1,501,563	1,705,776	4,394	4,992	1,505,957	1,710,768
1907	1,755,464	1,994,207	[a] 6,717	7,631	1,762,181	2,001,838
1908	1,815,001	2,061,841	7,310	8,304	1,822,311	2,070,145
1909	1,657,036	1,882,393	5,664	7,170	1,662,700	1,889,563
1910	1,520,458	1,727,240	3,208	4,062	1,523,664	1,730,882
1911	1,529,593	1,737,618	1,442	1,638	1,531,035	1,739,256
1912	1,458,290	1,656,617	3,040	3,454	1,461,330	1,660,071
1913	1,693,582	1,923,909	15,933	18,100	1,709,515	1,942,009

[a] Estimated.

PHILIPPINE ISLANDS.

The following information is taken from the report on the mineral resources of the Philippine Islands for 1912:

Interest in the petroleum field on Bondoc Peninsula continues unabated, but no further drilling exploration has been undertaken. This district has 3 shallow wells, 2 on Bahay River (depths 40 and 100 meters), and 1 on Vigo River (depth 21 meters). All 3 wells encountered oil in small quantities.

The known oil seeps in Cebu (Toledo and Algeria on the east coast) are under the control of a local business firm (Messrs. Smith Bell & Co.), but, except the 2 wells drilled at Toledo before the American occupation, no development has been attempted.

Traces of oil on the island of Palawan were reported recently, but the exact situation of the seeps is unknown. Likewise, reports of oil in the northern part of Leyte have been received without more detailed information. Messrs. Smith Bell & Co. undertook to investigate further reported occurrences of petroleum in northern Leyte in 1896, but the insurrection of that year put an end to that work before it was completed. Their engineer stated that he found petroleum in clay or shale, but had no opportunity for a thorough examination. Petroleum seeps are indicated on Spanish maps between the towns of Villaba and San Isidro on the northwest coast of Leyte.

Several samples of gilsonite, a mineral pitch, have been submitted to the Bureau of Science recently. This material also comes from the northern part of the island of Leyte near the town of Leyte. The gilsonite occurs in a bed about 1 meter thick, the outcrop of which is exposed for 6 meters along a small stream, according to the statement of the prospector, and is overlain by sandstone in a series of strata made up principally of blue shale or clay.

A well drilled in search of water at Janiuay, Iloilo, where petroleum and natural gas have been reported in the past, encountered a small flow of natural gas with salt water in a bed of sand and gravel at a depth of 542 meters. Small films of oil come up on the water with the gas, but may represent lubricants from joints of the steel well casing. Gas issues from the well constantly but without violence, accompanied by intermittent flows of salt water.

The Janiuay well penetrates a sedimentary series—clay, shale, and coarse sands. A well drilled recently at Oas, Albay, encountered inflammable gas at a depth of 120 meters. Oas is situated in an extensive area of alluvium, and the gas in this well is probably marsh gas from plant remains in the buried alluvium. Wells in alluvial deposits at various places have encountered small flows of inflammable gas which are believed to be marsh gas.

Early in 1914 oil seepages were examined at Toledo, Cebu, and a company is reported as formed for exploiting the region.

NEW ZEALAND.

There was great activity in oil exploration in New Zealand, which, besides the formation of new oil-producing companies, included the erection of a refinery at New Plymouth, North Island, capable of refining about 500 barrels a day—a good index of the present yield of the field. The Taranaki and East Coast Oil Properties (Ltd.) and the Kotuku Oil Fields Syndicate are new companies formed to exploit the Taranaki fields and the East Coast. The Royal Dutch group is also investigating the region.

A good flowing well was obtained by a local company at Blenheim near the end of 1913.

The region has been thoroughly described in a volume by J. D. Henry.

AFRICA.

EGYPT.

The drilling of unusually large wells in Egypt during 1913 and the development of a refinery close to Suez serve to emphasize the importance of these Red Sea fields, which have been described in previous reports. These fields have awakened great interest in oil indications in that part of the world. The importance of the region is well pointed out in the Petroleum World.[1]

SOMALILAND.

Sufficient indications of petroleum have been found by British geologists in Somaliland, East Africa, to justify investigations with a view to development.

SOUTH AFRICA.

Crude oil.—The prospect of obtaining oil in South Africa has been rendered much more definite by the careful investigation of Mr. E. H. Cunningham-Craig. He finds that, up to the present, the search for oil has been chiefly directed by such deceptive surface indications as "oils naturally distilled by the heat of intrusions, marsh gas, ferric hydroxide films, salt pans, and various other phenomena, even less pertinent."

These so-called indications have led away the prospector from any chance of achieving the desired result, and considerable capital has unfortunately been sunk in propositions which never from the first

[1] Petroleum World, London, May, 1914, p. 1.

have had the remotest prospect of success and which would never have been attempted had experienced scientific advice been obtained. The first real prospecting for petroleum in the Union has yet to be undertaken. Mr. Cunningham-Craig concludes that the Karroo System is the one hope for an oil field.

In the Stromberg Series in Cape Colony, Natal, and Basutoland,, the essential conditions are fulfilled. In the Transvaal and Natal, lower horizons (Beaufort Series) also furnish sufficient raw material and even in the Dwyka Shales a certain quantity of the necessary carbonaceous matter, of what origin it is unnecessary to inquire, has been proved to exist in many localities. The conditions of deposition necessary are a thick series of strata formed of alternations of porous and impervious groups of rock formation. The absence of igneous intrusions is also to be desired. These conditions are not fulfilled as well as could be wished in any part of the Union, owing to earth movements having been too slow and regular during the deposition of the Karroo System, and the fact that igneous intrusions of post-Karroo age are very widespread.

Favorable geological structure is found only in Cape Colony, and there only in a narrow strip at the southern edge of the Karroo. There is, however, a possibility that northeastern Natal in areas he was unable to visit might furnish favorable structures.

The folded belt of the Karroo System contains excellent anticlinal and dome structures beyond the southern margin of the area characterized by igneous intrusions, and so far as he has been able to ascertain no prospecting for petroleum has been done in that region. The prospects, it must be admitted, are not very hopeful. Only the lower part of the System is involved in the folded belt, and as the carbonaceous contents of the strata seem to decrease perceptibly to the southwest, the quantity of raw material can not be large. Yet even on its southern outcrop the White Band of the Dwyka contains a fair percentage of carbonaceous matter, sufficient in some localities to have admitted of its igniting spontaneously and burning. Impervious beds to act as a cover for any oil that may be beneath the surface are present in quantity in the Ecca Shales, but the presence of a sufficiently porous reservoir rock is problematical. Thus at the best, the conditions are not favorable for large productions. But before abandoning hope of striking petroleum in the Union, it might be as well to make some investigations in this folded belt.

On both theoretical and practical grounds Mr. Cunningham-Craig recommends that the area south of Aberdeen, near Jansenville, Saxony, and Klipplaat station should be examined. Carbonaceous beds in the lower strata must be looked for, and any porous rocks which may be present. If well-marked anticlined or elongated dome structures can be discovered in this area, the well-marked anticline or dome farthest north should be selected, where the White Band of the Dwyka is not less than 1,500 feet beneath the surface, and a well should be drilled to test the series as far as the White Band or even lower.

Though it is by no means certain that petroleum will be discovered such a well if successful will open up a wide area, and if unsuccessful will set at rest all hopes of striking oil in the Union.

A small production of oil will pay in South Africa, and, even if oil be not struck, it is quite possible that natural gas may be discovered under sufficient pressure to prove a valuable commercial asset.

Though the district near Jansenville and Klipplaat is here selected as being on the railway and easily accessible, it must be remembered that it is on the detailed geological work and its results that the area for testing must be selected. The composition of the Dwyka Beds must be one of the first considerations, and unless it appears that (1) sufficient carbonaceous matter is present, and (2) that the structures are suitable, some other district should be selected.

Natural gas.—There are areas in both the Transvaal and Natal, in the "Coal Measures," where natural gas can be found in fair quantity and might be utilized with profit. It will probably be found only beneath dolerite sheets, since thick impervious shale bands are rare. It is not probable, however, that supplies of gas under pressure sufficient to supply towns at a distance from the gas fields are likely to be found, but the gas may be made a source of profit locally. Gas wells should not be drilled within 600 yards of one another. In the neighborhood of Gruisfontein, Heidelberg District, further prospecting for gas is likely to be successful at comparatively shallow depths.

In the folded belt of the Karroo System the striking of gas in greater or less quantity is probable. A prospecting well for oil will serve the purpose of prospecting for gas also; hence it is not necessary to enlarge upon the point.

Oil shales.—In dealing with oil shales it must be remembered that in the Scottish shale fields great variations in quality are frequent in any seam, and it is not to be expected that shale seams in South Africa are likely to be free from similar variations. It has been found, however, that earth movements have affected shales prejudicially in Scotland. The almost entirely undisturbed state of the strata in South Africa should make the oil shales free from that source of deterioration. In Scotland 130 gallons a ton of shale (from torbanite mineral) is the greatest yield that has been obtained, but many shales are worked that yield no more than 20 or 22 gallons a ton; 18 to 22 pounds of ammonium sulphate a ton is considered a good yield.

Seams need not be very thick to be worth working if the yield of oil be good. In Scotland a 17-inch seam was worked together with a 2-foot seam of coal at Broxburn. The "Grey Shale" at Addiewell was 1 foot 8 inches in thickness, and the "Wee Seam" at Oakbank 2 feet thick, and immediately above the Levensent limestone a seam of 11 inches was worked. Thin seams, however, are not worked now. The crude oil always gives a considerable "loss in refining." These details are given to enable a comparison to be made with the South African shales.

In considering the prospects of the mining and distillation of oil shale the points to be noted specially are (1) accessibility of the area, (2) proximity to markets, (3) cost of mining, and (4) prices ruling in the nearest markets.

Though none of the shales examined, with the exception of that at Kikvorschfontein, are comparable with the best Scottish oil shales, the laboratory tests that have been made prove that very fair quantities of shale oil can be produced. Laboratory tests, however, are not exactly what is required; commercial tests on a large scale are absolutely necessary if we are to obtain an accurate idea of the value of the various seams.

The seams are unfortunately thin as a rule, and this will greatly increase the mining cost per ton. But against this must be placed the facts that the demand for oils in South Africa is large, that prices ruling at present are very high, and that freight charges are high also. Thus a shale too thin to be worked at a profit in many countries might prove very profitable to work in South Africa.

Mining will be a simpler matter in all the localities visited, and a 3-foot seam with good roof and floor should not cost more than 6s. or 7s. per ton to mine. To be on the safe side, 8s. may be taken as the cost per ton—an outside figure. Then, if as much as 20 gallons a ton can be obtained, a profitable industry is in sight. But yields considerably greater than 20 gallons of oil a ton may be expected. In addition, ammonium sulphate may be another source of profit. In England the crude sulphate sells at from £12 to £14 a ton, and it will doubtless be more expensive in South Africa, where there should be a considerable demand for it as a fertilizer. The recovery of this product will necessitate the making of sulphuric acid, which is very expensive to import, but the oil refining will require sulphuric acid in any case.

In dealing with thin seams, the mining costs per ton will, of course, be high (though 8s. per ton should not be exceeded), but the refining costs will be the same and the quantity of oil per ton may be greater.

The Kikvorschfontein, Mooifontein, Waaihoek, and Hlatimbe-Umkomaas areas should all be considered in this connection. Especial attention is called to the last of these, as it lies within 100 miles of Durban. It seems probable that these shale deposits may be found within 8 or 10 miles of a new railway line to Himeville, which has been projected. It is possible that much of the heavier oils might suit admiralty purposes as fuel oil, and the area nearest to the seaboard is obviously marked out as that which should supply liquid fuel. There is at present a considerable demand for oil for naval purposes, and requirements have recently been altered to admit of the use of oils with a sulphur percentage as high as 3.

Mr. Cunningham-Craig is of opinion that prospecting the folded belt of the Karroo System for crude petroleum and natural gas is of less importance than the development of the mining and refining of shale, and may therefore be relegated to a secondary place. All the evidence to hand at present leads to the belief that an oil-shale industry has good prospects of proving successful in South Africa, and he urges that no effort should be spared to insure a fair test of its possibilities.

ANALYSES OF PETROLEUM FROM VARIOUS PARTS OF THE UNITED STATES.

GENERAL STATEMENT.

The following tables have been compiled from all accessible publications in order to furnish a ready means of comparison of the various crude petroleums in the United States. They are based primarily on the compilation by J. P. Dunlop, of the United States Geological

Survey, of the analyses recorded in the following publications up to and including 1907:

- Publications of the United States Geological Survey.
- The State geological survey reports and bulletins of New York, Pennsylvania, West Virginia, Ohio, Kentucky, Tennessee, Indiana, Illinois, Kansas, Louisiana, Texas, Colorado, Wyoming, and California.
- "Mineral Industries" volumes of the Tenth and Eleventh censuses.
- Transactions of the American Institute of Mining Engineers.
- American Journal of Arts and Sciences from 1850 to 1907.
- Journal of the American Chemical Society.
- American Chemical Journal, 1878 to 1907.
- Journal of the Franklin Institute, 1840 to 1907.
- Journal of the Chemical Society, 1859 to 1907.
- Journal of the Society of Chemical Industry.
- Philosophical Magazine.
- Chemical News.

This compilation was published in Mineral Resources of the United States for 1907. Subsequently, many analyses have been made in the United States Geological Survey and have been published in various official bulletins, the volumes of Mineral Resources, etc. Many others have been made in the course of the studies of various oil fields and have not been published.

For convenience of access and comparison, these analyses have all been combined and arranged geographically.

The degrees of accuracy and the methods of expressing the results differ greatly in the analyses gathered from the general literature of the subject. In arranging the analyses effort has been made to show the variation in specific gravity, in percentage of sulphur, of asphalt, and of paraffin, and in distillation products. Other analytical data are given under "Remarks."

On the whole, the tables are very incomplete and show clearly the necessity for much additional work. The analyses cited show very full work in some fields and almost nothing in others. In Pennsylvania, New York, Ohio, Indiana, and the newer fields information is lacking as to even the exact locality from which many of the samples came and the conditions under which any particular specimen was obtained. Usually there is no statement as to care used in avoiding evaporation from the sample. Up to 1897 the analytical methods of the older analysts varied to such an extent that as much as 30 per cent difference in the proportion of naphtha will be shown in two samples from the same region, and thus a far greater difference will be shown between two samples from the same pool, as analyzed by the older analysts, than between the oils from widely separated districts. Yet there are no explanatory statements to make these differences intelligible. No more conclusive argument could be offered for the need of a general review of the analytical characteristics of all American oils.

This need was recognized by sending David T. Day, of the Geological Survey, to the Third International Petroleum Congress, held at Bucharest, Roumania, in 1907, where he aided in organizing for the first time an international commission for establishing uniform methods of examining crude petroleum and its products. This international commission considered, during the week in which the Congress was held, the various methods used by different authorities and formulated and recommended to the congress for international adoption a provisional system of analysis. This system was adopted by the congress and it was recommended to the various nations for general adoption pending any modifications which might be made by an international commission which this congress created for this purpose. This action was reported to the Congress of the United States in response to a resolution of the Senate, and the rules for analysis were printed as a Senate document.[1]

Since 1907 this international commission has held two general sessions, one in London in 1909 and one in Vienna in 1910. At each of these meetings the system adopted at Bucharest was confirmed, with slight additional rules designed to increase accuracy, the fundamental system remaining fixed.

With this uniform system as its basis, the United States Geological Survey in cooperation with various State geologists immediately began the collection of samples under uniform conditions from the various fields of the United States. These have been examined by exactly the same methods in order that they may be entirely comparable. The work is limited to crude oils, so that these various natural oils may be classified and be made to show their relations to the rocks in which they occur. The study of the composition of the products manufactured from them, as well as the processes by which they are refined, has been left to the Bureau of Mines. A collection, complete at that time, was made of the oils of the Mid-Continent field, including Kansas, Oklahoma, Caddo, and north Texas. The samples were collected at the wells by members of the Survey. Average specimens were also collected in each field from pipe-line tanks, because this showed the actual average, in which the largest wells were given fairer weight than by an arithmetical average of large and small wells. Efforts were made, in collecting these samples from pipe lines, to select those in which the oil had had chance to be well mixed. The samples were, therefore, as representative as possible. The samples from Illinois and other States were similarly collected by members of the Federal or State surveys.

METHOD OF ANALYSIS.

Gravity.—A set of very delicate specific gravity spindles was made especially for this investigation by C. Tagliabue & Sons. The samples are brought to a temperature of 60° F. in a cylinder cooled in a water bath. The specific gravity is then taken, and the tables show also the conversion of this figure into degrees Baumé.

Distillation.—The samples are then distilled by Engler's method as modified by Ubbelohde and adopted by the international commission. Thus 100 cubic centimeters of the crude oil, measured at 60° F., are delivered by a pipette into a distilling bulb holding about 125 cubic centimeters. The dimensions of this bulb are those prescribed by Engler; the length of neck, position of side tube, etc., are exactly given. The thermometer used is a nitrogen thermometer, reading to 550° C., which has been carefully standardized by the United States Bureau of Standards. The condenser tube, as prescribed by Engler,

[1] S. Doc. No. 469, 60th Cong., 1st sess., 1908.

is 75 centimeters long and has an inclination of 75 degrees from the horizontal. The point of initial boiling is taken when the first drop of oil fell from the condenser tube into the receiving flask. To avoid loss by evaporation the condenser tube is ground to fit into the graduated receiving flask, which is provided with a stop cock to draw off the oil at 150° C. and again at 300° C. Note is also taken of the proportions boiling within each range of 25° C., but these details are not published in the tables given herewith. The fraction between the initial boiling point and 150° C. (302° F.), constituting the gasoline fraction, and the fraction between 150° and 300° C. (302° and 572° F.), constituting the kerosene fraction, are examined as to specific gravity with a picnometer. The residuum is weighed as soon as cool; then its specific gravity is taken in the usual way and the volume calculated. As will be noted, the total thus obtained for the different fractions includes the sum of all variations in the determinations. This total for many samples slightly exceeds 100 per cent, due to errors in coefficient of expansion, etc., but for a greater number is considerably below that amount, owing to the presence of water, loss of volatile gasoline, etc.

Unsaturated hydrocarbons.—The method of Kramer and Bottcher is used for determining the unsaturated hydrocarbons present in the crude oil and in the distillate between 150° C. and 300° C. The quantity of gasoline in many samples was too small for systematic determination of the percentage of unsaturated hydrocarbons in it. The method consists in shaking 25 cubic centimeters of the crude petroleum with 25 cubic centimeters of sulphuric acid of specific gravity 1.83, corresponding to ordinary strong sulphuric acid, about the equivalent of that used in petroleum refining. The acid and oil are shaken in a small flask with a long neck, the neck holding 25 cubic centimeters. The flask is then filled with strong sulphuric acid until the oil which remains uncombined with the acid can be measured in the neck of the flask. The loss in volume between the original 25 cubic centimeters and the oil which remains undissolved by sulphuric acid is taken to represent the unsaturated hydrocarbons.

Paraffin wax.—This was determined by the Engler Holde method. Two parts of absolute alcohol and one part of absolute ether are used as the solvent, from which the paraffin wax is precipated on cooling to −20° C.

Asphalt.—The asphalt was determined by Holde's method, by weighing off 1 gram of residuum and shaking this with 40 cubic centimeters of gasoline which was free from unsaturated hydrocarbons and which boiled between 65° and 95° C. After shaking this is allowed to stand for 48 hours and the precipitated asphalt is dissolved in benzol, dried at 105°, and weighed. Accuracy greater than 1 per cent is not claimed for these analyses.

Sulphur.—The sulphur is sometimes determined by Burton's method of burning in a lamp and collecting the SO_2 and H_2SO_4 in a solution of Na_2CO_3 and titrating with methyl orange and sometimes by the bomb. When both methods are used on the same sample the results are consistent.

No attempt has been made in these tables to continue the compilation of analyses of other authorities since 1907.

Refinery analytical methods.—It may be well to note that the analyses made in refineries are intended not for comparative purposes but as a guide to what can be obtained, in the sort of still employed in that refinery, of products for which that refinery has a market at that time. Therefore instead of defining the gasoline yield as the product which distills over up to 150° C., the refiner includes in the gasoline or "crude naphtha" cut, all of the distillate which is lighter than a certain gravity. This gravity varies with his trade. When, however, they wish to compare crude oils from various sources, these refiners are coming to use the international system more and and more generally.

Analyses of petroleum from various parts of the United States.

Serial No.	Location of well.	Collected by—	Collected from—	Well.	Depth of well (feet).	Physical properties. Gravity at 60°F. Specific.	Baumé.	Color.	Odor.
	ALASKA.								
1	Katalla Bay		Well	10		0.8280	39.1		
2	Katalla		do	10		.7958	45.9		
3	Do		do	10		.8000	45.0		
4	Cold Bay		Seepage			.9547	16.6	Dark green	
5	Oil Bay		do			.9557	16.5	do	
	CALIFORNIA.								
6						.8348	37.7	Dark brown opaque.	
7	Alameda County; Alisol Oil Co		Tank			.8766	29.7	Brown	
8	Alameda County	Robert Anderson				.8850	28.2	Black	
9	Colusa County					.8257	39.6	Yellow	
10	Do					.9835	12.3		
11	Do					.9534	16.8		
12	Do					.9635	15.3		
13	Contra Costa County					.9667	14.8	Black	
	Fresno County:								
14	Coalinga		Tank, Oil City			.8568	33.4	Green	

1. U. S. Geol. Survey Bull. 225, 1904. Penniman and Browne, analysts.
2. U. S. Geol. Survey Mineral Resources, 1902, p. 583, 1903.
4-5. U. S. Geol. Survey Bull. 250, p. 121, 1905. Penniman and Browne, analysts.
6. Am. Chem. Soc. Jour., 1891. D. Woodman.
9. Am. Chem. Soc. Jour., vol. 25, p. 669. Edmond O'Neill.
10. California State Min. Bur. Bull. 19. M. L. Watts.
11. California State Min. Bur. Bull. 19.
12. U. S. Geol. Survey Mineral Resources, 1903, p. 178, 1904. Paul W. Prutzman, analyst.
13. Am. Chem. Soc. Jour., vol. 25, p. 669. Edmond O'Neill.
14. California State Min. Bur. Bull. 31.

Analyses of petroleum from various parts of the United States—Continued.

Serial No.	Location of well.	Distillation by Engler's method. Begins to distill at (°C.).	By volume. To 150° C. Cubic centimeters.	To 150° C. Specific gravity.	150°-300° C. Cubic centimeters.	150°-300° C. Specific gravity.	Residuum. Cubic centimeters.	Residuum. Specific gravity.	Total. Cubic centimeters.	Sulphur (per cent)	Paraffin (per cent)	Asphalt (per cent)	Water (per cent)	Unsaturated hydrocarbons (per cent). Crude	Unsaturated hydrocarbons (per cent). 150°-300°C.	Remarks.
	ALASKA.															
1	Katalla Bay		21.0	0.7573	51.0	0.8204	28.0		100.0							Residuum paraffin base.
2	Katalla		38.5		31.0		30.5		100.0	Tr.						Residuum all over 285° C.; cold test—did not chill at 3° F.
3	Do		34.2		34.4		31.0		99.6							
4	Cold Bay	225			13.3	.8772	86.7		100.0	0.116						86.7 p. ct. residuum includes 8.1 p. ct. coke and loss and products distilled under 120 mm. pressure up to 350° C., and also products by destructive distillation.
5	Oil Bay	230			13.2	.8777	86.8		100.0	.098						86.8 p. ct. residuum includes 5.6 p. ct. coke and loss and products distilled under 120 mm. pressure up to 350° C., and also products by destructive distillation.
	CALIFORNIA.															
6			10.0	.730	40.0		50.0		100.0							Lubricating oil, 40 p. ct.; residuum, 10 p. ct.
7	Alameda County; Alisol Oil Co.	175			48.0	.8279	52.0	0.9272	100.0		5.4	0.9				
8		160			47.0	.8202	53.0	.9504	100.0							
9	Colusa County				a77.8							0.50				a 150°-350° C.
10	Do		0.0		16.25	.9111	83.75		100.0							Sample contained sludge.
11	Do		Tr.		a21.6	.8533	78.4		100.0							300°-350° C., 3 p. ct. Sample contained sludge.
12	Do		0		a19.0		81.0		100.0							a 150°-270° C. Maumene No. 0.306.
13	Contra Costa County		3.7		a54.5		42.8		101.0			21.0				a 150°-350° C.
	Fresno County:															
14	Coalinga		(a)													Gasoline, 2.3 p. ct.; engine distillate, 22.3 p. ct.; kerosene, 28.6 p. ct.; stove oil, 10.3 p. ct.; gas oil, 9.9 p. ct. a Temperature not given.

Analyses of petroleum from various parts of the United States—Continued.

Serial No.	Location of well.	Collected by—	Collected from—	Well.	Depth of well (feet).	Physical properties. Gravity at 60°F. Specific.	Baumé.	Color.	Odor.
	CALIFORNIA—continued.								
	Fresno County—Continued.								
15	Coalinga		Tank, top sand oil.			0.8974	26.0	Black	
16	Do		Pipe line			.9296	20.6		
17	Do		Pipe line, Ora crude.			.9321	20.2		
18	Do					.8537	34.0		
19	Do					.8521	34.3		
20	Do					.9880	11.7		
21	Coalinga; M. K. & T. Oil Co.					.9589	16.0		
22	Coalinga								
23	Do		Spring			.9743	13.7		
24	Do					.7609	54.0		
25	Do					.9028	25.1	Brown	
26	Do					.9511	17.2	do	
27	Do					.9320	20.2	do	
28	Do					.8459	35.5	Greenish	
29	Coalinga; California Oilfield, Ltd		Well	2	1,020	.9150	23.0		
30	Do		do	11	1,125	.8679	31.3		
31	Coalinga		do	R. C. Baker	590	.9756	13.5		

15–17. California State Min. Bur. Bull. 31.
18. California State Min. Bur. Bull. 19, p. 204.
19–20. California State Min. Bur. Ann. Rept. 1894, p. 352.
21. U. S. Geol. Survey; from card reporting production, 1905.
22. U. S. Geol. Survey Mineral Resources, 1897, p. 100, 1898.
23. California State Min. Bur. Bull. 3, p. 90.
24. U. S. Geol. Survey Mineral Resources, 1896, p. 845, 1897. Frederick Salathe, analyst.
25–27. Am. Chem. Soc. Jour., vol. 25, p. 609. Edmond O'Neill.
28. Am. Chem. Jour., vol. 19, p. 802. Charles F. Mabery.
29–31. California State Min. Bur. Bull. 31. H. N. Cooper, chemist.

Analyses of petroleum from various parts of the United States—Continued.

Serial No.	Location of well.	Distillation by Engler's method. Begins to distill at (° C.)	By volume. To 150° C. Cubic centimeters.	To 150° C. Specific gravity.	150°–300° C. Cubic centimeters.	150°–300° C. Specific gravity.	Residuum. Cubic centimeters.	Residuum. Specific gravity.	Total. Cubic centimeters.	Sulphur (per cent)	Paraffin (per cent)	Asphalt (per cent)	Water (per cent)	Unsaturated hydrocarbons (per cent). Crude	Unsaturated hydrocarbons (per cent). 150°–300°C.	Remarks.
	CALIFORNIA—continued.															
	Fresno County—Continued.															
15	Coalinga		([a])									17.0				Gasoline, benzine, and distillate, 12.38 p ct.; kerosene and stove oil, 30.30 p. ct. [a] Temperature not given.
16	Do		([a])									13.34				Gasoline and benzine, 3.89 p. ct.; kerosene and stove oil, 13.35 p. ct. [a] Temperature not given.
17	Do		([a])									22.7				Engine distillate, 4.34 p. ct.; kerosene, 41.3 p. ct. [a] Temperature not given.
18	Do		32.6	0.800	43.6	0.8372	23.8		100.0							300°–350° C., 12 p. ct., sp. gr. 0.9091.
19	Do		32.6	.800	[a]44.2	.8488	23.2		100.0							[a] 150°–250°C.; 250°–320°C., 12 p. ct., sp. gr. 0.911.
20	Do		0		[a] 8.5		91.5		100.0							[a] Up to 320° C.
21	Coalinga, M. K. & T. Oil Co.		0		14.5		85.5		100.0			9.5				
22	Coalinga		18–20		47–48											Heavy fuel oil, 10 to 13 p. ct.
23	Do		0		[a] 3.3	.820	96.7		100.0							[a] Up to 320° C.
24	Do	49	30.0		[b]60.0		10.0		100.0			10.0				[a] 49°–141° C.; [b] 141°–275° C. Residuum hard asphalt.
25	Do		18.0		[a]48.7		33.3		100.0			16.2				[a] 150°–350° C.; 350° C. to asphalt, 18 p. ct.
26	Do		.8		[a]57.5		41.7		100.0			25.4				[a] 150°–350° C.; 350° C. to asphalt, 14.5 p. ct.
27	Do		1.1		[a]62.4		36.5		100.0			14.6				[a] 150°–350° C.; 350° C. to asphalt, 21.50 p. ct.
28	Do		33.06	.7829	57.85	.8608	9.09		100.0	0.21						Combustion gives carbon 86.24 p. ct.; hydrogen, 13.08 p. ct.; bromine absorption, 9.07 p. ct.
29	Coalinga; California Oilfield, Ltd.		5.7	.7716	34.1	.8582	60.2		100.0	.45						Calorific value per c. c., 9,726. Viscosity by Redwood viscometer, 172 at 15° C., 37 at 85° C.
30	Do		24.2	.7317	38.3	.8473	37.5		100.0	.38		9.1				Calorific value per c. c., 9,321. Viscosity by Redwood viscometer, 56 at 15° C., 32.5 at 85° C.
31	Coalinga				13.7	.8888	86.3		100.0	.78		31.8				Viscosity by Redwood viscometer, 186 at 85° C.; calorific value per c. c., 10,088.

Analyses of petroleum from various parts of the United States—Continued.

Serial No.	Location of well.	Collected by—	Collected from—	Well.	Depth of well (feet).	Physical properties.			
						Gravity at 60°F.		Color.	Odor.
						Specific.	Baumé.		
	CALIFORNIA—continued.								
	Fresno County—Continued.								
32	Coalinga; Home Oil Co.		Well	Blue Goose No. 3	1,350	0.8530	34.1		
33	Coalinga; 14, T. 20 S., R. 14 E.		do			.9831	12.4		
34	Coalinga; 24, T. 20 S., R. 14 E.		do			.9609	15.7		
35	Coalinga; T. 20 S., R. 14 E.		Pipe line			.9562	16.4		
36	Coalinga; sec. 6, T. 20 S., R. 15 E.		Well			.9472	17.8		
37	Coalinga; sec. 31, T. 19 S., R. 15 E.		do			.9415	18.7		
38	Coalinga; sec. 28, T. 19 S., R. 15 E.		Tank			.9247	21.4		
39	Coalinga; sec. 20, T. 19 S., R. 15 E.		do			.8568	33.4		
40	Do		Well			.8000	45.0		
41	Alcade district; sec. 29, T. 18 S., R. 13 E.		do			.9091	24.0		
42	Vallecitos district		Spring			.9150	23.0		
43	Do		Well			.9750	13.6		
44	Oil City-Coalinga		Tank average			.8542	33.9		
45	Do					.8000	45.0		
46	Do					.8584	33.1		
47	Twenty-eight oil district					.9415	18.7		
48	Do					.9211	22.0	Dark brown	

32. California State Min. Bur. Bul. 31. H. N. Cooper, chemist.
33–42. California State Min. Bur. Bull. 31. P. W. Prutzman.
43. California State Min. Bur. Bull. 3, p. 90. Laboratory analysis.
44. California State Min. Bur. Bull. 31, p. 192.
45–48 U. S. Geol. Survey Mineral Resources. 1903, p. 177, 1904. Paul W. Prutzman, analyst.

Analyses of petroleum from various parts of the United States—Continued.

Serial No.	Location of well.	Distillation by Engler's method. Begins to distill at (° C.)	By volume. To 150° C. Cubic centimeters.	To 150° C. Specific gravity.	150°–300° C. Cubic centimeters.	150°–300° C. Specific gravity.	Residuum. Cubic centimeters.	Residuum. Specific gravity.	Total. Cubic centimeters.	Sulphur (per cent)	Paraffin (per cent)	Asphalt (per cent)	Water (per cent)	Unsaturated hydrocarbons (per cent). Crude	Unsaturated hydrocarbons (per cent). 150°–300° C.	Remarks.
	CALIFORNIA—continued.															
	Fresno County—Continued.															
32	Coalinga; Home Oil Co.	......	36.1	0.7973	55.0	0.8760	8.9	....	100.0	0.06	......	4.1	......	......	......	Calorific value per c. c., 9,040; viscosity by Redwood viscometer, 28.5 at 15° C., 2.55 at 85° C.
33	Coalinga; 14, T. 20 S., R. 14 E.	......	0	....	*a* 0	....	34.8	....	100.0	......	......	34.8	......	......	......	*a* 150°–270° C.; above 270° C., 65.2 p. ct.
34	Coalinga; 24, T. 20 S., R. 14 E.	......	0	....	*a* 5.8	.8594	94.2	....	100.0	......	......	27.9	......	......	......	*a* 150°–270° C.; above 270° C., 64.5 p. ct.
35	Coalinga; T. 20 S., R. 14 E.	......	0	....	*a* 6.5	.8563	93.5	....	100.0	......	......	21.7	......	......	......	*a* 150°–270° C.; above 270° C., 70 p. ct.
36	Coalinga; sec. 6, T. 20 S., R. 15 E.	......	0	....	*a* 18.3	.8495	81.7	....	100.0	......	......	20.1	......	......	......	*a* 150°–270° C.; above 270° C., 58.6 p. ct.
37	Coalinga; sec. 31, T. 19 S., R. 15 E.	......	0	....	*a* 15.0	.8573	85.0	....	100.0	......	......	22.1	......	......	......	*a* 150°–270° C.; above 270° C., 62.4 p. ct.
38	Coalinga; sec. 28, T. 19 S., R. 15 E.	......	1.0	....	*a* 25.0	.8353	74.0	....	100.0	......	......	15.2	......	......	......	*a* 150°–270° C.; above 270° C., 54 p. ct.
39	Coalinga; sec. 20, T. 19 S., R. 15 E.	......	28.0	.7928	*a* 50.0	.861	22.0	....	100.0	......	......	Tr.	......	......	......	*a* 150°–270° C.; above 270° C., 21 p. ct.
40	Do.	......	52.0	.7701	*a* 27.0	.806	21.0	....	100.0	......	......	0	......	......	......	*a* 150°–270° C.; above 270° C., 18 p. ct.
41	Alcade district; sec. 29, T. 18 S., R. 13 E.	......	1.0	....	*a* 33.0	.8388	66.0	....	100.0	......	......	6.6	......	......	......	*a* 150°–270° C.; above 270° C., 57.9 p. ct.
42	Vallecitos district	......	10.7	.7568	*a* 31.0	.8314	58.3	....	100.0	......	......	21.3	......	......	......	*a* 150°–270° C.; above 270° C., 35.9 p. ct.
43	Do.	......	......	....	*a* 10.4	.886	89.6	....	100.0	......	......	......	......	......	......	*a* Up to 320° C.
44	Oil City-Coalinga	......	11.4	.7521	*a* 35.8	.813	52.8	....	100.0	......	......	......	......	......	......	Residue liquid.
45	Do.	......	52.0	....	*a* 27.0	....	21.0	....	100.0	......	......	0	......	......	......	*a* 150°–270° C.
46	Do.	......	28.0	....	*a* 50.0	....	22.0	....	100.0	.062	......	......	......	......	......	*a* 150°–270° C.; above 270° C., 22 p. ct.; nitrogen, 0.063 p. ct.
47	Twenty-eight oil district	......	1.0	....	*a* 18.0	....	81.0	....	100.0	......	......	20.0	......	......	......	*a* 150°–270° C.; above 270° C., 61 p. ct. Oil at 19° C., nitrogen, 0.314 p. ct.
48	Do.	69.5	6.0	....	*a* 26.0	....	68.0	....	100.0	.817	......	15.0	......	......	......	*a* 150°–270° C.; above 270° C., 53 p. ct. Viscosity by Engler instrument, 30, oil at 22° C.; nitrogen, 0.302 p. ct.

Analyses of petroleum from various parts of the United States—Continued.

Serial No.	Location of well.	Collected by—	Collected from—	Well.	Depth of well (feet).	Physical properties. Gravity at 60° F. Specific.	Baumé.	Color.	Odor.
	CALIFORNIA—continued.								
	Fresno County—Continued.								
49	Southwest district					0.9472	17.8		
50	Do					.9582	16.1	Black	
51	Fresno, San Benito					.9050	24.7		
52	Do					.8589	33.0		
53	Do					.9150	23.0		
54	Humboldt County					.9518	17.1	Yellow	
55	Do					.8973	26.0	do	
56	Do					.9014	25.3	do	
57	Do					.8810	28.9	Red brown	
58	Do					.8263	39.4	Yellow	
59	Do					.7854	48.3		
60	Mattole					.8163	41.5	Bright green	
	Kern County:								
61	Kern River					.9622	15.5		
62	Do		Tank average			.9622	15.5		
63	Kern River; sec. 8, T. 29 S., R. 28 E.		Well			.9972	10.4		

49–53. U. S. Geol. Survey Mineral Resources, 1903, p. 177, 1904. Paul W. Prutzman, analyst.
54–59 Am. Chem. Soc. Jour., vol. 25, p. 669. Edmond O'Neill.
61. California State Min. Bur. Bull 31. Paul W. Prutzman, chemist.
62. California State Min. Bur. Bull. 19. Thos. Price & Son, analysts.
63. California State Min. Bur. Bull. 31. Paul W. Prutzman, chemist.

Analyses of petroleum from various parts of the United States—Continued.

Serial No.	Location of well.	Distillation by Engler's method.								Sulphur (per cent)	Paraffin (per cent)	Asphalt (per cent)	Water (per cent)	Unsaturated hydrocarbons (per cent).		Remarks.
		Begins to distill at (° C.)	By volume.													
			To 150° C.		150°–300° C.		Residuum.		Total.							
			Cubic centimeters.	Specific gravity.	Cubic centimeters.	Specific gravity.	Cubic centimeters.	Specific gravity.	Cubic centimeters.					Crude	150°–300°C.	
	CALIFORNIA—continued.															
	Fresno County—Continued.															
49	Southwest district	......	0	....	a18.0	....	82.0	....	100.0	0.874	......	22.0	......	......	......	a 150°–270° C.; above 270° C., 60 p. ct. Nitrogen, 0.299 p. ct.
50	Do	......	0	....	a7.0	....	93.0	....	100.0	......	......	21.0	......	......	......	a 150°–270° C.; above 270° C., 72 p. ct. Nitrogen, 0.375 p. ct.
51	Fresno, San Benito	......	8.0	....	a31.0	....	61.0	....	100.0	......	......	16.0	......	......	......	a 150°–270° C.; above 270° C., 45 p. ct.
52	Do	......	20.0	....	a25.0	....	55.0	....	100.0	......	......	5.0	......	......	......	a 150°–270° C.; above 270° C., 50 p. ct.
53	Do	......	11.0	....	a31.0	....	58.0	....	100.0	......	......	22.0	......	......	......	a 150°–270° C.; above 270° C., 36 p. ct.
54	Humboldt County	......	......	....	a16.1	....	83.9	....	100.0	......	......	26.5	......	......	......	a 150°–270° C.; 250°–350° C., 53.60 p. ct.
55	Do	......	......	....	a15.7	....	84.3	....	100.0	......	......	4.9	......	......	......	a 150°–250° C.; 250°–350° C., 35.10 p. ct. Viscosity at 15.5° C., 3 (Engler method).
56	Do	......	13.7	....	a33.4	....	52.9	....	100.0	......	......	19.4	......	......	......	a 150°–250° C.; 250°–350° C., 22.20 p. ct.
57	Do	......	......	....	a47.5	....	52.5	....	100.0	......	......	7.5	......	......	......	a 150°–250° C.; 250°–350° C., 35.20 p. ct. Hydrogen, 12.03 p. ct.; carbon; 86.69 p. ct. Viscosity at 15.5° C., 1.57; at 85° C., 1.05 (Englers method).
58	Do	......	39.5	....	a29.8	....	30.7	....	100.0	......	......	4.7	......	......	......	a 150°–250° C.; 250°–350° C., 24 p. ct. Viscosity at 15.5° C., 1.1; at 85° C., 0.95 (Engler method).
59	Do	......	32.6	....	a28.2	....	39.2	....	100.0	......	......	5.0	......	......	......	a 150°–250° C.; 250°–350° C., 17.2 p. ct. Viscosity at 15.5° C., 1.17; at 85° C., 0.96 (Engler method).
60	Mattole	......	28.5	0.7447	a42.0	0.7977	29.5	....	100.0	......	......	0.0	9.0	......	......	a 150°–270° C.; above 270° C., 30 p. ct. Maumene No. 0.03.
	Kern County:															
61	Kern River	......	......	....	10.9	.874	89.1	....	100.0	......	......	......	......	......	......	300°–350° C., 10 p. ct.; sp. gr. 0.896.
62	Do	......	(a)	....	......	....	......	....	......	......	......	33.0	......	......	......	Run without care to avoid cracking in steam still; products varied. a Temperature not given.
63	Kern River; sec. 8, T. 29 S., R. 28 E.	......	......	....	......	....	100.0	....	100.0	......	......	31.9	......	......	......	Above 270° C., 65.8 p. ct., sp. gr. 0.9241.

Analyses of petroleum from various parts of the United States—Continued.

Serial No.	Location of well.	Collected by—	Collected from—	Well.	Depth of well (feet).	Physical properties. Gravity at 60°F. Specific.	Physical properties. Gravity at 60°F. Baumé.	Physical properties. Color.	Physical properties. Odor.
	CALIFORNIA—continued.								
	Kern County—Continued.								
64	Kern River; sec. 3, T. 29 S., R. 28 E.		Well			0.9722	14.0		
65	Kern River		Pipe line			.9642	15.2		
66	Kern River; Associated Oil Co.		Well	Omar 1	1,052	.9609	15.7		
67	Kern River; King Refining Co.		do		850	.9792	13.0		
68	Kern River		Tank			.9655	15.0		
69	Do					.9782	13.1	Black	
70	Do					.9673	14.7	do	
71	Do					.9655	15.0		
72	Midway					.9321	20.2	Black brown	
73	Midway; sec. 22, T. 32, N., R. 23 E.					.9790	13.0		
74	Midway; sec. 17, T. 32 N., R. 23 E.					.9517	17.1		
75	McKittrick					.9480	17.7	Black	
76	Do					.9650	15.1	do	

64–65. California State Min. Bur. Bull. 31. Paul W. Prutzman, chemist.
66–68. California State Min. Bur. Bull. 31. H. N. Cooper, chemist.
69, 70. Am. Chem. Soc. Jour., vol. 25. Edmond O'Neill.
71, 72. U. S. Geol. Survey Mineral Resources, 1903, p. 177, 1904. Paul W. Prutzman, analayst.
73, 74. California State Min. Bur. Bull. 31. Paul W. Prutzman, chemist.
75, 76. Am. Chem. Soc. Jour., vol. 25. Edmond O'Neill.

Analyses of petroleum from various parts of the United States—Continued.

Serial No.	Location of well.	Begins to distill at (° C.)	Distillation by Engler's method. By volume. To 150° C. Cubic centimeters.	To 150° C. Specific gravity.	150°–300° C. Cubic centimeters.	150°–300° C. Specific gravity.	Residuum. Cubic centimeters.	Residuum. Specific gravity.	Total. Cubic centimeters.	Sulphur (per cent)	Paraffin (per cent)	Asphalt (per cent)	Water (per cent)	Unsaturated hydrocarbons (per cent). Crude	Unsaturated hydrocarbons (per cent). 150°–300° C.	Remarks.
	CALIFORNIA—continued.															
	Kern County—Continued.															
64	Kern River; sec. 3, T. 29 S., R. 28 E.						100.0		100.0			35.2				Above 270° C., 61.1 p. ct., sp. gr. 0.9144.
65	Kern River				a13.0		87.0		100.0			16.2				a 150°–270° C.; above 270° C., 67.5 p. ct., sp. gr. 0.9259.
66	Kern River; Associated Oil Co.		0		20.2	0.8626	79.8		100.0	0.94		21.4				Caloric value per c. c., 9,989. 300° C. to asphalt, 56.5 p. ct. Viscosity at 85° C., 134; at 15.5° C., over 1,800 (Redwood viscometer used).
67	Kern River; King Refining Co.		0		22.5	.8901	77.5		100.0			31.1				300° C. to asphalt, 44.4 p. ct. Viscosity at 85° C., 410; at 15° C., over 1,800 (Redwood viscometer used).
68	Kern River		(a)									38.7				Still run in usual manner in making asphalt and distillate. a Temperature not given.
69	Do				a37.9		62.1		100.0			31.6				a 150°–350° C.; 350 C. to asphalt, 27.2 p. ct. B. t. u., 18,342.
70	Do		1.0		a29.0		71.0		100.0	.95		21.25				a 150°–350° C.; 350° C. to asphalt, 48.13 p. ct. B. t. u., 18,847.8. Viscosity at 15.5° C., 274.35; at 85° C., 3.35.
71	Do				a11.0		89.0		100.0	.612		35.0				a 150°–270° C.; above 270° C., 54 p. ct. Maumene No. 0.341. Oil at 15° C., nitrogen, 0.60 p. ct.
72	Midway		3.0		a24.0		73.0		100.0			20.0				a 150°–270° C.; 270° C. to asphalt, 53 p. ct. Oil at 20° C., nitrogen, 3.74 p. ct.
73	Midway; sec. 22, T. 32 N., R. 23 E.		0		a0		100.0		100.0			36.0				Above 270° C., 61.2 p. ct., sp. gr. 0.9168. a 150°–270° C.
74	Midway, sec. 17, T. 32 N., R. 23 E.				a5.7	.8589	94.3		100.0			36.7				a 150°–270° C.; 270° C. to asphalt, 54.2 p. ct.
75	McKittrick		0		a39.9		60.1		100.0	.87		14.25				a 150°–350° C.; 350° C. to asphalt, 45.82 p. ct. Hydrogen, 11.45 p. ct.; carbon, 86.06 p. ct. B. t. u., 18,675.
76	Do		Tr.		a32.0		68.0		100.0	.87		15.0				a 150°–350° C.; 350° C. to asphalt, 53.25 p. ct. B. t. u., 18,570.6.

Analyses of petroleum from various parts of the United States—Continued.

Serial No.	Location of well.	Collected by—	Collected from—	Well.	Depth of well (feet).	Physical properties.			
						Gravity at 60°F.		Color.	Odor.
						Specific.	Baumé.		
	CALIFORNIA—continued.								
	Kern County—Continued.								
77	McKittrick					0.9396	19.0		
78	Do					.9655	15.0		
79	McKittrick; sec. 13, T. 30 S., R. 21 E		Pipe line			.9655	15.0		
80	McKittrick; sec. 12, T. 30 S., R. 21 E		Well			.9649	15.1		
81	McKittrick; sec. 20, T. 30 S., R. 22 E		Tank			.9402	18.9		
82	McKittrick		Well			.9396	19.0		
83	McKittrick; Southern Pacific Oil Co.		do	5	500	.9425	18.5		
84	McKittrick; Associated Oil Co.		do	Shamrock 3	1,377	.9396	19.0		
85	McKittrick; Induna Oil Co.		do		900	.9747	13.6		
86	Sunset					.9715	14.1		
87	Do					1.000	9.9		

77, 78. U. S. Geol. Survey Mineral Resources, 1903, p. 177, 1904. Paul W. Prutzman, analyst.
79–82. California State Min. Bur. Bull. 31. Paul W. Prutzman, chemist.
83–87. California State Min. Bur. Bull. 31. H. N. Cooper, chemist.

Analyses of petroleum from various parts of the United States—Continued.

Serial No.	Location of well.	Begins to distill at (C.°)	Distillation by Engler's method. By volume. To 150° C. Cubic centimeters.	To 150° C. Specific gravity.	150°-300° C. Cubic centimeters.	150°-300° C. Specific gravity.	Residuum. Cubic centimeters.	Residuum. Specific gravity.	Total. Cubic centimeters.	Sulphur (per cent)	Paraffin (per cent)	Asphalt (per cent)	Water (per cent)	Unsaturated hydrocarbons (per cent). Crude	Unsaturated hydrocarbons (per cent). 150°-300° C.	Remarks.
	CALIFORNIA—continued.															
	Kern County—Continued.															
77	McKittrick	......	1.0	....	a22.0	....	77.0	....	100.0	0.87	......	21.0	......	......	......	a 150°-270° C.; 270° C. to asphalt, 56 p. ct. Maumene No. 0.347. Nitrogen, 0.8 p. ct.
78	Do	......	0	....	a11.0	....	89.0	....	100.0	.565	......	26.0	......	......	......	a 150°-270° C.; above 270° C., 63 p. ct. Maumene No. 0.365. Nitrogen, 0.29 p. ct. (according to Mabery and Hudson). (See Am. Chem. Jour., vol. 25, p. 253.)
79	McKittrick; sec. 13, T. 30 S., R. 21 E.	......	......	....	a11.0	0.8568	89.0	....	100.0	......	......	26.9	......	......	......	a 150°-270° C.; above 270° C., 59 p. ct.
80	McKittrick; sec. 12, T. 30 S., R. 21 E.	......	......	....	a11.4	.8464	88.6	....	100.0	......	......	28.9	......	......	......	a 150°-270° C.; above 270° C., 57.4 p. ct.
81	McKittrick; sec. 20, T. 30 S., R. 22 E.	......	0.5	....	a22.0	.8403	77.5	....	100.0	......	......	22.6	......	......	......	a 150°-270° C.; above 270° C., 53 p. ct.
82	McKittrick	......	.5	....	a22.0	.8299	77.5	....	100.0	......	......	27.6	......	......	......	a 150°-270° C.; above 270° C., 48.6 p. ct.
83	McKittrick; Southern Pacific Oil Co.	......	4.2	0.776	37.8	.8675	58.0	....	100.0	.77	......	22.5	......	......	......	a 300° C. to asphalt, 35 p. ct. Viscosity by Redwood viscometer at 15° C., 1,100; at 85° C., 54. Calorific value per c. c., 9,804.
84	McKittrick; Associated Oil Co.		4.0	.779	35.1	.8664	60.9	....	100.0	.76	......	21.0	......	......	......	300° C. to asphalt, 40.1 p. ct. Viscosity by Redwood viscometer at 15° C., 8,333; at 85° C., 50. Calorific value per c. c., 9,817.
85	McKittrick; Induna Oil Co.	......	......	....	26.7	.8830	73.3	....	100.0	1.08	......	23.0	10.0	......	......	300° C. to asphalt, 39.3 p. ct. Viscosity by Redwood viscometer at 15° C., over 1,800; at 85° C., 182. Calorific value per c. c., 10,092.
86	Sunset	......	(a)	....	12.7	.8589	87.3	....	100.0	......	......	29.3	......	......	......	a Temperature not given. Precautions taken against cracking.
87	Do	......	(a)	....	2.9	.8589	97.1	....	100.0	......	......	......	......	......	......	a Temperature not given. Sample probably the heaviest from any well in California.

Analyses of petroleum from various parts of the United States—Continued.

Serial No.	Location of well.	Collected by—	Collected from—	Well.	Depth of well (feet).	Physical properties. Gravity at 60° F. Specific.	Baumé.	Color.	Odor.
	CALIFORNIA—continued.								
	Kern County—Continued.								
88	Sunset; Western Minerals Co.		Well	1	500	0.9846	12.2		
89	Sunset; Alameda Oil Co.		do	1	790	.9816	12.6		
90	Sunset		Pipe line			.9722	14.0		
91	Do		do			.9504	17.3		
92	Do		Well	No. 2, group 2		.9710	14.2		
93	Do					.9655	15.0		
94	Do					.9504	17.3		
95	Do					1.0000	9.9		
96	Do					.9603	15.8	Black	
97	Do					.9267	21.1	do	
98	Do		Shallow well			.9784	13.1		

88–89. California State Min. Bur. Bull. 31. H. N. Cooper, chemist.
90–91. California State Min. Bur. Bull. 31. Paul W. Prutzman, chemist.
92–93. California State Min. Bur. Bull. 3. Laboratory analyses.
94–95. U. S. Geol. Survey Mineral Resources, 1903, p. 177, 1904. Paul Prutzman, analyst.
96–97. Am. Chem. Soc. Jour., vol. 25. Edmond O'Neill.
98. Pet. Rev., Jan. 5, 1907. Clifford Richardson.

Analyses of petroleum from various parts of the United States—Continued.

Serial No.	Location of well.	Distillation by Engler's method. Begins to distill at (° C.)	By volume. To 150° C. Cubic centimeters.	To 150° C. Specific gravity.	150°–300° C. Cubic centimeters.	150°–300° C. Specific gravity.	Residuum. Cubic centimeters.	Residuum. Specific gravity.	Total. Cubic centimeters.	Sulphur (per cent)	Paraffin (per cent)	Asphalt (per cent)	Water (per cent)	Unsaturated hydrocarbons (per cent). Crude	Unsaturated hydrocarbons (per cent). 150°–300° C.	Remarks.
	CALIFORNIA—continued.															
	Kern County—Continued.															
88	Sunset; Western Minerals Co.				27.4	0.8974	72.6		100.0			28.8				300° C. to asphalt, 36.4 p. ct. Viscosity by Redwood viscometer at 15° C., over 1,800; at 85° C., 410.
89	Sunset; Alameda Oil Co.				43.6	.8789	56.4		100.0	0.90		23.5				300° C. to asphalt, 34.5 p. ct. Viscosity by Redwood viscometer at 15° C., over 1,800; at 85° C., 82.5. Calorific value per c. c., 10,173.
90	Sunset				a12.0	.8439	88.0		100			32.0				a 150°–270° C.; above 270° C., 53 p. ct.
91	Do		4.1		a12.3	.8197	83.6		100			24.0				a 150°–270° C.; above 270° C., 57.6 p. ct.
92	Do				a14.0	.893	86.0		100							a Below 325° C.; below 250° C., 1 p. ct.
93	Do				14.2	.8589	85.8		100							300°–350° C., 5.2 p. ct., sp. gr. 0.875.
94	Do		4.0		a12.0		84.0		100	.86		24.0				a 150°–270° C.; above 270° C., 60 p. ct. Nitrogen, 0.476 p. ct.
95	Do				a5.0		95.0		100	1.253		51.0				a 150°–270° C.; above 270° C., 44 p. ct. Maumene No. 0.432. Nitrogen, 0.370 p. ct.
96	Do				a11.9		88.1		100	.86		23.9				a 150°–250° C.; 250°–350° C., 26.40 p. ct.; 350° C. to asphalt, 37.80 p. ct. Nitrogen, 0.047. B. t. u., 18,684.
97	Do		6.50		a17.26		76.24		100			11.0				a 150°–250° C.; 250°–350° C., 17.25 p. ct.; 350° C. to asphalt, 47.98 p. ct.
98	Do		a8.9	0.867	b32.0		59.1		100							Distilled in vacuo 26 mm.; 60°–100° C., 0.9 p. ct. a 60°–145° C. b 145°–270° C.; 190°–220° C., 8 p. ct., sp. gr. 0.9209; 220°–224° C., 8 p. ct., sp. gr. 0.9347; refractive index 1.523; 245°–270° C., 8 p. ct., sp. gr. 0.9621, refractive index 1.526. Other data showing results of treatment with 10 p. ct. solution NaOH and H_2SO_4.

Analyses of petroleum from various parts of the United States—Continued.

Serial No.	Location of well.	Collected by—	Collected from—	Well.	Depth of well (feet).	Physical properties.			
						Gravity at 60°F.		Color.	Odor.
						Specific.	Baumé.		
	CALIFORNIA—continued.								
	Los Angeles County:								
99	Little Moore Canyon		Well	1		0.9100	23.9		
100	Not located					.9709	14.2		
101	Los Angeles City, Park Street					.9534	16.8		
102	Do					.9520	17.0		
103	Do					.9515	17.1		
104	Do					.9539	16.8		
105	Do					.9528	16.9		
106	Do					.9565	16.4		
107	Do					.9580	16.1		
108	West Los Angeles City		Well	McIntosh		.9816	12.6		
109	Do		do	Maltman		.9702	14.3		
110	East End Field, Los Angeles City, Proudfitt & Parker.		do	2	1,225	.9699	14.4		
111	East End Field, Los Angeles City, Davis & Harrison.		do	10	1,275	.9774	13.2		
112	East End Field, Los Angeles City, Davis & Henderson.		do	Solans	950	.9467	17.9		
113	East End Field, Los Angeles City, Consolidated Crude Oil Co.		do	22	800	.9815	12.6		
114	Knob Hill, Los Angeles City, Los Angeles Rwy. Co.		do	Hubbell 2	1,250	.9558	16.5		

99. California State Min. Bur., 1887. W. D. Johnston, chemist.
100. California State Min. Bur. Bull. 11. Frederick Salathe.
101–109. California State Min. Bur. Laboratory analyses.
110–114. California State Min. Bur. Bull. 31. H. N. Cooper, chemist.

Analyses of petroleum from various parts of the United States—Continued.

Serial No.	Location of well.	Distillation by Engler's method.									Sulphur (per cent).	Paraffin (per cent).	Asphalt (per cent).	Water (per cent).	Unsaturated hydrocarbons (per cent).		Remarks.
		Begins to distill at (° C.)	By volume.														
			To 150° C.		150°–300° C.		Residuum.		Total.								
			Cubic centimeters.	Specific gravity.	Cubic centimeters.	Specific gravity.	Cubic centimeters.	Specific gravity.	Cubic centimeters.						Crude	150°–300°C.	
	CALIFORNIA—continued.																
	Los Angeles County:																
99	Little Moore Canyon	......	6.6	0.757	26.2	0.8141	67.2	......	100	......	......	......	......	......	......	......	150°–200° C., 11.20 p. ct., sp. gr. 0.787; 200°–250° C., 7 p. ct., sp. gr. 0.821.
100	Not located	......	Tr.	......	6.0	......	94.0	......	100	......	......	25.0	......	......	......	Pyridine base equals 3.2 p. ct.
101	Los Angeles City, Park Street.	......	Tr.	......	21.6	.8533	78.4	......	100	......	......	......	......	......	......	300°–350° C., 3 p. ct.
102	Do	......	Tr.	......	22.3	.8650	77.7	......	100	......	......	......	......	......	......	300°–350° C., 7.1 p. ct., sp. gr. 0.889.
103	Do	......	Tr.	......	23.2	.8589	76.8	......	100	......	......	......	......	......	......	300°–350° C., 8 p. ct., sp. gr. 0.8895.
104	Do	......	Tr.	......	27.2	.8589	72.8	......	100	......	......	......	......	......	......	300°–350° C., 5 p. ct., sp. gr. 0.8922.
105	Do	......	Tr.	......	20.0	.8441	80.0	......	100	......	......	......	......	......	......	300°–350° C., 4 p. ct.
106	Do	......	Tr.	......	13.0	.8662	87.0	......	100	......	......	......	......	......	......	300°–350° C., 3.4 p. ct.
107	Do	......	Tr.	......	13.4	.8721	86.6	......	100	......	......	......	......	......	......	300°–350° C., 7 p. ct., sp. gr. 0.8820.
108	West Los Angeles City	......	Tr.	......	1.6	......	98.4	......	100	......	......	......	......	......	......	300°–350° C., 4.4 p. ct.
109	Do	......	Tr	......	9.0	.8680	91.0	......	100	......	......	......	......	......	......	300°–350° C., 9.6 p. ct.
110	East End Field, Los Angeles City, Proudfitt & Parker.	......	0	......	17.9	.8871	82.1	......	100	......	......	28.8	......	......	......	Viscosity by Redwood viscometer over 1,800 at 15° C. 300° C. to asphalt, 51.1 p. ct. Gravities at 15° C.
111	East End Field, Los Angeles City, Davis & Harrison.	......	0	......	12.0	.8912	88.0	......	100	0.49	......	19.8	......	......	......	Viscosity by Redwood viscometer over 1,800 at 15° C. 300° C. to asphalt, 36.3 p. ct. Gravities at 15° C. Calorific value per c. c. 9,863.
112	East End Field, Los Angeles City, Davis & Henderson.	......	0	......	24.1	.8776	75.9	......	100	......	......	17.3	30.0	......	......	300° C. to asphalt, 57.6 p. ct. Gravities at 15°C. Viscosity by Redwood viscometer over 1,700 at 15° C.
113	East End Field, Los Angeles City, Consolidated Crude Oil Co.	......	0	......	12.3	.8835	87.7	......	100	......	......	16.2	44.6	......	......	Gravities at 15° C. 300° C. to asphalt, 25.8 p. ct. Viscosity by Redwood viscometer over 1,800 at 15° C.
114	Knob Hill, Los Angeles City, Los Angeles Rwy. Co.	......	0	......	25.5	.8592	74.5	......	100	......	......	21.5	......	......	......	Gravities at 15° C. 300° C. to asphalt, 51.6 p. ct. Viscosity by Redwood viscometer over 1,800 at 15° C.

Analyses of petroleum from various parts of the United States—Continued.

Serial No.	Location of well.	Collected by—	Collected from—	Well.	Depth of well (feet).	Physical properties: Gravity at 60°F. Specific.	Physical properties: Gravity at 60°F. Baumé.	Physical properties: Color.	Physical properties: Odor.
	CALIFORNIA—continued.								
	Los Angeles County—Continued.								
115	Middle Field, Los Angeles City, J. W. Shirley		Well	12	1,340	0.9559	16.5		
116	Middle Field, Los Angeles City, Park Crude Oil Co.		do	13	1,060	.9706	14.2		
117	Middle Field, Los Angeles City, E. A. Clampitt		do	1	1,080	.9736	13.8		
118	West End Field, Los Angeles City, Salt Lake Oil Co.		do	4	1,264	.9487	17.6		
119	West End Field, Los Angeles City, Brea Rancho Oil and Asphalt Co.		do	14	410	1.010			
120	West End Field, Los Angeles City, Westlake Oil Co.			7	370	.9860	12.0		
121	Los Angeles					.9756	13.5		
122	Do					.9649	15.1	Greenish	
123	Do					.9609	15.7		
124	Newhall district, sec. 13, T. 3 N., R. 16 W		Tank			.9511	17.2		
125	Newhall district, sec. 4, T. 3 N., R. 15 W		Well			.8107	42.7		

115–120. California State Min. Bur. Bull. 31. H. N. Cooper, chemist.
121. U. S. Geol. Survey Mineral Resources, 1903, p. 177, 1904. Paul W. Prutzman.
122–125. California State Min. Bur. Bull. 31. Paul W. Prutzman.

Analyses of petroleum from various parts of the United States—Continued.

Serial No.	Location of well.	Distillation by Engler's method. Begins to distill at (° C.)	To 150° C. Cubic centimeters.	To 150° C. Specific gravity.	150°–300° C. Cubic centimeters.	150°–300° C. Specific gravity.	Residuum. Cubic centimeters.	Residuum. Specific gravity.	Total. Cubic centimeters.	Sulphur (per cent)	Paraffin (per cent)	Asphalt (per cent)	Water (per cent)	Unsaturated hydrocarbons (per cent). Crude	Unsaturated hydrocarbons (per cent). 150°–300° C.	Remarks.
	CALIFORNIA—continued.															
	Los Angeles County—Con.															
115	Middle Field, Los Angeles City, J. W. Shirley.	......	0	....	21.5	0.8770	78.5	....	100	0.85	......	21.8	......	......	......	Gravities at 15° C. 300° C. to asphalt, 54.5 p. ct. Calorific value per c. c., 9,976. Viscosity by Redwood viscometer over 1,800 at 15° C.
116	Middle Field, Los Angeles City, Park Crude Oil Co.	......	0	....	26.3	.8852	73.7	....	100	1.18	......	25.3	......	......	......	Gravities at 15° C. 300° C. to asphalt, 44.2 p. ct. Calorific value per c. c., 10,073. Viscosity by Redwood viscometer over 1,800 at 15° C.
117	Middle Field, Los Angeles City, E. A. Clampitt.	......	0	....	20.0	.8805	80.0	....	100	1.30	......	28.8	......	......	......	Gravities at 15° C. 300° C. to asphalt, 47.2 p. ct. Calorific value per c. c., 9,377. Viscosity by Redwood viscometer over 1,800 at 15° C.
118	West End Field, Los Angeles City, Salt Lake Oil Co.	......	10.8	0.7542	32.2	.8712	57.0	....	100	......	......	26.8	......	......	......	Gravities at 15° C. 300° C. to asphalt, 29.7 p. ct., up to 100° C., 2.9 p. ct. Viscosity by Redwood viscometer 2,170 at 15° C.
119	West End Field, Los Angeles City, Brea Rancho Oil and Asphalt Co.	......	......	....	27.8	.8851	72.2	....	100	......	......	42.2	......	......	......	Gravities at 15° C. 300° C. to asphalt, 20.9 p. ct. Viscosity by Redwood viscometer over 1,800 at 15° C.
120	West End Field, Los Angeles City, Westlake Oil Co.	......	......	....	18.6	.9029	81.4	....	100	......	......	21.3	35.7	......	......	Gravities at 15° C. 300° C. to asphalt, 22.4 p. ct. Viscosity by Redwood viscometer over 1,800 at 15° C.
121	Los Angeles	......	......	....	10.0	....	90.0	....	100	1.082	......	31.0	......	......	......	150°–270° C.; above 270° C., 59 p. ct. Nitrogen 0.648 p. ct.
122	Do	......	......	....	20.0	.8739	80.0	....	100	......	......	13.3	......	......	......	150°–270° C.; above 270° C., 63.7 p. ct.
123	Do	......	......	....	17.2	.8739	82.8	....	100	......	......	25.7	......	......	......	150°–270° C.; above 270° C., 54.1 p. ct.
124	Newhall district, sec. 13, T. 3 N., R. 16 W.	......	......	....	21.9	.8388	78.1	....	100	......	......	25.9	......	......	......	150°–270° C.; above 270° C., 50.2 p. ct.
125	Newhall district, sec. 4, T. 3 N., R. 15 W.	......	51.0	.783	43.0	.8333	6.0	....	100	......	......	......	......	......	......	150°–270° C.: above 270° C., 4 p. ct.; loss 2 p. ct.

Analyses of petroleum from various parts of the United States—Continued.

Serial No.	Location of well.	Collected by—	Collected from—	Well.	Depth of well (feet).	Physical properties.			
						Gravity at 60°F.		Color.	Odor.
						Specific.	Baumé.		
	CALIFORNIA—continued.								
	Los Angeles County—Continued.								
126	Newhall district, Pearl Oil Co.		Well	3	662	0.9474	17.8		
127	Newhall district, Santa Ana Oil Co.		do	Santa No. 2	1,000	.9687	14.5		
128	Newhall district, Pacific Coast Oil Co.		do	2	1,000	.9666	14.8		
129	Newhall district, Santa Ana Oil Co.		do	2	1,000	.9879	11.7		
130	Newhall district, Pacific Coast Oil Co.		do	6	750	.8758	29.9		
131	Do		do	4	1,400	.8969	26.1		
132	Newhall district		do	Pico Canyon		.8440	35.9	Dark brown	
133	Do					.8088	43.1		
134	Do					.8107	42.7		
135	Do			Pico No. 2		.8650	31.9		

126. California State Min. Bur. Bull. 31. Paul W. Prutzman.
127–131. California State Min. Bur. Bull. 31. H. N. Cooper, chemist.
132–133. Soc. Chem. Indust. Jour., vol 6. Sir Boverton Redwood.
134. U. S. Geol. Survey Mineral Resources, 1903, p. 177, 1904. Paul W. Prutzman.
135. California State Min. Bur. Seventh Ann. Rept. W. D. Johnston, chemist.

Analyses of petroleum from various parts of the United States—Continued.

Serial No.	Location of well.	Distillation by Engler's method: Begins to distill at (°C.)	By volume: To 150° C.: Cubic centimeters.	To 150° C.: Specific gravity.	150°–300° C.: Cubic centimeters.	150°–300° C.: Specific gravity.	Residuum: Cubic centimeters.	Residuum: Specific gravity.	Total: Cubic centimeters.	Sulphur (per cent)	Paraffin (per cent)	Asphalt (per cent)	Water (per cent)	Unsaturated hydrocarbons (per cent): Crude	Unsaturated hydrocarbons (per cent): 150°–300° C.	Remarks.
	CALIFORNIA—continued.															
	Los Angeles County—Contd.															
126	Newhall district, Pearl Oil Co.	......	1.2	0.779	40.2	0.8723	58.6	....	100	0.49	......	22.7	......	......	......	300° C. to asphalt, 34.8 p. ct. Gravities at 15° C. Calorific value per c. c., 9,911. Viscosity by Redwood viscometer 1,355 at 15° C.
127	Newhall district, Santa Ana Oil Co.	......	......	....	23.7	.8767	76.3	....	100	.72	......	28.3	......	3.5	......	Gravities at 15° C. 300° C. to asphalt, 43.3 p. ct. Calorific value per c. c., 10,044. Viscosity by Redwood viscometer over 1,800 at 15° C.
128	Newhall district, Pacific Coast Oil Co.	......	......	....	34.2	.8816	65.8	....	100	.62	......	22.6	......	6.1	......	Gravities at 15° C. 300° C. to asphalt, 34.6 p. ct. Calorific value per c. c., 10,042. Viscosity by Redwood viscometer over 1,800 at 15° C.
129	Newhall district, Santa Ana Oil Co.	......	......	....	29.6	.8816	70.4	....	100	.69	......	22.6	......	4.2	......	Gravities at 15° C. 300° C. to asphalt 43 p. ct. Calorific value per c. c., 10,139. Viscosity by Redwood viscometer over 1,800 at 15° C.
130	Newhall district, Pacific Coast Oil Co.	......	20.3	.7686	34.1	.8424	45.6	....	100	......	......	10.9	......	......	......	Gravities at 15° C. 300° C. to asphalt, 30.3 p. ct. Viscosity by Redwood viscometer 61 at 15° C.
131	Do.	......	30.9	.7595	37.9	.8315	32.2	....	101	.28	......	6.8	......	......	......	Gravities at 15° C. 300° C. to asphalt, 23 p. ct. Calorific value per c. c., 9,322. Viscosity by Redwood viscometer 38.5 at 15° C.
132	Newhall district.	......	15.0	....	45.0	....	40.0	....	100	......	......	......	......	......	......	Lubricating oil, 32 p. ct.
133	Do.	......	12.5	....	78.47	....	9.03	....	100	......	......	5.3	......	......	......	....
134	Do.	......	51.0	....	a43.0	....	....	....	100	......	......	......	......	......	......	a 150°–270° C.; above 270° C., 6 p. ct.
135	Do.	......	10.6	.781	48.1	.8247	41.3	....	100	......	......	......	......	......	......	150°–200° C., 20.6 p. ct.; sp. gr., 0.800. 200°–250° C., 16.2 p. ct.; sp. gr., 0.883. 250°–300° C., 11.30 p. ct.; sp. gr., 0.858.

Analyses of petroleum from various parts of the United States—Continued.

Serial No.	Location of well.	Collected by—	Collected from—	Well.	Depth of well (feet).	Physical properties: Gravity at 60° F. Specific.	Physical properties: Gravity at 60° F. Baumé.	Physical properties: Color.	Physical properties: Odor.
	CALIFORNIA—continued.								
	Los Angeles County—Continued.								
136	Newhall district			Pico Canyon, H. & S., No. 3.		0.8460	35.5		
137	Do			Pico No. 4		.8250	39.7		
138	Do			Pico No. 9		.8360	37.5		
139	Do			Pico No. 13		.8320	38.3		
140	Do		Well	San Fernando		.8300	38.7		
141	Newhall district, Pacific Coast Oil Co.		do	Pico Canyon		.8414	36.4	Dark green	
142	Puente district								
143	Do		Tank	3, 4, 5, 6		.8220	40.3		

136–140. California State Min. Bur. Seventh Ann. Rept. W. D. Johnston, chemist.
141. Am. Chem. Jour., vol. 15, p. 19. Felix Lengfield and Edmond O'Neill.
142. U. S. Geol. Survey Mineral Resources, 1892, p. 650, 1893. Joseph D. Weeks.
143. California State Min. Bur. Seventh Ann. Rept. W. D. Johnston, chemist.

Analyses of petroleum from various parts of the United States—Continued.

Serial No.	Location of well.	Distillation by Engler's method. Begins to distill at (°C.)	By volume. To 150° C. Cubic centimeters.	To 150° C. Specific gravity.	150°-300° C. Cubic centimeters.	150°-300° C. Specific gravity.	Residuum. Cubic centimeters.	Residuum. Specific gravity.	Total. Cubic centimeters.	Sulphur (per cent)	Paraffin (per cent)	Asphalt (per cent)	Water (per cent)	Unsaturated hydrocarbons (per cent). Crude	Unsaturated hydrocarbons (per cent). 150°-300° C.	Remarks.
	CALIFORNIA—continued.															
136	Los Angeles County—Con. Newhall district	......	30.0	0.7484	35.8	0.8333	34.2	....	100	......	......	......	......	......	......	Below 100° C., 11.20 p. ct.; sp. gr., 0.723. 100°-125° C., 9.30 p. ct.; sp. gr., 0.752. 125°-150° C., 9.5 p. ct.; sp. gr., 0.775. 150°-200° C., 13.60 p. ct.; sp. gr., 0.802.
137	Do	......	28.8	.7347	35.6	.8135	35.6	....	100	......	......	......	......	......	......	Below 100° C., 9.10 p. ct.; sp. gr., 0.702. 100°-125° C., 10.4 p. ct.; sp. gr., 0.739. 125°-150° C., 9.3 p. ct.; sp. gr., 0.762. 150°-200° C., 13.4 p. ct.; sp. gr., 0.787.
138	Do	......	29.6	.7355	33.2	.8205	37.2	....	100	......	......	......	......	......	......	Below 100° C., 13.1 p. ct.; sp. gr., 0.710. 100°-125° C., 6.5 p. ct.; sp. gr., 0.743. 125°-150° C., 10 p. ct.; sp. gr., 0.764. 150°-200° C., 13.6 p. ct.; sp. gr., 0.794.
139	Do	......	24.5	.7352	36.2	.8124	39.3	....	100	......	......	......	......	......	......	Below 100° C., 9.7 p. ct.; sp. gr., 0.713. 100°-125° C., 8.8 p. ct.; sp. gr., 0.742. 125°-150° C., 6 p. ct.; sp. gr., 0.761. 150°-200° C., 12 p. ct.; sp. gr., 0.783.
140	Do	......	37.7	.7436	30.7	.8259	31.6	....	100	......	......	......	......	......	......	Below 100° C., 17.3 p. ct.; sp. gr., 0.720. 100°-125° C., 11 p. ct.; sp. gr., 0.753. 125°-150° C., 9.4 p. ct.; sp. gr., 0.776. 150°-200° C., 13.3 p. ct.; sp. gr., 0.803.
141	Newhall district, Pacific Coast Oil Co.	Below 40	......	....	......	....	......	....	....	......	......	......	......	......	......	Refractive index 1.481 at 14° C.; 18 liters distilled; collected every 10°; per cent distillate not given.
142	Puente district	......	15.0	....	26.0	....	59.0	....	100	......	......	18.0	......	......	......	
143	Do	......	27.0	.7421	23.4	.8360	49.6	....	100	......	......	......	......	......	......	Below 100° C., 10.6 p. ct.; sp. gr., 0.717. 100°-125° C., 8.7 p. ct.; sp. gr., .747. 125°-150° C., 7.7 p. ct.; sp. gr., 0.771. 150°-200° C., 10.2 p. ct.; sp. gr., 0.803.

Analyses of petroleum from various parts of the United States—Continued.

Serial No.	Location of well.	Collected by—	Collected from—	Well.	Depth of well (feet).	Physical properties: Gravity at 60° F. Specific.	Physical properties: Gravity at 60° F. Baumé.	Physical properties: Color.	Physical properties: Odor.
	CALIFORNIA—continued.								
	Los Angeles County—Continued.								
144	Puente district, Puente Oil Co.		Well	6	1,425	0.8775	29.5		
145	Puente district					.8893	27.4		
146	Do					.8929	26.8		
147	Do					.8929	26.8		
148	Do					.8799	29.1		
149	Do					.9193	22.3		
150	Do					.8861	28.0		
151	Sarcinesca Ranch, Union Oil Co.		Well	5	1,500	.9656	15.0		
152	Whittier Field					.9396	19.0		
153	Whittier Field, Whittier-Filmore Oil Co.		Well	1	2,300	.9669	14.8		
154	Whittier Field, Home Oil Co., sec. 22, T. 2 S.				1,713	.9291	20.7		
155	Whittier Field, Central Oil Co., sec. 22, T. 2 S.				1,856	.9215	21.9		
156	Whittier Field, sec. 26, T. 2 S., R. 11 W.		Well			.9309	20.4		

144–145. California State Min. Bur. Bull. 31. H. N. Cooper, chemist.
146–148. California State Min. Bur. Bull. 31. Paul W. Prutzman, chemist.
149–150. California State Min. Bur. Bull. 11. Laboratory analyses.
151. California State Min. Bur. Bull. 31. H. N. Cooper, chemist.
152. U. S. Geol. Survey Mineral Resources, 1903, p. 177, 1904. Paul W. Prutzman, analyst.
153. California State Min. Bur. Bull. 31. H. N. Cooper, chemist.
156. California State Min. Bur. Bull. 31. Paul W. Prutzman, chemist.

Analyses of petroleum from various parts of the United States—Continued.

Serial No.	Location of well.	Distillation by Engler's method.								Sulphur (per cent)	Paraffin (per cent)	Asphalt (per cent)	Water (per cent)	Unsaturated hydrocarbons (per cent).		Remarks.
		Begins to distill at (° C.).	By volume.													
			To 150° C.		150°–300° C.		Residuum.		Total.							
			Cubic centimeters.	Specific gravity.	Cubic centimeters.	Specific gravity.	Cubic centimeters.	Specific gravity.	Cubic centimeters.					Crude	150°–300° C.	
	CALIFORNIA—continued.															
	Los Angeles County—Con.															
144	Puente district, Puente Oil Co.		23.4	0.7564	33.1	0.8442	43.5		100	0.36		13.1				Gravities at 15° C. 100°–150° C., 8 p. ct. 300° C. to asphalt, 28.8 p. ct. Calorific value per c. c., 9,389. Viscosity by Redwood viscometer 66.5 at 15° C.
145	Puente district		10.2	.7323	35.91	.8019	53.89		100							150°–200° C., 13.47 p. ct.; sp. gr., 0.7656. 200°–250° C., 12.24 p. ct.; 250°–300° C., 10.2 p. ct.; sp. gr., 0.8413.
146	Do		10.5	.740	a28.0	.8065	61.5		100			26.0				a 150°–270° C.; above 270° C., 33 p. ct.
147	Do		12.5	.7415	a29.0	.8121	58.5		100			24.0				a 150°–270° C.; above 270° C., 33 p. ct.
148	Do		21.0	.7439	a24.0	.8168	55.0		100			22.1				a 150°–270° C.; above 270° C., 30.9 p. ct.
149	Do		Tr.		36.0	.7893	64.0		100							300°–350° C., 2.9 p. ct.; sp. gr., 0.8610.
150	Do		10.2	.7323	35.9	.8018	53.9		100							300°–350° C., 8.5 p. ct.; sp. gr., 0.8502.
151	Sarcinesca Ranch, Union Oil Co.				41.9	.8752	58.1		100			28.4				300° C., to asphalt, 28.5 p. ct.; sp. gr., 0.891. 150°–200° C., 5.2 p. ct.; sp. gr., 0.8197. 200°–250° C., 11.6 p. ct.; sp. gr., 0.8648. 250°–300° C., 25.1 p. ct.; sp. gr., 0.8915. Viscosity by Engler viscometer over 1,800 at 15° C.
152	Whittier field		5.0		a20.0		75.0		100	.70		37.0				a 150°–270° C.; above 270° C., 38 p. ct. Maumene No. 0.335. Nitrogen, 0.669.
153	Whittier Field, Whittier-Fillmore Oil Co.				28.6	.8834	71.4		100	.93		26.5				250°–300° C., 19.5 p. ct.; 300° C. to asphalt, 41.4 p. ct. Calorific value per c. c., 10,064. Gravities at 15° C. Viscosity by Redwood viscometer over 1,800 at 15° C.
154	Whittier Field, Home Oil Co., sec. 22, T. 2 S.		4.2	.7756	38.3	.8704	57.5		100			15.7				Gravities at 15° C. 300° C. to asphalt, 39.8 p. ct. Viscosity by Redwood viscometer 393 at 15° C.
155	Whittier Field, Central Oil Co., sec. 22, T. 2 S.		6.9	.7760	32.7	.8543	60.4		100			20.6				Gravities at 15° C. 300° C. to asphalt, 39.4 p. ct. Viscosity by Redwood viscometer 325 at 15° C.
156	Whittier Field, sec. 26, T. 2 S., R. 11 W.		0		a23.4	.8328	76.6		100			27.3				a 150°–270° C.; above 270° C., 45.3 p. ct.

Analyses of petroleum from various parts of the United States—Continued.

Serial No.	Location of well.	Collected by—	Collected from—	Well.	Depth of well (feet).	Physical properties. Gravity at 60°F. Specific.	Baumé.	Color.	Odor.
	CALIFORNIA—continued.								
	Los Angeles County—Continued.								
157	Whittier field, sec. 26, T. 2 S., R. 11 W		Well			0.9272	21.0		
158	Do		do			.9144	23.1		
159	Do		do			.9138	23.2		
	Marin County:								
160	Bolinas Bay		do			.9241	21.5		
161	Do					.9241	21.5		
162	Monterey County					.8929	26.8		
163	Do								
	Napa County:								
164	Berryessa Valley					.9642	15.2		
165	Do					.9642	15.2		
166	Do					.9677	14.7	Dark brown	
167	Do					.9625	15.5	Brown	
	Orange County:								
168	Fullerton, Columbia Oil Producing Co.		Well		680	.9378	19.3		
169	Fullerton, sec. 8, T. 3 S.		do	Santa Fe	2,404	.9399	19.0		
170	Fullerton, sec. 9, T. 3 S.		do	Santa Fe 39	1,705	.8536	34.0		

157-160. California State Min. Bur. Bull. 31. Paul W. Prutzman, chemist.
161, 162. U. S. Geol. Survey Mineral Resources, 1903, p. 177, 1904. Paul W. Prutzman, analyst.
163. California State Min. Bur. Seventh Ann. Rept., 1887. W. D. Johnston, chemist.
164. California State Min. Bur. Bull. 19. Paul W. Prutzman, analyst.
165. U. S. Geol. Survey Mineral Resources, 1903, p. 177, 1904. Paul W. Prutzman, analyst.
166-167. Am. Chem. Soc. Jour., vol. 25, p. 669. Edmond O'Neill.
168-170. California State Min. Bur. Bull. 31. H. N. Cooper, chemist.

Analyses of petroleum from various parts of the United States—Continued.

Serial No.	Location of well.	Begins to distill at (° C.).	Distillation by Engler's method. By volume. To 150° C. Cubic centimeters.	To 150° C. Specific gravity.	150°–300° C. Cubic centimeters.	150°–300° C. Specific gravity.	Residuum. Cubic centimeters.	Residuum. Specific gravity.	Total. Cubic centimeters.	Sulphur (per cent).	Paraffin (per cent).	Asphalt (per cent).	Water (per cent).	Unsaturated hydrocarbons (per cent). Crude	Unsaturated hydrocarbons (per cent). 150°–300° C.	Remarks.
	CALIFORNIA—continued.															
	Los Angeles County—Con.															
157	Whittier field, sec. 26, T. 2 S., R. 11 W.		2.1	0.7568	*a*23.9	0.8328	74.0		100			21.4				*a* 150°–270° C.; above 270° C., 48.4 p. ct.
158	Do		5.2	.7568	*a*27.3	.8314	67.5		100			20.2				*a* 150°–270° C.; above 270° C., 44.7 p. ct.
159	Do		4.7	.7475	*a*24.0	.8269	71.3		100			19.7				*a* 150°–270° C.; above 270° C., 46.9 p. ct.
	Marin County:															
160	Bolinas Bay		4.0	.7543	*a*20.7	.8088	75.3		100			22.9				*a* 150°–270° C.; above 270° C., 50 p. ct.
161	Do		2.0		*a*24.0		74.0		100			22.0				*a* 150°–270° C.; above 270° C., 52 p. ct. Maumene No. 0.370.
162	Monterey County		0		*a* 2.0		98.0		100							*a* 150°–270° C.; above 270° C., 98 p. ct.
163	Do		0		37.8	.868	62.2		100							180°–200° C., 9.4 p. ct., sp. gr., 0.840; 200°–250° C., 18 p. ct., sp. gr., 0.867.
	Napa County:															
164	Berryessa Valley								96.0	0.00		3.66				Temperature not given. Lubricating oil, 46 p. ct.; gas oil, 32 p. ct.; residuum, 18 p. ct.
165	Do		0		*a*15.0		85.0		100.0							*a* 150°–270° C.; above 270° C., 78 p. ct.; residuum, 7 p. ct. Maumene No. 0.153.
166	Do		0		*a*15.7		84.3		100.0			11.4				*a* 250°–350° C.; 350° C. to asphalt 72.6 p. ct.
167	Do		0		*a*87.0		13.0		100.0			9.0				*a* 250°–350° C.; 350° C. to asphalt, 4.2 p. ct.; hydrogen, 11.13 p. ct.; carbon, 88.08 p. ct. Viscosity 10.35 at 15.5° C. (Engler method).
	Orange County:															
168	Fullerton, Columbia Oil Producing Co.		8.1	.7481	34.6	.8638	57.3		100.0			25.8				Gravities at 15° C. 300° C. to asphalt, 31.2 p. ct. Viscosity by Redwood viscometer 1,020 at 15° C.
169	Fullerton, sec. 8, T. 3 S.		0		37.2	.8544	62.8		100.0	1.09		23.1				Gravities at 15° C. 300° C. to asphalt, 38.2 p. ct. Calorific value per c. c., 9,813. Viscosity by Redwood viscometer 1,790 at 15° C.
170	Fullerton, sec. 9, T. 3 S.		28.2	.7459	32.2	.8381	39.6		100.0	.41		11.0				Gravities at 15° C. 300° C. to asphalt, 26 p. ct. Calorific value per c. c., 9,200. Viscosity by Redwood viscometer 45.5 at 15° C.

Analyses of petroleum from various parts of the United States—Continued.

Serial No.	Location of well.	Collected by—	Collected from—	Well.	Depth of well (feet).	Physical properties. Gravity at 60°F. Specific.	Baumé.	Color.	Odor.
	CALIFORNIA—continued.								
	Orange County—Continued.								
171	Fullerton, Brea Canyon Oil Co.		Well	12	1,515	0.9147	23.1		
172	Fullerton, sec. 8, T. 3 S., R. 9 W.					.9596	15.9		
173	Do		Tank			.9315	20.3		
174	Do		Well			.9302	20.5		
175	Fullerton, sec. 1, T. 3 S., R. 10 W.		do			.9132	23.3		
176	Fullerton, sec. 9, T. 3 S., R. 9 W.		do			.8621	32.4		
177	Do		do			.8600	32.8		
178	Do		do			.8589	33.0		
179	Do		do			.8568	33.4		
180	Do		do			.8511	34.5		
181	Fullerton		do	Santa Fe		.9421	18.6	Brown	
	San Mateo County:								
182	(Not located)					.8163	41.5		
183	Do					.7830	48.8		
184	Do					.9206	22.1	Brown	

171. California State Min. Bur. Bull. 31. H. N. Cooper, Chemist.
172–180. California State Min. Bur. Bull. 31. Paul W. Prutzman, chemist.
181. Soc. Chem. Indust. Jour., No. 19. Clifford Richardson.
182–183. U. S. Geol. Survey Mineral Resources, 1903, p. 177, 1904. Paul W. Prutzman, analyst.
184. Am. Chem. Soc. Jour., vol. 25, p. 669. Edmond O'Neill.

Analysis of petroleum from various parts of the United States—Continued.

Serial No.	Location of well.	Distillation by Engler's method: Begins to distill at (°C.)	By volume: To 150° C.: Cubic centimeters.	To 150° C.: Specific gravity.	150°–300° C.: Cubic centimeters.	150°–300° C.: Specific gravity.	Residuum: Cubic centimeters.	Residuum: Specific gravity.	Total: Cubic centimeters.	Sulphur (per cent)	Paraffin (per cent)	Asphalt (per cent)	Water (per cent)	Unsaturated hydrocarbons (per cent): Crude	Unsaturated hydrocarbons (per cent): 150°–300° C.	Remarks.
	CALIFORNIA—continued.															
	Orange County—Continued.															
171	Fullerton, Brea Canyon Oil Co.	......	18.1	0.7597	36.9	0.8663	45.5	....	100.5	0.94	......	13.3	......	......	......	Gravities at 15° C. 300° C. to asphalt, 29.2 p. ct. Calorific value per c. c., 9,678. Viscosity by Redwood viscometer 264 at 15° C
172	Fullerton, sec. 8, T. 3 S., R. 9 W.	......	1.0	....	a14.0	.8393	85.0	....	100.0	......	......	42.0	......	......	......	a 150°–270° C.; above 270° C., 41 p. ct.
173	Do	......	Tr.	....	a23.0	.8178	77.0	....	100.0	......	......	32.1	......	......	......	a 150°–270° C.; above 270° C., 42.9 p. ct.
174	Do	......	3.4	.7535	a18.8	.8269	77.8	....	100.0	......	......	25.9	......	......	......	a 150°–270° C.; above 270° C., 47.6 p. ct.
175	Fullerton, sec. 1 T. 3 S., R. 10 W.	......	10.5	.7487	a25.5	.8240	64.0	....	100.0	......	......	31.6	......	......	......	a 150°–270° C.; above 270° C., 31.4 p. ct.
176	Fullerton, sec. 9, T. 3 S., R. 9 W.	......	21.7	.7403	a25.8	.8163	52.5	....	100.0	......	......	9.0	......	......	......	a 150°–270° C.; above 270° C., 41.8 p. ct.
177	Do	......	23.8	.7384	a27.7	.8202	49.5	....	101.0	......	......	16.7	......	......	......	a 150°–270° C.; above 270° C., 31.2 p. ct.
178	Do	......	24.8	.7334	a27.6	.8102	47.6	....	100.0	......	......	15.6	......	......	......	a 150°–270° C.; above 270° C., 31.4 p. ct.
179	Do	......	22.1	.7334	a30.8	.8173	47.1	....	100.0	......	......	8.0	......	......	......	a 150°–270° C.; above 270° C., 37.6 p. ct.
180	Do	......	22.9	.7288	a27.9	.8092	49.2	....	100.0	......	......	12.9	......	......	......	a 150°–270° C.; above 270° C., 33.4 p. ct.
181	Fullerton	35	2.4	.788	a8.2	.8319	89.4	....	100.0	......	......	......	......	......	......	a 135°–175° C., color of distillate pink, refractive index 1.435. Distillation under 25 mm. pressure, as follows: 40°–100° C., 4.2 p. ct.; sp. gr. 0.8745, refractive index, 1.455; 100°–150° C., 10.4 p. ct.; sp. gr., 0.9195, refractive index, 1.478; 150°–165° C., 7 p. ct.; sp. gr., 0.9547; refractive index, 1.496. Begins to crack; residue, 66.4 p. ct.
	San Mateo County:															
182	(Not located)	......	39.0	....	a46.0	....	15.0	....	100.0	......	......	......	......	......	......	a 150°–270° C.; above 270° C., 15 p. ct.
183	Do	......	48.0	....	a33.0	....	......	....	100.0	......	......	......	......	......	......	a 150°–270° C.; above 270° C., 19 p. ct.
184	Do	......	......	....	......	....	100.0	....	100.0	......	......	26.0	14.90	......	......	350° C. to asphalt, 58.9 p. ct. Viscosity, 10.96 at 15.5° C. (Engler method).

Analyses of petroleum from various parts of the United States—Continued.

Serial No.	Location of well.	Collected by—	Collected from—	Well.	Depth of well (feet).	Physical properties. Gravity at 60°F. Specific.	Physical properties. Gravity at 60°F. Baumé.	Physical properties. Color.	Physical properties. Odor.
	CALIFORNIA—continued.								
	San Mateo County—Continued.								
185	Half Moon Bay					0.8154	41.7	Greenish	
186	Do					.7830	48.8		
187	Purissima Canyon		Well	Lane		.8550	33.7		
188	Do		do	Tunitas		.7990	45.2		
	San Benito County:								
189	Bitterwater district, sec. 32, T. 18 S., R. 10 E		do			.8107	42.7	Green	
190	Bitterwater district, Nonpareil Petroleum Co		do			.8107	42.7	do	
191	Bitterwater district					.8107	42.7		
192	Santa Cruz County					.9587	16.0	Black	
	Santa Clara County:								
193	(Not located)					.8537	34.0	Light Brown	
194	Sargent, Watsonville Oil Co		Well	2	1,187	.9416	18.7		

185. California State Min. Bur. Bull. 31.
186. California State Min. Bur. Bull, 31. Paul W. Prutzman, chemist.
187–188. California State Min. Bur. Seventh Ann. Rept. W. D. Johnston, chemist.
189. California State Min. Bur. Bull. 31. Paul W. Prutzman, chemist.
190. California State Min. Bur. Bull. 31. Name of analyst not given.
191. U. S. Geol. Survey Mineral Resources, 1903, p. 177, 1904. Paul W. Prutzman.
192–193. Am. Chem. Soc. Jour., vol. 25. Edmond O'Neill.
194. California State Min. Bur. Bull. 31. H. N. Cooper, chemist.

Analyses of petroleum from various parts of the United States—Continued.

Serial No.	Location of well.	Distillation by Engler's method. Begins to distill at (° C.)	By volume. To 150° C. Cubic centimeters.	To 150° C. Specific gravity.	150°–300° C. Cubic centimeters.	150°–300° C. Specific gravity.	Residuum. Cubic centimeters.	Residuum. Specific gravity.	Total. Cubic centimeters.	Sulphur (per cent)	Paraffin (per cent)	Asphalt (per cent)	Water (per cent)	Unsaturated hydrocarbons (per cent). Crude	Unsaturated hydrocarbons (per cent). 150°–300° C.	Remarks.
	CALIFORNIA—continued.															
	San Mateo County—Contd.															
185	Half Moon Bay	......	47.0	0.7414	34.7	0.8254	18.3	....	100.0	......	......	......	......	......	......	Gasoline, 8.6 p. ct.; benzine, 12.9 p. ct.; engine distillate, 25.5 p. ct.; kerosene, 23.6 p. ct.; stove oil, 11.1 p. ct.; lubricants, 8 p. ct.
186	Do.	......	47.5	.728	a33.0	.800	19.5	....	100.0	......	......	......	......	......	......	a 150°–270° C.; above 270° C., 16 p. ct.
187	Purissima Canyon	......	18.0	.759	44.0	.817	38.0	....	100.0	......	......	......	......	......	......	
188	Do.	......	46.7	.7414	35.0	.820	18.3	....	100.0	......	......	......	......	......	......	Below 100° C., 9.9 p. ct.; 100°–125° C., 17.3 p. ct.; 125°–150° C., 19.5 p. ct.; 150°–200° C., 17.2 p. ct.; 200°–250° C., 11.8 p. ct.; 250°–300° C., 6 p. ct.
	San Benito County:															
189	Bitterwater district, sec. 32, T. 18 S., R. 10 E.	......	31.0	.7341	a37.6	.814	31.4	....	100.0	......	......	......	......	......	......	a 150°–270° C.; above 270° C., 25.7 p. ct.; sp. gr. 0.8772; residue, 4.3 p. ct.; not asphalt, though it contains that substance.
190	Bitterwater district, Nonpareil Petroleum Co.	......	30.0	....	50.0	....	20.0	....	100.0	......	......	......	......	......	......	Gasoline, 10 p. ct.; sp. gr., 0.7071; engine distillate, 20 p. ct.; sp. gr., 0.7547; kerosene, 35 p. ct.; sp. gr., 0.8046; stove oil, 15 p. ct., sp. gr. 0.8485; lubricants, 19.7 p. ct.; sp. gr. 0.9352.
191	Bitterwater district	......	28.0	....	a37.0	....	35.0	....	100.0	......	......	......	......	......	......	a 150–270° C.; above 270° C., 35 p. ct. Maumene No. 0.068.
192	Santa Cruz County	......	0	....	a6.2	....	93.8	....	100.0	......	......	22.8	21.5	......	......	a 150°–250° C.; 250°–350° C., 34 p. ct.; 350° C. to asphalt, 14.4 p. ct.
	Santa Clara County:															
193	(Not located)	......	15.0	....	a35.8	....	49.2	....	100.0	0.92	......	3.6	......	......	......	a 150°–250° C.; 250°–350° C., 31.2 p. ct.; 350° C. to asphalt, 14.4 p. ct. B. t. u. 20,145.6. Hydrogen, 12.88 p. ct., carbon, 86.08 p. ct.
194	Sargent, Watsonville Oil Co.	......	9.0	.7656	41.4	.8848	49.6	....	100.0	.83	......	19.6	......	......	......	Gravities at 15° C. Up to 100° C., 2 p. ct.; 100°–150° C., 7 p. ct.; 300° C. to asphalt, 27.2 p. ct. Calorific value per c. c., 9,786. Viscosity by Redwood viscometer, 750 at 15° C.

Analyses of petroleum from various parts of the United States—Continued.

Serial No.	Location of well.	Collected by—	Collected from—	Well.	Depth of well (feet).	Physical properties.			
						Gravity at 60°F.		Color.	Odor.
						Specific.	Baumé.		
	CALIFORNIA—continued.								
	Santa Clara County—Continued.								
195	Sargent		Tank			0.9569	16.3		
196	Do		do			.9511	17.2		
197	Do		Well			.9421	18.6		
198	Moodys Gulch, Golden Gate Petroleum Co		do			.8333	38.0		
199	Moodys Gulch		do	4		.8120	42.4		
200	Do					.8333	38.0		
	Santa Barbara County:								
201	Lompoc, Union Oil Co		Well	Hill No. 1	2,500	.9574	16.2		
202	Summerland, Sea Cliff Oil Co		do			.9665	14.9		
203	Summerland, Potomac Oil Co		do	4	260	.9603	15.8		
204	Summerland		Tank			.9655	15.0		
205	Do		do			.9722	14.0		
206	Do					.9858	12.0	Black	

195–198. California State Min. Bur. Bull. 31. Paul W. Prutzman, chemist.
199. California State Min. Bur. Seventh Ann. Rept. W. D. Johnston, chemist.
200. U. S. Geol. Survey Mineral Resources, 1903, p. 177, 1904. Paul W. Prutzman.
201–203. California State Min. Bur. Bull. 31. H. N. Cooper, chemist.
204. California State Min. Bur. Bull. 31. Paul W. Prutzman, chemist.
205. California State Min. Bur. Bull. 31. Analyst not given.
206. Am. Chem. Soc. Jour., vol. 25, p. 669. Edmond O'Neill.

Analyses of petroleum from various parts of the United States—Continued.

Serial No.	Location of well.	Distillation by Engler's method. Begins to distill at (°C.)	By volume. To 150° C. Cubic centimeters.	To 150° C. Specific gravity.	150°–300° C. Cubic centimeters.	150°–300° C. Specific gravity.	Residuum. Cubic centimeters.	Residuum. Specific gravity.	Total. Cubic centimeters.	Sulphur (per cent).	Paraffin (per cent).	Asphalt (per cent).	Water (per cent).	Unsaturated hydrocarbons (per cent). Crude	Unsaturated hydrocarbons (per cent). 150°–300° C.	Remarks.
	CALIFORNIA—continued.															
	Santa Clara County—Contd.															
195	Sargent	......	.8	....	*a*20.0	0.8383	79.2	....	100.0	......	......	24.2	......	......	......	*a* 150°–270° C.; above 270° C., 50 p. ct.
196	Do	......	1.0	....	*a*18.0	.8419	81.0	....	100.0	......	......	27.0	......	......	......	*a* 150°–270° C.; above 270° C., 52 p. ct.
197	Do	......	6.0	0.7568	*a*19.5	.8434	74.5	....	100.0	......	......	37.0	......	......	......	*a* 150°–270° C.; above 270° C., 35.5 p. ct.
198	Moodys Gulch, Golden Gate Petroleum Co.	......	25.0	.7527	38.1	.8046	36.9	....	100.0	......	......	......	......	......	......	No temperature given. Engine distillate, 25 p. ct.; sp. gr., 0.7527; gas oil, 33.9 p. ct.; sp. gr., 0.8642; paraffin, 0.3 p. ct.
199	Moodys Gulch	......	33.8	.7449	35.5	.8201	30.7	....	100.0	......	......	......	......	......	......	Below 100° C., 9.4 p. ct.; 100°–150° C., 24.4 p. ct.; sp. gr., 0.756; 150°–200° C., 17.1 p. ct.; sp. gr., 0.798; 200°–250° C., 14.8 p. ct.; sp. gr., 0.836.
200	Do	......	26.0	....	*a*35.0	....	39.0	....	100.0	......	......	0	......	......	......	*a* 150°–270° C.; above 270° C., 39 p. ct.
	Santa Barbara County:															
201	Lompoc, Union Oil Co.	......	5.2	....	31.5	.8417	63.3	....	100.0	4.43	......	20.6	7.0	......	......	Gravities at 15° C. Viscosity by Redwood viscometer over 1,800 at 15° C. 300° C. to asphalt, 34.3 p. ct. Calorific value per c. c., 9,822.
202	Summerland, Sea Cliff Oil Co.	......	0	....	28.4	....	71.6	....	100.0	.44	......	23.5	......	......	......	Gravities at 15° C. 300° C. to asphalt, 45.5 p ct. Calorific value per c. c., 10,001. Viscosity by Redwood viscometer over 1,800 at 15° C.
203	Summerland, Potomac Oil Co.	......	0	....	28.3	.8693	71.7	....	100.0	......	......	22.8	......	......	......	Gravities at 15° C. 300° C. to asphalt, 48 p. ct. Viscosity by Redwood viscometer over 1,800 at 15° C.
204	Summerland	......	0	....	*a*10.0	.8464	90.0	....	100.0	......	......	32.2	......	......	......	*a* 150°–270° C.; above 270° C., 54 p. ct.
205	Do	......	.1	....	7.0	.8187	92.9	....	100.0	......	......	37.1	......	......	......	Temperature not given. Gas oil, 16.3 p. ct., sp. gr. 0.8861; stove oil, 4 p. ct.; sp. gr., 0.8589.
206	Do	......	0	....	*a* 6.5	....	93.5	....	100.0	......	......	22.5	25.0	......	......	*a* 150°–250° C.; 250°–530° C., 17.10 p. ct.; 350° C. to asphalt, 27.5 p. ct. Viscosity 1,462 at 15.5° C. (Engler method.)

Analyses of petroleum from various parts of the United States—Continued.

Serial No.	Location of well.	Collected by—	Collected from—	Well.	Depth of well (feet).	Physical properties.			
						Gravity at 60° F.		Color.	Odor.
						Specific.	Baumé.		
	CALIFORNIA—continued.								
	Santa Barbara County—Continued.								
207	Summerland								
208	Do		Submarine well			0.9521	17.0		
209	Do					.9655	15.0		
210	Do					.9672	14.8		
211	Do					.9513	17.2		
212	Do					.9657	15.0		
213	Do					.9672	14.8		
214	Do					.9692	14.5		
215	Carreaga field					.9530	16.9	Black	

207. Pet. Rev., Dec. 8, 1906. Clifford Richardson.
208. Am. Acad. Arts and Sci., vol. 40, p. 340. C. F. Mabery and E. V. Zonl; also Franklin Inst. Jour., vol. 162, Jan., 1906.
209. U. S. Geol. Survey Mineral Resources, 1903, p. 177. 1904. Paul W. Prutzman.
210–214. California State Min. Bur. Bull. 11. Laboratory analyses.
215. U. S. Geol. Survey Mineral Resources, 1903, p. 177, 1904. Paul W. Prutzman.

Analyses of petroleum from various parts of the United States—Continued.

Serial No.	Location of well.	Distillation by Engler's method. Begins to distill at (° C.)	By volume. To 150° C. Cubic centimeters.	To 150° C. Specific gravity.	150°–300° C. Cubic centimeters.	150°–300° C. Specific gravity.	Residuum. Cubic centimeters.	Residuum. Specific gravity.	Total. Cubic centimeters.	Sulphur (per cent).	Paraffin (per cent).	Asphalt (per cent).	Water (per cent).	Unsaturated hydrocarbons (per cent). Crude	Unsaturated hydrocarbons (per cent). 150°–300° C.	Remarks.
	CALIFORNIA—continued.															
	Santa Barbara County—Con.															
207	Summerland											45.0				Distilled in vacuo of 26 mm. pressure gave 55 p. ct. of distillate, collected in 15 portions; sp. gr. of fractions as follows: 0.8712, 0.8833, 0.8893, 0.9034, 0.9155, 0.9336, 0.9417, 0.9477, 0.9618, 0.9678, 0.9738, 0.9802, 0.9830, 0.990, 0.9939.
208	Do									0.84						Nitrogen, 1.25 p. ct.; carbon, 86.32 p. ct.; hydrogen, 11.7 p. ct. Distilled under pressure of 60 mm. Only small quantities passed over below 175° C.; residue of 10 p. ct. remained at 356° C. Following hydrocarbons isolated: At 20° C., $C_{13}H_{24}$; 150°–155° C., sp. gr. 0.8621, $C_{16}H_{30}$; 175°–180° C., sp. gr. 0.8808, $C_{17}H_{30}$; 190°–195° C., sp. gr. 0.8919, $C_{18}H_{32}$; 210°–215° C., sp. gr. 0.8996, $C_{24}H_{44}$; 250°–255° C., sp. gr. 0.9299, $C_{27}H_{46}$; 310°–315° C., sp. gr. 0.9451, $C_{29}H_{50}$; 340°–345° C., sp. gr. 0.9778.
209	Do		0		a11.0		89.0		100.0	.898		40.0				a 150°–270° C.; above 270° C. 49 p. ct. Nitrogen, 0.88.
210	Do		0		11.0	0.8452	89.0		100.0							300°–350° C., 5 p. ct., sp. gr. 0.8722.
211	Do		Tr.		21.4		78.6		100.0							300°–350° C., 12 p. ct., sp. gr. 0.8962.
212	Do		Tr.		11.6	.8468	88.4		100.0							300°–350° C., 6.8 p. ct., sp. gr. 0.8900.
213	Do		Tr.		6.0		94.0		100.0							300°–350° C., 5 p. ct.
214	Do		Tr.		Tr.		100.0		100.0							300°–350° C., 4.6 p. ct.
215	Carreaga Field		1.0		a24.0		75.0		100.0			38.0				a 150°–270° C.; above 270° C., 38 p. ct. Maumene No. 4.82. Nitrogen, 0.43. Viscosity by Redwood viscometer 790 at 15° C.

Analyses of petroleum from various parts of the United States—Continued.

Serial No.	Location of well.	Collected by—	Collected from—	Well.	Depth of well (feet).	Physical properties.			
						Gravity at 60°F.		Color.	Odor.
						Specific.	Baumé.		
	CALIFORNIA—continued.								
	Santa Barbara County—Continued.								
216	Carreaga Field, Western Union Oil Co		Well			0.9303	20.5		
217	Do		do		2,776	.8508	34.6		
218	Near Casmalia Field, Western Union Oil Co		do	3	1,610	.9337	19.9		
219	Santa Maria Field, Pinal Oil Co		do	1,3	1,600	.8882	27.6		
220	Santa Maria Field					.9530	16.9		
221	Santa Maria Field, Pinal Oil Co								
222	(Not located)					.9804	12.8	Dark, almost black	

216–219. California State Min. Bur. Bull. 31. H. N. Cooper, chemist.
220. From 1905 statistical card giving production of well owner.
221–222. Am. Jour. Sci., 2d ser., vol. 43, p. 242. B. Silliman.

Analyses of petroleum from various parts of the United States—Continued.

Serial No.	Location of well.	Distillation by Engler's method. Begins to distill at (° C.)	By volume. To 150° C. Cubic centimeters.	To 150° C. Specific gravity.	150°–300° C. Cubic centimeters.	150°–300° C. Specific gravity.	Residuum. Cubic centimeters.	Residuum. Specific gravity.	Total. Cubic centimeters.	Sulphur (per cent)	Paraffin (per cent)	Asphalt (per cent)	Water (per cent)	Unsaturated hydrocarbons (per cent). Crude	Unsaturated hydrocarbons (per cent). 150°–300° C.	Remarks.
	CALIFORNIA—continued.															
	Santa Barbara County—Con.															
216	Carreaga Field, Western Union Oil Co.	......	12.0	0.7481	43.2	0.8677	44.8	....	100.0	......	......	17.9	......	......	......	Gravities at 15° C. 300° C. to asphalt, 27.4 p. ct.; 150°–200° C., 10.4 p. ct.; 200°–250° C., 8.3 p. ct.
217	Do	......	24.6	.7508	36.2	.8312	39.2	....	100.0	0.60	......	8.0	......	......	......	Gravities at 15° C. 300° C. to asphalt, 30.4 p. ct. Calorific value per c. c., 9,203. Viscosity by Redwood viscometer 47.4 at 15° C.
218	Near Casmalia Field, Western Union Oil Co.	......	6.9	.7596	30.8	.8508	62.3	....	100.0	2.08	......	22.0	......	......	......	Gravities at 15° C. 300° C. to asphalt, 39.5 p. ct. Calorific value per c. c., 9,907. Viscosity by Redwood viscometer 1,060 at 15° C.
219	Santa Maria Field, Pinal Oil Co.	......	25.9	.7460	30.6	.8469	43.5	....	100.0	1.56	......	12.0	......	......	......	Gravities at 15° C. 300° C. to asphalt, 29.7 p. ct. Calorific value per c. c., 9,364. Viscosity by Redwood viscometer 90 at 15° C.
220	Santa Maria Field	......	1.0	....	a24.0	.8260	75.0	....	100.0	......	......	41.9	......	......	......	a 150°–270° C.; above 270° C., 31.1 p. ct.
221	Santa Maria Field, Pinal Oil Co.		12.0	....	12.0	....	76.0	....	100.0	......	......	16.0	......	......	......	No temperature given. Gas oil, 10 p. ct.; lubricating oil, 50 p. ct.
222	(Not located)	......	......	....	......	....	......	....	....	......	......	......	......	......	......	Distillation to dryness produced 69.82 p. ct., sp. gr. 0.890 to 0.900; coke, water, and loss 30.18 p. ct. Oil of 0.885 sp. gr., 50 p. ct.; oil of 0.908 sp. gr., 17.5 p. ct. First distillate treated by cracking yielded a product having a density of about 0.885 at 60° F., or only 1° Baumé lower than before distillation. After treatment with sulphuric acid and soda and redistilling from soda it had a density of 0.880.

Analyses of petroleum from various parts of the United States—Continued.

Serial No.	Location of well.	Collected by—	Collected from—	Well.	Depth of well (feet).	Physical properties.			
						Gravity at 60°F.		Color.	Odor.
						Specific.	Baumé.		
	CALIFORNIA—continued.								
	Santa Barbara County—Continued.								
223	Hayward Petroleum Co.		Tunnel			0.9023	25.2		
224	(Not located)		Pico Spring			.8932	26.7		
225	(Not located) Canada Loga					.9184	22.4		
226	(Not located)		Spring			.9780	13.2		
227	Ojai Valley					.9175	22.6		

223–226. Am. Jour. Sci., 2d ser., vol. 47, p. 10. S. F. Peckham.
227. Pet. Rev., Dec. 27, 1906. Clifford Richardson.

Analyses of petroleum from various parts of the United States—Continued.

Serial No.	Location of well.	Distillation by Engler's method.								Sulphur (per cent)	Paraffin (per cent)	Asphalt (per cent)	Water (per cent)	Unsaturated hydrocarbons (per cent).		Remarks.
		Begins to distill at (° C.)	By volume.													
			To 150° C.		150°–300° C.		Residuum.		Total.							
			Cubic centimeters.	Specific gravity.	Cubic centimeters.	Specific gravity.	Cubic centimeters.	Specific gravity.	Cubic centimeters.					Crude	150°–300° C.	
	CALIFORNIA—continued.															
223	Santa Barbara County—Con. Hayward Petroleum Co.				15.0	0.810	85.0		100.0							40 to 50 p. ct. of middlings and 20 p. ct. light lubricating oil. Under pressure distillation 42 p. ct., sp. gr. 0.810; second pressure distillation of residue (49 p. ct.) yielded 44.15 p. ct.; second fractionation of sp. gr. 0.810, 12.25 p. ct. Total crude illuminating oil, 54.25 p. ct; lubricating oil, 31.85 p. ct.
224	(Not located)				20.0		80.0		100.0							Under pressure distillation yielded 56.72 p. ct., sp. gr. 0.810; second pressure distillation of residue (30.94 p. ct.) yielded 28.74 p. ct.; second fractionation of sp. gr. 0.810, 6.96 p. ct. Total crude illuminating oil, 62.68 p. ct.; lubricating oil 20.88 p. ct.
225	(Not located) Canada Loga.				3.0		97.0		100.0							Under pressure distillation yielded 40.33 p. ct., sp. gr. 0.810; second pressure distillation of residue (42.33 p. ct.) yielded 38.09 p. ct.; second fractionation of sp. gr. 0.810, 9.52 p. ct. Total crude illuminating oil, 49.85 p. ct.; lubricating oil, 25.87 p. ct.
226	(Not located)				2.5		97.5		100.0							Sample from same spring as No. 222. Under pressure distillation yielded 16.7 p. ct., sp. gr. 0.810; second pressure distillation of residue (55.3 p. ct., water 12.5 p. ct.) yielded 49.8 p. ct.; second fractionation of sp. gr. 0.810, 12.4 p. ct. Total crude illumunating oil, 29.1 p. ct.; lubricating oil, 37.1 p. ct.
227	Ojai Valley		23.4	0.7914	a31.8		43.8		99.0							a 150°–274° C.; 30°–80° C., 7.8 p. ct., sp. gr. 0.768; 80°–118° C., 7.8 p. ct., sp. gr. 0.7728; 118°–150° C., 7.8 p. ct., sp. gr. 0.8334.

Analyses of petroleum from various parts of the United States—Continued.

Serial No.	Location of well.	Collected by—	Collected from—	Well.	Depth of well (feet).	Physical properties.			
						Gravity at 60°F.		Color.	Odor.
						Specific.	Baumé.		
	CALIFORNIA—continued.								
228	Ventura County					0.9120	23.5		
229	Do					.8997	25.6		
230	Do		Mixed crude			.9091	24.0		
231	Do		Pipe line			.8974	26.0		
232	Do		do			.9021	25.2		
233	Do					.9830	12.4		
234	Do					.9159	22.9	Brown	
235	Do					.9165	22.8	do	
236	Do					.8918	27.0	Brown, thick	

228. U. S. Geol. Survey Mineral Resources, 1896, 1897; from California State Min. Bur. Bull. 11. Frederick Salathe, analyst.
229. U. S. Geol. Survey Mineral Resources, 1903, p. 177, 1904. Paul W. Prutzman.
230. California State Min. Bur. Bull. 1, p. 78. M. L. Watts.
231–232. California State Min. Bur. Bull. 31, p. 193.
233–235. Am. Chem. Soc. Jour., vol. 25, p. 669. Edmond O'Neill.
236. Am. Chem. Jour., vol. 19, p. 797. Chas. F. Mabery.

Analyses of petroleum from various parts of the United States—Continued.

Serial No.	Location of well.	Distillation by Engler's method.								Sulphur (per cent)	Paraffin (per cent)	Asphalt (per cent)	Water (per cent)	Unsaturated hydrocarbons (per cent).		Remarks.
		Begins to distill at (°C.)	By volume.													
			To 150° C.		150°–300° C.		Residuum.		Total.							
			Cubic centimeters.	Specific gravity.	Cubic centimeters.	Specific gravity.	Cubic centimeters.	Specific gravity.	Cubic centimeters.					Crude	150°–300°C.	
	CALIFORNIA—continued.															
228	Ventura County									0.40						Carbon, 84 p. ct.; hydrogen, 12.7 p. ct.; nitrogen, 1.7 p. ct.; oxygen, 1.2 p. ct.
229	Do		10.0		a24.0		66.0		100.0	1.5		22.0				a 150°–270° C.; above 270° C. 44 p. ct.; nitrogen, 0.606.
230	Do		7.0		23.0		70.0		100.0			11.0				Average yield from 100 barrels determined by running: Gasoline, sp. gr. 0.6796, 3 barrels; benzine, sp. gr. 0.7254, 4 barrels; kerosene, sp. gr. 0.800, 15 barrels; kerosene, sp. gr. 38°–40° B., 8 barrels; gas distillate, sp. gr. 0.8861, 21 barrels; spindle oil, sp. gr. 0.8974, 10 barrels; neutral oil, sp. gr. 0.915, 12 barrels; heavy neutral oil, sp. gr. 0.9272, 6 barrels; lubricating oil, sp. gr. 0.9722, 5 barrels.
231	Do		10.4	0.7254	28.0	0.8116	61.6		100.0			23.7				Gas oil, 16.1 p. ct., sp. gr. 0.8861; lubricating oil, 20.3, p. ct. sp. gr. 0.915.
232	Do		14.5	.7568	13.8	.8140	71.7		100.0			14.9				Stove oil, 14.4 p. ct., sp. gr. 0.8589; fuel distillate, 22.8 p. ct., sp. gr. 0.8974; lubricant, 16 p. ct., sp. gr. 0.9272.
233	Do		0		a11.2		88.8		100.0			36.5	9.5			a 150°–250° C.; 250°–350° C., 34.05 p. ct.; 350° C. to asphalt, 8.75 p. ct.
234	Do		12.0		a16.0		72.0		100.0			13.8				a 150°–250° C.; 250°–350° C., 54.5 p. ct.; 350° C. to asphalt, 2.2 p. ct.
235	Do		17.0		a11.5		71.5		100.0			41.0				a 150°–250° C.; 250°–350° C., 9 p. ct.; 350° C. to asphalt, 21.5 p. ct.
236	Do	60	9.7	.7395	29.1		61.2		100.0	.84						Gravities at 20° C. Bromine absorption, 17.72. Percentage of nitrogen compound, 0.53 p. ct.; carbon, 85.60 p. ct.; hydrogen, 12.84 p. ct. Residue above 300° C. thick, nearly solid tar. (Vacuum distillation also given.)

Analyses of petroleum from various parts of the United States—Continued.

Serial No.	Location of well.	Collected by—	Collected from—	Well.	Depth of well (feet).	Physical properties.			
						Gravity at 60°F.		Color.	Odor.
						Specific.	Baumé.		
	CALIFORNIA—continued.								
	Ventura County—Continued.								
237	Adams Canyon		Well	Green		0.8530	34.1		
238	Do		do	Wild Bill		.9150	23.0		
239	Do					.9091	24.0	Greenish	
240	Adams Canyon; Union Oil Co		Well	27	2,745	.8814	28.8		
241	Do		Green Oil tunnel			.9326	20.1		
242	Buckhorn district; Buckhorn Oil and Trans. Co.		Well	15	950	.9685	14.6		
243	Bardsdale Canyon; Union Oil Co.		do	Robinson No. 2		.8881	27.7		
244	Bardsdale Canyon; sec. 12, T. 3 N., R. 20 W.					.8861	28.0		
245	Bardsdale Canyon					.8905	27.2	Deep brown-black.	

237–238. California State Min. Bur. Seventh Ann. Rept., 1887. W. D. Johnston, chemist.
239. U. S. Geol. Survey Mineral Resources, 1896, p. 844, 1897; from California State Min. Bur. Bull. 1'
240–243. California State Min. Bur. Bull. 31. H. N. Cooper, chemist.
244. California State Min. Bur. Bull. 31. Paul W. Prutzman, chemist
245. Pet. Rev., Dec. 27, 1906. Clifford Richardson.

Analyses of petroleum from various parts of the United States—Continued.

Serial No.	Location of well.	Distillation by Engler's method. Begins to distill at (° C.)	By volume. To 150° C. Cubic centimeters.	To 150° C. Specific gravity.	150°–300° C. Cubic centimeters.	150°–300° C. Specific gravity.	Residuum. Cubic centimeters.	Residuum. Specific gravity.	Total. Cubic centimeters.	Sulphur (per cent)	Paraffin (per cent)	Asphalt (per cent)	Water (per cent)	Unsaturated hydrocarbons (per cent). Crude	Unsaturated hydrocarbons (per cent). 150°–300° C.	Remarks.
	CALIFORNIA—continued.															
	Ventura County—Contd.															
237	Adams Canyon	......	16.8	0.7518	42.4	0.8231	40.8	....	100.0	......	......	......	......	......	......	100°–125° C., 7.8 p. ct.; 150°–200° C., 18 p. ct.; 200°–250° C., 14.4 p. ct.
238	Do	......	9.2	.732	26.5	.8424	64.3	....	100.0	......	......	......	......	......	......	150°–200° C., 10.8 p. ct., sp. gr. 0.813; 200°–250° C., 8 p. ct., sp. gr. 0.846.
239	Do	......	5.2	....	24.5	....	70.3	....	100.0	......	......	7.0	......	......	......	Temperature not given. Gas distillate, 17.3 p. ct.; lubricating oil, 46 p. ct. Pyridine base equals 0.88 p. ct.
240	Adams Canyon; Union Oil Co.	......	18.1	.7717	28.5	.8356	53.4	....	100.0	0.48	......	9.8	......	......	......	Gravities at 15° C. 300° C. to asphalt, 43 p. ct. Calorific value per c. c., 9,384. Viscosity by Redwood viscometer 162.5 at 15° C.
241	Do	......	.8	....	41.5	.8461	57.7	....	100.0	.32	......	16.6	......	......	......	Gravities at 15° C. 300° C. to asphalt, 40 p. ct. Calorific value per c. c., 9,889. Viscosity by Redwood viscometer 247 at 15° C.
242	Buckhorn district; Buckhorn Oil and Trans. Co.	......	0	....	27.2	....	72.8	....	100.0	......	......	23.0	......	......	......	Gravities at 15° C. 300° C. to asphalt, 40.4 p. ct. Water, 9.3 p. ct. Viscosity by Redwood viscometer over 1,800 at 15° C.
243	Bardsdale Canyon; Union Oil Co.	......	19.5	.735	31.5	.839	49.0	....	100.0	1.74	......	16.9	......	......	......	Gravities at 15° C. 300° C. to asphalt, 29 p. ct. Calorific value per c. c., 9,310. Viscosity by Redwood viscometer 205 at 15° C.
244	Bardsdale Canyon; sec. 12, T. 3 N., R. 20 W.	......	13.0	.7307	a20.5	.8074	66.5	....	100.0	......	......	25.6	......	......	......	a 150°–270° C.; above 270° C., 40 p. ct.
245	Bardsdale Canyon	......	a22.0	.7406	......	....	......	....	....	......	......	......	......	......	......	Gravities at 20° C. a 62°–154° C. 62°–120° C., 10 p. ct., refractive index 1.414. Under 26 mm. pressure, 48°–116° C., 13 p. ct., sp. gr. 0.7972, refractive index 1.443; 116°–152° C., 12 p. ct., sp. gr. 0.842; 152°–198° C., 11 p. ct., sp. gr. 0.8724; 198°–255° C., 10 p. ct., sp. gr. 0.9035 at 25° C.; 255°–310° C., 6 p. ct., sp. gr. 0.9216 at 45° C.; residue, 25.4 p. ct.

Analyses of petroleum from various parts of the United States—Continued.

Serial No.	Location of well.	Collected by—	Collected from—	Well.	Depth of well (feet).	Physical properties.			
						Gravity at 60°F.		Color.	Odor.
						Specific.	Baumé.		
	CALIFORNIA—continued.								
	Ventura County—Continued.								
246	Sespe district					0.9402	18.9		
247	Four Forks					.9196	22.2		
248	Do					.8687	31.2	Reddish brown	
249	Do					.9091	24.0		
250	Do					.9021	25.2		

246, 247. California State Min. Bur. Bull. 1. Analyst not given.
248. Pet. Rev., Jan. 5, 1907. Clifford Richardson.
249, 250. U. S. Geol. Survey Mineral Resources, 1896, p. 845, 1897. Frederick Salathe, analyst.

Analyses of petroleum from various parts of the United States—Continued.

Serial No.	Location of well.	Distillation by Engler's method.									Sulphur (per cent)	Paraffin (per cent)	Asphalt (per cent)	Water (per cent)	Unsaturated hydrocarbons (per cent).		Remarks.
		Begins to distill at (° C.)	By volume.														
			To 150° C.		150°-300° C.		Residuum.		Total.								
			Cubic centimeters.	Specific gravity.	Cubic centimeters.	Specific gravity.	Cubic centimeters.	Specific gravity.	Cubic centimeters.						Crube	150°-300°C.	
	CALIFORNIA—continued.																
	Ventura County—Contd.																
246	Sespe district	......	......	......	28.21	0.8081	71.79	......	100.0		......	......	......	......	......	......	300°-350° C., 2.95 p. ct. by volume, 2.7 p. ct. by weight, sp. gr. 0.8608; 200° C., 7.27 p. ct. by volume, 6 p. ct. by weight, sp. gr. 0.7649; 250° C., 9.47 p. ct. by volume, 8.07 p. ct. by weight, sp. gr. 0.8012.
247	Four Forks	......	......	......	33.47	.8051	66.53	......	100.0		......	......	......	......	......	......	300°-350° C., 6.63 p. ct. by volume, 6.21 p. ct. by weight, sp. gr. 0.8604; 200° C., 6.94 p. ct. by volume, 5.80 p. ct. by weight, sp. gr. 0.7684; 250° C., 16.84 p. ct. by volume, 14.64 p. ct. by weight, sp. gr. 0.8005.
248	Do	48	20.0	......	......	......	......	......	......		......	......	......	......	......	......	*a* 48°-148° C.; 48°-115° C., 10 p. ct., sp. gr. 0.7483, refractive index 1.418; 115°-148° C., 10 p. ct., sp. gr. 0.7066, refractive index 1.412. Under 26 mm. pressure, 56°-96° C., 10 p. ct., sp. gr. 0.7855, refractive index 1.437; 96°-138° C., 10 p. ct., sp. gr. 0.820, refractive index 1.454; 138°-173° C., 10 p. ct., sp. gr. 0.847, refractive index 1.469; 173°-219° C., 10 p. ct., sp. gr. 0.837, refractive index 1.484; 219°-265° C., 10 p. ct., sp. gr. 0.9026, refractive index 1.502; 265°-284° C., 10 p. ct., sp. gr. 0.9214, refractive index 1.513. Residue 21.2 p. ct.
249	Do	......	6.0	......	17.1	......	76.9	......	100.0		......	......	......	......	......	......	Gas distillates, 29.5 p. ct., lubricating, 34.4 p. ct., asphalt and loss, 13 p. ct. Pyridine base equals 1.75 p. ct.
250	Do	......	7.3	0.7368	*a*19.5	.8140	73.2	......	100.0		......	......	12.4	......	......	......	*a* At 330° C., gas distillates 25 p. ct., sp. gr. 0.8861; lubricating oil, 35.8 p. ct., sp. gr. 0.9091. Pyridine base equals 2.3 p. ct.

Analyses of petroleum from various parts of the United States—Continued.

Serial No.	Location of well.	Collected by—	Collected from—	Well.	Depth of well (feet).	Physical properties.			
						Gravity at 60°F.		Color.	Odor.
						Specific.	Baumé.		
	CALIFORNIA—continued.								
	Ventura County—Continued.								
	Sespe district—Continued.								
251	Four Forks		Well	Sespe No. 2		0.8590	33.0		
252	Do		Tar Creek			.8330	38.1		
253	Do		do			.9125	23.4		
254	Do		do			.9129	23.3		
255	Do					.9196	22.2		
256	Do			Kentuck		.9015	25.3		
257	Four Forks; California Oil Co		Well			.9402	18.9		
258	Four Forks; Union Oil Co		do	7	1,175	.8701	30.9		
259	Piru district; Modelo Oil Co			22	1,100	.8838	28.4		
260	Piru district; sec. 8, T. 4 N., R. 18 W		Tank			.8940	26.6		
261	One-half m. west of Santa Paula; Scott & Gilmore					.9302	20.5		
262	Do					.9486	17.6		
263	Limekiln Canyon; Eureka Oil Co					.8805	29.0		

251, 252. California State Min. Bur. Seventh Ann. Rept., 1887. W. D. Johnston, chemist.
253–257. California State Min. Bur. Bull. 11. Laboratory analyses.
258–259. California State Min. Bur. Bull. 31. H. N. Cooper, chemist.
261–262. California State Min. Bur. Bull. 11. Laboratory analyses.
263. U. S. Geol. Survey Mineral Resources, 1896, p. 844, 1897. Frederick Salathe, analyst.

Analyses of petroleum from various parts of the United States—Continued.

Serial No.	Location of well.	Distillation by Engler's method: Begins to distill at (° C.)	By volume: To 150° C.: Cubic centimeters.	To 150° C.: Specific gravity.	150°–300° C.: Cubic centimeters.	150°–300° C.: Specific gravity.	Residuum: Cubic centimeters.	Residuum: Specific gravity.	Total: Cubic centimeters.	Sulphur (per cent)	Paraffin (per cent)	Asphalt (per cent)	Water (per cent)	Unsaturated hydrocarbons (per cent): Crude	Unsaturated hydrocarbons (per cent): 150°–300° C.	Remarks.
	CALIFORNIA—Continued.															
	Ventura County—Contd. Sespe district—Contd.															
251	Four Forks	......	27.1	0.7317	28.8	0.8271	44.1	......	100.0	......	......	......	......	......	......	Below 100° C., 9.1 p. ct., sp. gr. 0.700; 100°–125° C., 9.2 p. ct., sp. gr. 0.734; 150°–200° C., 11.8 p. ct., sp. gr. 0.798; 200°–250° C., 9. p. ct., sp. gr. 0.822.
252	Do	......	22.3	.7447	27.8	.8480	49.9	......	100.0	......	......	......	......	......	......	Below 100° C., 10 p. ct., sp. gr. 0.720; 100°–150° C., 6.8 p. ct., sp. gr. 0.755; 150°–200° C. 9.7 p. ct., sp. gr. 0.809; 200°–250° C., 11 p. ct., sp. gr. 0.856.
253	Do	......	7.6	.735	33.8	.8118	58.6	......	100.0	......	......	......	......	......	......	300°–350° C., 6 p. ct., sp. gr. 0.8834.
254	Do	......	8.4	.7240	32.6	.8117	59.0	......	100.0	......	......	......	......	......	......	300°–350° C., 4 p. ct.
255	Do	......	Tr.	......	33.4	.8044	66.6	......	100.0	......	......	......	......	......	......	300°–350° C., 6.6 p. ct., sp. gr. 0.8604.
256	Do	......	6.0	.7200	30.8	.8082	63.2	......	100.0	......	......	......	......	......	......	300°–350° C., 2.5 p. ct., sp. gr. 0.8662.
257	Four Forks; California Oil Co.	......	Tr.	......	28.1	.8112	71.9	......	100.0	......	......	......	......	......	......	300°–350° C., 2.9 p. ct., sp. gr. 0.8608.
258	Four Forks; Union Oil Co.	......	19.5	.7353	30.0	.8299	50.5	......	100.0	......	......	13.2	......	......	......	300° C. to asphalt, 34.9 p. ct., sp. gr. 0.8769. Viscosity by Redwood viscometer 77 at 15° C.
259	Piru district; Modelo Oil Co.	......	23.3	.7523	35.5	.8514	41.2	......	100.0	......	......	16.6	......	......	......	300° C. to asphalt, 24.2 p. ct., sp. gr. 0.8911. Viscosity by Redwood viscometer 63 at 15° C.
260	Piru district; sec. 8, T. 4 N., R. 18 W.	......	13.8	.7392	*a*32.4	.8197	53.8	......	100.0	......	......	12.9	......	......	......	*a* 150°–270° C.; above 270° C., 38.9 p. ct.
261	One-half m. west of Santa Paula; Scott & Gilmore.	......	Tr.	......	28.0	.8272	72.0	......	100.0	......	......	......	......	......	......	300°–350° C., 3.2 p. ct.
262	Do	......	Tr.	......	6.0	.8465	94.0	......	100.0	......	......	......	......	......	......	300°–350° C., 7.6 p. ct.
263	Limekiln Canyon; Eureka Oil Co.	......	14.1	......	26.4	......	59.5	......	100.0	......	......	......	......	......	......	Gas distillate, 24 p. ct.; lubricating distillate, 27 p. ct.; asphalt and loss, 8.5 p. ct. Pyridine base equals 1.44 p. ct.

Analyses of petroleum from various parts of the United States—Continued.

Serial No.	Location of well.	Collected by—	Collected from—	Well.	Depth of well (feet).	Physical properties.			
						Gravity at 60° F.		Color.	Odor.
						Specific.	Baumé.		
	CALIFORNIA—continued.								
	Ventura County—Continued.								
264	Whider Canyon, 12 miles northwest of Santa Paula; Burrows & Sons.		Well	6	958	0.8767	29.7		
265	Do		Garrett tunnel		1,000	.8828	28.6		
266	Ojai district; Whidden Double		Well	4	284	.9759	13.5		
267	Salt Marsh Canyon (near Santa Paula); Union Oil Co.		do	11		.9351	19.7		
268	Timber Canyon (near Santa Paula); Los Angeles Pacific Ry. Co.		do	3		.8481	35.1		
269	Santa Paula district; Los Angeles Pacific Ry. Co.		do	Capital crude 20	1,000	.8900	27.3		
270	Santa Paula district; sec. 11, T. 4 N., R. 22 W.		Tank			.9873	11.8		
271	Santa Paula district		Well			.9021	25.2	Green	
272	Do		Pipe line			.8997	25.6		
273	Do		Well			.8974	26.0		
274	Do		do			.8929	26.8		

264, 266, 267. California State Min. Bur. Bull. 31. H. N. Cooper, chemist.
268. California State Min. Bur. Bull. 31. Paul W. Prutzman.
269. California State Min. Bur. Bull. 31. H. N. Cooper, chemist.
270–275. California State Min. Bur. Bull. 31. Paul W. Prutzman.

Analyses of petroleum from various parts of the United States—Continued.

Serial No.	Location of well.	Distillation by Engler's method. Begins to distill at (° C.)	By volume. To 150° C. Cubic centimeters.	To 150° C. Specific gravity.	150°–300° C. Cubic centimeters.	150°–300° C. Specific gravity.	Residuum. Cubic centimeters.	Residuum. Specific gravity.	Total. Cubic centimeters.	Sulphur (per cent)	Paraffin (per cent)	Asphalt (per cent)	Water (per cent)	Unsaturated hydrocarbons (per cent). Crude	Unsaturated hydrocarbons (per cent). 150°–300° C.	Remarks.
	CALIFORNIA—continued.															
	Ventura County—Contd.															
264	Whider Canyon, 12 miles northwest of Santa Paula; Burrows & Sons.	......	26.6	0.7305	27.4	0.8431	46.0	....	100.0	0.72	......	14.8	......	......	......	Gravities at 15° C. 300° C. to asphalt, 30 p. ct., sp. gr. 0.892. Calorific value per c. c., 9,332. Viscosity by Redwood viscometer 77 at 15° C.
265	Do	......	12.3	.7798	44.6	.8437	43.1	....	100.0	......	......	6.2	......	......	......	Gravities at 15° C. 300° C. to asphalt, 37.3 p. ct., sp. gr. 0.9014. Viscosity by Redwood viscometer 53 at 15° C.
266	Ojai district; Whidden Double.	......	0	....	31.0	.8620	69.0	....	100.0	1.48	......	38.1	......	......	......	Gravities at 15° C. 300° C. to asphalt, 30.8 p. ct. sp. gr. 0.8925. Calorific value per c. c. 8,892. Viscosity by Redwood viscometer over 1,800 at 15° C.
267	Salt Marsh Canyon (near Santa Paula); Union Oil Co.	......	10.1	.7571	25.9	.8558	64.0	....	100.0	......	......	20.7	......	......	......	Gravities at 15° C. 300° C. to asphalt, 40.1 p. ct., sp. gr. 0.9156. Viscosity by Redwood viscometer 878 at 15° C.
268	Timber Canyon (near Santa Paula); Los Angeles Pacific Rwy. Co.	......	30.3	.7318	29.3	.8324	40.4	....	100.0	......	......	10.6	......	......	......	All gravities at 15° C. 300° C. to asphalt 28 p. ct., sp. gr. 0.8875. Viscosity by Redwood viscometer 45.8 at 15.5° C.
269	Santa Paula district; Los Angeles Pacific Rwy. Co.	......	25.8	.7545	28.6	.8535	4.46	....	100.0	......	......	13.0	......	......	......	Gravities at 15° C. 300° C. to asphalt 31.8 p. ct., sp. gr. 0.9154. Viscosity by Redwood viscometer 61.6 at 15° C.
270	Santa Paula district; sec. 11, T. 4 N., R. 22 W.	......	0	....	0	(*a*)	100.0	....	100.0	......	......	41.7	......	......	......	*a* 150°–270° C.; above 270° C. 56 p. ct., sp. gr. 0.905.
271	Santa Paula district	......	12.5	.7621	*a*25.5	.8353	62.0	....	100.0	......	......	11.8	......	......	......	*a* 150°–270° C.; above 270° C. 50.2 p. ct., sp. gr. 0.915.
272	Do	......	10.0	.7427	*a*24.0	.8163	66.0	....	100.0	......	......	25.3	......	......	......	*a* 150°–270° C.; above 270° C. 38 p. ct., sp. gr. 0.8767.
273	Do	......	10.0	.7527	*a*27.0	.8294	63.0	....	100.0	......	......	16.0	......	......	......	*a* 150°–270° C.; above 270° C. 44 p. ct., sp. gr. not given.
274	Do	......	13.0	.7609	*a*26.5	.8284	60.5	....	100.0	......	......	11.0	......	......	......	*a* 150°–270° C.; above 270° C. 45.9 p. ct.

Analyses of petroleum from various parts of the United States—Continued.

Serial No.	Location of well.	Collected by—	Collected from—	Well.	Depth of well (feet).	Physical properties. Gravity at 60°F. Specific.	Baumé.	Color.	Odor.
	CALIFORNIA—continued.								
	Ventura County—Continued.								
275	Santa Paula district; sec. 17, T. 4 N., R. 21 W.		Tank			0.8895	27.4		
276	Sulphur Mountain district; Wheeler Canyon		Tunnel						
277	Sulphur Mountain district; Sulphur Mountain Petroleum Co.		Well	1	2,150	.9486	17.6		
278	Sulphur Mountain district		Pinkerton tunnel			.9333	20.0	Green	
279	Do		do			.9398	19.0		
280	Do		do			.9333	20.0	Green	
281	Do		Magie tunnel			.9773	13.3		
282	West of Santa Paula		Well	O'Hara		.9435	18.4		
283	Do		do			.9769	13.3		
284	Silverthread district					.9366	19.5		
285	Do					.9255	21.3		
286	Do					.9369	19.4		
287	Do					.9442	18.3		
288	Do					.9590	16.0		
289	Torrey Canyon district; Union Oil Co.		Well	52	1,410	.8758	29.9		

276. Am. Jour. Sci., 3 ser., vol. 48, p. 252. S. F. Peckham.
277. California State Min. Bur. Bull. 31. H. N. Cooper, chemist.
278–288. California State Min. Bur. Bull. 11. Analyst not given.
289. California State Min. Bur. Bull. 31. H. N. Cooper, chemist.

Analyses of petroleum from various parts of the United States—Continued.

Serial No.	Location of well.	Distillation by Engler's method. Begins to distill at (° C.)	By volume. To 150° C. Cubic centimeters.	To 150° C. Specific gravity.	150°–300° C. Cubic centimeters.	150°–300° C. Specific gravity.	Residuum. Cubic centimeters.	Residuum. Specific gravity.	Total. Cubic centimeters.	Sulphur (per cent)	Paraffin (per cent)	Asphalt (per cent)	Water (per cent)	Unsaturated hydrocarbons (per cent). Crude	Unsaturated hydrocarbons (per cent). 150°–300° C.	Remarks.
	CALIFORNIA—continued.															
	Ventura County—Contd.															
275	Santa Paula district; sec. 17, T. 4 N., R. 21 W.	...	19.4	0.7400	*a*26.1	0.8230	54.5	...	100.0	...	...	18.8	...	...	...	*a* 150°–270° C.; above 270° C. 35.2 p. ct.
276	Sulphur Mountain district; Wheeler Canyon.	...	...	...	...	...	...	...	...	...	...	...	...	...	...	Average composition, hydrogen, 11.819 p. ct.; carbon, 86.934 p. ct.; nitrogen, 1.1095 p. ct.
277	Sulphur Mountain district; Sulphur Mountain Petroleum Co.	...	7.9	.7576	44.3	.8702	47.8	...	100.0	...	...	25.0	...	...	...	Gravities at 15° C. 300° C. to asphalt 20 p. ct., sp. gr. 0.9302. Viscosity by Redwood viscometer 2,240 at 15° C.
278	Sulphur Mountain district.	...	...	...	27.6	.8242	72.4	...	100.0	...	...	...	...	...	...	300°–350° C., 5 p. ct., sp. gr. 0.862.
279	Do	...	Tr.	...	26.8	.8351	74.2	...	101.0	...	...	...	...	...	...	300°–350° C., 5 p. ct., sp. gr. 0.8701.
280	Do	...	Tr.	...	27.6	.8242	73.4	...	101.0	...	...	...	...	...	...	300°–350° C., 5 p. ct., sp. gr. 0.8620.
281	Do	...	Tr.	...	Tr.	...	100.0	...	100.0	...	...	...	...	...	...	300°–350° C., 16 p. ct., sp. gr. 0.8701.
282	West of Santa Paula	...	Tr.	...	26.4	.8252	73.6	...	100.0	...	...	...	...	...	...	300°–350° C., 6 p. ct., sp. gr. 0.8738.
283	Do	...	Tr.	...	13.0	.8530	87.0	...	100.0	...	...	...	...	...	...	300°–350° C., 3 p. ct.
284	Silverthread district	...	5.0	.7560	23.2	.8006	71.8	...	100.0	...	...	...	...	...	...	300°–350° C., 5.8 p. ct., sp. gr. 0.8764.
285	Do	...	7.0	.7428	28.2	.8007	64.8	...	100.0	...	...	...	...	...	...	300°–350° C., 6.4 p. ct., sp. gr. 0.8612.
286	Do	...	Tr.	...	34.2	.8157	65.8	...	100.0	...	...	...	...	...	...	300°–350° C., 7.6 p. ct., sp. gr. 0.8791.
287	Do	...	Tr.	...	27.6	.8117	72.4	...	100.0	...	...	...	...	...	...	300°–350° C., 4 p. ct., sp. gr. 0.8790.
288	Do	...	Tr.	...	5.0	.8500	95.0	...	100.0	...	...	...	...	...	...	300°–350° C., 7 p. ct., sp. gr. 0.8780.
289	Torrey Canyon district; Union Oil Co.	...	18.7	.7394	28.1	.8312	53.2	...	100.0	0.71	...	16.6	...	...	...	300° C. to asphalt, 33.7 p. ct., sp. gr. 0.8720. Calorific value per c. c., 9,293. Viscosity by Redwood viscometer 103 at 15° C.

Analyses of petroleum from various parts of the United States—Continued.

Serial No.	Location of well	Collected by—	Collected from—	Well.	Depth of well (feet).	Physical properties. Gravity at 60°F. Specific.	Baumé.	Color.	Odor.
	CALIFORNIA—continued.								
	Ventura County—Continued.								
290	Torrey Canyon district					0.8650	31.9	Dark reddish brown.	
291	Do					.8917	27.0		
292	Do		Tank			.9174	22.6		
293	Do		Well			.9097	23.9		
294	Do		do			.8855	28.1		
	COLORADO.								
295	Boulder County					.8304	38.6		
296	Fremont County, Florence					.8696	31.0	Dark green	
297	Do		Well		2,455	.8750	30.0		

290. Pet. Rev., Dec. 27, 1906. Clifford Richardson.
291. U. S. Geol. Survey Mineral Resources, 1896, p. 844, 1897; from California State Min. Bur. Bull. 11. Frederick Salathe, chemist.
292–294. California State Min. Bur. Bull. 31. Paul W. Prutzman.
295. U. S. Geol. Survey Mineral Resources, 1901, p. 560, 1902. R. G. Hoffman, F. Salathe.
296. Pet. Rev., Nov. 24, 1896. Clifford Richardson.

Analyses of petroleum from various parts of the United States—Continued.

Serial No.	Location of well.	Distillation by Engler's method. Begins to distill at (°C.)	By volume. To 150° C. Cubic centimeters.	To 150° C. Specific gravity.	150°–300° C. Cubic centimeters.	150°–300° C. Specific gravity.	Residuum. Cubic centimeters.	Residuum. Specific gravity.	Total. Cubic centimeters.	Sulphur (per cent).	Paraffin (per cent).	Asphalt (per cent).	Water (per cent).	Unsaturated hydrocarbons (per cent). Crude	Unsaturated hydrocarbons (per cent). 150°–300° C.	Remarks.
	CALIFORNIA—continued.															
	Ventura County—Continued.															
290	Torrey Canyon district..	47	18.4	0.7418												*a* 47°–116° C., 6 p. ct., sp. gr. 0.7200, refractive index 1,412; 116°–145° C., 12.4 p. ct., sp. gr. 0.7523, refractive index 1.428. Under 26 mm. pressure 36°–94° C., 12.7 p. ct., sp. gr. 0.7912, refractive index 1.440; 94°–132° C., 14 p. ct., sp. gr. 0.8255, refractive index 1.458; 132°–195° C., 17.6 p. ct., sp. gr. .8520, refractive index 1.475; 195°–242° C., 15 p. ct., sp. gr. 0.8808, refractive index 1.491; 242°–280° C., 15 p. ct., sp. gr. 0.8981 (at 40° C.), refractive index 1.504; 280°–310° C., 6.2 p. ct. (solid hydrocarbon), sp. gr. 0.9156, refractive index 1.523.
291	Do		9.2		21.5		69.3		100.0							No temperature given. Gas distillate, 26 p. ct.; lubricating distillate, 30.3 p. ct.; asphalt and loss, 13 p. ct. Pyridine bases equal 1.52 p. ct.
292	Do		0		*a*30.0	0.8294	70.0		100.0			15.4				*a* 150°–270° C.; above 270° C., 53.2 p. ct.
293	Do		7.2	.7609	*a*26.7	.8333	66.1		100.0			25.5				*a* 150°–270° C.; above 270° C., 38.9 p. ct.
294	Do		16.6	.7621	*a*23.6	.8245	59.8		100.0			21.1				*a* 150°–270° C.; above 270° C., 35.7 p. ct.
	COLORADO.															
295	Boulder County		16.0	.7368	40.0	.8000	44.0		100.0							Burning oil, 150° F. fire test.
296	Fremont County, Florence..				35–40						10.4			19.0		Fixed carbon, 1.6; character of residuum, soft; loss, 200° C. (7 hours), 2.4 p. ct.
297	Do	122	1.5		27.0	.7988	70.2	0.9079	98.7		9.23					

Analyses of petroleum from various parts of the United States—Continued.

Serial No.	Location of well.	Collected by—	Collected from—	Well.	Depth of well (feet).	Physical properties. Gravity at 60°F. Specific.	Baumé.	Color.	Odor.
	COLORADO—continued.								
	Mesa County.								
298	De Beque	D. T. Day	Well		150	0.8345	37.75	Yellow	Aromatic.
299	Three-fourths mile northwest of De Beque	E. B. Woodruff	do	1		.8997	25.6	Greenish brown	Do.
	Rio Blanco County.								
300	Rangely, sec. 21, T. 2 N., R. 102 W	H. S. Gale	do	1		.8092	43.0	Red	Like Pa. oil.
	ILLINOIS.								
	Clark County.								
	Johnson Township:								
301	Weaver lease, sec. 23					.8872	27.8	Olive green	
302	W. D. Misner lease; Pure Oil Co	J. P. Dunlop	Well	6	606	.8631	32.2	Light green	
303	M. Misner lease; Pure Oil Co	do	do	7	610	.8660	31.7	Dark green	
304	Z. E. Brant farm, sec. 26; Ohio Oil Co	do	do	2	480	.8680	31.3	Light green	
305	Do	do	do	5	474	.8700	30.9	Medium green	
306	Ohio Oil Co., Martinsville	do	Pipe line			.8780	29.5	Light green	
307	Northern part; Ohio Oil Co., Martinsville	do	do			.8761	29.8	Medium green	
	Parker Township:								
308	Briscoe lease, sec. 29					.8730	30.4	Olive green	

301, 308. Illinois State Geol. Survey Bull. 2. F. F. Grout, analyst.

Analyses of petroleum from various parts of the United States—Continued.

Serial No.	Location of well.	Distillation by Engler's method. Begins to distill at (° C.)	By volume. To 150° C. Cubic centimeters.	To 150° C. Specific gravity.	150°–300° C. Cubic centimeters.	150°–300° C. Specific gravity.	Residuum. Cubic centimeters.	Residuum. Specific gravity.	Total. Cubic centimeters.	Sulphur (per cent)	Paraffin (per cent)	Asphalt (per cent)	Water (per cent)	Unsaturated hydrocarbons (per cent). Crude	Unsaturated hydrocarbons (per cent). 150°–300°C.	Remarks.
	COLORADO—continued.															
	Mesa County.															
298	Debeque	145	1.0	....	42.0	0.7188	56.5	0.8427	93.5	......	19.65	......	......	12.4	4.0	
299	Three-fourths mile northwest of Debeque.	225	......	....	27.0	.7471	70.9	.8511	97.9	......	27.23	......	......	......	......	
	Rio Blanco County.															
300	Rangely, sec. 21, T. 2 N., R. 102 W.	48	28.0	0.680	42.0	.751	30.0	....	100.0	......	......	......	......	......	......	
	ILLINOIS.															
	Clark County.															
	Johnson Township:															
301	Weaver lease, sec 23	88	4.4	.7450	33.2	.8120	62.4	....	100.0	0.13	......	......	......	......	......	Sp. gr. of lubricating oil, 0.863; coke and loss, 12.4 p. ct.
302	W. D. Misner lease; Pure Oil Co.	75	11.5	.7318	35.0	.8174	53.5	....	100.0	......	......	......	......	......	......	Lower sand oil.
303	M. Misner lease; Pure Oil Co.	75	8.0	.7193	32.0	.8065	60.0	....	100.0	.30	......	......	......	......	......	Do.
304	Z. E. Brant farm, sec. 26; Ohio Oil Co.	75	10.5	.7261	30.5	.8141	59.0	....	100.0	.27	......	......	......	......	......	Upper sand oil.
305	Do	75	10.0	.7275	33.0	.8186	57.0	....	100.0	.24	......	......	......	......	......	Do.
306	Ohio Oil Co., Martinsville.	70	10.0	.7326	33.0	.8183	57.0	....	100.0	.23	......	......	......	......	......	
307	Northern part; Ohio Oil Co., Martinsville.	80	11.0	.7371	29.5	.8147	59.5	....	100.0	.26	......	......	......	......	......	
	Parker Township:															
308	Briscoe lease, sec. 29	......	8.6	.741	34.8	.8138	56.6	....	100.0	.73	......	......	......	......	......	Sp. gr. of lubricating oil, 0.853; coke and loss, 8.6 p. ct.

Analyses of petroleum from various parts of the United States—Continued.

Serial No.	Location of well.	Collected by—	Collected from—	Well.	Depth of well (feet).	Physical properties.			
						Gravity at 60°F.		Color.	Odor.
						Specific.	Baumé.		
	ILLINOIS—continued.								
	Clark County—Continued.								
	Parker Township—Continued.								
	Oil-field pool—								
309	S. Spellbring farm, sec. 7; Ohio Oil Co.	J. P. Dunlop	Well	7	330	0.8460	35.5	Light green	Hydrogen sulphide.
310	M. K. Young farm, sec. 18; Ohio Oil Co.	do	do	27	330	.8460	35.5	do	Do.
311	G. H. Jeffries farm, sec. 20; Ohio Oil Co.	do	do	21	325	.8530	34.1	do	Do.
	Parker Township pool—								
312	J. Turner lease, sec. 33; Ohio Oil Co.	do	do	2, 4, 5, 6, 7, 10	300	.8790	29.3	Medium green	Do.
313	Do	do	do	12	300	.8790	29.3	Brown	Do.
314	Kelly farm, sec. 33; Treat & Crawford	do	do	1, 2, 3, 4	300	.8650	31.9	Light green	Do.
315	N. J. Linn farm; Mars Oil & Gas Co.	do	do	1-9	280-320	.8568	33.4	do	Do.
	Casey Township:								
316	Ohio Oil Co., Casey	Ohio Oil Co.	do	79	2,450	.8299	38.7	Dark green	Sulphur.
	Crawford County.								
	Oblong Township:								
317	Birch lease					.870	30.9	Olive green	

317. Illinois State Geol. Survey Bull. 2. F. F. Grout, analyst.

Analyses of petroleum from various parts of the United States—Continued.

Serial No.	Location of well.	Distillation by Engler's method. Begins to distill at (° C.)	By volume. To 150° C. Cubic centimeters.	To 150° C. Specific gravity.	150°–300° C. Cubic centimeters.	150°–300° C. Specific gravity.	Residuum. Cubic centimeters.	Residuum. Specific gravity.	Total. Cubic centimeters.	Sulphur (per cent)	Paraffin (per cent)	Asphalt (per cent)	Water (per cent)	Unsaturated hydrocarbons (per cent). Crude	Unsaturated hydrocarbons (per cent). 150°–300°C.	Remarks.
	ILLINOIS—continued.															
	Clark County—Continued.															
	Parker Township—Contd. Oil-field pool—															
309	S. Spellbring farm, sec. 7; Ohio Oil Co.	63	14.0	0.7745	31.0	0.8145	55.0	....	100.0	0.48	......	......	......	......	......	
310	M. K. Young farm, sec. 18; Ohio Oil Co.	55	10.5	.7357	34.0	.8184	55.5	....	100.0	.35	......	......	......	......	......	
311	G. H. Jeffries farm; sec. 20; Ohio Oil Co.	55	15.5	.7323	30.5	.8173	54.0	....	100.0	.47	......	......	......	......	......	
	Parker Township pool—															
312	J. Turner lease, sec. 33; Ohio Oil Co.	65	8.5	.7557	25.0	.8278	66.5	....	100.0	.30	......	......	......	......	......	
313	Do...............	65	8.0	.7008	27.0	.8268	65.0	....	100.0	.37	......	......	......	......	......	
314	Kelly farm, sec. 33; Treat & Crawford.	75	11.5	.7433	30.5	.8193	58.0	....	100.0	.48	......	......	......	......	......	
315	N. J. Linn farm; Mars Oil & Gas Co.	65	14.0	.7473	25.0	.8216	61.0	....	100.0	.38	......	......	......	......	......	
	Casey Township:															
316	Ohio Oil Co., Casey......	85	8.0	.7222	33.0	.7833	56.1	0.8861	97.1	......	......	......	......	......	......	
	Crawford County.															
	Oblong Township:															
317	Birch lease..............	60	3.5	.749	36.8	.8060	59.7	....	100.0	.10	......	......	......	......	......	Sp. gr. of lubricating oil, 0.849; coke and loss, 9.5 p. ct.

Analyses of petroleum from various parts of the United States—Continued.

Serial No.	Location of well.	Collected by—	Collected from—	Well.	Depth of well (feet).	Physical properties.			
						Gravity at 60° F.		Color.	Odor.
						Specific.	Baumé.		
	ILLINOIS—continued.								
	Crawford County—Continued.								
	Robinson pool:								
318	Mitchell Oil Co	J. P. Dunlop	Well	1, 2, 3	950	0.8460	35.5	Medium green	
319	Graswald lease; G. E. Thomas	do	do	1	970	.8542	33.9	Light green	
320	Miller lease; Fisher Oil Co	do	do	2	945	.8712	30.7	do	
321	Quick lease; John Markham	do	do	7	960	.8380	37.0	Dark green	
322	E. E. Newlin farm, 2½ miles west of Robinson		do	6		.8375	37.1	Brown	
	Montgomery Township:								
	Duncansville pool—								
323	J. W. Creswell	J. P. Dunlop	do	1	970	.9150	23.0	do	
324	Higgins lease; M. Bernstein Co	do	do	1	965	.9192	22.3	do	
325	Martinsville, Ohio Oil Co	do	Pipe-line			.8552	33.7	Light green	
326	W.C. Jones, Robinson, NW. cor. NW. ¼ sec. 28, T. 7, R. 2.	W. C. Jones	Well	1	1,140	.8490	34.9	Dark green	
	Cumberland County.								
	Union Township:								
327	Queen farm, sec. 13; Campbell, McElroy & Bell	J. P. Dunlop	Pipe-line	5, 8, 9, 10, 11, 13, 21	400	.8390	36.9	Light green	
328	Do	do	Well	1, 2, 3, 4, 17, 18, 19.	400	.8410	36.5	do	

Analyses of petroleum from various parts of the United States—Continued.

Serial No.	Location of well.	Begins to distill at (° C.)	To 150° C. Cubic centimeters.	To 150° C. Specific gravity.	150°–300° C. Cubic centimeters.	150°–300° C. Specific gravity.	Residuum. Cubic centimeters.	Residuum. Specific gravity.	Total. Cubic centimeters.	Sulphur (per cent)	Paraffin (per cent)	Asphalt (per cent)	Water (per cent)	Unsaturated hydrocarbons (per cent). Crude	Unsaturated hydrocarbons (per cent). 150°–300°C.	Remarks.
	ILLINOIS—continued.															
	Crawford County—Continued.															
	Robinson pool:															
318	Mitchell Oil Co.	80	8.0	0.7183	39.0	0.7941	53.0	....	100.0	0.16	......	......	......	......	......	
319	Graswald lease; G. E. Thomas.	60	16.0	.733	34.0	.8135	50.0	....	100.0	.17	......	......	......	......	......	
320	Miller lease; Fisher Oil Co.	80	11.5	.7531	32.0	.8266	56.5	....	100.0	.19	......	......	......	......	......	
321	Quick lease; John Markham.	51	20.0	.7705	32.0	.8107	48.0	....	100.0	.15	......	......	......	......	......	
322	E. E. Newlin farm, 2½ miles west of Robinson.	69	13.0	.728	33.0	.7954	52.1	0.9132	98.1	......	2.57	.74	(a)	......	......	a Present
	Montgomery Township:															
	Duncansville pool—															
323	J. W. Creswell	80	1.0	....	24.5	.8391	74.5	....	100.0	.39	......	......	......	......	......	
324	Higgins lease; M. Bernstein Co.	75	4.0	....	20.0	.8507	76.0	....	100.0	.39	......	......	......	......	......	
325	Martinsville, Ohio, Oil Co.	75	15.0	.7338	37.0	.8103	48.0	....	100.0	.17	......	......	......	......	......	
326	W. C. Jones, Robinson, NW. cor. NW. ¼ sec. 28, T. 7, R. 2.	95	13.0	.7386	37.0	.8028	50.0	.9235	100.0	......	3.71	1.56	......	......	......	
	Cumberland County.															
	Union Township:															
327	Queen farm, sec. 13; Campbell, McElroy & Beli.	60	18.0	.7211	38.0	.8146	44.0	....	100.0	.20	......	......	......	......	......	Oil from first sand.
328	Do.	60	18.0	.7201	30.0	.8071	52.0	....	100.0	.24	......	......	......	......	......	Do.

Analyses of petroleum from various parts of the United States—Continued.

Serial No.	Location of well.	Collected by—	Collected from—	Well.	Depth of well (feet).	Physical properties.			
						Gravity at 60°F.		Color.	Odor.
						Specific.	Baumé.		
	ILLINOIS—continued.								
	Cumberland County—Continued.								
	Union Township—Continued.								
329	Underwood lease, sec. 13, Ohio Oil Co	J. P. Dunlop	Well	17	577	0.8780	29.5	Light green	
330	Siggins pool, Ohio Oil Co., Martinsville	do	Pipe line			.8690	31.1	Medium green	
	Lawrence County.								
	Petty Township:								
	Bridgeport pool—								
331	W. E. Neil lease; Braden Oil Co.	J. P. Dunlop	Well	3	1,435	.8330	38.1	Light green	
332	Eshelman lease; Bridgeport Oil Co	do	do	2	900	.8542	33.9	Dark green	
333	Do	do	do	4	900	.8642	32.0	do	
334	Thorn lease; Ohio Oil Co	do	do	2, 12	1,300	.8552	33.7	Medium green	
335	Do	do	do	13, 14, 17	1,300	.8552	33.7	do	
336	Do	do	do	8, 10	1,300	.8563	33.5	Light green	
337	Macpherson lease (100 acres); Kirkwood Oil Co.	do	do	1	1,500	.8280	39.1	Dark green	
338	Macpherson lease (20 acres); Kirkwood Oil Co.	do	do	1	1,500	.8260	39.5	Medium green	
339	Snowden Bros. & Co., Bridgeport					.8309	38.5		

Analyses of petroleum from various parts of the United States—Continued.

Serial No.	Location of well.	Distillation by Engler's method. Begins to distill at (°C.)	By volume. To 150° C. Cubic centimeters.	To 150° C. Specific gravity.	150°–300° C. Cubic centimeters.	150°–300° C. Specific gravity.	Residuum. Cubic centimeters.	Residuum. Specific gravity.	Total. Cubic centimeters.	Sulphur (per cent)	Paraffin (per cent)	Asphalt (per cent)	Water (per cent)	Unsaturated hydrocarbons (per cent). Crude	Unsaturated hydrocarbons (per cent). 150°–300°C.	Remarks.
	ILLINOIS—continued.															
	Cumberland County—Contd.															
	Union Township—Contd.															
329	Underwood lease, sec. 13, Ohio Oil Co.	80	10.1	0.719	34.0	0.8215	55.9	......	100.0	0.33	......	......	......	......	......	Lower sand oil contains 8 p. ct. water.
330	Siggins pool, Ohio Oil Co., Martinsville.	80	13.0	.7268	33.0	.7983	54.0	......	100.0	.19	......	......	......	......	......	
	Lawrence County.															
	Petty Township:															
	Bridgeport pool—															
331	W. E. Neil lease; Braden Oil Co.	......	21.0	.7106	33.0	.811	46.0	......	100.0	.17	......	5.04	......	......	......	Lower Bridgeport sand.
332	Eshelman lease; Bridgeport Oil Co.	47	15.0	.7175	32.0	.8211	53.0	......	100.0	.24	......	......	......	......	......	Upper sand.
333	Do.	70	14.5	.7197	31.0	.8218	54.5	......	100.0	......	......	......	......	......	......	Do.
334	Thorn lease; Ohio Co.	75	16.5	.7193	31.0	.794	52.5	......	100.0	......	......	......	......	......	......	Buchanan sand.
335	Do.	68	16.5	.7265	41.0	.8193	42.5	......	100.0	.20	......	......	......	......	......	Do.
336	Do.	75	14.0	.7248	32.0	.8188	54.0	......	100.0	.21	......	......	......	......	......	Do.
337	Macpherson lease (100 acres); Kirkwood Oil Co.	45	21.0	.7313	25.0	.8103	54.0	......	100.0	.13	......	......	......	......	......	
338	Macpherson lease (20 acres); Kirkwood Oil Co.	40	23.0	.7113	31.5	.8101	45.5	......	100.0	.17	......	......	......	......	......	
339	Snowden Bros. & Co., Bridgeport.	......	16.8	......	31.2	......	52.0	......	100.0	......	......	......	......	......	......	From statistical report to U. S. Geological Survey in 1907.

Analyses of petroleum from various parts of the United States—Continued.

Serial No.	Location of well.	Collected by—	Collected from—	Well.	Depth of well (feet).	Physical properties. Gravity at 60° F. Specific.	Baumé.	Color.	Odor.
	ILLINOIS—continued.								
	Lawrence County—Continued.								
	Petty Township—Continued.								
340	Geo. Cooper farm, Indian Refining Co., Lawrenceville.	Indian Refining Co.	Well		1,700	0.8475	35.2	Dark green	Sulphur.
341	Ohio Oil Co., Martinsville	J. P. Dunlop	Pipe line			.8470	35.3	Light green	
	Bridgeport Township:								
342	C. Cummings farm, Indian Refining Co., Lawrenceville.	Indian Refining Co.	Well		1,700	.8289	38.9	Dark green	Do.
	Lawrence Township:								
343	R. M. Kirkwood farm, Indian Refining Co., Lawrenceville.	do	do		1,700	.8378	37.1	do	Do.
	Macoupin County.								
344	Rinaker & Rinaker		Well			.8917	27.0	Black	
	Marion County.								
345	Near Junction City, NW. ¼ sec. 32, T. 2 N., R. 1 E.	C. S. Jennings	Well	2	565	.8557	33.6	Dark green	
346	Do	do	do	3	561½	.8626	32.3	do	

Analyses of petroleum from various parts of the United States—Continued.

Serial No.	Location of well.	Distillation by Engler's method.									Sulphur (per cent).	Paraffin (per cent).	Asphalt (per cent).	Water (per cent).	Unsaturated hydrocarbons (per cent).		Remarks.
		Begins to distill at (° C.)	By volume.														
			To 150° C.		150°-300° C.		Residuum.		Total.								
			Cubic centimeters.	Specific gravity.	Cubic centimeters.	Specific gravity.	Cubic centimeters.	Specific gravity.	Cubic centimeters.						Crude	150°-300°C.	
	ILLINOIS—continued.																
	Lawrence County—Contd.																
	Petty Township—Contd.																
340	Geo. Cooper farm, Indian Refining Co., Lawrenceville.	110	6.0	0.7480	40.0	0.7944	54.2	0.9021	100.2	......	1.96	......	Tr.	......	......	Green oil sand.
341	Ohio Oil Co., Martinsville.	71	15.0	.7276	34.0	.8053	51.0	....	100.0	0.17	......	......	......	......	......	
	Bridgeport Township:																
342	C. Cummings farm, Indian Refining Co., Lawrenceville.	73	12.0	.7230	35.0	.7874	49.2	.9067	96.2	......	4.31	......	Tr.	......	......	Do.
	Lawrence Township:																
343	R. M. Kirkwood farm, Indian Refining Co., Lawrenceville.	90	13.0	.7305	32.0	.7844	51.9	.9044	96.9	......	3.30	......	Tr.	......	......	Do.
	Macoupin County.																
344	Rinaker & Rinaker.........	155	......	....	21.0	.8283	74.7	.9530	98.7	......	......	......	2.74	......	......	
	Marion County.																
345	Near Junction City, NW. ¼ sec. 32, T. 2 N., R. 1 E.	95	6.5	.7390	34.0	.7815	57.3	.9168	97.8	......	4.21	0.53	......	......	......	
346	.....do.....................	108	3.5	.7430	36.5	.7887	59.2	.9132	99.2	......	5.48	.38	......	......	......	

Analyses of petroleum from various parts of the United States—Continued.

Serial No.	Location of well.	Collected by—	Collected from—	Well.	Depth of well (feet).	Physical properties.			
						Gravity at 60° F.		Color.	Odor.
						Specific.	Baumé.		
	ILLINOIS—continued.								
	Montgomery County.								
347	Litchfield					0.9236	21.6		
	Randolph County.								
348	Sparta					.8420	36.3		
	INDIANA.								
349	Dubois County, Birdseye					.8500	34.7		
350	Grant County, Van Buren					.8531	34.1		
351	Jasper County					.9280	20.9		
352	Do		Refinery run			.9371	19.4		
353	Vigo County, Terre Haute					.8790	29.3		

347, 348, Illinois State Geol. Survey Bull. 2. F. F. Grout, analyst.
349. Indiana Dept. Geol. and Nat. Resources Repts., 1903. Analysis by chemist of St. Louis Sampling & Testing Works
350. Indiana Dept. Geol. and Nat. Resources Repts., 1901. W. A. Noyes, analyst.
351. Indiana Dept. Geol. and Nat. Resources Repts., 1903. Mariner and Hoskins, analysts.
352. Indiana Dept. Geol. and Nat. Resources Repts., 1904. R. Levering.
353. Indiana Dept. Geol. and Nat. Resources Repts., 1901. W. A. Noyes, Analyst.

Analyses of petroleum from various parts of the United States—Continued

Serial No.	Location of well.	Distillation by Engler's method. Begins to distill at (° C.)	By volume. To 150° C. Cubic centimeters.	To 150° C. Specific gravity.	150°–300° C. Cubic centimeters.	150°–300° C. Specific gravity.	Residuum. Cubic centimeters.	Residuum. Specific gravity.	Total. Cubic centimeters.	Sulphur (per cent)	Paraffin (per cent)	Asphalt (per cent)	Water (per cent)	Unsaturated hydrocarbons (per cent). Crude	Unsaturated hydrocarbons (per cent). 150°–300° C.	Remarks.
	ILLINOIS—continued.															
	Montgomery County.															
347	Litchfield	110	1.3	(*a*)	16.9	0.852	81.8	....	100.0	......	......	......	......	......	......	Sp. gr. of lubricating oil, 0.863; coke and loss, 10.7 p. ct.; sample out of ground some months.[a] Specimens too small to test.
	Randolph County.															
348	Sparta	......	14.0	0.729	37.0	.7972	49.0	....	100.0	......	......	......	......	......	......	Sp. gr. of lubricating oil, 0.850; coke and loss, 7 p. ct.; sample had stood some time; burning point, 22° C.
	INDIANA.															
349	Dubois County, Birdseye	......	17.4	....	26.9	....	55.5	....	99.8	......	......	......	......	......	......	Lubricating oil, 42.2 p. ct.; residium, 13.3 p. ct.; sample from Southern Oil Co., Evansville, Ind.
350	Grant County, Van Buren	......	7.2	.719	32.6	.7965	60.2	....	100.0	0.83	......	......	......	......	......	300°–350° C., 14.8 p. ct.; ;sp. gr., 0.844; 350°–390° C., 41.8 p. ct.; sp. gr., 0.860.
351	Jasper County	......	......	....	......	....	97.0	....	97.0	1.26	......	2.9	......	......	......	Cold test, 7° F.; fire test, 437° F.
352	Do	248	......	....	......	....	......	....	100.0	......	......	47.0	......	......	......	Total distillates obtained when running crude down to asphalt, 49 p. ct.; loss, 4 p. ct.
353	Vigo County, Terre Haute	......	......	....	39.6	.8254	60.4	....	100.0	.72	......	......	......	......	......	300°–350° C., 14.8 p. ct.; sp. gr., 0.867; 350°–390° C., 40.6 p. ct.; sp. gr., 0.879.

Analyses of petroleum from various parts of the United States—Continued.

Serial No.	Location of well.	Collected by—	Collected from—	Well.	Depth of well (feet).	Physical properties.			
						Gravity at 60° F.		Color.	Odor.
						Specific.	Baumé.		
	KANSAS.								
	Allen County.								
	Humboldt pool:								
354	McKinley Crude Oil Co., Humboldt	J. P. Dunlop	Settling tank			0.8878	27.7	Dark green	
355	McKinley Crude Oil Co., Humboldt, Logan Township.	do	Well	11	851	.8895	27.4	Black	
356	Fussman lease, Logan Township, Frank Fussman, Humboldt.	do	do	1	850	.8822	28.7	do	
357	Do	do	do	3	850	.8850	28.2	do	
	Chanute pool:								
358	Hedrich lease, I. N. Knapp, Chanute	do	do	6	700	.8706	30.8	Dark green	
359	Beach lease, Rex Oil and Gas Co., Chanute	do	do	16	751	.8647	31.9	do	
360	Do	do	do	12	737	.8647	31.9	do	
361	Kansas Cooperative Refining Co., Chanute	do	Tank			.8615	32.5	Black	
362	Chanute Refining Co., Chanute	do	Pipe line			.8637	32.1	Dark brown	
	Moran pool:								
363	Carroll lease, Eastern Kansas Oil Co., Moran	do	Well	4	735	.8794	29.2	Black	
364	Smith lease, Eastern Kansas Oil Co., Moran	do	do	2	735	.8799	29.1	do	
365	Newton lease, E. F. Holman, Moran	do	do	5	735	.8712	30.7	do	
366	Eastern Kansas Oil Co., Moran	do	Pipe line			.8589	33.0	do	

Analyses of petroleum from various parts of the United States—Continued.

Serial No.	Location of well.	Distillation by Engler's method.								Sulphur (per cent).	Paraffin (per cent).	Asphalt (per cent).	Water (per cent).	Unsaturated hydrocarbons (per cent).		Remarks.
		Begins to distill at (° C.)	By volume.													
			To 150° C.		150°-300° C.		Residuum.		Total.							
			Cubic centimeters.	Specific gravity.	Cubic centimeters.	Specific gravity.	Cubic centimeters.	Specific gravity.	Cubic centimeters.					Crude	150°-300°C.	
	KANSAS.															
	Allen County.															
	Humbolt pool:															
354	McKinley Crude Oil Co., Humboldt.	123	1.0	....	29.0	0.8152	68.9	0.9247	98.9	......	3.93	2.33	......	32.8	2	
355	McKinley Crude Oil Co., Humboldt, Logan Township.	110	3.0	....	29.0	.8142	67.0	.9284	99.0	......	1.92	2.68	......	23.6	6	
356	Fussman lease, Logan Township, Frank Fussman, Humboldt.	108	5.0	0.7460	26.5	.8205	67.4	.9272	98.9	......	2.10	1.03	......	29.6	......	
257	Do..................	85	3.5	.7515	27.0	.8160	67.2	.9284	97.7	......	7.92	.39	......	41.2	8	
	Chanute pool:															
358	Hedrich lease, I. N. Knapp, Chanute.	125	3.0	.7500	37.5	.8029	59.3	.9229	99.8	......	3.78	.89	......	26.0	1	
359	Beach lease, Rex Oil and Gas Co., Chanute.	109	5.0	.7350	36.0	.7993	57.8	.9223	98.8	......	4.25	1.23	......	24.0	1	
360	Do..................	110	6.0	.7375	36.0	.7992	56.6	.9204	98.6	......	4.71	1.45	......	22.4	......	
361	Kansas Cooperative Refining Co., Chanute.	90	7.5	.7156	33.0	.8022	58.7	.9192	99.2	......	1.45	1.50	......	24.0	8	
262	Chanute Refining Co., Chanute.	113	4.5	.7405	35.0	.7927	57.2	9174	96.7	......	4.32	1.15	......	24.4	8	
	Moran pool:															
363	Carroll lease, Eastern Kansas Oil Co., Moran.	95	8.0	.7275	29.0	.8137	61.0	.9358	98.0	......	1.21	2.63	......	19.6	3	
364	Smith lease, Eastern Kansas Oil Co., Moran.	78	10.0	.7105	25.5	.8125	64.5	.9180	100.0	......	3.48	1.66	......	29.2	......	
365	Newton lease, E. F. Holman, Moran.	75	7.5	.7190	25.0	.8135	60.3	.9409	92.8	......	3.94	2.67	......	28.0	......	
366	Eastern Kansas Oil Co., Moran.	106	3.0	.7330	37.0	.7822	59.5	.9192	99.5	......	4.61	2.32	......	27.6	6	

Analyses of petroleum from various parts of the United States—Continued.

Serial No.	Location of well.	Collected by—	Collected from—	Well.	Depth of well (feet).	Physical properties.			
						Gravity at 60° F.		Color.	Odor.
						Specific.	Baumé.		
	KANSAS—continued.								
	Chautauqua County.								
	Peru pool:								
367	Prairie Oil & Gas Co., Peru station, Independence.	J. P. Dunlop	Pipe line			0.8526	34.2	Black	
368	F. G. Hill's lease, Interstate Oil & Gas Co., Peru	do	Well	1, 2	1,070	.8557	33.6	Dark green	
369	Hill's lease, Central Pool Oil Co., Peru	do	Settling tank	1–12	1,100	.8521	34.3	do	
370	Interstate lease, Pittsburgh Oil & Gas Co., Peru	do	Well	1	1,100	.8454	35.6	Black	
371	Do	do	do	6	1,100	.8500	34.7	do	
	Elk County.								
	Longton pool:								
372	Allen County Investment Co., Longton	J. P. Dunlop	Well	2	585	.8637	32.1	Black	
373	Do	do	Settling tank			.8631	32.2	do	
	Franklin County.								
	Rantoul pool:								
374	Springer lease, Hardison & Streeter, Rantoul	J. P. Dunlop	Well	1–4	350	.8557	33.6	Black	
375	Tullows lease, Hardison & Streeter, Rantoul	do	do	6	350	.8750	30.0	do	

Analyses of petroleum from various parts of the United States—Continued.

Serial No.	Location of well.	Distillation by Engler's method. Begins to distill at (° C.)	To 150° C. Cubic centimeters.	To 150° C. Specific gravity.	150°–300° C. Cubic centimeters.	150°–300° C. Specific gravity.	Residuum. Cubic centimeters.	Residuum. Specific gravity.	Total. Cubic centimeters.	Sulphur (per cent)	Paraffin (per cent)	Asphalt (per cent)	Water (per cent)	Unsaturated hydrocarbons (per cent). Crude	Unsaturated hydrocarbons (per cent). 150°–300°C.	Remarks.
	KANSAS—continued.															
	Chautauqua County.															
	Peru pool:															
367	Prairie Oil & Gas Co., Peru station, Independence.	87	7.0	0.7244	32.5	0.7934	58.7	0.9150	98.2	......	3.81	0.35	......	27.6	5	
368	F. G. Hill's lease, Interstate Oil & Gas Co., Peru.	110	7.0	.7310	37.0	.7975	53.2	.9150	97.2	......	5.79	1.53	......	24.8	......	
369	Hill's lease, Central Pool Oil Co., Peru.	80	12.0	.7160	30.0	.7945	55.5	.9138	97.5	......	5.24	.20	......	24.8	3	
370	Interstate lease, Pittsburgh Oil & Gas Co., Peru.	77	11.0	.7218	30.0	.7988	55.3	.9162	96.3	......	4.54	.42	......	12.4	6	
371	Do.................	66	13.0	.7177	31.5	.8015	52.5	.9174	97.0	......	5.41	.34	......	......	3	
	Elk County.															
	Longton pool:															
372	Allen County Investment Co., Longton.	98	12.0	.7202	27.5	.7920	59.3	.9229	98.8	......	7.19	.89	......	29.6	5	
373	Do.................	96	6.0	.7360	31.0	.7890	59.6	.9198	96.6	......	4.30	1.56	......	30.8	......	
	Franklin County.															
	Rantoul pool:															
374	Springer lease, Hardison & Streeter, Rantoul.	76	11.5	.7116	29.5	.7950	54.9	.9272	95.9	......	3.45	2.29	......	34.0	.....	
375	Tullows lease, Hardison & Streeter, Rantoul.	136	1.0	....	39.0	.7892	60.0	.9358	100.0	......	3.98	2.80	......	26.0	2	

Analyses of petroleum from various parts of the United States—Continued.

Serial No.	Location of well.	Collected by—	Collected from—	Well.	Depth of well (feet).	Physical properties. Gravity at 60° F. Specific.	Baumé.	Color.	Odor.
	KANSAS—continued.								
	Franklin County—Continued.								
	Rantoul pool—Continued.								
376	Prairie Oil & Gas Co., Pump station, Rantoul	J. P. Dunlop	Tank			0.8578	33.2	Black	
	Kay County.								
377	Newkirk Gas & Mineral Co., Newkirk		Well	1		.8511	34.5		
	Miami County.								
	Paola pool:								
378	C. J. Hafey, Paola	J. P. Dunlop	Well	4	360	.8511	34.5	Black	
	Montgomery County.								
	Coffeyville pool:								
379	Gilroy lease, Brown Brokerage Co., Coffeyville	J. P. Dunlop	Well	1–15	600	.8822	28.7	Dark green	
380	M. Davis lease, Dunkley & Odell, Coffeyville	do	Settling tank	1–40	625	.8717	30.6	Black	
	Wayside pool:								
381	J. Hall lease, Lynch & McSweeney, Wayside	do	Well	1, 2	800	.8696	31.0	do	
382	Do	do	Settling tank			.8838	28.4	do	

377. U. S. Geol. Survey Mineral Resources, 1903, p. 671, 1904. Edwin De Barr, analyst.

Analyses of petroleum from various parts of the United States—Continued.

Serial No.	Location of well.	Begins to distill at (° C.)	Distillation by Engler's method. By volume. To 150° C. Cubic centimeters.	To 150° C. Specific gravity.	150°–300° C. Cubic centimeters.	150°–300° C. Specific gravity.	Residuum. Cubic centimeters.	Residuum. Specific gravity.	Total. Cubic centimeters.	Sulphur (per cent).	Paraffin (per cent).	Asphalt (per cent).	Water (per cent).	Unsaturated hydrocarbons (per cent). Crude	Unsaturated hydrocarbons (per cent). 150°–300°C.	Remarks.
	KANSAS—continued.															
	Franklin County—Contd.															
	Rantoul pool—Continued.															
376	Prairie Oil & Gas Co., Pump station, Rantoul.	103	5.5	0.7220	33.5	0.7850	59.7	0.9217	98.7	......	4.34	1.93	......	26.4	6	
	Kay County.															
377	Newkirk Gas & Mineral Co., Newkirk.	......	......	......	......	......	......	......	100.0	......	......	......	......	......	......	Below 170° C., 9.1 p. ct.; 170°–315° C., 43.75 p. ct.; lubricating oil, 37 p. ct.; solid oil and residuum, 10.15 p. ct.
	Miami County.															
	Paola pool:															
378	C. J. Hafey, Paola......	80	10.0	.7202	33.0	.7964	55.8	.9223	98.8	......	7.44	2.94	......	19.6	8	
	Montgomery County.															
	Coffeyville pool:															
379	Gilroy lease, Brown Brokerage Co., Coffeyville.	173	......	......	31.0	.8082	66.2	.9138	97.2	......	5.31	.17	......	22.0	......	
380	M. Davis lease, Dunkley & Odell, Coffeyville.	100	6.0	.7289	33.0	.8030	58.3	.9241	97.3	......	......	......	......	24.4	......	
	Wayside pool:															
381	J. Hall lease, Lynch & McSweeney, Wayside.	75	9.5	.7100	28.0	.8080	59.9	.9396	97.4	......	4.66	.61	......	35.6	......	
382	Do................	81	5.0	.7315	28.0	.7962	66.0	.9290	99.0	......	(a)	(a)	......	50.0	8	a With Kansas 390.

Analyses of petroleum from various parts of the United States—Continued.

Serial No.	Location of well.	Collected by—	Collected from—	Well.	Depth of well (feet).	Physical properties. Gravity at 60° F. Specific.	Baumé.	Color.	Odor.
	KANSAS—continued.								
	Montgomery County—Continued.								
	Bolton pool:								
383	G. L. Bank lease, Miller Rider & Co., Independence.	J. P. Dunlop	Well	4	1,180	0.8424	36.2	Black	
384	Prairie Oil & Gas Co., station 5, Independence	do	Pipe line			.8495	34.8	do	
385	Federal Gas & Oil Co., Cherryvale		Well			.8730	30.4		
	Neosho County.								
	Erie pool:								
386	Webb lease, Northland Oil & Gas Co., Erie	J. P. Dunlop	Tank			.8739	30.2	Black	
387	Barger lease, Buckeye Oil & Gas Co., Erie	do	Well	2	520	.8658	31.7	do	
388	Thayer		do	Ordway		.8490	34.9		
	Wilson County.								
	Neodesha pool:								
389	D. Johnson lease, Dolly Johnson Oil & Gas Co., Neodesha.	J. P. Dunlop	Well	13	800	.8373	37.2	Dark green	

385. Pet. Rev., Feb. 2, 1907. Clifford Richardson.
388. Mineral resources of Kansas, 1897. E. H. Bailey, analyst.

Analyses of petroleum from various parts of the United States—Continued.

Serial No.	Location of well.	Begins to distill at (° C.)	To 150° C. Cubic centimeters.	To 150° C. Specific gravity.	150°–300° C. Cubic centimeters.	150°–300° C. Specific gravity.	Residuum. Cubic centimeters.	Residuum. Specific gravity.	Total. Cubic centimeters.	Sulphur (per cent)	Paraffin (per cent)	Asphalt (per cent)	Water (per cent)	Unsaturated hydrocarbons (per cent). Crude	Unsaturated hydrocarbons (per cent). 150°–300°.	Remarks.
	KANSAS—continued.															
	Montgomery County—Con.															
383	Bolton pool: G. L. Bank lease, Miller Rider & Co., Independence.	72	14.7	0.7273	31.0	0.8095	49.2	0.9365	94.9	......	......	......	......	20.0	......	
384	Prairie Oil & Gas Co., Station 5, Independence.	109	7.0	.7358	36.5	.7982	55.6	.9126	99.1	......	6.31	0.55	......	24.0	6	
385	Federal Gas & Oil Co., Cherryvale.	......	......	......	......	......	......	......	......	......	......	......	......	......	......	Distillation in vacuo, 20 mm. pressure, 60°–140° C., 16.3 p. ct.; 140°–300° C., 53.9 p. ct. Character of residuum at 200° C., soft, paraffin; 280°-300° C., solid.
	Neosho County.															
386	Erie pool: Webb lease, Northland Oil & Gas Co., Erie.	135	1.0	....	34.0	.8000	64.1	.9115	99.1	......	4.78	3.20	......	27.2	7	
387	Barger lease, Buckeye Oil & Gas Co., Erie.	110	3.0	....	35.0	.7960	61.8	.9162	99.8	......	1.22	.88	......	23.6	2	
388	Thayer	......	16.7	.7282	39.2	.8093	41.1	.8663	100.0	......	......	......	......	......	......	
	Wilson County.															
389	Neodesha pool: D. Johnson lease, Dolly Johnson Oil & Gas Co., Neodesha.	80	17.0	.7172	30.0	.8005	48.6	.9079	95.6	......	(*a*)	(*a*)	......	18.0	......	*a* With Kansas 390.

Analyses of petroleum from various parts of the United States—Continued.

Serial No.	Location of well.	Collected by—	Collected from—	Well.	Depth of well (feet).	Physical properties.			
						Gravity at 60°F.		Color.	Odor.
						Specific.	Baumé.		
	KANSAS—continued.								
	Wilson County—Continued.								
	Neodesha pool—Continued.								
390	T. Johnson lease, Prairie Oil & Gas Co., Neodesha.	J. P. Dunlop	Well	3	820	0.8368	37.3	Black	
391	Dolly Johnson Oil & Gas Co., Neodesha	do	Settling tank			.8568	33.4	Dark green	
392	Neodesha		Well	Main		.8350	37.7		
393	Do		do	Kimball		.8350	37.7		
	KENTUCKY.								
	Allen County.								
394	Petroleum pool, Newman farm, Southern Oil & Gas Co., Petroleum.	Cass Burrus for M. J. Munn.	Well		810	.8490	34.9	Brown	Like Pa. oil.
	Bath County.								
395	Ragland pool, Ragland farm, J. W. Radcliffe	J. W. Radcliffe for M. J. Munn.	Well		366	.8963	26.2	do	Do.

392, 393. Mineral resources of Kansas, 1897. E. H. Bailey, analyst.

Analyses of petroleum from various parts of the United States—Continued.

Serial No.	Location of well.	Begins to distill at (° C.)	Distillation by Engler's method. By volume. To 150° C. Cubic centimeters.	To 150° C. Specific gravity.	150°–300° C. Cubic centimeters.	150°–300° C. Specific gravity.	Residuum. Cubic centimeters.	Residuum. Specific gravity.	Total. Cubic centimeters.	Sulphur (per cent).	Paraffin (per cent).	Asphalt (per cent).	Water (per cent).	Unsaturated hydrocarbons (per cent). Crude	Unsaturated hydrocarbons (per cent). 150°–300°C.	Remarks.
	KANSAS—continued.															
	Wilson County—Continued.															
	Neodesha pool—Continued.															
390	T. Johnson lease, Prairie Oil & Gas Co., Neodesha.	88	16.0	0.7158	36.0	0.7925	47.7	0.9091	99.7	......	[a]3.40	[a]0.08	......	20.0	......	[a] Includes Kansas 381 and Kansas 389.
391	Dolly Johnson Oil & Gas Co., Neodesha.	135	1.0	....	40.5	.7991	57.0	.9109	98.5	......	5.79	.10	......	30.0	3	
392	Neodesha	......	19.1	.7205	38.1	.8081	42.8	....	100.0	......	......	......	......	......	......	
393	Do	......	19.8	.7252	34.8	.8105	45.4	....	100.0	......	......	......	......	......	......	
	KENTUCKY.															
	Allen County.															
394	Petroleum pool, Newman farm, Southern Oil & Gas Co., Petroleum.	71	12.5	.7373	41.0	.8144	45.3	.9162	98.8	......	3.65	2.10	Tr.	18.8	7.0	
	Bath County.															
395	Ragland pool, Ragland farm, J. W. Radcliffe.	136	1.0	....	29.0	.8151	69.6	.9434	99.6	......	2.13	0	Tr.	30.0	5.0	Ragland sand.

Analyses of petroleum from various parts of the United States—Continued.

Serial No.	Location of well.	Collected by—	Collected from—	Well.	Depth of well (feet).	Physical properties.			
						Gravity at 60° F.		Color.	Odor.
						Specific.	Baumé.		
	KENTUCKY—continued.								
	Lawrence County.								
396	Lower Lawrence County		Well		320	0.8531	34.1	Brownish black	
397	Busseyville 1		do			.8104	42.75	Light green	Like Pa. oil.
398	Busseyville 2		do			.8187	41.0	do	Do.
399	Busseyville 3		do			.8226	40.2	do	Do.
	Morgan County.								
400	Buck Run field, Union Township, sec. 11, Harrison farm.	M. W. Crouch	Tank			.8092	43.0	Dark green	Do.
	Ohio County.								
401	West Kentucky Oil Co., Hartford		Well	1	1,777	.8383	37.0	do	Do.
	Wayne County.								
402	Parnell pool, Polly Lair farm, P. M. Burwald, Monticello.	M. W. Crouch	Well	1	692	.8083	43.2	Light green	Do.
403	Sinking pool, Wood Oil Co., Monticello	M. J. Munn	do	Chrisman 1	600	.8154	41.7	Dark green	Do.
404	Oil Valley pool, Ohio & Kentucky Oil Refining Co., Oil Valley.	do	do	4	690	.8154	41.7		Do.

396. Kentucky Geol. Survey, 1888. Robert Peter, chemist.

Analyses of petroleum from various parts of the United States—Continued.

Serial No.	Location of well.	Begins to distill at (° C.)	To 150° C. Cubic centimeters.	To 150° C. Specific gravity.	150°–300° C. Cubic centimeters.	150°–300° C. Specific gravity.	Residuum. Cubic centimeters.	Residuum. Specific gravity.	Total. Cubic centimeters.	Sulphur (per cent).	Paraffin (per cent).	Asphalt (per cent).	Water (per cent).	Unsaturated hydrocarbons (per cent). Crude	Unsaturated hydrocarbons (per cent). 150°–300° C.	Remarks.
	KENTUCKY—continued.															
	Lawrence County.															
396	Lower Lawrence County	......	......	......	......	......	......	......	......	......	......	......	......	......	......	Submitted to distillation until 91.4 p. ct. passed over; distillate then fractionally distilled, 160° C., 16.3 p. ct. of original; 160°–320° C., 39 p. ct.
397	Busseyville 1	70	9.5	0.7245	34.5	0.7756	49.4	0.8861	93.4	......	......	......	......	......	......	
398	Busseyville 2	70	7.5	.7100	38.0	.7759	49.5	.8923	95.0	......	......	......	......	......	......	
399	Busseyville 3	73	13.0	.7156	33.0	.7854	49.0	.8917	95.0	......	......	......	......	......	......	
	Morgan County.															
400	Buck Run field, Union Township, sec. 11, Harrisson farm.	95	13.0	.7270	35.0	.7796	50.7	.8557	98.7	......	5.40	0	......	8.4	6.8	First Cow Run sand.
	Ohio County.															
401	West Kentucky Oil Co., Hartford.	70	7.0	.707	32.0	.7802	57.4	.9201	96.4	......	3.6	0	Tr.	......	......	
	Wayne County.															
402	Parnell pool, Polly Lair farm, P. M. Burwald, Monticello.	43	27.0	.7047	33.0	.8017	37.3	.9061	97.3	......	2.47	0	......	14.8	6.0	Sunnybrook sand.
403	Sinking pool, Wood Oil Co., Monticello.	65	22.0	.7273	36.0	.8043	38.6	.9038	96.6	......	3.73	.56	......	11.6	2.0	Beaver Creek sand.
404	Oil Valley pool, Ohio & Kentucky Oil Refining Co., Oil Valley.	50	20.0	.7129	36.0	.7989	39.7	.9121	95.7	......	3.34	1.78	......	14.8	2.0	Do.

Analyses of petroleum from various parts of the United States—Continued.

Serial No.	Location of well.	Collected by—	Collected from—	Well.	Depth of well (feet).	Physical properties.			
						Gravity at 60° F		Color.	Odor.
						Specific.	Baumé.		
	KENTUCKY—continued.								
	Wayne County—Continued.								
405	Johnson Fork field	M. J. Munn	Well			0.8408	36.5	Brown	Like Pa. oil.
406		do	do			.8235	40.0	Dark green	Do.
407	Cooper pool, B. S. Huffaker farm, Penn Lubricating Co., Monticello.	M. W. Crouch	do	5		.8178	41.2	Black	Do.
408	Turkey Rock pool. Slickford district, Jos. Brown & Co., Slickford.	M. J. Munn	do	Morris 4		.8163	41.5	Dark green	Do.
409	Rocky Branch pool (near Monticello), Grant Roberts farm. Dempsey Oil Co., Bradford, Pa., first oil from well.	M. W. Crouch	do	2	187	.9021	25.2	Black	Do.
410	Parmleysville pool (north end), James Burnett farm. Ross Wetzel & Co., Parmleysville.	M. J. Munn	do	3		.8348	37.7	Dark green	Do.
411	H. M. Caldwell, Monticello		do			.8211	40.5	do	
	Warren County.								
412	Sunnyside					.8426	36.2		

412. Pet. Rev., Oct. 27, 1906. Clifford Richardson.

Analyses of petroleum from various parts of the United States—Continued.

Serial No.	Location of well.	Begins to distill at (° C.)	Distillation by Engler's method. By volume. To 150° C. Cubic centimeters.	To 150° C. Specific gravity.	150°–300° C. Cubic centimeters.	150°–300° C. Specific gravity.	Residuum. Cubic centimeters.	Residuum. Specific gravity.	Total. Cubic centimeters.	Sulphur (per cent).	Paraffin (per cent).	Asphalt (per cent).	Water (per cent).	Unsaturated hydrocarbons (per cent). Crude	Unsaturated hydrocarbons (per cent). 150°–300° C.	Remarks.
	KENTUCKY—continued.															
	Wayne County—Continued.															
405	Johnson Fork field..........	53	13.5	0.7201	32.0	0.7980	49.9	0.9235	95.4	......	3.01	2.66	......	31.2	4.0	
406	....	60	16.5	.7187	32.0	.7934	46.9	.9056	95.4	......	4.57	0	......	18.8	7.0	
407	Cooper pool, B. S. Huffaker farm, Penn Lubricating Co., Monticello.	35	25.0	.7155	29.0	.8062	42.1	.9186	96.1	......	2.65	.80	......	14.4	14.0	Beaver Creek sand.
408	Turkey Rockpool, Slickford district, Jos. Brown & Co., Slickford.	60	23.0	.7181	36.0	.7947	40.2	.9038	99.2	......	2.31	.36	......	15.6	14.0	
409	Rocky Branch pool (near Monticello), Grant Roberts farm. Dempsey Oil Co., Bradford, Pa., first oil from well.	170	......	....	26.0	.8183	73.0	.9259	99.0	......	5.49	......	Tr.	63.0	3.0	
410	Parmleysville pool (north end), James Burnett farm, Ross Wetzel & Co., Parmleysville.	76	13.0	.7174	36.0	.7959	47.9	.9115	96.9	......	5.09	......	Tr.	2.0	5.0	Do.
411	H. M. Caldwell, Monticello..	67	16.0	.7148	37.5	.9979	41.2	.9150	94.7	......	4.93	.41	......	......	......	
	Warren County.															
412	Sunnyside..................	67	19.0	....	37.0	....	44.0	....	100.0	......	......	......	......	......	......	Volatility in open dish, 150° C. (7 hours), 40.7 p. ct.; 160° C., 44.5 p. ct.; 200° C., 58 p. ct. To constant weight, 150° C. (42 hours), 70.6 p. ct.; 160° C. (7 hours), 73.8 p. ct.

Analyses of petroleum from various parts of the United States—Continued.

Serial No.	Location of well.	Collected by—	Collected from—	Well.	Depth of well (feet).	Physical properties.			
						Gravity at 60° F.		Color.	Odor.
						Specific.	Baumé.		
	LOUISIANA.								
	Caddo Parish.								
413	Hostetter farm, Mooringsport	G. D. Harris	Well			0.8187	41.0	Black	Like Okla. oil.
414	Caddo Oil and Mineral Co	do	do	Gilbert 1		.8264	39.4	do	Do.
415	Frank Filer Lease, NW. ¼ SE. ¼ sec. 7, T. 15, R. 20	do	Tank	1	2,250	.9211	22.0	do	Do.
416	Old Caddo Oil and Gas Co., E. K. Smith's land	do	Well	1	1,620	.8723	30.5	do	Do.
417	NW. ¼ NW. ¼ sec. 7, T. 15, R. 20	do	do	Richardson 2	2,245	.8929	26.8	do	Do.
418	Black Bayou Oil Co., SW. ¼ sec. 10, T. 15, R. 20	do	do	1	2,220	.9150	23.0	do	Do.
419	1 mile southeast of Vivian, NW. ¼ NE. ¼ sec. 36, T. 22 N, R. 16 W.	do	do	Dawes 1	1,050	.9253	21.3	do	Do.
420	Caddo Oil and Gas Co., E. K. Smith's farm	do	do	4	2,260	.9211	22.0	Brown	Do.
421	Caddo Oil and Gas Co., E. K. Smith's farm, SE. ¼ SW. ¼ sec. 1, T. 16, R. 20.	do	do	5		.8889	27.5	Black	Do.
422	Richardson Oil Co., NE. ¼ NW. ¼ sec. 32, T. 15 W., R. 21 N.	do	do	4	2,132	.9121	23.5	do	Do.
423	Brown Oil Co., Black Bayou	Brown Oil Co	do	1	+2,300	.9109	23.7	Brown	
424	James Bayou					.8065	43.6		

Analyses of petroleum from various parts of the United States—Continued.

Serial No.	Location of well.	Distillation by Engler's method. Begins to distill at (° C.)	By volume. To 150° C. Cubic centimeters.	To 150° C. Specific gravity.	150°–300° C. Cubic centimeters.	150°–300° C. Specific gravity.	Residuum. Cubic centimeters.	Residuum. Specific gravity.	Total. Cubic centimeters.	Sulphur (per cent).	Paraffin (per cent).	Asphalt (per cent).	Water (per cent).	Unsaturated hydrocarbons (per cent). Crude	Unsaturated hydrocarbons (per cent). 150°–300°C.	Remarks.
	LOUISIANA.															
	Caddo Parish.															
413	Hostetter farm, Mooringsport.	138	3.0	....	55.0	0.7778	40.4	0.8866	98.4	......	1.70	0.09	......	......	......	
414	Caddo Oil & Mineral Co.....	136	1.5	....	49.0	.7778	49.1	.8805	99.6	......	5.30	.25	......	......	......	
415	Frank Filer Lease, NW. ¼ SE. ¼ sec. 7, T. 15, R. 20.	200	......	....	12.0	.8510	82.9	.9061	94.9	......	7.78	.91	......	......	......	Contains water.
416	Old Caddo Oil & Gas Co., E. K. Smith's land.	210	......	....	28.0	.8299	69.5	.8895	97.5	......	7.32	.14	......	......	......	Do.
417	NW. ¼ NW. ¼ sec. 7, T. 15, R. 20.	173	......	....	20.0	.8408	79.0	.9061	99.0	......	5.29	.50	......	......	......	Do.
418	Black Bayou Oil Co., SW. ¼ sec. 10, T. 15, R. 20.	210	......	....	18.0	.8450	81.2	.9138	99.2	......	......	.24	......	......	......	Do.
419	1 mile southeast of Vivian, NW. ¼ NE. ¼ sec. 36, T. 22 N., R. 16 W.	265	......	....	17.0	.8406	82.9	.9302	99.9	......	......	.22	......	......	......	Do.
420	Caddo Oil & Gas Co., E. K. Smith's farm.	200	......	....	14.0	.8142	59.0	.8974	73.0	......	3.64	.34	20	......	......	0.7 p. ct. clay.
421	Caddo Oil & Gas Co., E. K. Smith's farm, SE. ¼ SW. ¼ sec. 1, T. 16, R. 20.	220	......	....	18.0	.8406	79.4	.9003	97.4	......	4.78	.64	......	......	......	Much water.
422	Richardson Oil Co., NE. ¼ NW. ¼ sec. 32, T. 15 W., R. 21 N.	220	......	....	16.5	.8713	66.6	.9241	83.1	......	......	.54	......	......	......	Do.
423	Brown Oil Co., Black Bayou.	248	......	....	10.5	.8690	88.2	.9235	98.7	......	......	......	......	......	......	
424	James Bayou................	95	15.0	0.7275	47.0	.7770	40.0	.8739	102.0	0	7.02	......	12.8	......	......	

Analyses of petroleum from various parts of the United States—Continued.

Serial No.	Location of well.	Collected by—	Collected from—	Well.	Depth of well (feet).	Physical properties.			
						Gravity at 60°F.		Color.	Odor.
						Specific.	Baumé.		
	LOUISIANA—continued.								
	Calcasieu Parish.								
425	Jennings		Well	Heywood	1,000	0.9093	24.0		
426	Welsh			do	700	.9276	20.9		
427	Do					.9380	19.3	Olive green	
	Evangeline Parish.								
428	Sample No. 1		Tank			.8626	32.3		
429	Sample No. 2		Well			.8653	31.8		
	St. Martins Parish.								
430	Moresi Co., Anse Le Butte		Well	2	600	.9392	19.1		
431	Robt. Martin, Bayou Bouillion		do			.8590	33.0	Brownish black	
432	Do				900	.9669	14.8		
433	Bayou Laroupe		Well	Prospect well; not finished.	400	.9604	15.8		

425–426. Am. Chem. Soc. Jour., vol. 25, p. 1154. C. R. Coates and A. Best.
427. U. S. Geol. Survey Mineral Resources, 1905, p. 872, 1906. F. C. Thiele.
430. Am. Chem. Soc. Jour., vol. 25, p. 1154. C. R. Coates and A. Best.
431. U. S. Geol. Survey Bull. 282, 1906. Metz and Custiss, analysts.
432–433. Am. Chem. Soc. Jour., vol. 27, p. 1317. C. R. Coates and A. Best.

Analyses of petroleum from various parts of the United States—Continued.

Serial No.	Location of well.	Begins to distill at (°C.)	Distillation by Engler's method. By volume. To 150° C. Cubic centimeters.	To 150° C. Specific gravity.	150°–300° C. Cubic centimeters.	150°–300° C. Specific gravity.	Residuum. Cubic centimeters.	Residuum. Specific gravity.	Total. Cubic centimeters.	Sulphur (per cent).	Paraffin (per cent).	Asphalt (per cent).	Water (per cent).	Unsaturated hydrocarbons (per cent). Crude	Unsaturated hydrocarbons (per cent). 150°–300° C.	Remarks.
	LOUISIANA—continued.															
	Calcasieu Parish.															
425	Jennings	200			41.0		59.0		100.0	0.39		5.0				From 300°–350° C., 24 p. ct.; 350° C. to asphalt, 30 p. ct.; B. t. u., 19,814.
426	Welsh	230			19.0		81.0		100.0	.32		9.0				From 300°–350° C., 23 p. ct.; 350° C. to asphalt, 49 p. ct.; color of fraction, nearly colorless, light yellow on standing; B. t. u., 19,000.
427	Do	Over 91	1.05	0.831	30.07	0.852	68.88		100.0	.0						Lubricating oil, 65.38 p. ct.; coke and loss, 3.5 p. ct.; viscosity, 36.8 by Engler's method.
	Evangeline Parish.															
428	Sample No. 1	175			59.0	.8493	40.0	0.8980	99.0	.15	0	0		6.8		
429	Sample No. 2	173			59.0	.8493	41.0	.9009	100.0	.15	0	0		8.8		
	St. Martins Parish.															
430	Moresi Co., Anse Le Butte.	240			16.0		84.0		100.0	.20		9.0				B. t. u. 19,300. When residue heated and evaporated in open dish it was hard, black, shiny, with conchoidal fractures; sp. gr., 1.123. Analysis residuum of asphalt showed volatile, 71 p. ct.; fixed carbon, 28.6 p. ct.; ash, 0.4 p. ct.
431	Robt. Martin, Bayou Bouillon.		4.3		28.4		67.3		100.0							Above 300° C., lubricating oil, 42 p. ct.; asphalt and coke, 15.5 p. ct.; loss, 9.8 p. ct.
432	Do	275			11.0		89.0		100.0	.57						From 300°–350° C., 62 p. ct.; color of fraction, yellow; B. t. u., 18,500; residue, asphaltic.
433	Bayou Laroupe	265			6.0		94.0		100.0	Low						From 300°–350° C., 7 p. ct.; color of fraction, yellow; residue, asphaltic.

Analyses of petroleum from various parts of the United States—Continued.

Serial No.	Location of well.	Collected by—	Collected from—	Well.	Depth of well (feet).	Physical properties.			
						Gravity at 60°F.		Color.	Odor.
						Specific.	Baumé.		
	MICHIGAN.								
	Saginaw County.								
433a	Saginaw Development Co.	L. L. Linton	Well		2,340	0.8065	43.6	Light	Like Pa. oil.
	St. Clair County.								
434	Port Huron					.8333	38.0	Dark green	
	MISSOURI.								
	Cass County.								
435	Belton								
	NEW MEXICO.								
	Eddy County.								
436	Two miles east of Dayton, 10 miles southeast of Artesia; owned by W. S. Williams.	W. M. Dougherty.	Artesian well		1,000	.8951	26.4	Black	Sulphur.
437	Three miles south of Dayton; A. F. Lucas, Washington, D. C.	A. F. Lucas	Well		914	.9186	22.4	do	Do.
438	Dayton pool; Roswell Oil Co., Artesia	G.E.Morgan (manager Producers Oil Co.).	do	Hammond 1	914	.9168	22.7	do	Do.
439	Do	David T. Day	do	do	914	.9109	23.7	do	Do.

434. U. S. Geol. Survey Mineral Resources, 1905, p. 879, 1906.
435. U. S. Geol. Survey Mineral Resources, 1902, p. 566, 1904. Prof. Frankforter.

Analyses of petroleum from various parts of the United States—Continued.

Serial No.	Location of well.	Distillation by Engler's method.								Sulphur (per cent).	Paraffin (per cent).	Asphalt (per cent).	Water (per cent).	Unsaturated hydrocarbons (per cent).		Remarks.
		Begins to distill at (°C.)	By volume.													
			To 150° C.		150°–300° C.		Residuum.		Total.					Crude	150°–300°C.	
			Cubic centimeters.	Specific gravity.	Cubic centimeters.	Specific gravity.	Cubic centimeters.	Specific gravity.	Cubic centimeters.							
	MICHIGAN.															
	Saginaw County.															
433a	Saginaw Development Co...	98	15.0	0.7251	52.0	0.7854	33.4	0.8834	100.4	......	0.78	0	0	......	......	
	St. Clair County.															
434	Port Huron..................	......	15.0	....	55.0	....	30.0	....	100.0	......	......	......	......	......	......	Lubricating oil, 20 p. ct.; tar, 5 p. ct.; coke, 5 p. ct. (Taken from card reporting production.)
	MISSOURI.															
	Cass County.															
435	Belton......................	......	10.0	....	19.0	....	71.0	....	100.0	......	8.0	......	......	......	......	Lubricating oil, 53 p. ct.; residue tar, 10 p. ct.; with only a trace of organic matter.
	NEW MEXICO.															
	Eddy County.															
436	Two miles east of Dayton, 10 miles southeast of Artesia; owned by W. S. Williams.	217	......	....	30.0	.8395	68.9	.9241	98.9	(a)	......	0.56	......	(a)	(a)	a Not determined.
437	Three miles south of Dayton; A. F. Lucas, Washington, D. C.	137	Tr.	....	28.5	.8564	68.4	.9444	96.9	(a)	0	0	......	20.0	60.0	Do.
438	Dayton pool; Roswell Oil Co., Artesia.	188	......	....	28.0	.8541	72.0	.9396	100.0	(a)	0	3.65	......	28.4	12.0	Do.
439	Do..........................	142	1.0	....	31.0	.8417	68.1	.9390	100.1	(a)	0	3.91	......	25.6	14.0	Do.

Analyses of petroleum from various parts of the United States—Continued.

Serial No.	Location of well.	Collected by—	Collected from—	Well.	Depth of well (feet).	Physical properties. Gravity at 60° F. Specific.	Baumé.	Color.	Odor.
	OHIO.								
	Allen County.								
440	Lima					0.7910	47.0	Dark Green	
441	Do					.8350	37.7	Dark brown, slightly fluorescent.	
442	Do					.8500	34.7	Dark brown	
443	Do					.8380	37.1		
	Fairfield County.								
444	Bremen pool, Rush Creek Township; L. Groves farm	J. A. Bownocker	Well		2,462	.7848	48.4	Medium green	Like Pa. oil.
445	Pleasantville pool, Richland Township; J. G. Ruff farm	do	do		+2,345	.8046	44.0	Dark green	Do.
	Hancock County.								
446	Findlay, Peerless Refining Co					.8380	37.1		
	Knox County.								
447	Bladenburg pool, Jackson Township	J. A. Bownocker	Well	McKee	2,771	.8469	35.3	Dark green	Like Pa. oil.

440. Am. Chem. Soc. Jour., vol. 13, p. 168. Mandell and Bourgougnon.
441. Am. Chem. Soc. Jour., vol. 13, p. 179. Durand Woodman.
442. Am. Chem. Soc. Jour., vol. 13, p. 180. Durand Woodman.
443. Franklin Inst. Jour., Nos. 834, 835. C. F. Mabery.
446. Am. Chem. Jour., vol. 17., p. 714. Charles F. Mabery.

Analyses of petroleum from various parts of the United States—Continued.

Serial No.	Location of well.	Distillation by Engler's method. Begins to distill at (° C.)	By volume. To 150° C. Cubic centimeters.	To 150° C. Specific gravity.	150°–300° C. Cubic centimeters.	150°–300° C. Specific gravity.	Residuum. Cubic centimeters.	Residuum. Specific gravity.	Total. Cubic centimeters.	Sulphur (per cent).	Paraffin (per cent).	Asphalt (per cent).	Water (per cent).	Unsaturated hydrocarbons (per cent). Crude	Unsaturated hydrocarbons (per cent). 150°–300°C.	Remarks.
	OHIO.															
	Allen County.															
440	Lima	23	16.0	0.700	68.0	0.788	16.0	....	100.0	......	......	......	......	......	......	Paraffin oil 6 p. ct.; sp. gr., 0.813.
441	Do	......	10.0	Under .730	50.0	....	40.0	....	100.0	......	......	......	......	......	......	Lubricating oil, 30 p. ct.; sp. gr., 0.830.
442	Do	......	......	....	......	....	......	....	....	0.655	......	......	0.7	......	......	Gives naphtha and burning oil 56.8 p. ct.; heavy oil (above 500° F.), 32 p. ct.; residuum, 9.6 p. ct.
443	Do	......	9.75	.7282	37.13	.7871	53.12	....	100.0	.37	......	......	......	......	......	300°–350° C., 8.63 p. ct.; sp. gr., 0.8242; bromine absorption, 6.1 p. ct.
	Fairfield County.															
444	Bremen pool, Rush Creek Township; L. Groves farm.	68	15.0	.7036	40.0	.7698	42.0	0.8557	97.0	......	8.33	0	None.	11.6	4.0	Clinton sand.
445	Pleasantville pool, Richland Township; J. G. Ruff farm.	96	10.0	.7195	43.0	.7751	45.8	.8647	98.8	......	5.36	0	None.	10.0	4.0	Do.
	Hancock County.															
446	Findlay, Peerless Refining Co.	......	9.75	.7282	37.13	.7871	52.13	....	99.01	......	......	......	......	......	......	Bromine absorption of distillate, 110°–150° C., 0.73 p. ct.; 150°–220° C., 1.74 p. ct.; 220°–257° C., 4.84 p. ct.; 257°–300° C., 5.04 p. ct.; 300°–330° C., 12.10 p. ct.; residuum, 19.50 p. ct.
	Knox County.															
447	Bladenburg pool; Jackson Township.	75	14.0	.7201	26.0	.7973	56.3	.9063	96.3	......	4.17	0	Much	19.6	7.0	Clinton sand.

Analyses of petroleum from various parts of the United States—Continued.

Serial No.	Location of well.	Collected by—	Collected from—	Well.	Depth of well (feet).	Physical properties: Gravity at 60°F. Specific.	Physical properties: Gravity at 60°F. Baumé.	Physical properties: Color.	Physical properties: Odor.
	OHIO—continued.								
	Monroe County.								
448	Decker pool (near Lewisville), Summit Township, sec. 23; Minard Run Oil Co., Bradford, Pa.; C. B. Buchanan lease.	M. W. Crouch	Well	1	1,500	0.7955	46.0	Light green	Like Pa. oil.
449	Decker pool (near Lewisville), Summit Township, sec. 23; Henry Dillar farm; W. G. Decker, Washington, Pa.	do	do	4	1,400	.7982	45.4	Dark amber	Do.
450	Near (250 feet) Ohio No. 5; Henry Dillar farm; W. G. Decker, Washington, Pa.	do	do	2	1,480	.7977	45.5	Medium green	Do.
451	Jerusalem pool, Malaga Township; Unity Oil Co., Woodsfield; Ernest Harper lease.	do	do	1		.8373	37.2	Dark amber	Do.
452	Jerusalem pool, Sunsbury Township; W. R. Gatchell lease; Central Gas Co., Woodsfield.	do	do	1	1,200	.7848	48.4	Medium amber	Do.
453	Clarington pool, Salem Township; Sterling farm, 2 miles north of Clarington; Consolidated Oil & Gas Co., Pittsburgh, Pa,	do	do	4	1,504	.7968	45.7	do	Do.

Analyses of petroleum from various parts of the United States—Continued.

Serial No.	Location of well.	Begins to distill at (° C.)	Distillation by Engler's method. By volume. To 150° C. Cubic centimeters.	To 150° C. Specific gravity.	150°–300° C. Cubic centimeters.	150°–300° C. Specific gravity.	Residuum. Cubic centimeters.	Residuum. Specific gravity.	Total. Cubic centimeters.	Sulphur (per cent).	Paraffin (per cent).	Asphalt (per cent).	Water (per cent).	Unsaturated hydrocarbons (per cent). Crude	Unsaturated hydrocarbons (per cent). 150°–300°C.	Remarks.
	OHIO—continued.															
	Monroe County.															
448	Decker pool (near Lewisville), Summit Township, sec. 23; Minard Run Oil Co., Bradford, Pa.; C. B. Buchanan lease.	77	18.0	0.7175	38.0	0.7787	42.4	0.8653	98.4	......	2.82	0	Much	3.2	3.0	Big Injun sand.
449	Decker pool (near Lewisville), Summit Township, sec. 23; Henry Dillar farm; W. G. Deeker, Washington, Pa.	87	16.0	.7225	39.0	.7758	44.9	.8563	99.9	......	5.47	0	Much	2.8	3.0	Keener sand.
450	Near (250 feet) Ohio No. 5; Henry Dillar farm; W. G. Decker, Washington, Pa.	97	11.0	.8255	43.0	.7896	44.1	.8531	98.1	......	2.23	0	Much	......	8.0	Big Injun sand.
451	Jerusalem pool, Malaga Township; Unity Oil Co., Woodsfield; Ernest Harper lease.	100	5.0	.7815	30.0	.8195	63.6	.8589	98.6	......	5.65	......	Tr.	24.0	5.0	Keener sand.
452	Jerusalem pool, Sunsbury Township; W. R. Gatchell lease; Central Gas Co., Woodsfield.	55	19.0	.6837	35.5	.7696	43.1	.8568	97.6	......	3.60	0	......	6.8	4.0	Lime sand.
453	Clarington pool, Salem Township; Sterling farm, 2 miles north of Clarington; Consolidated Oil & Gas Co., Pittsburgh, Pa.	90	15.0	.7210	40.0	.7771	43.7	.8578	98.7	......	5.65	0	......	4.0	4.0	Lime and Keener sands.

Analyses of petroleum from various parts of the United States—Continued.

Serial No.	Location of well.	Collected by—	Collected from—	Well.	Depth of well (feet).	Physical properties.			
						Gravity at 60°F.		Color.	Odor.
						Specific.	Baumé.		
	OHIO—continued.								
	Monroe County—Continued.								
454	Graysville pool, Washington Township; Scarbraugh farm; Pure Oil Co., Woodsfield.	M. W. Crouch	Well	4		0.7782	49.9	Amber	Like Pa. oil.
455	Olive Township; C. W. Brown farm	C. W. Brown, for M. J. Munn.	do	1		.8260	39.5	Dark amber	Do.
456	Griflith pool, Center Township; Markle heirs farm; Pure Oil Co., Woodsfield.	M. W. Crouch	do	2		.7937	46.4	Light amber	Do.
457	Bethel Township, sec. 7; Weber farm; Carter Oil Co., Sisterville, W. Va.	do	do			.7739	50.9	Dark amber	Do.
	Morgan County.								
458	Milner pool; J. W. Calvert farm	do	do	1	325	.8046	44.0	Dark green	Do.
459	Milner pool; Milner farm	do	do			.8023	44.5	do	Do.
	Noble County.								
460	Macksburg field, Jefferson Township; Geo. Rue farm	do	do	3	516	.8154	41.7	do	Do.
461	Do	do	do	2	1,470	.8159	41.6	do	Do.
462	Belle Valley pool, Noble Township; Harry Barnhouse lease; Chris McKee, Belle Valley.	do	do	7	1,465	.8240	39.9	do	Do.

Analyses of petroleum from various parts of the United States—Continued.

Serial No.	Location of well.	Distillation by Engler's method: Begins to distill at (° C.)	By volume: To 150° C.: Cubic centimeters.	To 150° C.: Specific gravity.	150°–300° C.: Cubic centimeters.	150°–300° C.: Specific gravity.	Residuum: Cubic centimeters.	Residuum: Specific gravity.	Total: Cubic centimeters.	Sulphur (per cent).	Paraffin (per cent).	Asphalt (per cent).	Water (per cent).	Unsaturated hydrocarbons (per cent): Crude	Unsaturated hydrocarbons (per cent): 150°–300°C.	Remarks.
	OHIO—continued.															
	Monroe County—Continued.															
454	Graysville pool, Washington Township; Scarbraugh farm; Pure Oil Co., Woodsfield.	70	25.0	0.7020	38.0	0.7715	36.7	0.8526	99.7	......	3.35	0	......	6.0	2.0	Keener sand.
455	Olive Township; C. W. Brown farm.	67	12.0	.7290	33.0	.7934	53.5	.8663	98.5	......	11.24	0	......	22.8	5.0	
456	Griffith pool, Center Township; Markle heirs farm; Pure Oil Co., Woodsfield.	75	18.5	.7232	42.0	.7893	39.3	.8537	99.8	......	3.56	0	......	5.6	5.0	Do.
457	Bethel Township, sec. 7; Weber farm; Carter Oil Co., Sisterville, W. Va.	65	19.0	.7034	51.0	.7721	28.5	.8521	98.5	......	2.91	0	......	4.8	5.0	Firs Cow Run sand.
	Morgan County.															
458	Milner pool; J. W. Calvert farm.	74	14.5	.7137	38.5	.7815	43.6	.8669	96.6	......	5.36	0	......	11.6	5.0	Do.
459	Milner pool; Milner farm....	70	19.0	.7141	37.0	.7834	43.2	.8623	99.2	......	5.74	0	......	4.4	5.0	Peeker sand.
	Noble County.															
460	Macksburg field, Jefferson Township; Geo. R. Rue farm.	115	5.0	.7435	43.0	.7801	50.0	.8626	98.0	......	6.15	0	......	3.6	3.0	Macksburg 500-foot sand.
461	Do....................	62	15.0	.7215	30.0	.7908	51.3	.8783	96.3	......	4.86	0	......	6.0	2.0	Berea sand.
462	Belle Valley pool, Noble Township; Harry Barnhouse lease; Chris McKee, Belle Valley.	57	13.0	.7250	28.0	.7463	55.8	.8805	96.8	......	5.44	0	......	3.2	4.0	Keener sand.

Analyses of petroleum from various parts of the United States—Continued.

Serial No.	Location of well.	Collected by—	Collected from—	Well.	Depth of well (feet).	Physical properties: Gravity at 60°F. Specific.	Physical properties: Gravity at 60°F. Baumé.	Physical properties: Color.	Physical properties: Odor.
	OHIO—continued.								
	Noble County—Continued.								
463						0.8293	38.8		
	Perry County.								
464	San Toy pool, Bearfield Township; McCarty farm; Chapman lease.	M. W. Crouch	Well	3	1,260	.8240	39.9	Dark green	Like Pa. oil.
465	Crooksville pool, Harrison Township; Ohio Fuel Co. lot	J. A. Bownocker	do		3,407	.8014	44.7	Light amber	Do.
466	New Straitsville pool, Coal Township; Clancy lot	do	do		3,106	.7923	46.7	(?)	Do.
	Vinton County.								
467	Jackson Township; Clinton farm	J. A. Bownocker	Well		2,480	.7959	45.9	Medium green	Do.
	Washington County.								
468	Macksburg, Moseley farm			9	From 140-foot sand.	.8118	42.5	Light amber	

463. Soc. Chem. Indust. Jour., No. 20. Clifford Richardson. U. S. Geol. Survey Bull. 282, 1906.
468. Am. Chem. Jour., vol. 18, p. 218. Charles F. Mabery and Orton C. Dunn.

Analyses of petroleum from various parts of the United States—Continued.

Serial No.	Location of well.	Distillation by Engler's method.									Sulphur (per cent).	Paraffin (per cent).	Asphalt (per cent).	Water (per cent).	Unsaturated hydrocarbons (per cent).		Remarks.
		Begins to distill at (° C.)	By volume.														
			To 150° C.		150°–300° C.		Residuum.		Total.								
			Cubic centimeters.	Specific gravity.	Cubic centimeters.	Specific gravity.	Cubic centimeters.	Specific gravity.	Cubic centimeters.						Crude	150°–300° C.	
	OHIO—continued.																
	Noble County—Continued.																
463	....	85	23.0	0.7297	21.0	0.8014	......	....	....	0.6	......	......	......	5.0	......	Crude oil, carbon, 85 p. ct.; hydrogen, 13.80 p. ct.; oxygen and nitrogen, 0.60 p. ct. Distillate, 300°–350° C., 21 p. ct.; sp. gr., 0.8404; refractive index, 1.468; 350°–400° C., 27 p. ct.; sp. gr., 0.8643; refractive index, 1.481. Viscosity by P. R. R. pipetto 42.
	Perry County.																
464	San Toy pool, Bearfield Township; McCarty farm; Chapman lease.	60	18.0	.7230	27.0	.7981	52.2	0.8917	97.2	......	6.16	0	Tr.	8.0	5.0	Berea sand.
465	Crooksville pool, Harrison Township; Ohio Fuel Co. lot.	98	7.0	.7215	45.0	.7736	45.6	.8663	97.6	......	6.63	0	......	10.0	4.0	Clinton sand.
466	New Straitsville pool, Coal Township; Clancy lot.	80	17.5	.7141	33.0	.7753	45.7	.8706	96.2	......	8.30	0	......	10.8	6.0	Do.
	Vinton County.																
467	Jackson Township, Clinton farm.	102	4.0	.7140	51.0	.7673	43.6	.8600	98.0	......	5.62	0	0	5.6	4.0	Do.
	Washington County.																
468	Macksburg, Moseley farm...	......	a15.47	....	b45.81	....	......	....	....	......	......	......	......	......	......	Crude oil, carbon, 85 p. ct.; hydrogen, 13.77 p. ct.; nitrogen, 0.027 p. ct.; bromine absorption, 7.62 p. ct. a Up to 160° C.; b 160°–310° C.

Analyses of petroleum from various parts of the United States—Continued.

Serial No.	Location of well.	Collected by—	Collected from—	Well.	Depth of well (feet).	Physical properties.			
						Gravity at 60°F.		Color.	Odor.
						Specific.	Baumé.		
	OHIO—continued.								
	Washington County—Continued.								
469	Macksburg, Warren farm			1	From 1,500-foot sand.	0.8274	39.2	Amber	
470	Macksburg, J. S. Dunn farm			6	From 500-foot sand.	.7971	45.7	do	
471	Macksburg, McLauth farm				From 300-foot sand.	.8205	40.6	Peculiar reddish tinge.	
472	Macksburg, Moseley farm		Well	1	From 700-foot sand.	.8138	42.0	Amber	
473	Archers Fork, Ward farm		do	1	Berea grit oil.	.7939	46.4	Light amber	Like Pa. oil.
474	Germantown pool, Liberty Township; Hendershot lease, Consolidated Oil & Mining Co., Saltpeter.	M. W. Crouch	do	1	827	.8023	44.5	Medium green	Do.
475	Fifteen pool, Liberty Township	do	do		1,260	.7865	48.0	Dark amber	Do.

469. Am. Chem. Jour., vol. 18, p. 221. Charles F. Mabery and Orton C. Dunn.
470-471. Am. Chem. Jour., vol. 18, p. 219. Charles F. Mabery and Orton C. Dunn.
472. Am. Chem. Jour., vol. 18, p. 220. Charles F. Mabery and Orton C. Dunn.
473. Am. Chem. Jour., vol. 18, p. 225. Charles F. Mabery and Orton C. Dunn.

Analyses of petroleum from various parts of the United States—Continued.

Serial No.	Location of well.	Begins to distill at (° C.)	Distillation by Engler's method. By volume. To 150° C. Cubic centimeters.	To 150° C. Specific gravity.	150°–300° C. Cubic centimeters.	150°–300° C. Specific gravity.	Residuum. Cubic centimeters.	Residuum. Specific gravity.	Total. Cubic centimeters.	Sulphur (per cent).	Paraffin (per cent).	Asphalt (per cent).	Water (per cent).	Unsaturated hydrocarbons (per cent). Crude	Unsaturated hydrocarbons (per cent). 150°–300° C.	Remarks.
	OHIO—continued.															
	Washington County—Contd.															
469	Macksburg, Warren farm	......	a10.64	......	b29.17	......	......	......	......	......	......	......	......	......	......	Crude oil, carbon, 85.42 p. ct.; hydrogen, 14.59 p. ct.; nitrogen, 0.064 p. ct.; bromine absorption, 9.96 p. ct. a Up to 160° C.; b 160°–310° C.
470	Macksburg, J. S. Dunn farm	......	a20.32	......	b31.32	......	......	......	......	......	......	......	......	......	......	Crude oil, carbon, 84.19 p. ct.; hydrogen, 14.75 p. ct.; nitrogen, 0.015 p. ct.; bromine absorption, 9.46 p. ct. a Up to 160° C.; b 160°–310° C.
471	Macksburg, McLauth farm	......	a14.12	......	b33.27	......	......	......	......	......	......	......	......	......	......	Crude oil, carbon, 84.45 p. ct.; hydrogen, 13.79 p. ct.; nitrogen, 0.018 p. ct.; bromine absorption, 8.45 p. ct. a Up to 160° C.; b 160°–310° C.
472	Macksburg, Moseley farm	......	a20.69	......	b33.08	......	......	......	......	......	......	......	......	......	......	Crude oil, carbon, 84.56 p. ct.; hydrogen, 14.33 p. ct.; nitrogen, 0.038 p. ct.; bromine absorption, 5.93 p. ct. a Up to 160° C.; b 160°–310° C.
473	Archers Fork, Ward farm	......	a29.65	......	b35.32	......	......	......	......	......	......	......	......	......	......	Crude oil, carbon, 84.35 p. ct.; hydrogen, 14.72 p. ct.; nitrogen, 0.038 p. ct.; bromine absorption, 6.25 p. ct. a Up to 160° C.; b 160°–310° C.
474	Germantown pool, Liberty Township; Hendershot lease, Consolidated Oil & Mining Co., saltpeter.	65	16.0	.7175	35.0	0.7797	45.4	0.8679	96.4	......	6.43	0	......	6.0	2.0	First Cow Run sand.
475	Fifteen pool, Liberty Township.	60	20.0	.6970	37.0	.7716	42.1	.8537	99.1	......	7.25	0	......	12.4	2.0	Maxton sand.

Analyses of petroleum from various parts of the United States—Continued.

Serial No.	Location of well.	Collected by—	Collected from—	Well.	Depth of well (feet).	Physical properties.			
						Gravity at 60°F.		Color.	Odor.
						Specific.	Baumé.		
	OKLAHOMA.								
	Creek County.								
	Bird Creek and Skiatook pools:								
476	Prairie Oil & Gas Co., Tulsa, Bird Creek district	J. P. Dunlop	Pipe line			0.8626	32.3	Dark green	
477	N. Chisholm lease, Creek & Indiana Investment Co., Sperry.	do	Well	1	1,420	.8495	34.8	do	
478	Do	do	do	4	1,200	.8563	33.5	do	
	Skiatook pool:								
479	Smith lease, Shawnee Oil Co., Sperry	do	do	1	1,408	.8480	35.1	do	
480	Do	do	do	4	1,412	.8439	35.9	do	
481	Chisholm lease, Shawnee Oil Co., Sperry	do	do	2	1,466	.8328	38.1	do	
	Glenn pool:								
482	Grace Berryhill lease, Oklahoma State Oil Co., Kiefer.	do	do	9-13	1,500	.8459	35.5	Black	
483	Pittman farm, sec. 7, T. 17 N., R. 12, Argue & Compton, Tulsa.	do	do	11	1,500	.8459	35.5	do	
484	Pump station, Prairie Oil & Gas Co., Kiefer	do	Pipe line			.8464	35.4	do	
485	Thos. Berryhill lease, Indiana Oil & Gas Co., Kiefer.	do	Well	7	1,518	.8439	35.9	do	

Analyses of petroleum from various parts of the United States—Continued.

Serial No.	Location of well.	Begins to distill at (° C.)	Distillation by Engler's method. By volume. To 150° C. Cubic centimeters.	To 150° C. Specific gravity.	150°–300° C. Cubic centimeters.	150°–300° C. Specific gravity.	Residuum. Cubic centimeters.	Residuum. Specific gravity.	Total. Cubic centimeters.	Sulphur (per cent).	Paraffin (per cent).	Asphalt (per cent).	Water (per cent).	Unsaturated hydrocarbons (per cent). Crude	Unsaturated hydrocarbons (per cent). 150°–300°C.	Remarks.
	OKLAHOMA.															
	Creek County.															
	Bird Creek and Skiatook pools:															
476	Prairie Oil & Gas Co., Tulsa, Bird Creek district.	120	2.0	....	37.5	0.8070	60.6	0.9003	100.1	......	7.30	0.28	......	29.2	6	
477	N. Chisholm lease, Creek & Indiana Investment Co., Sperry.	100	7.0	0.7380	38.5	.8018	52.8	.9021	98.3	......	2.87	.62	......	29.2	9	
478	Do	122	Tr.	....	40.5	.8030	57.0	.9021	97.5	......	8.41	.42	......	14.0	11	
	Skiatook pool:															
479	Smith lease, Shawnee Oil Co., Sperry.	95	6.0	.7348	37.0	.7898	54.9	.9032	97.9	......	7.35	.23	......	14.8	7	
480	Do	98	5.0	.7440	36.0	.7858	58.8	.8997	99.8	......	9.74	.50	......	12.8	10	
481	Chisholm lease, Shawnee Oil Co., Sperry.	68	11.0	.7142	33.5	.7968	51.8	.8974	96.3	......	6.65	.14	......	13.2	10	
	Glenn pool:															
482	Grace Berryhill lease, Oklahoma State Oil Co., Kiefer.	112	7.5	.7464	42.0	.7980	50.0	.9061	99.5	......	5.41	.11	......	21.2	6	
483	Pittman farm, sec. 7, T. 17 N., R. 12, Argue & Compton, Tulsa.	105	8.5	.7566	42.0	.8001	49.9	.9032	100.4	......	6.98	.45	......	22.8	7	
484	Pump station, Prairie Oil & Gas Co., Kiefer.	100	4.5	....	46.0	.7942	49.9	.9032	100.4	......	5.99	.24	......	27.6	9	
485	Thos. Berryhill lease, Iudiana Oil & Gas Co., Kiefer.	105	8.0	.7508	44.5	.8008	48.0	.9091	100.5	......	7.53	.90	......	20.8	6	

Analyses of petroleum from various parts of the United States—Continued.

Serial No.	Location of well.	Collected by—	Collected from—	Well.	Depth of well (feet).	Physical properties. Gravity at 60°F. Specific.	Physical properties. Gravity at 60°F. Baumé.	Physical properties. Color.	Physical properties. Odor.
	OKLAHOMA—continued.								
	Creek County—Continued.								
	Glenn pool—Continued.								
486	Wm. Berryhill lease, Indiana Oil & Gas Co., Kiefer.	J. P. Dunlop	Well	15	1,529	0.8333	38.0	Black	
487	W. B. Self lease, Prairie Oil & Gas Co., Tulsa	do	do	23	1,523	.8373	37.2	do	
488	Do	do	do	7	1,553	.8424	36.2	do	
	Mounds pool.								
489	Corndoffer lease, sec. 18, T. 16, R. 12, Swasey Oil Co., Fort Worth, Tex.	do	do	1	2,340	.8631	32.2	Bright green	
	Kiowa County.								
	Gotebo pool:								
490	Ricketts lease, Whitewater Oil & Gas Co., Gotebo.	J. P. Dunlop	Well	2	365	.8480	35.1	Black	
491	Seney lease, Deering Oil & Gas Co., Gotebo	do	Tank	2	443	.8552	33.7	do	
	Marshall County.								
492	Mal-Millan Oil Co., Madill, sec. 5, T. 5. S., R. 5 E.	W. J. Reed	Well	6	420	.7887	47.5	Light green	

Analyses of petroleum from various parts of the United States—Continued.

No.	Location of well.	Begins to distill at (° C.)	Distillation by Engler's method. By volume. To 150° C. Cubic centimeters.	To 150° C. Specific gravity.	150°–300° C. Cubic centimeters.	150°–300° C. Specific gravity.	Residuum. Cubic centimeters.	Residuum. Specific gravity.	Total. Cubic centimeters.	Sulphur (per cent).	Paraffin (per cent).	Asphalt (per cent).	Water (per cent).	Unsaturated hydrocarbons (per cent). Crude	Unsaturated hydrocarbons (per cent). 150°–300° C.	Remarks.
	OKLAHOMA—continued.															
	Creek County—Continued.															
	Glenn pool—Continued.															
486	Wm. Berryhill lease, Indiana Oil & Gas Co., Kiefer.	80	11.5	0.7260	43.5	0.7964	45.3	0.9079	100.3	......	11.46	0.35	......	21.6	4	
487	W. B. Self lease, Prairie Oil & Gas Co., Tulsa.	94	10.0	.7328	41.0	.7968	47.6	.9021	98.6	......	3.12	.21	......	16.8	5	
488	Do..................	98	10.0	.7402	42.5	.7990	47.6	.9079	100.1	......	9.70	.51	......	26.4	6	
	Mounds pool:															
489	Corndoffer lease, sec. 18, T. 16, R. 12, Swasey Oil Co., Fort Worth, Tex.	175	......	....	38.5	.8126	59.9	.8992	98.4	......	8.44	.62	......	12.4	4	
	Kiowa County.															
	Gotebo pool:															
490	Ricketts lease, Whitewater Oil & Gas Co., Gotebo.	115	3.5	.7399	45.5	.7828	51.5	.9097	100.5	......	5.56	1.30	......	29.6	15	
491	Seney lease, Deering Oil & Gas Co., Gotebo.	128	2.0	....	40.0	.7884	56.9	.9186	98.9	......	5.01	.31	......	57.2	3	
	Marshall County.															
492	Mal-Millan Oil Co., Madill, sec. 5, T. 5 S., R. 5 E.	65	22.0	.7118	38.0	.7788	36.8	.8669	96.8	......	7.41	.00	......	......	......	

Analyses of petroleum from various parts of the United States—Continued.

Serial No.	Location of well.	Collected by—	Collected from—	Well.	Depth of well (feet).	Physical properties. Gravity at 60°F. Specific.	Baumé.	Color.	Odor.
	OKLAHOMA—continued.								
	Muskogee County.								
	Muskogee pool, new field:								
493	Evans lease, Julia Oil Co., Muskogee	J. P. Dunlop	Well	1	1,553	0.8328	38.1	Green	
494	Do	do	do	3	1,473	.8264	39.4	do	
495	K. Stevens lease, Success Oil and Gas Co., Muskogee.	do	do	2	1,558	.8314	38.4	do	
496	J. W. Siebold lease, Success Oil and Gas Co., Muskogee.	do	do	1	1,574	.8343	37.8	do	
497	Fort Worth Development Co. lease, of Richmond Development Co., Muskogee.	do	do	1	1,702	.8333	38.0	do	
498	G. W. Sadler lease, Huckleberry & Co., Muskogee.	do	do	3	1,735	.8348	37.7	do	
499	Prairie Oil and Gas Co., Muskogee	do	Pipe-line tank			.8358	37.5	Olive green	
	Muskogee pool, old field:								
500	Pioneer Oil and Gas Co., Muskogee	do	Well	1, 2, 3	1,000	.8216	40.4	Light olive green	
501	P. Connolly, Muskogee	do	do	Connelly	1,000	.8279	39.1	do	
502	Do	do	do	Reeves	1,000	.8328	38.1	do	

Analyses of petroleum from various parts of the United States—Continued.

Serial No.	Location of well.	Begins to distill at (°C.)	Distillation by Engler's method. By volume. To 150° C. Cubic centimeters.	To 150° C. Specific gravity.	150°–300° C. Cubic centimeters.	150°–300° C. Specific gravity.	Residuum. Cubic centimeters.	Residuum. Specific gravity.	Total. Cubic centimeters.	Sulphur (per cent).	Paraffin (per cent).	Asphalt (per cent).	Water (per cent).	Unsaturated hydrocarbons (per cent). Crude	Unsaturated hydrocarbons (per cent). 150°–300° C.	Remarks.
	OKLAHOMA—continued.															
	Muskogee County.															
	Muskogee pool, new field:															
493	Evans lease, Julia Oil Co., Muskogee.	97	11.0	0.7332	36.0	0.7960	52.8	0.8866	99.8	......	7.64	0.0	......	15.2	4	
494	Do	83	11.0	.7218	36.0	.7976	51.4	.8855	98.4	......	6.03	.0	......	16.8	5	
495	K. Stevens lease, Success Oil and Gas Co., Muskogee.	93	12.0	.7298	38.0	.7984	50.3	.8861	100.3	......	2.24	.0	......	15.2	3	
496	J. W. Siebold lease, Success Oil and Gas Co., Muskogee.	90	7.0	.7316	40.0	.7876	52.4	.8861	99.4	......	1.24	.0	......	16.8	2	
497	Fort Worth Development Co. lease, of Richmond Development Co., Muskogee.	90	11.0	.7090	37.0	.7986	51.2	.8861	99.2	......	1.52	.0	......	16.4	8	
498	G. W. Sadler lease, Huckleberry & Co., Muskogee.	98	5.0	.7410	40.0	.7828	54.6	.8855	99.6	......	6.96	.0	......	16.0	4	
499	Prairie Oil and Gas Co., Muskogee.	99	3.5	.7415	41.0	.7816	55.5	.8838	100.0	......	12.45	.0	......	17.6	2	
	Muskogee pool, old field:															
500	Pioneer Oil and Gas Co., Muskogee.	110	5.5	.7415	46.0	.7812	43.7	.8745	95.2	......	3.88	.0	......	12.0	4	
501	P. Connolly, Muskogee	115	4.0	.7520	48.0	.7856	48.4	.8750	100.4	......	2.15	.0	......	11.2	2	
502	Do	140	Tr.	....	46.0	.7810	53.2	.8745	99.2	......	4.91	.0	......	12.4	2	

Analyses of petroleum from various parts of the United States—Continued.

Serial No.	Location of well.	Collected by—	Collected from—	Well.	Physical properties.				
					Depth of well (feet).	Gravity at 60°F.		Color.	Odor.
						Specific.	Baumé.		
	OKLAHOMA—continued.								
	Nowata County.								
	Childers pool:								
503	Sec. 35, T. 27, R. 16, Susan Connor lease, New York and Pennsylvania Oil Co., Nowata.	J. P. Dunlop	Well	1	735	0.8449	35.7	Dark green	
504	Sec. 8, T. 26, R. 16, Jane Clagett lease, F. D. Bailey, Nowata.	do	do	3	750	.8439	35.9	do	
	Delaware pool:								
505	Sec. 31, T. 27, R. 16, Wolf lease, Davis & Berrian, Nowata.	do	do	1	812	.8493	34.8	Light green	
506	Sec. 33, T. 27, R. 16, Edgar Bean lease, Van Vleck & Graham Oil Co., Nowata.	do	do	4	830	.8424	36.2	Dark green	
	Delaware and Childers pools:								
507	Prairie Oil and Gas Co., Station 40, Nowata	do	Tank			.8500	34.7	Dark brown	
	Nowata and Rogers counties.								
	Shallow sand pool:								
508	Prairie Oil and Gas Co., Station 38, Nowata	J. P. Dunlop	Pipe line			.8537	34.0	Black	

Analyses of petroleum from various parts of the United States—Continued.

Serial No.	Location of well.	Begins to distill at (°C.)	Distillation by Engler's method. By volume. To 150° C. Cubic centimeters.	To 150° C. Specific gravity.	150°–300° C Cubic centimeters.	150°–300° C Specific gravity.	Residuum. Cubic centimeters.	Residuum. Specific gravity.	Total. Cubic centimeters.	Sulphur (per cent).	Paraffin (per cent).	Asphalt (per cent).	Water (per cent).	Unsaturated hydrocarbons (per cent). Crude	Unsaturated hydrocarbons (per cent). 150°–300°C.	Remarks.
	OKLAHOMA—continued.															
	Nowata County.															
	Childers pool:															
503	Sec. 35, T. 27, R. 16, Susan Connor lease, New York and Pennsylvania Oil Co., Nowata.	80	14.0	0.7415	33.0	0.8035	51.2	0.9090	98.2	......	4.51	0.75	......	38.4	10	
504	Sec. 8, T. 26, R. 16, Jane Claggett lease, F. D. Bailey, Nowata.	78	11.0	.7270	36.0	.8024	51.1	.9091	98.1	......	4.59	.93	......	22.0	7.5	
	Delaware pool:															
505	Sec. 31, T. 27, R. 16, Wolf lease, Davis & Berrian, Nowata.	65	16.5	.7435	35.0	.8195	47.4	.9156	98.9	......	4.18	1.69	......	18.4	8	
506	Sec. 33, T. 27, R. 16, Edgar Bean lease, Van Vleck & Graham Oil Co., Nowata.	81	9.0	.7182	38.5	.7966	51.6	.9138	99.1	......	8.23	1.74	......	12.8	10	
	Delaware and Childers pools:															
507	Prairie Oil and Gas Co., Station 40, Nowata.	107	3.0	....	42.0	.7918	49.8	.9103	94.8	......	4.45	.26	......	24.0	3	
	Nowata and Rogers counties.															
	Shallow sand pool:															
508	Prairie Oil and Gas Co., Station 38, Nowata.	100	7.0	.7380	39.0	.8034	53.8	.9103	99.8	......	3.04	.12	......	24.4	3	

Analyses of petroleum from various parts of the United States—Continued.

Serial No.	Location of well.	Collected by—	Collected from—	Well.	Depth of well (feet).	Physical properties. Gravity at 60°F. Specific.	Physical properties. Gravity at 60°F. Baumé.	Physical properties. Color.	Physical properties. Odor.
	OKLAHOMA—continued.								
	Okmulgee County.								
	Morris pool:								
509	Prairie Oil and Gas Co., Morris	J. P. Dunlop	Settling tank			0.8459	35.5	Light green	
510	Meridian lease, Brown Oil and Gas Co., Morris	do	Well	1	1,600	.8383	37.0	Dark green	
511	Do	do	do	4	1,600	.8403	36.6	Green	
	Bald Hill pool:								
512	Buchanan lease, Burns & Caton, Morris	do	do	1	1,680	.8531	34.1	Dark green	
513	J. W. Buchanan lease, J. Harmon, Morris	do	do	1	1,703	.8578	33.2	do	
	Osage County.								
	Bartlesville pool:								
514	Prairie Oil and Gas Co., Bartlesville	J. P. Dunop	Pipe line			.8584	33.1	Dark green	
515	Lease 31, Colliver Consolidated Oil Co., Markham & Ball, Bartlesville.	do	Well	5	1,487	.8521	34.3	Black	
516	Do	do	do	6	1,480	.8505	34.6	do	
517	Lot 32, Illuminating Oil Co., Bartlesville	do	do	20	1,500	.8547	33.8	Dark green	
	Shallow sand pool:								
518	T. 26 N., Skelton-Moore Oil Co., Bartlesville	do	do	14	1,088	.8398	36.7	Black	

Analyses of petroleum from various parts of the United States—Continued.

Serial No.	Location of well.	Begins to distill at (° C.)	To 150° C. Cubic centimeters.	To 150° C. Specific gravity.	150°–300° C. Cubic centimeters.	150°–300° C. Specific gravity.	Residuum. Cubic centimeters.	Residuum. Specific gravity.	Total. Cubic centimeters.	Sulphur (per cent).	Paraffin (per cent).	Asphalt (per cent).	Water (per cent).	Unsaturated hydrocarbons (per cent). Crude	Unsaturated hydrocarbons (per cent). 150°–300°C.	Remarks.
	OKLAHOMA—continued.															
	Okmulgee County.															
	Morris pool:															
509	Prairie Oil and Gas Co., Morris.	112	3.0	....	34.0	0.7924	62.1	0.8866	99.1	......	11.90	0	......	10.0	1	
510	Meridian lease, Brown Oil and Gas Co., Morris.	82	10.0	0.7260	30.0	.7988	57.1	.8861	97.1	......	9.46	0	......	13.6	3	
511	Do	75	13.0	.7338	31.0	.8008	56.4	.8895	100.4	......	6.75	0.10	......	13.2	8	
	Bald Hill pool:															
512	Buchanan lease, Burns & Caton, Morris.	110	5.5	.7515	36.0	.8018	58.0	.9003	99.5	......	3.43	.15	......	20.0	8	
513	J. W. Buchanan lease, J. Harmon, Morris.	131	1.5	....	35.5	.8096	62.4	.8992	99.4	......	5.70	.76	......	16.4	3	
	Osage County.															
	Bartlesville pool:															
514	Prairie Oil and Gas Co., Bartlesville.	130	3.0	.7625	39.0	.8116	58.7	.8980	100.7	......	5.27	.18	......	25.2	2	
515	Lease 31, Colliver Consolidated Oil Co., Markham & Ball, Bartlesville.	115	3.0	....	43.5	.7818	54.0	.8992	100.5	......	2.73	1.00	......	20.4	9	
516	Do	105	3.5	.7499	42.0	.7808	51.5	.9044	97.0	......	2.61	1.34	......	30.8	12	
517	Lot 32, Illuminating Oil Co., Bartlesville.	113	3.5	.7574	44.0	.7868	52.4	.9009	99.9	......	7.90	1.12	......	21.0	0	
	Shallow sand pool:															
518	T. 26 N., Skelton-Moore Oil Co., Bartlesville.	76	11.5	.7101	35.0	.7869	51.9	.9050	98.4	......	......	1.26	......	21.2	8	

Analyses of petroleum from various parts of the United States—Continued.

Serial No.	Location of well.	Collected by—	Collected from—	Well.	Depth of well (feet).	Physical properties.			
						Gravity at 60°F.		Color.	Odor.
						Specific.	Baumé.		
	OKLAHOMA—continued.								
	Pawnee County.								
	Cleveland pool:								
519	Prairie Oil & Gas Co., Cleveland station	J. P. Dunlop	Tank			0.8485	35.0	Black	
520	Center east side W. ½ S. 20, T. 21, R. 8, Minnetonka Oil Co., Cleveland.	Robert Wood	Well	Jones 2	1,352	.8363	37.4		
521	Center SW. ¼ 17-21-18, Minnetonka Oil Co., Cleveland.	do	do	Alderson 6	1,706	.8408	36.5		
522	SW. SE. 18-21-8, Minnetonka Oil Co., Cleveland	do	do	Haviland 7	1,799	.8192	40.9		
523	NW. ¼ 20-21-8, Minnetonka Oil Co., Cleveland	do	do	Jones 26	2,047	.8192	40.9		
524	NW. cor. NE. ¼ 21-21-8, Minnetonka Oil Co., Cleveland.	do	do	R. Lucas 1	2,075	.8197	40.8		
525	SW., NW. 20-21-8, Minnetonka Oil Co., Cleveland.	do	do	Jones 10	2,235	.8226	40.2		
	Cleveland pool in city limits:								
526	Laterette lease, Test Oil Co., Cleveland	J. P. Dunlop	do	16		.8516	34.4	Dark green	
527	Do	do	do	17		.8542	33.9	do	
528	Do	do	do	15		.8516	34.4	do	
529	Ohio & Indiana Oil Co., Cleveland	do	do	8-9		.8516	34.4	do	

Analyses of petroleum from various parts of the United States—Continued.

Serial No.	Location of well.	Begins to distill at (°C.)	To 150° C. Cubic centimeters.	To 150° C. Specific gravity.	150°–300° C. Cubic centimeters.	150°–300° C. Specific gravity.	Residuum. Cubic centimeters.	Residuum. Specific gravity.	Total. Cubic centimeters.	Sulphur (per cent).	Paraffin (per cent).	Asphalt (per cent).	Water (per cent).	Unsaturated hydrocarbons (per cent). Crude	Unsaturated hydrocarbons (per cent). 150°–300° C.	Remarks.
	OKLAHOMA—continued.															
	Pawnee County.															
	Cleveland pool:															
519	Prairie Oil & Gas Co., Cleveland station.	97	10.0	0.7428	37.5	0.8074	52.5	0.8980	100.0	......	6.06	0.20	......	34.8	5	
520	Center east side, W. ½ Sec. 20, T. 21, R. 8, Minnetonka Oil Co., Cleveland.	105	10.0	.741	38.5	.7923	51.1	.8963	99.6	......	5.7	0	......	......	......	Taylor sand.
521	Center SW. ¼ 17-21-18, Minnetonka Oil Co., Cleveland.	70	11.0	.7345	35.0	.8061	50.1	.8966	96.1	......	4.5	0	......	......	......	
522	SW., SE. 18-21-8, Minnetonka Oil Co., Cleveland.	78	6.0	.717	39.5	.778	50.5	.884	96.0	......	4.2	0	......	......	......	Oswego sand.
523	NW. ¼ 20-21-8, Minnetonka Oil Co., Cleveland.	80	9.0	.7145	45.0	.784	44.2	.896	98.2	......	6.1	0	......	......	......	Skinner sand.
524	NW. cor. NE. ¼ 21-21-8, Minnetonka Oil Co., Cleveland.	78	8.0	.721	43.0	.780	47.5	.896	98.5	......	4.2	0	......	......	......	Peru sand.
525	SW., NW. 20-21-8, Minnetonka Oil Co., Cleveland.	105	4.0	.7265	48.0	.774	47.8	.892	99.8	......	7.6	0	......	......	......	Bartlesville sand.
	Cleveland pool in city limits:															
526	Laterette lease, Test Oil Co., Cleveland.	100	9.5	.7794	35.0	.8166	55.4	.8980	99.9	......	7.75	.03	......	38.4	3	
527	Do	115	2.5	.7705	40.0	.8060	55.4	.8992	97.9	......	6.63	.15	......	35.2	2	
528	Do	103	7.0	.7586	36.0	.8124	56.4	.8980	99.4	......	7.86	.81	......	39.2	2	
529	Ohio & Indiana Oil Co., Cleveland.	117	4.5	.7670	39.0	.8060	55.9	.8980	99.4	......	6.62	.30	......	34.8	2	

Analyses of petroleum from various parts of the United States—Continued.

Serial No.	Location of well.	Collected by—	Collected from—	Well.	Depth of well (feet).	Physical properties. Gravity at 60°F. Specific.	Baumé.	Color.	Odor.
	OKLAHOMA—continued.								
	Pawnee County—Continued.								
	Cleveland pool, Jordan Valley Township:								
530	Cory lease, F. M. Martin, Cleveland	J. P. Dunlop	Well	1	1,157	0.8464	35.4	Dark green	
531	L. L. Corey lease, J. E. Martin, Cleveland	do	do	1	1,174	.8403	36.6	do	
532	Berger lease, Prairie Oil & Gas Co., Independence, Kans.	do	do	7	1,800	.8388	36.9	do	
533	Do	do	do	4	1,750	.8605	32.7	do	
534	Lowery lease, Louisiana Purchase Oil Co., Cleveland.	do	do	2	1,620	.8459	35.5	do	
535	Do	do	do	6	1,600	.8669	31.5	do	
	Rogers County.								
	Alluwe pool:								
536	Sec. 16, T. 24, R. 17, Horace M. Adams, Chelsea	J. P. Dunlop	Well	12	400	.8413	36.4	Dark green	
537	Do	do	do	11	400	.8413	36.4	Greenish black	
	Chelsea pool:								
538	Sec. 16, T. 24, R. 16, Steuben lease, H. M. Adams, Chelsea.	do	do	38	500	.8511	34.5	do	
539	Sec. 14, T. 24, R 16, Bennett lease, H. M. Adams, Chelsea.	do	do	1	498	.8516	34.4	Dark brown	

Analyses of petroleum from various parts of the United States—Continued.

Serial No.	Location of well.	Distillation by Engler's method.									Sulphur (per cent).	Paraffin (per cent).	Asphalt (per cent).	Water (per cent).	Unsaturated hydrocarbons (per cent).		Remarks.
		Begins to distill at (°C.)	By volume.														
			To 150° C.		150°-300° C.		Residuum.		Total.								
			Cubic centimeters.	Specific gravity.	Cubic centimeters.	Specific gravity.	Cubic centimeters.	Specific gravity.	Cubic centimeters.						Crude	150°-300°C.	
	OKLAHOMA—continued.																
	Pawnee County—Contd.																
	Cleveland pool, Jordan Valley Township:																
530	Cory lease, F. M. Martin, Cleveland.	110	5.0	0.7530	44.0	0.7992	48.8	0.8974	97.8		......	5.55	0.05	......	32.4	3	
531	L. L. Cory lease, J. E. Martin, Cleveland.	108	7.5	.7398	44.5	.7882	48.0	.8974	100.0		......	5.59	1.18	......	33.2	5	
532	Berger lease, Prairie Oil & Gas Co., Independence, Kans.	80	10.0	.7200	43.5	.7978	46.5	.9056	100.0		......	5.42	1.12	......	38.8	7	
533	Do..................	120	1.0	.7603	41.0	.8030	56.9	.8969	98.9		......	5.68	.92	......	20.4	12	
534	Lowery lease, Louisiana Purchase Oil Co., Cleveland.	85	15.5	.7452	36.0	.8119	48.5	.9032	100.0		......	4.38	.82	......	26.4	......	
535	Do..................	140	Tr.	....	39.5	.8139	60.7	.9038	100.2		......	7.26	.63	......	25.2	4	
	Rogers County.																
	Alluwe pool:																
536	Sec. 16, T. 24, R. 17, Horace M. Adams, Chelsea.	67	10.0	.7134	33.0	.7910	54.2	.9091	97.2		......	6.14	0.55	......	21.2	9	
537	Do..................	65	15.0	.7245	32.0	.7995	50.1	.9168	97.1		......	2.89	4.01	......	23.2	9	
	Chelsea pool:																
538	Sec. 16, T. 24, R. 16, Steuben lease, H. M. Adams, Chelsea.	80	13.5	.7148	31.0	.8035	54.8	.9168	99.3		......	9.10	1.26	......	26.0	8	
539	Sec. 14, T. 24, R. 16, Bennett lease, H. M. Adams, Chelsea.	97	6.0	.7206	35.0	.7924	54.6	.9272	95.6		......	4.16	2.19	......	26.4	13	

Analyses of petroleum from various parts of the United States—Continued.

Serial No.	Location of well.	Collected by—	Collected from—	Well.	Depth of well (feet).	Physical properties. Gravity at 60°F. Specific.	Baumé.	Color.	Odor.
	OKLAHOMA—continued.								
	Seminole County.								
	Wewoka pool:								
540	Wewoka Realty & Trust Co., Wewoka	J. P. Dunlop	Well	1	1,625	0.8844	28.3	Black	
	Tulsa County.								
	Red Fork pool:								
541	J. I. Yorgee lease, Robt. Galbreath, Tulsa	J. P. Dunlop	Well	3	638	.8368	37.3	Green	
542	Do	do	do	5	601	.8323	38.2	Dark green	
543	Van Yorgee lease, Robt. Galbreath, Tulsa	do	Leader pipe	1–7	1,240	.8413	36.4	do	
544	Missouri Lincoln Trust Co. lease, L. E. Mallory & Son, Tulsa.	do	Well	1	1,200	.8358	37.5	Black	
545	Pump station at Red Fork, Prairie Oil & Gas Co., Independence, Kans.	do	Pipe line			.8594	32.9	do	
	Washington County.								
	Bartlesville pool:								
546	Prairie Oil & Gas Co., Bartlesville	J. P. Dunlop	Pipe line			.8521	34.3	Dark green	
	Dewey and north of Dewey:								
547	T. 27, Williams lease, Stubbs & Lowe, Dewey	do	Well	4	1,200	.8605	32.7	do	

Analyses of petroleum from various parts of the United States—Continued.

Serial No.	Location of well.	Distillation by Engler's method.								Sulphur (per cent).	Paraffin (per cent).	Asphalt (per cent).	Water (per cent).	Unsaturated hydrocarbons (per cent).		Remarks.
		Begins to distill at (°C.)	By volume.													
			To 150° C.		150°–300° C.		Residuum.		Total.							
			Cubic centimeters.	Specific gravity.	Cubic centimeters.	Specific gravity.	Cubic centimeters.	Specific gravity.	Cubic centimeters.					Crude	150°–300°C.	
	OKLAHOMA—continued.															
	Seminole County.															
	Wewoka pool:															
540	Wewoka Realty & Trust Co., Wewoka.	128	1.5	....	30.0	0.8266	67.3	0.9067	98.8	......	6.28	0.90	......	30.0	3	
	Tulsa County.															
	Red Fork pool:															
541	J. I. Yorgee lease, Robt. Galbreath, Tulsa.	88	15.0	0.7195	36.0	.7945	48.5	.9073	99.5	......	2.60	0	......	22.4	......	
542	Do................	93	9.0	.7220	40.5	.7814	48.5	.9038	98.0	......	4.39	0	......	17.6	1	
543	Van Yorgee lease, Robt. Galbreath, Tulsa.	90	14.0	.7352	37.0	.7992	48.9	.8855	99.9	......	6.37	.05	......	22.4	2	
544	Missouri Lincoln Trust Co. lease, L. E. Mallory & Son, Tulsa.	97	8.0	.7268	44.5	.7882	47.0	.9021	99.5	......	3.92	.35	......	14.4	3	
545	Pump station at Red Fork, Prairie Oil & Gas Co., Independence, Kans.	110	4.0	.7430	38.0	.7948	55.8	.9103	97.8	......	4.88	.15	......	18.4	1	
	Washington County.															
	Bartlesville pool:															
546	Prairie Oil & Gas Co., Bartlesville.	103	8.0	.7378	37.0	.8090	54.5	.9038	99.5	......	3.75	.23	......	24.4	4	
	Dewey and north of Dewey:															
547	T. 27, Williams lease, Stubbs & Lowe, Dewey.	103	3.0	....	42.0	.8008	55.0	.9103	100.0	......	6.07	.47	......	18.8	1	

Analyses of petroleum from various parts of the United States—Continued.

Serial No.	Location of well.	Collected by—	Collected from—	Well.	Depth of well (feet).	Physical properties.			
						Gravity at 60°F.		Color.	Odor.
						Specific.	Baumé.		
	OKLAHOMA—continued.								
	Washington County—Continued.								
	Dewey and north of Dewey—Continued.								
548	Berger lease, Woodward & Roll, Dewey	J. P. Dunlop	Well	1	525	0.8772	29.6	Black	
549	McEwen lease, Stubbs & Lowe, Dewey	do	do	5	500	.8605	32.7	do	
	Webber pool:								
550	Shaler lease, Bartles Oil Co., Dewey	do	do	7	1,250	.8368	37.3	Dark green	
551	Stubbs & Lowe, Dewey	do	do	2	1,200	.8485	35.0	do	
552	(R. C. A.) Adams Oil & Gas Co., Washington, D. C.	do	do	1	1,300	.8547	33.8	do	
	PENNSYLVANIA.								
553	(Not located)					.8175	41.3		
554	Do		Pipe line			.8014	44.7		
555	Do					a.8160	41.6		

553. Dinglers' Polytech. Jour., vol. 261, pp. 29-34. C. Engler and I. Levin.
554. Soc. Chem. Indust. Jour., No. 20, p. 691. Clifford Richardson and E. C. Wallace.
555. Am. Chem. Soc. Jour., vol. 1, p. 195. A. Bourgougnon.

Analyses of petroleum from various parts of the United States—Continued.

Serial No.	Location of well.	Begins to distill at (°C.)	Distillation by Engler's method, by volume: To 150° C., Cubic centimeters	To 150° C., Specific gravity	150°–300° C., Cubic centimeters	150°–300° C., Speci gravity	Residuum, Cubic centimeters	Residuum, Specific gravity	Total, centimeters	Sulphur (per cent).	Paraffin (per cent).	Asphalt (per cent).	Water (per cent).	Unsaturated hydrocarbons (per cent): Crude	Unsaturated hydrocarbons (per cent): 150°–300° C.	Remarks.
	OKLAHOMA—continued.															
	Washington County—Contd.															
	Dewey and north of Dewey—Continued.															
548	Berger lease, Woodward & Roll, Dewey.	128	1.0	0.8549	32.0	0.7972	63.3	0.9024	96.3	......	3.50	1.43	......	38.0	2	
549	McEwen lease, Stubbs & Lowe, Dewey.	80	9.5	.7299	28.0	.7968	58.5	.9241	96.0	......	3.68	1.26	......	34.8	......	
	Webber pool:															
550	Shaler lease, Bartles Oil Co., Dewey.	70	13.0	.7214	33.0	.8008	51.9	.9067	97.9	......	3.01	.94	......	20.8	4	
551	Stubbs & Lowe, Dewey.	98	6.0	.7339	40.0	.7928	53.9	.9079	99.9	......	6.81	.99	......	20.5	11	
552	(R. C. A.) Adams Oil & Gas Co., Washington, D. C.	95	7.5	.7559	39.0	.8128	53.1	.8906	99.6	......	2.26	.85	......	30.8	14	
	PENNSYLVANIA.															
553	(Not located)................	82	21.0	....	38.25	....	40.75	....	100.0	......	......	......	......	......	......	
554	Do....................	80	21.0	.7188	41.0	.7984	37.00	....	99.0	0.06	......	......	......	......	1.8	Viscosity by P. R. R. pipette 37. Crude oil, carbon, 86.10 p. ct.; hydrogen, 13.90 p. ct. 300°–350° C., 14 p. ct.; sp. gr., 0.8338; refractive index, 1.462.
555	Do....................	......	[b]20.3	....	[c]59.7	....	......	....	100.0	......	......	......	......	......	......	[a] Sp. gr. at 0° C.; [b] up to 140° C.; [c] 140°–200° C. Composition of crude oil, carbon, 82 p. ct.; hydrogen, 14.8 p. ct.; oxygen, 3.2 p. ct. Heat of combustion, 9,963.

Analyses of petroleum from various parts of the United States—Continued.

Serial No.	Location of well.	Collected by—	Collected from—	Well.	Depth of well (feet).	Physical properties: Gravity at 60° F. Specific.	Physical properties: Gravity at 60° F. Baumé.	Physical properties: Color.	Physical properties: Odor.
	PENNSYLVANIA—continued.								
556	(Not located)					a0.8861	28.0		
557	Do					.8160	41.6		
558	Perry County, Millerstown					.7901	47.2		
559	Venango County					.8822	28.7	Dark brown	
	TEXAS.								
	Bexar County.								
560	San Antonio			Walsh		.8800	29.1	Reddish brown	
561	Do			Dullnig		.9179	22.5	do	
	Hardin County.								
	Sour Lake pool:								
562	Township 75, Cannon tract, O. T. Taber, Sour Lake.	O. T. Taber	Well	3	1,310	.9067	24.4	Dark green	Sulphur.
563	Taber Oil Co., Sour Lake	David T. Day	do	a 1	1,780	.9272	21.0	Black	Do.
564	Rodger's tract, township 81, Taber Oil Co., Sour Lake.	O. T. Taber	do	1		.9421	18.6	do	Do.
565	Graham and Gore, Sour Lake	David T. Day	do	3	1,745	.9144	23.1	do	Do.
566	Sun Co., Beaumont	do	do	2	1,020	.9352	19.7	Dark green	Do.

556. Am. Chem. Soc. Jour., vol. 1, p. 195. A. Bourgougnon.
557. Soc. Chem. Indust. Jour., No. 19, p. 123. Analysis by Bolley.
558. Am. Chem. Soc. Jour., vol. 1, p. 204. A. Bourgougnon.
559. Henry, J. T., History of petroleum. B. Silliman, analyst.
560. Texas Univ. Min. Survey Bull. 1, p. 51. O. H. Palm, analyst.
561. Texas Univ. Min. Survey Bull. 1, p. 51. S. H. Worrell.

Analyses of petroleum from various parts of the United States—Continued.

Serial No.	Location of well.	Distillation by Engler's method. Begins to distill at (°C.)	By volume. To 150° C. Cubic centimeters.	To 150° C. Specific gravity.	150°–300° C. Cubic centimeters.	150°–300° C. Specific gravity.	Residuum. Cubic centimeters.	Residuum. Specific gravity.	Total. Cubic centimeters.	Sulphur (per cent).	Paraffin (per cent).	Asphalt (per cent).	Water (per cent).	Unsaturated hydrocarbons (per cent). Crude	Unsaturated hydrocarbons (per cent). 150°–300°C.	Remarks.
	PENNSYLVANIA—continued.															
556	(Not located)	......	......	....	b12.0	....	......		....	......	......	......	......	......	......	a Sp. gr., 0° C.; b up to 280° C. Composition of crude oil, carbon, 84.9 p. ct.; hydrogen, 13.7 p. ct.; oxygen, 1.4 p. ct.
557	Do	......	19.7	....	44.77	0.792	35.52	....	99.99	......	......	......	......	......	......	(Article written by Clifford Richardson.)
558	Perry County, Millerstown	......	17.0	0.693	43.0	.765	40.0	....	100.0	......	......	......	......	......	......	Separated into 100 fractions; percentages, 17, 43, 40, are approximate; residuum, 10 p. ct.
559	Venango County	......	8.55	....	a42.78	....	b48.67	....	100.0	......	......	......	......	......	......	a 150°–270° C.; b includes loss and water.
	TEXAS.															
	Bexar County.															
560	San Antonio	......	4.73	.745	36.90	.8117	58.37	....	100.0	2.02	......	......	......	......	......	Residue, 10 p. ct.; loss, 0.30 p. ct.; fraction up to 250° C., colorless.
561	Do	......	1.10	....	a27.30	....	71.60	....	100.0	1.52	......	......	......	......	......	a 150°–275° C.; residue, 8.40 p. ct.; loss, 2.20 p. ct.
	Hardin County.															
	Sour Lake pool:															
562	Township 75, Cannon tract, O.T.Taber, Sour Lake.	95	3.0	....	31.0	.8597	65.9	0.9440	99.9	......	0	0	Tr.	31.2	11.0	Beatty sand.
563	Taber Oil Co., Sour Lake	185	......	....	20.0	.8721	79.4	.9409	99.4	......	0	.40	Tr.	46.0	9.0	
564	Rodger's tract, township 81, Taber Oil Co., Sour Lake.	187	......	....	19.0	.8761	80.4	.9472	99.4	......	0	.57	Tr.	36.4	9.0	
565	Graham and Gore, Sour Lake.	95	1.0	....	25.0	.8377	72.0	.9377	98.0	......	0	0	Tr.	31.2	11.0	
566	Sun Co., Beaumont	170	......	....	23.0	.8750	76.7	.9569	99.7	......	0	0	......	59.6	11.0	

Analyses of petroleum from various parts of the United States—Continued.

Serial No.	Location of well.	Collected by—	Collected from—	Well.	Depth of well (feet).	Physical properties.			
						Gravity at 60°F.		Color.	Odor.
						Specific.	Baumé.		
	TEXAS—continued.								
	Hardin County—Continued.								
	Sour Lake pool—Continued.								
567	Minor Oil Co. (Caprock oil from Shoestring)	David T. Day	Well	23	1,100	0.9026	25.1	Black	Sulphur.
568	Sour Lake					.9630	15.4		
569	Do					.9494	17.5	Reddish brown	
570	Saratoga pool, Rio Bravo Oil Co., Houston	David T. Day	Well	220	994	.9472	17.8	Black	Do.
571	Do	do	do	265	1,377	.9217	21.9	do	Do.
572	Gulf coast oil					.9272	21.0		
573	Batson, United Oil & Refining Co., Beaumont		Refining sample			.8878	27.7		
	Harris County.								
	Humble pool:								
574	W. S. Farish, Houston (Caprock oil)	David T. Day	Well		1,174	.9198	22.2	Black	Do.
575	Patrick Bros., Humble; shallow well	do	do		900	.9340	19.9	Dark green	Do.
	Jack County.								
576						.9211	22.0	Blackish brown	

568. Am. Chem. Jour., vol. 22, p. 489. F. C. Thiele. Texas Univ. Min. Survey Bull. 1, p. 43.
569. Soc. Chem. Indust. Jour., No. 19, p. 122. Clifford Richardson.
573. U. S. Geol. Survey Bull. 282, 1906. N. M. Fenneman.

Analyses of petroleum from various parts of the United States—Continued.

Serial No.	Location of well.	Begins to distill at (° C.)	Distillation by Engler's method. By volume. To 150° C. Cubic centimeters.	To 150° C. Specific gravity.	150°–300° C. Cubic centimeters.	150°–300° C. Specific gravity.	Residuum. Cubic centimeters.	Residuum. Specific gravity.	Total. Cubic centimeters.	Sulphur (per cent).	Paraffin (per cent).	Asphalt (per cent).	Water (per cent).	Unsaturated hydrocarbons (per cent). Crude	Unsaturated hydrocarbons (per cent). 150°–300°C.	Remarks.
	TEXAS—continued.															
	Hardin County—Continued.															
	Sour Lake pool—Continued.															
567	Minor Oil Co. (Caprock oil from Shoestring).	96	2.0	....	32.0	0.8401	65.4	0.9409	99.4	......	0	0.55	......	22.8	5.0	
568	Sour Lake..............	......	a0.1	....	21.08	.8282	78.82	....	100.0	......	......	20.0	......	......	......	a To 160° C.
569	Do..............	......	6.6	a0.8693	b15.3	.8974	c78.1	....	100.0	......	......	....	......	......	......	a At 20° C.; b 150°–175° C.; c reddish-brown maltha, very sticky. Refractive indices, a 1.474, b 1.489, c 1.500.
570	Saratoga pool, Rio Bravo Oil Co., Houston.	212	......	....	18.0	.8856	81.1	.9615	99.1	......	0	.74	Tr.	66.8	9.0	
571	Do..............	175	......	....	28.0	.8661	72.0	.9504	100.0	......	0	.59	Tr.	36.4	9.0	
572	Gulf coast oil..............	185	......	....	20.0	.8721	79.4	.9409	99.4	......	0	.40	......	46.0	......	
573	Batson, United Oil & Refining Co., Beaumont.	......	6.5	....	20.4	....	73.1	....	100.0	......	......	6.0	......	......	......	14.4 p. ct. solar oil, 46.7 p. ct. lubricating oil.
	Harris County:															
	Humble pool:															
574	W. S. Farish, Honston (Caprock oil).	118	.5	....	40.0	.8646	58.3	.9615	98.8	......	0	3.17	Tr.	26.4	5.0	
575	Patrick Bros., Humble; shallow well.	223	......	....	18.0	.8938	81.1	.9321	99.1	......	0	......	......	32.4	3.0	
	Jack County.															
576	....	137	.88	....	17.53	.8399	81.59	....	100.0	......	......	......	......	......	......	300° C. up, 68.99 p. ct.; asphalt and coke, 12.60 p. ct. Special precaution against cracking. Result of redistillation of distillate also given by which gasl ine and illuminating oil product increased by cracking.

Analyses of petroleum from various parts of the United States—Continued.

Serial No.	Location of well.	Collected by—	Collected from—	Well.	Depth of well (feet).	Physical properties.			
						Gravity at 60°F.		Color.	Odor.
						Specific.	Baumé.		
	TEXAS—continued.								
	Jefferson County.								
577	Beaumont					0.922	21.9		
578	Do					.920	22.2		
579	Do					.9115	23.6	Dark green	
580	Do					.9217	21.9		
581	Do		Well	Lucas	1,200	.9228	21.7		
582	Do			Forward Reduction Co.		.950	17.4		
583	Do					.925	21.4		
584	Do			Higgins Fuel and Oil Co.		.9103	23.8	Reddish brown	

577. U. S. Geol. Survey Mineral Resources, 1901, p. 571, 1902. Sir Boverton Redwood.
578. U. S. Geol. Survey Mineral Resources 1901, p. 571, 1902. J. E. Denton; (a) Richardson and Wallace.
579. Chem. Trade Jour., Mar. 2, 1901. Emery Manufacturing Co., Bradford, Pa.
580. U. S. Geol. Survey Bull. 282, 1906. United Oil & Refining Co., Beaumont.
581. Am. Chem. Soc. Jour., vol. 25, p. 1154. C. R. Coates and Alfred Best.
582. Am. Chem. Soc. Jour., vol. 22, p. 551. C. F. Mabery and D. M. Buck.
583. Texas Univ. Min. Survey Bull. 1, p. 76. Ledoux & Co., analysts.
584. Texas Univ. Min. Survey Bull. 1, p. 74. O. H. Palm, analyst.

Analyses of petroleum from various parts of the United States—Continued.

Serial No.	Location of well.	Distillation by Engler's method. Begins to distill at (° C.)	By volume. To 150° C. Cubic centimeters.	To 150° C. Specific gravity.	150°–300° C. Cubic centimeters.	150°–300° C. Specific gravity.	Residuum. Cubic centimeters.	Residuum. Specific gravity.	Total. Cubic centimeters.	Sulphur (per cent).	Paraffin (per cent).	Asphalt (per cent).	Water (per cent).	Unsaturated hydrocarbons (per cent). Crude	Unsaturated hydrocarbons (per cent). 150°–300° C.	Remarks.
	TEXAS—continued. *Jefferson County.*															
577	Beaumont									1.33						Viscosity, Redwood standard (188 seconds), 33.3 at 15.5° C.; fluid at 0° F. Carbonaceous residue on distillation to dryness, 4.40 p. ct.; caloric value, B. t. u., 19,388.
578	Do	83								1.75				39.00		Carbon, 84.60 p. ct.; hydrogen, 10.90 p. ct.; oxygen and nitrogen, 2.87 p. ct. Cold test, 6°F.; calorific value, B. t.u., 19,060. Carbon, 85.03 p. ct.; hydrogen, 12.30 p. ct.
579	Do		3.12		12.5		84.38		100.0							No evidence of congealing at 5° F.; 4 gallons distilled gravity of first 10-pint samples of distillates, 38.9° B., 33.1° B., 32.6° B., 31.6° B., 30.8° B., 29.3° B., 28.6° B., 27.6° B., 26.7° B. Fuel oil, 78.12 p. ct.
580	Do		1.8		17.1		81.1		100.0			7.5				Solar oil, 15.4 p. ct.; lubricating oil, 52.2 p. ct.
581	Do	150			36.0		64.0		100.0	1.96		8.0				300°–350° C., 26 p. ct.; 350° to asphalt, 30 p. ct. Large quantities H_2S evolved 115°–150° C.; B. t. u., 19,923.
582	Do									.94						Distilled in vacuo under 13mm. pressure; up to 150° C., 10 p. ct.; sp. gr., 0.8753; 150°–230° C., 32 p. ct.; sp. gr., 0.9222; 230°–300° C., 21 p. ct.; sp. gr., 0.9602; above 300° C., 37p. ct. (very thick). Sulphur by Carius method.
583	Do		a6.0	0.851	b41.5		52.5	0.8798	100.0	2.04						a Up to 200° C.; b 200°–300° C.
584	Do		2.9	.7938	39.8		57.3	.8759	100.0	2.40						B. t. u., 19,785. Heavy oil, 42.6 p. ct.; sp. gr., 0.9078; residue, 7.6 p. ct.; loss, 7 p. ct. Distillates above 617° C., 36.8 p. ct.; sp. gr., 0.9094.

Analyses of petroleum from various parts of the United States—Continued.

Serial No.	Location of well.	Collected by—	Collected from—	Well	Depth of well (feet).	Physical properties. Gravity at 60° F. Specific.	Baumé.	Color.	Odor.
	TEXAS—continued.								
	Jefferson County—Continued.								
585	Beaumont					0.9121	23.5		
586	Do		Well	Lucas		.9206	22.1	Brown opaque	
587	Do		do	do		.9121	23.5		
588	Do		do	do	From 1,130-foot sand.	.9162	22.8		
589	Do		do	do	895–899	.9218	21.9		
590	Do		do	do		.9200	22.2		
	Spindletop pool:								
591	L. P. Hammond & Co., Chicago, Ill	David T. Day	do	*b* 1	1,130	.9085	24.1	Dark green	Sulphur.
592	Wilson-Broach Co., Beaumont	do	do	*c* 3	815	.9126	23.4	do	Do.

585. Texas Univ. Min. Survey Bull. 1, p, 75. L. W. Wilkinson.
586. Franklin Inst. Jour., September, 1902. F. C. Thiele.
587. Soc. Chem. Indust. Jour., vol. 20, p. 691, 1900. Richardson and Wallace.
588, 589. Texas Univ. Min. Survey Bull. 1, p. 72. E. P. Shock, analyst.
590. Am. Chem. Soc. Jour., vol. 23, p. 264. C. F. Mabery.

Analyses of petroleum from various parts of the United States—Continued.

Serial No.	Location of well.	Distillation by Engler's method. Begins to distill at (° C.)	By volume. To 150° C. Cubic centimeters.	To 150° C. Specific gravity.	150°–300° C. Cubic centimeters.	150°–300° C. Specific gravity.	Residuum. Cubic centimeters.	Residuum. Specific gravity.	Total. Cubic centimeters.	Sulphur (per cent).	Paraffin (per cent).	Asphalt (per cent).	Water (per cent).	Unsaturated hydrocarbons (per cent). Crude	Unsaturated hydrocarbons (per cent). 150°–300° C.	Remarks.
	TEXAS—continued.															
	Jefferson County—Contd.															
585	Beaumont	......	......	......	33.7	......	......	......	......	......	......	......	......	......	......	300°–360° C., 7.5 p. ct.
586	Do	......	6.45	......	35.0 36.0	....	58.55 64.0	0.872	100.0 100.0	......	......	6.34	......	......	......	Test of kerosene, color, prime white, flash point, 120° F.; light lubricating, 21.05 p. ct.; medium lubricating, 21.05 p. ct.; heavy lubricating, 10.52 p. ct.; loss, gas, and sulphur, 5.04 p. ct.
587	Do	110	2.5	......	40.0	......	57.5	.8749	100.0	1.75	......	......	......	39.0	......	Ultimate composition: Carbon, 85.03 p. ct.; hydrogen, 12.30 p. ct.; oxygen and nitrogen, 0.92 p. ct. Volatility in open dish (7 hours), 110° C., 19.19 p. ct.; 162° C., 31.31 p. ct.; 205° C., 57.57 p. ct.
588	Do	......	[a]1.78	......	[b]44.08	......	54.14	......	100.0	......	......	......	......	......	......	*a* To 160° C.; *b* 160°–360° C.; residue, 4.24 p. ct.; loss, 5.26 p. ct.
589	Do	......	[a]1.96	......	[b]53.77	......	44.27	......	100.0	......	......	......	......	......	......	*a* To 160° C.; *b* 160°–360° C.; residue, 3.33 p. ct.; loss, 3.86 p. ct.
590	Do	......	......	......	......	......	......	......	......	2.16	......	......	......	......	......	Distilled under atmospheric pressure, 145°–200° C., 4 p. ct.; 200°–250° C., 11 p. ct. Distilled uner 14 mm. pressure, 95°–100° C., 17 p. ct.; 150°–200° C., 17 p. ct.; 200°–250° C., 51 p. ct.; residue, 15 p. ct. Nitrogen more than 1 p. ct.
	Spindletop pool:															
591	L. P. Hammond & Co., Chicago, Ill.	135	.5	......	37.0	0.8611	62.3	.9396	99.8	......	0	0	Tr.	22.8	8.0	
592	Wilson-Broach Co., Beaumont.	153	......	......	33.5	.8699	65.7	.9434	99.2	......	0	0	......	25.2	6.0	

Analyses of petroleum from various parts of the United States—Continued.

Serial No.	Location of well.	Collected by—	Collected from—	Well.	Depth of well (feet).	Physical properties.			
						Gravity at 60°F.		Color.	Odor.
						Specific.	Baumé.		
	TEXAS—continued.								
	Marion County.								
593	Caddo (La.) pool, J. M. Guffey Co., Beaumont	David T. Day	Well	Burr 1	±2,300	0.8065	43.6	Brown	Like Pa. oil.
	Medina County.								
594	Dunlay					.9031	25.0	Reddish brown	
	McLennan County.								
595	Waco					.8432	36.0		
	Navarro County.								
596	Corsicana								
597	Do					.8604	32.7	Dark brown	
598	Do					.8292	38.8	Very dark brown, opaque.	
599	Do					.8493	34.8	Dark reddish brown, green fluorescence.	
600	Do								
601	Powell pool, H. G. Johnston, Corsicana; Stout lease	H. G. Johnston	Well	7	815	.9121	23.5	Black	Aromatic.

594. Texas Univ. Min. Survey Bull. 1, p. 52. O. H. Palm, analyst.
595. Texas Univ. Min. Survey Bull. 1, p. 5. D. E. Everhart, analyst.
596. Texas Agr. Exper. Sta. Bull. 11; U. S. Geol. Survey Mineral Resources, 1897, p. 848, 1898.
597. Texas Univ. Min. Survey Bull. 1, p. 48. W. H. Harper, analyst.
598. Texas Univ. Min. Survey Bull. 1, p. 49. E. H. Ernshaw, analyst.
599. Soc. Chem. Indust. Jour., vol. 19, p. 121. Clifford Richardson.
600. Am. Chem. Jour., vol. 22, p. 489. F. C. Thiele, analyst.

Analyses of petroleum from various parts of the United States—Continued.

Serial No.	Location of well.	Begins to distill at (° C.)	To 150° C. Cubic centimeters.	To 150° C. Specific gravity.	150°–300° C. Cubic centimeters.	150°–300° C. Specific gravity.	Residuum. Cubic centimeters.	Residuum. Specific gravity.	Total. Cubic centimeters.	Sulphur (per cent).	Paraffin (per cent).	Asphalt (per cent).	Water (per cent).	Unsaturated hydrocarbons (per cent). Crude	Unsaturated hydrocarbons (per cent). 150°–300°C.	Remarks.
	TEXAS—continued.															
	Marion County.															
593	Caddo (La.) pool, J. M. Guffey & Co., Beaumont.	100	6.0	0.7305	50.5	0.7646	42.9	0.8739	99.4	......	7.02	......	......	12.8	5.0	
	Medina County.															
594	Dunlay	172	6.10	.7519	29.94	.8330	63.96	....	100.0	2.09	......	......	......	......	......	Residuum semisolid asphalt; 13.50 p. ct. of distillate colorless.
	McLennan County.															
595	Waco	......	a1.39	....	b40.03	....	c58.58	....	100.0	......	......	......	......	......	......	a Up to 205° C.; b between 205° C. and 271° C.; c principally paraffin and paraffin oil.
	Navarro County.															
596	Corsicana	80	a34.6	....	b40.0	....	25.4	....	100.0	......	......	......	......	......	......	a Up to 140° C.; b 140°–305° C. Above 305° C., 15.8 p. ct.; coke residue, 9.6 p. ct.
597	Do	77	a24.78	.755	b59.94	....	15.28	....	100.0	......	......	......	......	......	......	a Portion of fraction 77–203° F. lost before measured; b 150°–280° C. Up to 150° distillate colorless.
598	Do	54.4	a15.5	.7090	b39.75	.7881	44.75	....	100.0	......	......	......	......	......	......	a To 149° C.; b to 288° C. Distillate colorless up to 500° C.
599	Do	57	a28.0	.7819	b15.8	.8244	56.2	....	100.0	......	......	......	......	......	......	a To 151° C.; b 151°–180° C., distilled at 25 mm. pressure. Volatile: 100° C., 10.8 p. ct. naphtha; 162° C., 35.7 p. ct. naphtha; 204° C., 11.2 p. ct. naphtha. Cracking begins 175° C.
600	Do	......	10.8	.710	54.5	.796	34.7	....	100.0	......	......	......	......	......	......	
601	Powell pool, H. G. Johnston, Corsicana; Stout lease.	168	......	....	19.5	.8571	80.1	.9296	99.6	......	0	0	......	31.6	5.0	

Analyses of petroleum from various parts of the United States—Continued.

Serial No.	Location of well.	Collected by—	Collected from—	Well.	Depth of well (feet).	Physical properties. Gravity at 60°F. Specific.	Baumé.	Color.	Odor.
	TEXAS—continued.								
	Navarro County—Continued.								
602	Corsicana pool, Staley & Barnsdall, Corsicana	David T. Day	Well	13	1,000 – 1,100	0.8500	34.7	Black	Aromatic.
	Pecos County.								
603	Fort Stockton					.9250	21.4	Very dark brown, opaque.	
	Reeves County.								
	Ross pool (near Toyah):								
604		David T. Day	Well	Leatherman	265	.9079	24.2	Dark green	H_2S.
605	East of Leatherman well; Producers Oil Co., Houston.	do	do	1		.8658	31.7	do	Do.
606	Toyah					.9126	23.4	Dark brown	
	Travis County.								
607	Waters Park					.9708	14.2	Black; brown in thin layers.	

603. Texas Univ. Min. Survey Bull. 1, p. 53. O. H. Palm, analyst.
606. Texas Univ. Min. Survey Bull. 9, p. 66. O. H. Palm, analyst.
607. Texas Univ. Min. Survey Bull. 15.

Analyses of petroleum from various parts of the United States—Continued.

Serial No.	Location of well.	Distillation by Engler's method.									Sulphur (per cent).	Paraffin (per cent).	Asphalt (per cent).	Water (per cent).	Unsaturated hydrocarbons (per cent).		Remarks.
		Begins to distill at (° C.)	By volume.														
			To 150° C.		150°–300° C.		Residuum.		Total.								
			Cubic centimeters.	Specific gravity.	Cubic centimeters.	Specific gravity.	Cubic centimeters.	Specific gravity.	Cubic centimeters.						Crude	150°–300°C.	
	TEXAS—continued.																
	Navarro County—Continued.																
602	Corsicana pool, Staley & Barnsdall, Corsicana.	138	1.0	....	46.0	0.7934	51.4	0.9056	98.4	......	3.96	0.38	Tr.	15.2	3.0	
	Pecos County.																
603	Fort Stockton	......	(a)	....	(b)	....	......	....	....	......	......	......	......	......	......	[a] To 200° C.; [b] 200°–360° C. Distillate above 360° C., 27.02 p. ct.; residue, 15.54 p. ct., loss, 2.68 p. ct.
	Reeves County.																
	Ross pool (near Toyah):																
604	Leatherman well	172	......	....	23.0	.8449	76.7	.9302	99.7	......	0	0	......	28.4	6.0	
605	East of Leatherman well; Producers Oil Co., Houston.	128	6.0	0.7710	36.0	.8176	57.9	.9115	99.9	......	0	0	......	18.8	6.0	
606	Toyah	......	16.0	.7404	24.6	.8466	60.3	....	100.0	1.00	......	......	......	......	......	Oil flows at 3° F.; burning point, 230° F. B. t. u. 19,440. 325°–350° C., 50 p. ct. heavy oil, loss, 5.3 p. ct.; residue, 14 p. ct. by weight. Viscosity by Engler method 20 at 23° C.
	Travis County.																
607	Waters Park	......	......	....	58.1	.9144	......	....	....	1.26	......	......	......	......	......	B. t. u. 18,835. Distillation, 35 mm. pressure. Residue, ivory black, brilliant luster, sticky.

Analyses of petroleum from various parts of the United States—Continued.

Serial No.	Location of well.	Collected by—	Collected from—	Well.	Depth of well (feet).	Physical properties. Gravity at 60°F. Specific.	Baumé.	Color.	Odor.
	UTAH.								
	San Juan County.								
608		M. R. Campbell				0.8755	29.9	Black	
609	Goodridge townsite, E. L. Goodridge, Goodridge	E. L. Goodridge	Well	1	225	.8363	37.4	do	
610	Do	do	do	4	263	.8264	39.4	do	
611	Monumental Oil Co	E. G. Woodruff	do	Jackson	625	.8314	38.4	do	
612	South Side Oil Co	do	do	Anderson	300	.8202	40.7	do	
613	T. 42 S., R. 19 E	do	do	Arcola	600	.8388	36.9	Dark green	
	Washington County.								
614	Virgin River					.9116	23.6		
615	Do					.9144	23.1		
616	Do					.9150	23.0		
617	Do	Clarence Gerry	Well	Holohan 1		.9180	22.5	Black	Sulphur.
618	Oil City					.8333	38.0		
	Uinta County.								
619	Whiskey Run (near Dragon), Tunnel Mining Co., Dragon.	David T. Day	Tunnel			.9511	17.2	Brown	Aromatic.

614–615. The Tribune, Salt Lake City, Utah, Dec. 29, 1907.
616. Deseret Evening News, Salt Lake City, Utah, Dec. 14, 1907.
618. Henry R. Ellis, mining engineer.

Analyses of petroleum from various parts of the United States—Continued.

Serial No.	Location of well.	Distillation by Engler's method. Begins to distill at (° C.)	By volume. To 150° C. Cubic centimeters.	To 150° C. Specific gravity.	150°–300° C. Cubic centimeters.	150°–300° C. Specific gravity.	Residuum. Cubic centimeters.	Residuum. Specific gravity.	Total. Cubic centimeters.	Sulphur (per cent).	Paraffin (per cent).	Asphalt (per cent).	Water (per cent).	Unsaturated hydrocarbons (per cent). Crude	Unsaturated hydrocarbons (per cent). 150°–300°C.	Remarks.
	UTAH.															
	San Juan County.															
608	....	212	......	....	29.0	0.8283	71.5	0.9035	100.5	......	5.77	3.32	......	21.2	6.0	
609	Goodridge townsite, E. L. Goodridge, Goodridge.	90	10.0	0.7375	38.0	.7967	51.6	.8974	99.6	......	7.31	......	Tr.	......	......	
610	Do........................	70	12.0	.7245	36.0	.7941	49.3	.8974	97.3	0.26	6.09	.80	Tr.	20.4	1.0	
611	Monumental Oil Co.........	78	11.0	.7235	35.0	.7976	51.0	.8946	97.0	.18	5.29	.60	......	14.8	6.0	Stray sand.
612	South Side Oil Co...........	73	12.0	.7130	36.0	.7941	49.5	.8975	97.5	.20	3.25	.49	......	14.4	8.0	Baby or "Goodridge" sand.
613	T. 42 S., R. 19 E............	97	10.0	.7395	37.0	.8021	52.0	.8986	99.0	.40	6.79	1.11	......	19.2	6.0	Mendenhall sand.
	Washington County.															
614	Virgin River................	......	0	....	30.63	....	69.37	....	100.0	......	......	......	......	......	......	Lubricating oil, 43 p. ct.; coke and loss, 26.37 p. ct.
615	Do........................	......	......	....	......	....	......	....	100.0	1.38	......	......	......	......	......	Kerosene, 52° B., 8 p. ct.; neutral oil, 35.3° B., 20 p. ct.; 36.1° B., 40 p. ct.; 33° B., 23 p. ct. Residuum containing considerable paraffin, 9 p. ct.
616	Do........................	......	......	....	......	....	......	....	....	......	3.4	......	......	......	......	Kerosene, 11.8 p. ct.; heavy signal oil, 9.5 p. ct.; light lubricating oil, 9 p. ct.; heavy lubricating oil, 55.9 p. ct.; residuum, 7.7 p. ct.; loss, 2.1 p. ct.
617	Do........................	60	2.1	....	19.5	.784	78.4	....	100.0	.45	29.4	5.9	......	......	......	
618	Oil City....................	......	......	....	......	....	......	....	....	......	......	......	......	......	......	Naptha, 70° to 250° C., 12.5 p. ct., 63° B.; light-burning oil 250° to 400°C., 21.2 p. ct., 51° B.; heavy-burning oil, 400° to 500°C., 19.2 p. ct., 41 B.; heavy oils, 500°C. up, 43 p. ct., 33° B.
	Uinta County.															
619	Whiskey Run (near Dragon), Tunnel Mining Co., Dragon.	250	......	....	28.0	.9135	70.0	.9804	98.0	......	......	......	Tr.	......	......	

Analyses of petroleum from various parts of the United States—Continued.

Serial No.	Location of well.	Collected by—	Collected from—	Well.	Depth of well (feet).	Physical properties. Gravity at 60°F. Specific.	Baumé.	Color.	Odor.
	WEST VIRGINIA.								
	Doddridge County.								
620	Eagles Mills; Chas. Stewart	M. J. Munn	Well	8		0.7941	46.3	Dark green	Like Pa. oil.
621	One mile south of Eagles Mills; Chas. Stewart	do	do	16		.7756	50.5	Medium green	Do.
622	Sullivan pool, 1 mile west Center Point, McElroy Creek; Laura Sweeney lease; South Penn Oil Co., Oil City, Pa.	do	do	2		.7874	47.8	Dark amber	Do.
623	Morgansville pool; J. W. Allen lease; H. E. Donohue, Morgansville.	do	do	1		.8014	44.7	Medium green	Do.
	Harrison County.								
624	Shinnston pool, Clay district; E. J. Whiteman lease; South Penn Oil Co., Oil City, Pa.	David T. Day	do	3	2,015	.7977	45.5	Medium amber	Do.
	Lewis County.								
625	About 1½ miles southwest of Churchville; M. A. Egan lease; South Penn Oil Co., Oil City, Pa.	M. J. Munn	do	1		.8240	39.9	Light green	Do.
626	McDonald lease	do	do	6		.8235	40.0	Black	Do.

Analyses of petroleum from various parts of the United States—Continued.

Serial No.	Location of well.	Begins to distill at (°C.)	Distillation by Engler's method. By volume. To 150° C. Cubic centimeters.	To 150° C. Specific gravity.	150°–300° C. Cubic centimeters.	150°–300° C. Specific gravity.	Residuum. Cubic centimeters.	Residuum. Specific gravity.	Total. Cubic centimeters.	Sulphur (per cent).	Paraffin (per cent).	Asphalt (per cent).	Water (per cent).	Unsaturated hydrocarbons (per cent). Crude	Unsaturated hydrocarbons (per cent). 150°–300°C.	Remarks.
	WEST VIRGINIA.															
	Doddridge County.															
620	Eagles Mills; Chas. Stewart..	53	16.0	0.7078	40.0	0.7797	41.6	0.8679	97.6	......	5.10	0	0	10.8	5.0	Big Injun sand.
621	One mile south of Eagles Mills; Chas. Stewart.	63	20.0	.7018	38.0	.7778	36.0	.8552	*a* 94.0	......	6.30	0	0	13.2	5.0	Big Injun sand. *a* Low because of very volatile hydrocarbons.
622	Sullivan pool, 1 mile west Center Point, McElroy Creek; Laura Sweeney lease; South Penn Oil Co., Oil City, Pa.	55	19.0	.7146	40.0	.7810	37.9	.8589	96.9	......	6.02	0	0	16.0	4.0	
623	Morgansville pool; J. W. Allen lease; H. E. Donohue, Morgansville.	58	16.0	.7162	38.0	.7868	41.2	.8674	95.2	......	5.19	0	0	16.8	4.0	First Cow Run sand.
	Harrison County.															
624	Shinnston pool, Clay district; E. J. Whiteman lease; South Penn Oil Co., Oil City, Pa.	72	14.0	.7104	40.0	.7777	44.1	.8505	98.1	......	9.73	0	0	12.8	4.0	Fifty-foot sand.
	Lewis County.															
625	About 1½ miles southwest of Churchville; M. A. Egan lease; South Penn Oil Co., Oil City, Pa.	120	3.5	.7435	41.0	.7846	55.3	.8679	99.8	......	6.77	0	0	14.4	5.0	
626	McDonald lease............	80	9.5	.7260	36.0	.7865	53.8	.8739	99.3	......	7.10	0	0	18.8	5.0	Gantz sand.

Analyses of petroleum from various parts of the United States—Continued.

Serial No.	Location of well.	Collected by—	Collected from—	Well.	Depth of well (feet).	Physical properties.			
						Gravity at 60°F.		Color.	Odor.
						Specific.	Baumé.		
	WEST VIRGINIA—continued.								
	Morion County.								
627						0.8069	43.5		
	Pleasants County.								
628	Boyd heirs' farm; Horseneck	G. P. Grimsley	Well		280	.8149	41.8	Medium green	Like Pa. oil.
629	Jefferson Township; French Creek Oil Co., Marietta, Ohio.	do	do	Smith		.8173	41.3	Light green	Do.
630	Jefferson Township; French Creek Oil Co., Marietta, Ohio.	do	do	Amber		.7923	46.7	Medium green	Do.
631	McKim Township; S. Y. Ramage Oil Co., Oil City, Pa.	do	do		994	.8135	42.1	Dark green	Do.
632	Spindle Top; Schultz Farm Oil Co., St. Marys	do	do		1,040	.7896	47.3	do	Do.
633	Sugar Valley; Sherlock and Toronski, Canton, Ohio	do	do		1,443	.7861	48.1	Light green	Do.
634	Do	do	do		635	.7735	51.0	Medium green	Do.
635	Arvilla pool, Heneghan & Hanlan Oil Co., Sistersville.	do	do		615	.7883	47.6	do	Do.
636	Lytton pool; South Penn Oil Co., Oil City, Pa	do	do			.7726	51.2	Dark amber	Do.
637	Washington Township; Elmer Edmunds & Co., St. Marys.	do	do		1,260	.7756	50.5	Green	

Analyses of petroleum from various parts of the United States—Continued.

Serial No.	Location of well.	Distillation by Engler's method. Begins to distill at (° C.)	By volume. To 150° C. Cubic centimeters.	To 150° C. Specific gravity.	150°–300° C. Cubic centimeters.	150°–300° C. Specific gravity.	Residuum. Cubic centimeters.	Residuum. Specific gravity.	Total. Cubic centimeters.	Sulphur (per cent).	Paraffin (per cent).	Asphalt (per cent).	Water (per cent).	Unsaturated hydrocarbons (per cent). Crude	Unsaturated hydrocarbons (per cent). 150°–300°C.	Remarks.
	WEST VIRGINIA—continued.															
	Marion County.															
627	.....	75	15.5	0.7065	34.0	0.7865	.....	.....	.....	.....	.....	.....	.....	.....	.....	Gordon sand.
	Pleasants County.															
628	Boydheirs' farm; Horseneck.	99	17.0	.7400	35.0	.7899	47.9	0.8642	99.9	.....	6.95	0	0	4.0	4.0	Horseneck sand.
629	Jefferson Township; French Creek Oil Co., Marietta, Ohio.	140	.7	.....	48.0	.7798	50.8	.8573	99.5	.....	7.72	0	0	6.0	1.0	Maxton sand.
630	Jefferson Township; French Creek Oil Co., Marietta, Ohio.	80	22.0	.7175	36.0	.7780	40.5	.8560	98.5	.....	4.87	0	0	7.6	3.0	Do.
631	McKim Township; S. Y. Ramage Oil Co., Oil City, Pa.	119	4.0	.7475	49.0	.7811	46.2	.8642	99.2	.....	6.71	0	0	3.6	5.0	First Cow Run sand.
632	Spindle Top; Schultz Farm Oil Co., St. Marys.	73	18.0	.7160	39.5	.8003	39.7	.8607	97.2	.....	7.25	0	0	4.0	3.0	Do.
633	Sugar Valley; Sherlock and Toronski Canton, Ohio.	92	15.0	.7120	45.0	.7683	38.5	.8511	98.5	.....	6.44	0	0	6.4	3.0	Big Injun sand.
634	*Do*	73	19.0	.7040	45.0	.7690	36.0	.8492	100.0	.....	5.49	0	0	6.0	4.0	First Cow Run sand.
635	Arvilla pool; Heneghan & Hanlan Oil Co., Sistersville.	123	2.0	.....	68.0	.7623	29.7	.8413	99.7	.....	3.18	0	0	4.0	4.0	Do.
636	Lytton pool; South Penn Oil Co., Oil City, Pa.	68	24.5	.7060	37.0	.7753	34.0	.8549	[a]95.5	.....	4.87	0	0	7.6	4.0	Big Injun sand. [a]Low total because of escape of very volatile hydrocarbons.
637	Washington Township; Elmer Edmunds & Co., St. Marys.	53	20.0	.6950	41.0	.7673	35.5	.8584	96.5	.....	.....	0	.....	.....	.....	Big Injun sand.

Analyses of petroleum from various parts of the United States—Continued.

Serial No.	Location of well.	Collected by—	Collected from—	Well.	Depth of well (feet).	Physical properties. Gravity at 60°F. Specific.	Baumé.	Color.	Odor.
	WEST VIRGINIA—continued.								
	Pleasants County—Continued.								
638	Smith Bros. & Sweeney, St. Marys	G. P. Grimsley	Well		1,234	0.7883	47.6	Green	
639	Sweeney Bros. & Co., St. Marys	do	do		1,327	.8005	44.9	do	
640	Ohio & West Virginia Oil Co., St. Marys	do	do		1,330	.7865	48.0	do	
641	Do	do	do		1,365	.7865	48.0	do	
642	J. D. Dinsmoor & Co., St. Marys	do	do		1,673	.7870	47.9	do	
643	Ohio & West Virginia Oil Co., St. Marys	do	do		590	.8041	44.1	do	
644	Do	do	do		1,130	.8074	43.4	do	
645	J. D. Dinsmoor & Co., St. Marys	do	do		546	.8041	44.1	do	
646	Grant Township; N. Y. Producers' Oil Co., Belmont pool.	do	do		1,400	.7870	47.9	do	
647	Jefferson Township; Dinsmoor Oil Co., St. Marys	do	do			.7982	45.4	do	
	Ritchie County.								
648	Grant Township; Cairo Oil Co., Cairo; Moats (Cairo) Pool.	G. P. Grimsley	Well		1,717	.8895	27.4	Brown	Like Pa. oil.
649	Do	do	do		1,842	.8102	42.8	Light green	Do

Analyses of petroleum from various parts of the United States—Continued.

Serial No.	Location of well.	Begins to distill at (° C.)	Distillation by Engler's method. By volume. To 150° C. Cubic centimeters.	To 150° C. Specific gravity.	150°-300° C. Cubic centimeters.	150°-300° C. Specific gravity.	Residuum. Cubic centimeters.	Residuum. Specific gravity.	Total. Cubic centimeters.	Sulphur (per cent).	Paraffin (per cent).	Asphalt (per cent).	Water (per cent).	Unsaturated hydrocarbons (per cent). Crude	Unsaturated hydrocarbons (per cent). 150°-300°C.	Remarks.
	WEST VIRGINIA—continued.															
	Pleasants County—Contd.															
638	Smith Bros. & Sweeney, St. Marys.	73	15.0	0.7076	43.5	0.7688	39.4	0.8578	97.9	......	9.00	0	......	......	......	
639	Sweeney Bros. & Co., St. Marys.	97	14.0	.7173	42.0	.7700	43.4	.8573	99.4	......	6.68	0	......	......	......	Keener sand.
640	Ohio & West Virginia Oil Co., St. Marys.	68	18.0	.7050	39.0	.7716	39.3	.8587	96.3	......	7.86	0	......	......	......	Do.
641	Do.	59	20.0	.7080	36.0	.7744	39.1	.8600	95.1	......	8.43	0	......	......	......	Do.
642	J. D. Dinsmoor & Co., St. Marys.	70	16.5	.7111	41.0	.7694	34.5	.8573	92.0	......	5.00	0	......	......	......	Big Injun sand.
643	Ohio & West Virginia Oil Co., St. Marys.	89	18.0	.7256	39.5	.7818	42.8	.8653	100.3	......	8.92	0	......	......	......	First Cow Run sand.
644	Do.	85	16.0	.7202	37.0	.7784	46.2	.8663	99.2	......	5.46	0	......	......	......	Salt sand.
645	J. D. Dinsmoor & Co., St. Marys.	87	10.0	.7220	45.0	.7686	44.4	.8621	99.4	......	5.56	0	......	......	......	First Cow Run sand.
646	Grant Township; N. Y. Producers' Oil Co., Belmont pool.	53	27.5	.7093	33.0	.7826	36.7	.8666	97.2	......	2.45	0	......	......	......	Berea sands.
647	Jefferson Township; Dinsmoor Oil Co., St. Marys.	74	8.0	.7165	43.5	.7686	42.5	.8613	94.0	......	6.93	0	......	......	......	First Cow Run sand.
	Ritchie County.															
648	Grant Township; Cairo Oil Co., Cairo; Moats (Cairo) pool.	226	......	......	11.0	.8525	88.7	.8906	99.7	......	4.08		0	32.8	7.0	Salt sand.
649	Do.	118	6.0	.7460	46.0	.7791	48.0	.8547	100.0	......	6.30	0	0	6.0	3.0	Keener sand.

Analyses of petroleum from various parts of the United States—Continued.

Serial No.	Location of well.	Collected by—	Collected from—	Well.	Depth of well (feet).	Physical properties. Gravity at 60° F. Specific.	Baumé.	Color.	Odor.
	WEST VIRGINIA—continued.								
	Ritchie County—Continued.								
650	Grant Township; Cairo Oil Co., Cairo; Davidson (Cairo) pool.	G. P. Grimsley	Well		1,538	0.8102	42.8	Medium green	Like Pa. oil.
651	Oil Ridge pool, Grant Township; R. G. Gillespie Oil Co., Pittsburgh, Pa.	do	do			.8000	45.0	do	Do.
652	Elm Run pool, Bunnell Oil Co., Parkersburg	do	do		2,145	.8000	45.0	Medium amber	Do.
653	Volcano pool, Grant Township; Mount Farm Oil Co., Volcano.	do	do		600	.8130	42.2	Medium green	Do.
654	Long Run field, Grant Township; Bando Oil Co., Baltimore, Md.	do	do		1,588	.8037	44.2	Dark green	Do.
655	McFarlan pool, Murphy Township; Cairo Oil Co., Cairo.	do	do		1,494	.8005	44.9	do	Do.
656	Do	do	do		1,549	.7705	51.7	Light green	Do.
657	Do	do	do	Donaldson	1,534	.8149	41.8	Medium green	Do.
658	Cairo pool, Grant Township; Ellen Hall farm; Cairo Oil Co., Cairo.	do	do	1	1,654	.8154	41.7	Medium amber	Do.
659	Cairo pool, Grant Township; Cairo Oil Co., Cairo; Biddie Deem farm.	do	do	2	1,491	.8051	43.9	Dark green	Do.

Analyses of petroleum from various parts of the United States—Continued.

No.	Location of well.	Distillation by Engler's method. Begins to distill at (° C.)	By volume. To 150° C. Cubic centimeters.	To 150° C. Specific gravity.	150°–300° C. Cubic centimeters.	150°–300° C. Specific gravity.	Residuum. Cubic centimeters.	Residuum. Specific gravity.	Total. Cubic centimeters.	Sulphur (per cent).	Paraffin (per cent).	Asphalt (per cent).	Water (per cent).	Unsaturated hydrocarbons (per cent). Crude	Unsaturated hydrocarbons (per cent). 150°–300° C.	Remarks.
	WEST VIRGINIA—continued.															
	Ritchie County—Continued.															
650	Grant Township; Cairo Oil Co., Cairo; Davidson (Cairo) pool.	105	7.5	0.7310	45.5	0.7781	47.2	0.8631	100.2	......	7.84	0	0	7.2	4.0	Salt sand.
651	Oil Ridge pool, Grant Township; R. G. Gillespie Oil Co., Pittsburgh, Pa.	87	17.0	.7161	39.0	.7780	43.5	.8610	99.5	......	6.36	0	0	7.2	3.0	Do.
652	Elm Run pool; Bunnel Oil Co., Parkersburg.	93	10.0	.7175	44.0	.7717	44.9	.8610	98.9	......	9.15	0	0	6.4	4.0	Keener sand.
653	Volcano pool, Grant Township; Mount Farm Oil Co., Volcano.	115	7.0	.7360	43.0	.7762	47.7	.8906	97.7	......	7.17	0	0	7.6	3.0	Heavy oil sand.
654	Long Run field, Grant Township; Bando Oil Co., Baltimore, Md.	108	3.0	.7370	49.0	.7659	48.0	.8573	100.0	......	6.92	0	0	8.0	4.0	Salt sand.
655	McFarlan pool, Murphy Township; Cairo Oil Co., Cairo.	90	16.0	.7175	39.0	.7773	45.0	.8618	100.0	......	4.22	0	Tr.	8.4	2.0	Cairo salt sand.
656	Do....................	65	22.0	.6930	37.0	.8076	35.2	.8516	*a* 94.2	......	5.98	......	......	6.4	3.0	Cairo salt sand. *a* Low total because of escape of very volatile hydrocarbons; average of three distillations.
657	Do....................	130	2.5	.7420	46.0	.7741	51.4	.8565	99.9	......	9.05	0	......	7.6	4.0	Cairo salt sand.
658	Cairo pool, Grant Township; Ellen Hall farm; Cairo Oil Co., Cairo.	137	1.0	....	49.0	.7767	50.1	.8552	100.1	......	8.16	0	Tr.	6.0	3.0	Big Injun sand.
659	Cairo pool, Grant Township; Cairo Oil Co., Cairo; Biddie Deem farm.	90	10.0	.7235	39.5	.7761	48.1	.8610	97.6	......	9.48	0	Tr.	6.4	3.0	Cairo salt sand.

Analyses of petroleum from various parts of the United States—Continued.

Serial No.	Location of well.	Collected by—	Collected from—	Well.	Depth of well (feet).	Physical properties.			
						Gravity at 60°F.		Color.	Odor.
						Specific.	Baumé.		
	WEST VIRGINIA—continued.								
	Ritchie County—Continued.								
660	Highland pool, Clay Township; Carter Oil Co., Sistersville.	G. P. Grimsley	Well			0.7865	48.0	Light green	Like Pa. oil.
661	Whiskey Run pool, Clay Township; South Penn Oil Co., Oil City, Pa.	do	do		1,786	.7684	52.2	Medium amber	Do.
662	Wolf Pen pool, Grant Township; McBride Oil Co., Pittsburgh, Pa.	do	do		1,750	.7874	47.8	Dark green	Do.
663	Wolf Pen pool, Grant Township; Sarber Oil & Gas Co., Parkersburg.	do	do		1,950	.7804	49.4	Light green	Do.
664	Harrisville pool, Union Township; Hartman Oil Co., Pittsburgh, Pa.	do	do			.7839	48.6	Light amber	Do.
665	Harrisville pool, Union Township; Harrisville Heat & Light Co., Harrisville.	do	do		1,850	.7977	45.5	Dark amber	Do.
666	Clay Township; McKelvey Oil Co., Pittsburgh, Pa.	do	do		1,790	.7959	45.9	Medium amber	Do.
667	Flanagan pool, Union Township; Carter Oil Co., Sistersville.	do	do			.7986	45.3	Dark green	Do.
668	Inland pool, Union Township; South Penn Oil Co., Oil City, Pa.	do	do			.7986	45.3	do	Do.

Analysis of petroleum from various parts of the United States—Continued.

Serial No.	Location of well.	Distillation by Engler's method. Begins to distill at (°C.)	By volume. To 150° C. Cubic centimeters.	To 150° C. Specific gravity.	150°–300° C. Cubic centimeters.	150°–300° C. Specific gravity.	Residuum. Cubic centimeters.	Residuum. Specific gravity.	Total. Cubic centimeters.	Sulphur (per cent).	Paraffin (per cent).	Asphalt (per cent).	Water (per cent).	Unsaturated hydrocarbons (per cent). Crude	Unsaturated hydrocarbons (per cent). 150°–300°C.	Remarks.
	WEST VIRGINIA—continued.															
	Ritchie County—Continued.															
660	Highland pool, Clay Township; Carter Oil Co., Sistersville.	79	11.0	0.7045	44.0	0.7706	41.1	0.8513	96.1	......	3.61	0	Tr.	6.4	4.0	Keener sand.
661	Whiskey Run pool, Clay Township; South Penn Oil Co., Oil City, Pa.	70	24.0	.7010	37.5	.7711	34.5	.8516	96.0	......	7.37	0	Tr.	8.4	4.0	Big Injun sand
662	Wolf Pen pool, Grant Township; McBride Oil Co., Pittsburgh, Pa.	92	7.0	.7055	50.0	.7616	40.4	.8587	97.4	......	5.35	0	......	7.2	3.0	Keener sand.
663	Wolf Pen pool, Grant Township; Sarber Oil & Gas Co., Parkersburg.	84	13.5	.7000	39.0	.7638	41.8	.8495	*a* 94.3	......	5.00	0	(?)	8.4	4.0	Keener sand. *a* Low because of escape of very volatile hydrocarbons.
664	Harrisville pool, Union Township; Hartman Oil Co., Pittsburgh, Pa.	71	20.0	.7145	39.0	.7763	38.3	.8537	97.3	......	7.44	0	......	6.8	3.0	Squaw sand.
665	Harrisville pool, Union Township; Harrisville Heat & Light Co., Harrisville.	93	17.0	.7265	42.0	.7770	40.9	.8485	99.9	......	5.32	0	......	5.6	4.0	Big Injun sand.
666	Clay Township; McKelvey Oil Co., Pittsburgh, Pa.	103	6.5	.7300	53.0	.7709	40.7	.8485	100.2	......	6.52	0	......	5.6	4.0	Squaw sand.
667	Flanagan pool, Union Township; Carter Oil Co., Sistersville.	74	15.0	.7170	41.0	.7804	42.3	.8647	98.3	......	6.33	0	......	7.2	4.0	Keener sand.
668	Inland pool, Union Township; South Penn Oil Co., Oil City, Pa.	75	11.0	.7085	38.5	.7731	45.4	.8618	*a* 94.9	......	6.58	0	......	7.6	4.0	Maxton and Big Injun sand. *a* Low because of very volatile hydrocarbons.

Analyses of petroleum from various parts of the United States—Continued.

Serial No.	Location of well.	Collected by—	Collected from—	Well.	Depth of well (feet).	Physical properties.			
						Gravity at 60° F.		Color.	Odor.
						Specific.	Baumé.		
	WEST VIRGINIA—continued.								
	Ritchie County—Continued.								
669	Prunty pool, Union Township; Carter Oil Co., Sistersville.	G. P. Grimsley	Well			0.7701	51.8	Dark green	Like Pa. Oil.
670	Cairo pool, Grant Township; J. H. Hatfield lease; Cairo Oil Co., Cairo.	M. J. Munn	do	2		.8144	41.9	Medium green	Do.
	Tyler County.								
671	J. F. Ingraham. Lot No. 1	M. J. Munn	do		2,670	.8078	43.3	Medium amber	Do.
	Wood County.								
672	Pohick pool, Williams Township; Clark & Ritchie Co., Marietta, Ohio.	G. P. Grimsley	do			.8140	42.0	Dark green	Do.
673	Braz pool, Williams Township; Clark & Ritchie Co., Marietta, Ohio.	do	do		634	.7950	46.1	Medium green	Do.
674	Williams Township; Henderson Oil Co., Marietta, Ohio.	do	do		850	.8055	43.8	Brown	Do.
675	Eppelsin pool, Williams Township; Mallory Bros. and Stewart, Parkersburg.	do	do		920	.8111	42.6	Dark green	Do.
676	Union Township; McGinnis Oil Co., Williamstown	do	do		1,215	.8250	39.7	do	Do.

Analysis of petroleum from various parts of the United States—Continued.

Serial No.	Location of well.	Distillation by Engler's method. Begins to distill at (° C.)	By volume. To 150° C. Cubic centimeters.	To 150° C. Specific gravity.	150°–300° C. Cubic centimeters.	150°–300° C. Specific gravity.	Residuum. Cubic centimeters.	Residuum. Specific gravity.	Total. Cubic centimeters.	Sulphur (per cent).	Paraffin (per cent).	Asphalt (per cent).	Water (per cent).	Unsaturated hydrocarbons (per cent). Crude	Unsaturated hydrocarbons (per cent). 150°–300° C.	Remarks.
	WEST VIRGINIA—continued.															
	Ritchie County—Continued.															
669	Prunty pool, Union Township; Carter Oil Co., Sistersville.	122	3.0	0.7440	47.0	0.7771	50.5	0.8581	100.5	......	8.67	0	......	5.6	4.1	Big Injun sand.
670	Cairo pool, Grant Township; J. H. Hatfield lease; Cairo Oil Co., Cairo.	58	17.0	.7097	36.0	.7846	44.0	.8615	97.0	......	7.30	0	Tr.	......	6.0	
	Tyler County.															
671	J. F. Ingraham. Lot No. 1..	70	14.0	.7163	38.0	.7840	46.7	.8621	98.7	......	6.11	0	......	12.8	5.0	Alvy-Gordon sand.
	Wood County.															
672	Pohick pool, Williams Township; Clark & Ritchie Co., Marietta, Ohio.	97	10.0	.7190	39.0	.7766	50.3	.8679	99.3	......	5.89	0	Tr.	11.2	3.0	Macksburg and Maxton sand.
673	Braz pool, Williams Township; Clark & Ritchie Co., Marietta, Ohio.	73	10.0	.7045	42.0	.7420	44.3	.8658	98.3	......	6.32	0	Tr.	10.4	4.0	First Cow Run sand.
674	Williams Township; Henderson Oil Co., Marietta, Ohio.	98	13.0	.7245	41.0	.7776	46.2	.8608	100.2	......	5.33	0	Tr.	9.2	4.0	Do.
675	Eppelsin pool, Williams Township; Mallory Bros. and Stewart, Parkersburg.	110	3.0	.7320	47.0	.7721	47.1	.8679	97.1	......	4.99	0	Tr.	3.6	4.0	Second Cow Run sand.
676	Union Township; McGinnis Oil Co., Williamstown.	131	3.0	....	44.0	.7766	51.4	.9265	98.4	......	5.61	0	Tr.	11.2	4.0	Salt sand.

Analyses of petroleum from various parts of the United States—Continued.

Serial No.	Location of well.	Collected by—	Collected from—	Well.	Depth of well (feet).	Physical properties.			
						Gravity at 60°F.		Color.	Odor.
						Specific.	Baumé.		
	WEST VIRGINIA—continued.								
	Wood County—Continued.								
677	Union Township; McGinnis Oil Co., Williamstown.	G. P. Grimsley	Well		1,069	0.8023	44.5	Dark green	Like Pa. oil.
678	Williams Township; Consolidated Oil Co, Pittsburgh, Pa.	do	do		770	.8009	44.8	do	Do.
679	Williams Township; Lydecker Tool Co., Marietta, Ohio.	do	do			.8526	34.2	do	Do.
680	Volcano field, Walker Township (lubricating oil); canic Oil and Gas Co., Parkersburg.	do	do		350	.8750	30.0	do	Do.
681	Volcano pool, Walker Township; Volcanic Oil and Gas Co., Parkersburg.	do	do		600	.8429	36.1	do	Do.
	WYOMING.								
682	Norwood Spring					.8822	28.7		
	Big Horn County.								
683	Bighorn basin, Greybull field, 2 miles southwest of Byron; Montana-Wyoming Oil Co.	Robt. Anderson	Well	1, 2, 5	550–600	.8140	42.0	Dark amber	

682. Wyoming Ter. Geologist's Report, 1887. Louis D. Ricketts, W. H. Kent, analysts.

Analysis of petroleum from various parts of the United States—Continued.

Serial No.	Location of well.	Distillation by Engler's method.								Sulphur (per cent).	Paraffin (per cent).	Asphalt (per cent).	Water (per cent).	Unsaturated hydrocarbons (per cent).		Remarks.
		Begins to distill at (° C.)	By volume.													
			To 150° C.		150°-300° C.		Residuum.		Total.							
			Cubic centimeters.	Specific gravity.	Cubic centimeters.	Specific gravity.	Cubic centimeters.	Specific gravity.	Cubic centimeters.					Crude	150°-300° C.	
	WEST VIRGINIA—continued.															
	Wood County—Continued.															
677	Union Township; MeGinnis Oil Co., Williamstown.	70	11.5	0.7095	36.5	0.7748	47.8	0.8676	a 95.8	......	5.90	0	Tr.	12.0	4.0	Second Streak Salt sand. a Low total because of escape of very volatile hydrocarbons; average of three distillations.
678	Williams Township; Consolidated Oil Co., Pittsburgh, Pa.	87	17.0	.7205	38.0	.7766	44.3	.8615	99.3	......	5.69	0	0	10.4	3.0	First Cow Run sand.
679	Williams Township; Lydecker Tool Co., Marietta, Ohio.	170	......	....	31.0	.7949	69.1	.8807	100.1	......	8.84	0	0	0	4.0	Berea sand.
680	Volcano field, Walker Township (lubricating oil); Volcanic Oil and Gas Co., Parkersburg.	165	......	....	16.0	.8356	82.4	.8872	98.4	......	0	0	Much	21.6	5.0	Heavy oil sand.
681	Volcano pool, Walker Township; Volcano Oil and Gas Co., Parkersburg.	123	1.5	....	33.0	.7954	65.8	.8663	100.3	......	5.81	0	Much	14.0	4.0	Keener sand, heavy oil sand, Big Injun sand.
	WYOMING.															
682	Norwood Spring............	......	a5.07	.8051	b75.33	.8421	19.60	....	100.0	......	......	......	......	......	......	a 26°-130° C.; b 130°-260° C.
	Big Horn County.															
683	Bighorn basin, Greybull field, 2 miles southwest of Byron; Montana - Wyoming Oil Co.	85	8.5	.7446	56.0	.8036	33.4	.869	97.9	0.09	3.78	......	......	11.2	12.0	Colorado shale; wells close together.

Analyses of petroleum from various parts of the United States—Continued.

Serial No.	Location of well.	Collected by—	Collected from—	Well.	Depth of well (feet).	Physical properties. Gravity at 60°F. Specific.	Baume.	Color.	Odor.
	WYOMING—continued.								
	Big Horn County—Continued.								
684	SE. cor. lot 2, sec. 17, T. 52 N., R. 93 W.; bluff west of Bighorn River; Bighorn Oil & Gas Co.	Robt. Anderson	Well	1	975	0.7821	49.0	Green	
685	Do	do	do	1	*a* 350	.8235	40.0	Dark amber	
	Bonanza field:								
686	T. 49 N., R. 91 W. (Jan., 1902)		Spring			.8450	35.7	Bright green; red by transmitted light.	
687	T. 49 N., R. 91 W. (Sept. 24, 1902)		do			.8500	34.7	do	
688	Sec 13, T. 49 N., R. 91 W		Well	Henderson		.8446	35.8	Strong green fluorescence, color red.	
689	Cottonwood, T. 47 N., R. 90 W					.9020	25.2	Brownish red by transmitted light; dark green by reflected light.	
	Converse County.								
690	Douglas					.9610	15.7		
691	Do					.9210	22.0		

686, 687, 689–691. Wyoming Univ. Bull. 6 E. E. Slosson, analyst.
688. Wyoming Mines and Minerals, 1904. E. E. Slosson, analyst.

Analyses of petroleum from various parts of the United States—Continued.

Serial No.	Location of well.	Begins to distill at (° C.)	To 150° C. Cubic centimeters.	To 150° C. Specific gravity.	150°–300° C. Cubic centimeters.	150°–300° C. Specific gravity.	Residuum. Cubic centimeters.	Residuum. Specific gravity.	Total. Cubic centimeters.	Sulphur (per cent).	Paraffin (per cent).	Asphalt (per cent).	Water (per cent).	Unsaturated hydrocarbons (per cent). Crude	Unsaturated hydrocarbons (per cent). 150°–300° C.	Remarks.
	Distillation by Engler's method. By volume.															
	WYOMING—continued.															
	Big Horn County—Continued.															
684	SE. cor. lot 2, sec. 17, T. 52 N., R. 93 W.; bluff west of Bighorn River; Bighorn Oil & Gas Co	68	14.0	0.7400	42.0	0.7706	37.0	0.8516	93.0	0.005	7.04	......	......	32.4	7.0	Sand in lower part of Colorado shale.
685	Do	......	......	......	......	......	......	......	......	......	......	......	......	......	......	Colorado shale. *a* Small quantity of oil in bailer.
	Bonanza field:															
686	T. 49 N., R. 91 W. (Jan., 1902).	......	10.0	.736	*a*50.0	.8194	40.0	......	100.0	.0149	......	......	......	......	......	13° F. added on account of altitude of Laramie, Wyo. *a* 150°–310° C. 300 c. c. distilled in 10 fractions 30 c. c. each.
687	T. 49 N., R. 91 W. (Sept. 24, 1902).	......	*a*10.0	.762	*b*40.0	.8275	50.0	......	100.0	......	......	......	......	......	......	*a* 67°–164° C.; *b* 164°–304.5° C. 13° F. added on account of altitude of Laramie, Wyo. 280 c. c. distilled in 10 fractions.
688	Sec. 13, T. 49 N., R. 91 W.	......	*a*10.0	.736	*b*50.0	......	40.0	......	100.0	......	......	......	......	......	......	Paraffin 2 to 4 p. ct. *a* 80°–142° C.; *b* 142°–303° C.
689	Cottonwood, T. 47 N., R. 90 W.	......	*a*10.0	......	*b*40.0	......	50.0	......	100.0	......	......	......	......	......	......	*a* To 164° C.; *b* 164°–305.5° C.
	Converse County.															
690	Douglas	......	......	......	*a*9.81	.884	90.19	......	100.0	......	......	......	......	......	......	*a* 179.2°–315° C. 13° F. added on account of altitude of Laramie, Wyo. 480.5 grams distilled, which contained 30 grams of water.
691	Do	......	......	......	*a*54.6	.8689	45.4	......	100.0	......	......	......	......	......	......	Oil sand retorted and oil distilled. 13° F. added on account of altitude of Laramie, Wyo. *a* 177.2°–297.2° C.

Analyses of petroleum from various parts of the United States—Continued.

Serial No.	Location of well.	Collected by—	Collected from—	Well.	Depth of well (feet).	Physical properties. Gravity at 60°F. Specific.	Physical properties. Gravity at 60°F. Baumé.	Physical properties. Color.	Physical properties. Odor.
	WYOMING—continued.								
	Converse County—Continued.								
692	No. 203	V. H. Barnett	Well			0.8439	35.9	Olive green	
693	No. 6	do	do	2		.9309	20.4	Dark green	
694	No. 57, 6 miles southeast of Glenrock	do	do		600	.9743	13.7	do	
	Crook County.								
695	Belle Fourche		do			.9150	23.0	Bright red by transmitted light; dark green by reflected light.	
696	Moorcroft; Butte Crude Petroleum Co					.9390	19.1		
	Fremont County.								
697	Lander		Washakie spring			.8725	30.5	Bright red by transmitted light; green by reflected light.	
699	Do	C. H. Wegemann				.9126	23.4	Dark brown	
700	Do	do				.9121	23.5	do	
701	Do	do				.9126	23.4	do	
702	Do	do				.9091	24.0	do	
703	Do	do				.8121	42.4	Green	
704	Near Dallas, T. 30 N., R. 99 W	E. G. Woodruff	Well	3	750	.9198	22.2	Dark brown	

695. Wyoming Univ. Bull. 3. E. E. Slosson, analyst.
696. From 1906 statistical card, U. S. Geol. Survey.
697. Wyoming Univ. Bull. 2. E. E. Slosson, analyst.

Analyses of petroleum from various parts of the United States—Continued.

Serial No.	Location of well.	Begins to distill at (° C.)	Distillation by Engler's method. By volume. To 150° C. Cubic centimeters.	To 150° C. Specific gravity.	150°–300° C. Cubic centimeters.	150°–300° C. Specific gravity.	Residuum. Cubic centimeters.	Residuum. Specific gravity.	Total. Cubic centimeters.	Sulphur (per cent).	Paraffin (per cent).	Asphalt (per cent).	Water (per cent).	Unsaturated hydrocarbons (per cent). Crude	Unsaturated hydrocarbons (per cent). 150°-300°C.	Remarks.
	WYOMING—continued.															
	Converse County—Contd.															
692	No. 203	80	8.0	0.7205	38.5	0.7928	50.2	0.9340	96.7	......	2.0	......	......	......	......	
693	No. 6	235	......	....	6.0	.8605	82.2	.9434	a 88.8	......	......	......	Tr.	......	......	a Distillation sample included much sediment.
694	No. 57, 6 miles southeast of Glenrock.	225	......	....	2.0	....	97.1	.9852	99.1	......	......	......	2	......	......	
	Crook County.															
695	Belle Fourche	......	......	....	a22.38	.8485	77.62	....	100.0	0.303	......	......	......	......	......	a Up to 297° C.; burning point, 149° C. Viscosity by Engler method, 37.7 at 20° C.; freezing point, 0° C.
696	Moorcroft; Butte Crude Petroleum Co.	......	3.0	....	40.0	....	57.0	....	100.0	......	......	......	......	......	......	(Analysis made by Von Schulz & Son, Denver, Colo.)
	Fremont County.															
697	Lander	......	......	....	......	....	......	....	....	......	......	......	......	......	......	Sample had been weathered and had lost some of its lighter constituents. Viscosity 1.55 at 20° C., Engler method.
699	Do	120	2.0	....	23.5	.8041	69.9	.9543	95.4	......	.91	4.02	......	46.4	4.0	
700	Do	93	2.0	....	21.0	.8067	75.2	.9589	98.2	......	1.27	5.69	......	50.8	4.0	
701	Do	105	1.5	....	24.0	.8018	73.9	.9605	99.4	......	.90	11.04	......	58.0	4.0	
702	Do	108	2.5	....	23.0	.8047	73.1	.9589	98.6	......	.62	15.26	......	50.8	9.0	
703	Do	77	14.0	.7244	41.0	.7999	41.1	.8755	96.1	......	5.85	0	......	10.4	5.0	
704	Near Dallas, T. 30 N., R. 99 W.	93	2.5	....	22.0	....	......	....	....	......	......	......	......	50.4	......	Flask broke. Water in oil.

Analyses of petroleum from various parts of the United States—Continued.

Serial No.	Location of well.	Collected by—	Collected from—	Well.	Depth of well (feet).	Physical properties. Gravity at 60°F. Specific.	Baumé.	Color.	Odor.
	WYOMING—continued.								
	Fremont County—Continued.								
705	Near Dallas, T. 30 N., R. 99 W.	E. G. Woodruff	Well	2	400	0.9126	23.4	Dark brown	
706	Do.	do	do	10	825	.9121	23.5	do	
707	Do.	do	do	11	965	.9126	23.4	do	
708	Do.	do	do	13	697	.9091	24.0	do	
709	Popo Agie, near Lander					.9000	25.6	Almost black; red-brown by transmitted light.	
710	Big Horn Basin	C. W. Washburne.	Well			.8315	38.4	Transparent red	
711	Shoshone; T. 1 S., R. 1 E. W. M.	T. G. Burnet	Shale spring	12		.8573	33.3	Light green	
712	Do.	do	Tar spring			.9950	10.7	Black	
713	Plunkett well (near oil spring), N. ½ NE. ¼ sec. 26, T. 1 S., R. 1 E., Wind River.	E. G. Woodruff	Well		250	.8121	42.4	Light green	Like Pa. oil.
714	Do.	do	do		300	.8121	42.4	do	Do.
715	Shoshone Oil Co. No. 1	D. F. Hewett	do			.8454	35.6	Dark green	
716	Shoshone Oil Co. No. 2	do	do			.8335	37.9	Green	
717	Shoshone Basin					.9110	23.7		
718	Do.					.9450	18.2		
719	Shoshone Field					.9960	10.6	Black and thick	
720	Do.								
721	Do.					.9660	14.9		

709. Wyoming Univ. Bull. 2. E. E. Slosson, analyst; U. S. Geol. Survey Mineral Resources, 1897, 1898.
717–718. Soc. Chem. Indust. Jour., No. 6, p. 408. Sir Boverton Redwood.
719. Wyoming Univ. Bull. 2. E. E. Slosson, analyst.
720–721. Wyoming Ter. Geologist Report, 1886. Wyner and Harland, analysts.

Analyses of petroleum from various parts of the United States—Continued.

Serial No.	Location of well.	Distillation by Engler's method. Begins to distill at (° C.)	By volume. To 150° C. Cubic centimeters.	To 150° C. Specific gravity.	150°–300° C. Cubic centimeters.	150°–300° C. Specific gravity.	Residuum. Cubic centimeters.	Residuum. Specific gravity.	Total. Cubic centimeters.	Sulphur (per cent).	Paraffin (per cent).	Asphalt (per cent).	Water (per cent).	Unsaturated hydrocarbons (per cent). Crude	Unsaturated hydrocarbons (per cent). 150°–300°C.	Remarks.
	WYOMING—continued.															
	Fremont County—Continued.															
705	Near Dallas, T. 30 N., R. 99 W.	120	2.0	....	23.5	0.8041	69.9	0.9543	95.4	......	0.91	4.02	......	46.4	4.0	
706	Do	93	2.0	....	21.0	.8067	75.2	.9589	98.2	......	1.27	5.69	......	50.8	4.0	
707	Do	105	1.5	....	24.0	.8018	73.9	.9605	99.4	......	.90	11.04	......	58.0	4.0	
708	Do	108	2.5	....	23.0	.8047	73.1	.9589	98.6	......	.62	15.26	......	50.8	9.0	
709	Popo Agie, near Lander	95	2–5	....	30–40	.810–.830	......	....	....	0.66	4.0	......	......	......	......	Fire test 58° C.; viscosity by Engler method, 13.28 at 20° C. Lubricating oil, sp. gr. 0.910–0.940, 35 to 40 p. ct.; coke, 7 to 10 p. ct.
710	Big Horn Basin	77	14.0	0.7220	45.5	.7800	40.5	....	100.0	......	......	......	......	......	......	
711	Shoshone; T. 1 S., R. 1 E., W. M.	143	Tr.	....	51.0	.8271	48.7	.8929	99.7	......	......	......	......	......	......	
712	Do	......	......	....	......	....	......	....	....	......	......	......	......	......	......	
713	Plunkett well (near oil spring), N. ½ NE. ¼ sec. 26, T. 1 S., R. 1 E., Wind River.	83	13.0	.7183	40.0	.7943	45.9	.8563	98.9	......	4.51	0	......	8.4	5.0	
714	Do	77	14.0	.7244	41.0	.7994	41.1	.8755	96.1	......	5.85	0	......	10.4	5.0	
715	Shoshone Oil Co. No. 1	190	......	....	37.0	.8169	59.6	.9278	96.6	......	7.6	......	(a)	......	......	a Present.
716	Shoshone Oil Co. No. 2	169	......	....	48.0	.8009	52.4	.8696	100.4	......	8.0	0	0	......	......	
717	Shoshone Basin	......	2.5	....	27.5	....	......	....	....	......	......	......	......	......	......	Lubricating oil, 52.5 p. ct., sample 6.
718	Do	......	0	....	10.0	....	......	....	....	......	......	......	......	......	......	Lubricating oil, 72.5 p. ct., sample 7.
719	Shoshone Field	......	0	....	......	....	......	....	....	......	......	......	......	......	......	Only small quantity distilled; water in sample so that flash point not determined.
720	Do	......	0	....	17.0	.807	83.0	....	100.0	......	......	......	......	......	......	Lubricating oil, sp. gr. 0.810–0.824, 21 p. ct.; sp. gr. 0.840–0.844, 20 p. ct.; sp. gr. 0.906, 27 p. ct. Coke, 14 p. ct.
721	Do	......	0	....	......	....	......	....	100.0	......	......	......	......	......	......	Lubricating oil, sp. gr. 0.842–0.847, 19 p. ct.; sp. gr. 0.926–0.935, 45 p. ct.; sp. gr. 0.957, 12.5 p. ct. Coke, 14.5 p. ct.; loss, 9 p. ct.

Analyses of petroleum from various parts of the United States—Continued.

Serial No.	Location of well.	Collected by—	Collected from—	Well.	Depth of well (feet).	Physical properties. Gravity at 60°F. Specific.	Gravity at 60°F. Baumé.	Color.	Odor.
	WYOMING—continued.								
	Natrona County.								
722	Rattlesnake Basin					0.9920	11.1	Black	
723	Salt Creek; Pa. Oil Co		Well			.9095	23.9	Bright red by transmitted light, dark green by reflected light.	
724	Do							Green	
725	Dutch No. 1 (sample 1)	C. H. Wegemann	Well		+1,000	.8221	40.3	do	
726	Dutch No. 1 (sample 2)	do	do			.8255	39.6	do	
727	Dutch No. 1 (sample 3)	do	do			.8221	40.3	do	
728	Shannon No. 10	do	do		847	.9097	23.9	Olive green	
729	Shannon No. 12	do	do		843	.9085	24.1	Green	
730	Iba	do	do			.8314	38.4	do	
731	Stock	do	do			.8563	33.5	Dark green	
	Powder River (Tisdale field):								
731a	Oil Canyon	do	Open pit			.9180	22.5	Black	Sulphur.
732	Salt Canyon	do	Oil seep			.9056	24.6	do	
733	Do	do	Tunnel			.9106	23.75	do	
734	Trail Canyon	do	Open pit			.9150	23.0	do	
735	Oil Mountain district		Spring						
	Uinta County.								
736	Spring Valley		Well	Union Pacific					
737	Do		do	do		.8211	40.5		

722. Wyoming Ter. Geologist Report, 1886. Wyner and Harland, analysts.
723. Wyoming Univ. Bull. 1. E. E. Slosson, analyst.
724. U. S. Geol. Survey Mineral Resources, 1894, 1895. Analysis by Wilbur C. Knight.
735. Wyoming Univ. Bull. 4. E. E. Slosson, analyst.
736. U. S. Geol. Survey Bull. 285, 1906. Analysis by Theodore Price and Son.
737. U. S. Geol. Survey Bull. 285, 1906. G. W. Gray, analyst.

Analyses of petroleum from various parts of the United States—Continued.

Serial No.	Location of well.	Distillation by Engler's method. Begins to distill at (°C.)	By volume. To 150° C. Cubic centimeters.	To 150° C. Specific gravity.	150°–300° C. Cubic centimeters.	150°–300° C. Specific gravity.	Residuum. Cubic centimeters.	Residuum. Specific gravity.	Total. Cubic centimeters.	Sulphur (per cent).	Paraffin (per cent).	Asphalt (per cent).	Water (per cent).	Unsaturated hydrocarbons (per cent). Crude	Unsaturated hydrocarbons (per cent). 150°–300°C.	Remarks.
	WYOMING—continued.															
	Natrona County.															
722	Rattlesnake Basin						100.0		100.0							Lubricating oil, sp. gr. 0.854–0.860, 29.80 p. ct.; sp. gr. 0.933, 7.40 p. ct.; sp. gr. 0.950, 23 p. ct. Coke, 30 p. ct.
723	Salt Creek; Pa. Oil Co.															Distillations made in various ways. Viscosity at 20° C., 15.74, Engler method.
724	Do		1.2	0.739	12.13	0.8313	86.67		100.0							Lubricating oil, 76.765 p. ct.; coke, 3.0075 p. ct.; ash, 0.148 p. ct.; loss, 6.4816 p. ct.
725	Dutch No. 1 (sample 1)	76	8.0	.7220	38.0	.7881	49.3	0.8963	95.3		4.97			16.4	4.0	
726	Dutch No. 1 (sample 2)	76	11.0	.7210	36.0	.7934	50.0	.9088	97.0		4.91			13.2	4.0	
727	Dutch No. 1 (sample 3)	66	16.0	.7114	29.0	.7911	52.4	.8861	97.4		6.44			14.4	5.0	
728	Shannon No. 10	204			12.5	.7673	86.9	.9192	99.4		1.14			15.2	6.0	
729	Shannon No. 12	213			10.0	.8673	86.6	.9211	96.6					14.8	8.0	
730	Iba	84	11.0	.7215	34.0	.7875	54.0	.8923	99.0		5.56			13.2	4.0	
731	Stock	126	1.0		36.0	.7854	62.4	.9032	99.4		5.63			13.2	4.0	
	Powder River (Tisdale field):															
731a	Oil Canyon	190			14.0	.8546	84.3	.9302	98.3	0.38	0	2.31	0.19	33.2	6.0	
732	Salt Canyon									.27						
733	Do	240			16.5	.8498	80.6	.9226	97.1	.55	3.12	2.30	2.42	27.2	8.0	
734	Trail Canyon	210			20.5	.8541	78.7	.9356	99.2	.38	0	2.58	.10	31.6	8.0	
735	Oil Mountain district				*a*5.0	.860	95.0		100.0	.10						*a* 207°–307° C. Flash, 104° C.; fractionated into 20 portions.
	Uinta County.															
736	Spring Valley		28.0		24.0		48.0		100.0							Signal oil, 8 p. ct.; lubricating oil, 23 p. ct.; paraffin, 17 p. ct.
737	Do		19.0		35.0		46.0		100.0							Lubricating oil, 42 p. ct.; coke, 1.8 p. ct.; loss, 2 p. ct. Sample taken June 29, 1902, from car loaded Jan. 26, 1902.

Analyses of petroleum from various parts of the United States—Continued.

Serial No.	Location of well.	Collected by—	Collected from—	Well.	Depth of well (feet).	Physical properties.			
						Gravity at 60°F.		Color.	Odor.
						Specific.	Baumé.		
	WYOMING—continued.								
	Uinta County—Continued.								
738	Spring Valley		Well	Union Pacific		0.8100	42.8		
739	Spring Valley; at 650 feet, sand		do	do		.8250	39.7		
740	Spring Valley; Pittsburg-Salt Lake Oil Co		do			.8100	42.8		
741	Spring Valley					.8329	38.1	Olive green	
742	Do					.8176	41.2		
743	Sec. 10, T. 26 N., R. 113 W	A. R. Schultz	Pit			.9415	18.7	Dark brown	Oxidized.
744	Carter district		Spring			.9240	21.5	Black	
745	Twin Creek district		do			.9352	19.7	do	
	Weston County.								
746	Newcastle; near B. & M. Rwy		Spring			.9230	21.7	Red-brown by transmitted light, dark green by reflected light, opaque and viscous.	

738. U. S. Geol. Survey Bull. 285, p. 352, 1906.
739. U. S. Geol. Survey Bull. 285, 1906. Louis Falkenau, analyst.
740. U. S. Geol. Survey Bull. 285, 1906. C. F. Mabery, analyst.
741. U. S. Geol. Survey Mineral Resources, 1902, 1904. F. Salathe, analyst
742. U. S. Geol. Survey Mineral Resources, 1902, 1904. Wilbur C. Knight.
744–745. Wyoming Univ. Bull. 3. E. E. Slosson, analyst.
746. Wyoming Univ. Bull. 5. E. E. Slosson, analyst.

Analyses of petroleum from various parts of the United States—Continued.

Serial No.	Location of well.	Distillation by Engler's method. Begins to distill at (° C.)	By volume. To 150° C. Cubic centimeters.	To 150° C. Specific gravity.	150°–300° C. Cubic centimeters.	150°–300° C. Specific gravity.	Residuum. Cubic centimeters.	Residuum. Specific gravity.	Total. Cubic centimeters.	Sulphur (per cent).	Paraffin (per cent).	Asphalt (per cent).	Water (per cent).	Unsaturated hydrocarbons (per cent). Crude	Unsaturated hydrocarbons (per cent). 150°–300° C.	Remarks.
	WYOMING—continued.															
	Uinta County—Continued.															
738	Spring Valley		20–30		30–40											Paraffin, 10–20 p. ct. Fraction, 77°–130° C., sp. gr. 0.723; 130°–170° C., sp. gr. 0.754; 170°–200° C., sp. gr. 0.780; 200°–259° C., sp. gr. 0.804.
739	Spring Valley; at 650 feet, sand.		a15.0	0.740	b33.1	0.802	49.5		97.6							a 19°–150° C.; b 150°–255° C. 255°–317° C., 27.1 p. ct.; sp. gr. 0.830; bituminous soluble, 1 p. ct.; carbon and ash, 1 p. ct.
740	Spring Valley; Pittsburg-Salt Lake Oil Co.		21.3	.7179	a39.7	.8046	39.0		100.0	0.03						a 150°–305° C. 305°–350° C., 16.4 p. ct.; paraffin, 6.2 p. ct.; residue, 7.2 p. ct. Oil begins to crack at 350° C.
741	Spring Valley		27.0		25.5		47.5		100.0							Signal oil, 7 p. ct.; lubricating oil, 40.5 p. ct.
742	Do															Sample taken at first strike, fractional distillations 10 parts: 77°–130° C., 120°–170° C., 170°–200° C., 200°–259° C., 259°–292° C., 292°–320° C., 320°–350° C., 350°–370° C., 370°–380° C., 380°–400° C. Paraffin, 10–15 p. ct.
743	Sec. 10, T. 26 N., R. 113 W.	90	Tr.		34.0	.89	66.0		100.0							
744	Carter district									.10						Freezing point, 0° C. 277°–357° C., 41.9 p. ct.; sp. gr. 0.866, color dark red; 357°–372° C., 38.1 p. ct.; sp. gr. 0.867, color opaque.
745	Twin Creek district									0						277°–344° C., 54 p. ct.; sp. gr. 0.881; flash point, 62° C.; burning point, 97°. C.
	Weston County.															
746	Newcastle; near B. & M. Rwy.															Fractionally distilled into 10 portions; 107°–267° C., 267°–319° C., 319°–355° C., 355°–372° C., 372°–383° C., 383°–389° C., 389°–395° C., 395°–407° C. Contains paraffin.

Analyses of petroleum from various parts of the United States—Continued.

Serial No.	Location of well.	Collected by—	Collected from—	Well.	Depth of well (feet).	Physical properties.			
						Gravity at 60°F.		Color.	Odor.
						Specific.	Baumé.		
	WYOMING—continued.								
	Weston County—Continued.								
747	Newcastle		American spring			0.9200	22.2	Red-brown by transmitted light.	
748	Do		Middle spring			.9160	22.8	Red-brown by transmitted light, opaque and viscous.	
749	Do		Eagle spring			.9168	22.7	do	

747–749. **Wyoming Univ. Bull. 5. E. E. Slosson, analyst.**

Analyses of petroleum from various parts of the United States—Continued.

Serial No.	Location of well.	Distillation by Engler's method.									Sulphur (per cent).	Paraffin (per cent).	Asphalt (per cent).	Water (per cent).	Unsaturated hydrocarbons (per cent).		Remarks.
		Begins to distill at (°C.)	By volume.														
			To 150° C.		150°–300° C.		Residuum.		Total.								
			Cubic centimeters.	Specific gravity.	Cubic centimeters.	Specific gravity.	Cubic centimeters.	Specific gravity.	Cubic centimeters.						Crude	150°–300°C.	
	WYOMING—continued.																
	Weston County—Continued.																
747	Newcastle																Fractionally distilled into 10 portions: 107°–303° C., 303°–319° C., 319°–353° C., 353–367° C., 367°–374° C., 374°–375° C., 375°–377° C., 377°–379° C., 379°–382° C., 382°–392° C. Contains paraffin.
748	Do																Fractionally distilled: 117°–277° C., 277°–327° C., 327°–353° C., 353°–367° C., 367°–375° C., 375°–382° C., 382°–394° C. Contains paraffin.
749	Do																Burning point, 153° C. Fractionally distilled 20 portions, sp. gr. of first 8 fractions as follows: 0.868, 0.874, 0.881, 0.888, 0.892, 0.897, 0.897, 0.897; color light yellow. Viscosity by Engler method at 15.5° C., 29.43.

Analyses of petroleum from other countries.

Serial No.	Location of well.	Collected by—	Collected from—	Well.	Depth of well (feet).	Physical properties.			
						Gravity at 60°F.		Color.	Odor.
						Specific.	Baumé.		
	MEXICO.								
	Vera Cruz Province.								
750	Toplla	W. S. Cummins	Well	Sharp, No. 1	2,300	0.7839	48.6		Aromatic.
	NEW ZEALAND.								
	Gisbourne district.								
751	Gisbourne	W. L. Clayton	Well	1	655	.8642	32.0	Green	
	Tavanak district.								
752	Gisbourne	W. L. Clayton	Well	2		.8495	34.8	Brown	
	PHILIPPINE ISLANDS.								
	Province of Tayabos.								
753	East coast of Tayabos	O. A. Leary			*a* 120	.8318	38.3	Claret	
	SPAIN.								
	Province of Cadiz.								
754	Near Villa Martin	U. S. consulate at Seville.	Well		312	.7973	45.6	Light amber	
755	Do	do	do		275	.8018	44.6	do	

Analyses of petroleum from other countries—Continued.

Serial No.	Location of well.	Begins to distill at (°C.)	Distillation by Engler's method. By volume. To 150° C. Cubic centimeters.	To 150° C. Specific gravity.	150°–300° C. Cubic centimeters.	150°–300° C. Specific gravity.	Residuum. Cubic centimeters.	Residuum. Specific gravity.	Total. Cubic centimeters.	Sulphur (per cent).	Paraffin (per cent).	Asphalt (per cent).	Water (per cent).	Unsaturated hydrocarbons (per cent). Crude	Unsaturated hydrocarbons (per cent). 150°–300°C.	Remarks.
	MEXICO.															
	Vera Cruz Province.															
750	Topila	155	......	....	98.0	0.7829	2.4	....	100.4	(*a*)	Tr.	0	0	......	......	*a* Not determined.
	NEW ZEALAND.															
	Gisbourne district.															
751	Gisbourne	210	......	....	43.0	.7300	57.1	0.8923	100.1	......	8.88	......	Some.	16.4	7.0	Gray sandstone.
	Tavanak district.															
752	Gisbourne	97	10.0	0.7805	50.0	.8281	39.9	.8969	99.9	......	14.78	......	Some.	24.4	2.9	
	PHILIPPINE ISLANDS.															
	Province of Tayabos.															
753	East coast of Tayabos	100	18.0	.7698	58.0	.8304	23.5	.9498	99.5	......	......	......	......	15.2	9.0	*a* Below surface of well.
	SPAIN.															
	Province of Cadiz.															
754	Near Villa Martin	87	27.5	.7375	53.0	.8088	18.4	.8727	98.9	0	2.52	......	......	5.6	5.0	
755	Do	108	19.0	.7414	60.0	.8000	21.0	.8708	100.0	0	3.20	......	......	7.6	7.0	

UNITED STATES GEOLOGICAL SURVEY PUBLICATIONS, 1901-1913, ON THE OIL FIELDS OF THE UNITED STATES.

The following publications of the United States Geological Survey refer to the oil fields of the United States; the later papers supplement the general description of the oil and gas fields given in these reports for 1907 and 1908:

ANNUAL REPORTS.

[a] Eighth Annual Report of the United States Geological Survey, 1886-87, J. W. Powell, Director, 1889.
Pt. II, pp. 475-1063, pls. liv-lxii. $1.50.
The Trenton limestone as a source of petroleum and inflammable gas in Ohio and Indiana, by Edward Orton, pp. 475-662, pls. liv-lx.

Eleventh Annual Report of the United States Geological Survey, 1889-90, J. W. Powell, Director, 1891.
Pt. I. Geology, 757 pp., 66 pls.
The natural gas field of Indiana, by Arthur John Phinney, pp. 587-742, pls. lxii-lxvi.

[a] Nineteenth Annual Report of the United States Geological Survey, 1897-98, Charles D. Walcott, Director.
Pt. II. Papers chiefly of a theoretic nature, v, 958 pp., 172 pls., 1899. $2.65.
The Cretaceous formation of the Black Hills as indicated by the fossil plants, by L. F. Ward with the collaboration of W. P. Jenney, W. M. Fontaine, and F. H. Knowlton, pp. 521-946, pls. liii-clxxii.

[a] Twenty-second Annual Report of the United States Geological Survey, 1900-1901, Charles D. Walcott, Director, 1901.
Pt. III. Coal, oil, cement, 763 pp., 53 pls. $2.00.
The Gaines oil field of northern Pennsylvania, by M. L. Fuller, pp. 573-627, pls. xxxvi-xliii.

PROFESSIONAL PAPERS.

[a] 53. Geology and water resources of the Bighorn Basin, Wyoming, by C. A. Fisher, 72 pp., 16 pls., 1907. 60c.

[a] 56. Geography and geology of a portion of southwestern Wyoming, with special reference to coal and oil, by A. C. Veatch. 178 pp., 26 pls., 1907. 60c.

65. Geology and water resources of the northern portion of the Black Hills and adjoining regions in South Dakota and Wyoming, by N. H. Darton. 105 pp. 24 pls., 1909.

BULLETINS.

[a] 128. The Bear River formation and its characteristic fauna, by C. A. White. 108 pp., 11 pls., 1895. 15c.

184. Oil and gas fields of the western interior and northern Texas coal measures and of the Upper Cretaceous and Tertiary of the western Gulf coast, by George I. Adams. 64 pp. 10 pls., 1901. 30c.

[a] 198. The Berea grit oil sand in the Cadiz quadrangle, Ohio, by W. T. Griswold. 43 pp., 1 pl., 1902. 10c.

212. Oil fields of the Texas-Louisiana Gulf Coastal Plain, by C. W. Hayes and William Kennedy. 174 pp., 11 pls., 1903. 20c.

[a] 213. Contributions to economic geology, 1902; S. F. Emmons and C. W. Hayes, geologists in charge. 449 pp., 1903. 25c.
The petroleum fields of California, by George H. Eldridge, p. 306.
The Boulder, Colo., oil field, by N. M. Fenneman, p. 322.
Asphalt, oil, and gas in southwestern Indiana, by Myron L. Fuller, p. 333.
Structural work during 1901 and 1902 in the eastern Ohio oil fields, by W. T. Griswold, p. 336.
Oil fields of the Texas-Louisiana Gulf Coastal Plain, by C. W. Hayes, p. 345.

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[a] Geological Survey's stock of the paper is exhausted, but many of the papers marked in this way may be purchased from the Superintendent of Documents, Washington, D. C., at the prices indicated.

[a] 225. Contributions to economic geology, 1903; S. F. Emmons and C. W. Hayes, geologists in charge. 527 pp., 1 pl., 1904. 35c.
    Petroleum fields of Alaska and the Bering River coal fields, by G. C. Martin, p. 365.
    Structure of the Boulder oil field, Colorado, with records for the year 1903, by N. M. Fenneman, p. 383.
    The Hyner gas pool, Pennsylvania, by M. L. Fuller, p. 392.
    Oil and gas fields of eastern Greene County, Pa., by Ralph W. Stone, p. 396.

238. Economic geology of the Iola quadrangle, Kansas, by G. I. Adams, Erasmus Haworth, and W. R. Crane. 83 pp., 11 pls., 1904. 25c.

250. The petroleum fields of the Pacific coast of Alaska, with an account of the Bering River coal deposits, by G. C. Martin. 64 pp., 7 pls., 1905.

256. Mineral resources of the Elders Ridge quadrangle, Pennsylvania, by R. W. Stone. 86 pp., 12 pls., 1905.

259. Report on progress of investigations of mineral resources of Alaska in 1904, by A. H. Brooks and others. 196 pp., 3 pls., 1905. 15c.

[a] 260. Contributions to economic geology, 1904; by S. F. Emmons and C. W. Hayes, geologists in charge. 620 pp., 4 pls., 1905. Out of print.
    The Florence, Colo., oil field, by N. M. Fenneman, p. 436.
    Notes on the geology of the Muskogee oil field, Oklahoma, by J. A. Taff and M. K. Shaler, p. 441.
    Oil and gas in the Independence quadrangle, Kansas, by F. C. Schrader and Erasmus Haworth, p. 446.
    Oil fields of the Texas-Louisiana Gulf coast, by N. M. Fenneman, p. 459.
    Oil and asphalt prospects in Salt Lake Basin, Utah, by J. M. Boutwell, p. 468.

264. Record of deep-well drilling for 1904, by M. L. Fuller, E. F. Lines, and A. C. Veatch. 106 pp., 1905. 10c.

265. Geology of the Boulder district, Colorado, by N. M. Fenneman. 101 pp., 5 pls., 1905.

[a] 279. Mineral resources of the Kittanning and Rural Valley quadrangles, Pennsylvania, by Charles Butts. 198 pp., 11 pls., 1906.

[a] 282. Oil fields of the Texas-Louisiana Gulf Coastal Plain, by N. M. Fenneman. 146 pp., 11 pls., 1906. 20c.

[a] 285. Contributions to economic geology, 1905; S. F. Emmons and E. C. Eckel, geologists in charge. 506 pp., 13 pls., 1906. Out of print.
    The Salt Lake oil field near Los Angeles, Cal., by Ralph Arnold, p. 357.
    The Nineveh and Gordon oil sands in western Greene County, Pa., by F. G. Clapp, p. 362.

286. Economic geology of the Beaver quadrangle, Pennsylvania, by L. H. Woolsey. 132 pp., 8 pls., 1906.

[a] 296. Economic geology of the Independence quadrangle, Kansas, by F. C. Schrader and Erasmus Haworth. 74 pp., 6 pls., 1906.

[a] 298. Record of deep-well drilling for 1905, by Myron L. Fuller and Samuel Sanford. 299 pp., 1906. 25c.

[a] 300. Economic geology of the Amity quadrangle in eastern Washington County, Pa., by F. G. Clapp. 145 pp., 8 pls., 1907.

[a] 304. Oil and gas fields of Greene County, Pa., by R. W. Stone and F. G. Clapp. 110 pp., 3 pls., 1907. 45c.

[a] 309. The Santa Clara Valley, Puente Hills, and Los Angeles oil districts, southern California, by G. H. Eldridge and Ralph Arnold. 266 pp., 41 pls., 1907. 80c.

[a] 314. Report on progress of investigations of mineral resources of Alaska in 1906, by A. H. Brooks and others. 235 pp., 4 pls., 1907. 30c.

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[a] 318. Geology of oil and gas fields in Steubenville, Burgettstown, and Claysville quadrangle, Ohio, West Virginia, and Pennsylvania, by W. T. Griswold and M. J. Munn. 196 pp., 13 pls., 1907. 75c.

[a] 321. Geology and oil resources of the Summerland district, Santa Barbara County, Cal., by Ralph Arnold. 91 pp., 20 pls., 1907. 25c.

[a] 322. Geology and oil resources of the Santa Maria oil district, Santa Barbara County, Cal., by Ralph Arnold and Robert Anderson. 161 pp., 26 pls., 1907. 50c.

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[a] Geological Survey's stock of the paper is exhausted, but many of the papers marked in this way may be purchased from the Superintendent of Documents, Washington, D. C., at the prices indicated.

[a] 335. Geology and mineral resources of the Controller Bay region, Alaska, by G. C. Martin. 141 pp., 10 pls., 1908. 70c.

[a] 340. Contributions to economic geology, 1907, Part I: Metals and nonmetals except fuels. C. W. Hayes, Waldemar Lindgren, geologists in charge. 482 pp., 7 pls., 1908. 30c.

Oklahoma: Northeastern Oklahoma, by C. E. Siebenthal, pp. 210–213. California: Contra Costa County, Miner ranch field, by Ralph Arnold. Utah: Southern Utah oil field, by G. B. Richardson. Wyoming: Bighorn Basin gas fields, by C. W. Washburne; Uinta County, Labarge oil field, by A. R. Schultz, pp. 339–374.

346. Structure of the Berea oil sand in the Flushing quadrangle, Ohio, by W. T. Griswold. 30 pp., 2 pls., 1908.

[a] 350. Geology of the Rangely oil district, Rio Blanco County, Colo., with a section on the water supply, by H. S. Gale. 60 pp., 4 pls., 1908. 20c.

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364. Geology and mineral resources of the Laramie basin, Wyoming, by N. H. Darton and C. E. Siebenthal. 81 pp., 8 pls., 1909.

365. The fractionation of crude petroleum by capillary diffusion, by J. E. Gilpin and M. P. Cram. 33 pp., 1908.

381. Contributions to economic geology, 1908, Part II: Mineral fuels. M. R. Campbell, geologist in charge. 599 pp., 24 pls., 1910.

Geology and oil prospects of the Reno region, Nevada, by R. Anderson. Two areas of oil prospecting in Lyon County, western Nevada, by R. Anderson. Analyses of crude petroleum from Oklahoma and Kansas, by D. T. Day. The Madill oil pool, Oklahoma, by J. A. Taff and W. J. Reed. Development in the Boulder and Florence oil fields, Colorado, by C. W. Washburne, pp. 475–544.

[b] 392. Commercial deductions from comparisons of gasoline and alcohol tests on internal-combustion engines, by R. M. Strong. 38 pp., 1909.

[a] 394. Papers on the conservation of mineral resources. 214 pp., 12 pls., 1909.

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429. Oil and gas in Louisiana, with a brief summary of their occurrence in adjacent States, by G. D. Harris. 192 pp., 22 pls., 1910.

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Natural gas in North Dakota, by A. G. Leonard. The San Juan oil field, Utah, by H. E. Gregory. Gas and oil prospects near Vale, Oreg., and Payette, Idaho, by C. W. Washburne. Gas prospects in the Harney Valley, Oregon, by C. W. Washburne. Preliminary report on the geology and oil prospects of the Cantua-Panoche region, California, by Robert Anderson.

450. Mineral resources of the Llano-Burnet region, Texas, with an account of the pre-Cambrian geology, by Sidney Paige. 103 pp., 5 pls., 1911.

[a] 452. The Lander and Salt Creek oil fields, Wyoming. The Lander oil field, Fremont County, by E. G. Woodruff; The Salt Creek oil field, Natrona County, by C. H. Wegemann. 87 pp., 12 pls., 1911. 30c.

454. Coal, oil, and gas of the Foxburg quadrangle, Pennsylvania, by E. W. Shaw and M. J. Munn. 85 pp., 10 pls., 1911.

456. Geology of the oil and gas fields of the Carnegie quadrangle, Pennsylvania, by M. J. Munn. 99 pp., 5 pls., 1911.

467. Geology and mineral resources of parts of Alaska Peninsula, by W. W. Atwood. 137 pp., 14 pls., 1911.

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471. Contribution to economic geology (short papers and preliminary reports), 1910. Part II: Mineral fuels. M. R. Campbell, geologist in charge. 663 pp., 62 pls., 1912.

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475. Diffusion of petroleum through fuller's earth, by J. Elliott Gilpin and O. E. Bransky. 50 pp., 1911.

[a] 491. The data of geochemistry (second edition), by F. W. Clarke. 782 pp., 1911. 70c.

531. Contributions to economic geology (short papers and preliminary reports), 1911. Part II: Mineral fuels. M. R. Campbell, geologist in charge. 68 pp., 6 pls., 1913.

The Menifee gas field and Ragland oil field, Kentucky, by M. J. Munn. Oil and gas development in north-central Oklahoma, by R. H. Wood. Geology and petroleum resources of the De Beque oil field, Colorado, by E. G. Woodruff. Geologic structure of the Punxsutawney, Curwensville, Houtzdale, Barnesboro, and Patton quadrangles, central Pennsylvania, by G. H. Ashley and M. R. Campbell.

541. Contributions to economic geology (short papers and preliminary reports), 1912. Part II: Mineral fuels. M. R. Campbell, geologist in charge.

Oil and gas in the northern part of the Cadiz quadrangle, Ohio, by D. D. Condit. Gas from mud lumps at the mouth of the Mississippi, by E. W. Shaw. Structure of the Fort Smith-Poteau gas field, Arkansas-Oklahoma, by C. D. Smith. The Glenn oil and gas pool and vicinity, Oklahoma, by C. D. Smith. The Douglas oil and gas field, Converse County, Wyo., V. H. Barnet. The Shoshone River section, Wyoming, by D. F. Hewett. Oil and gas near Green River, Grand County, Utah, by C. T. Lupton. Petroleum near Dayton, N. Mex., by G. B. Richardson. Reconnaissance of the Barstow-Kramer region, California, by R. W. Pack.

543. Geology and geography of a portion of Lincoln County, Wyo., by A. R. Schultz. 141 pp., 11 pls., 1914.

547. Reconnaissance of the Grandfield district, Oklahoma, by M. J. Munn. 85 pp., 5 pls., 1914.

579. Reconnaissance of oil and gas fields in Wayne and McCreary counties, Ky., by M. J. Munn. 105 pp., 6 pls., 1914.

581. Contributions to economic geology (short papers and preliminary r ports). 1913. Part II: Mineral fuels. M. R. Campbell, geologist in charge. 1914.

Three advance chapters issued as indicated below; others to follow: (*a*) Oil shale of northwestern Colorado and northeastern Utah, by E. G. Woodruff and David T. Day. (*b*) Oil and gas in the western part of the Olympic Peninsula, Washington, by C. T. Lupton. (*c*) The Moorcroft oil field, Crook County, Wyo.; Possibilities of oil in the Big Muddy dome, Converse and Natrona counties, Wyo., by V. H. Barnett.

585. Useful minerals of the United States, compiled by Samuel Sanford and R. W. Stone. 250 pp., 1914.

In preparation.

581-d. Geology and oil prospects of Waltham, Priest, Bitterwater, and Peachtree valleys, central California, with notes on coal, by R. W. Pack and W. A. English.

590. Reconnaissance of the geology and oil prospects of northwestern Oregon, by C. W. Washburne.

——. Geology and oil resources of the western border of the San Joaquin Valley, California, by Robert Anderson and R. W. Pack.

[a] Geological Survey's stock of the paper is exhausted, but many of the papers marked in this way may be purchased from the Superintendent of Documents, Washington, D. C., at the prices indicated.

WATER-SUPPLY PAPERS.

113. The disposal of strawboard and oil-well wastes, by R. L. Sackett and Isaiah Bowman. 52 pp., 4 pls., 1905.
149. Preliminary list of deep borings in the United States, second edition with additions, by N. H. Darton. 175 pp., 1905.

FOLIOS OF THE GEOLOGIC ATLAS OF THE UNITED STATES CONCERNING PETROLEUM AND NATURAL-GAS FIELDS, 1897-1911.[a]

40. Wartburg, Tenn., by A. Keith. 1897.
53. Standingstone, Tenn., by M. R. Campbell. 1899.
72. Charleston, W. Va., by M. R. Campbell. 1901. Out of print.
76. Austin, Tex., by R. T. Hill and T. W. Vaughan. 1902.
82. Masontown-Uniontown, Pa., by M. R. Campbell. 1902. Out of print.
92. Gaines, Pa.-N. Y., by M. L. Fuller and W. C. Alden. 1903.
94. Brownsville-Connellsville, Pa., by M. R. Campbell. 1903.
102. Indiana, Pa., by G. B. Richardson. 1904.
105. Patoka, Ind.-Ill., by M. L. Fuller and F. G. Clapp. 1904.
107. Newcastle, Wyo.-S. Dak., by N. H. Darton. 1904.
115. Kittanning, Pa., by C. Butts and F. Leverett. 1904.
121. Waynesburg, Pa., by R. W. Stone. 1905.
123. Elders Ridge, Pa., by R. W. Stone. 1905.
125. Rural Valley, Pa., by C. Butts. 1905.
132. Muskogee, Okla., by J. A. Taff. 1906.
134. Beaver, Pa., by L. H. Woolsey. 1906.
135. Nepesta, Colo., by C. A. Fisher. 1906.
144. Amity, Pa., by F. G. Clapp. 1907.
146. Rogersville, Pa., by F. G. Clapp. 1907.
148. Joplin district, Mo.-Kans., by W. S. T. Smith and C. E. Siebenthal. 1907. Out of print. (To be reprinted.)
159. Independence, Kans., by F. C. Schrader. 1908.
163. Santa Cruz, Cal., by J. C. Branner, J. F. Newsome, and R. Arnold. 1909. Out of print.

[b]165. Aberdeen-Redfield, S. Dak., by J. E. Todd. 1909.
[b]172. Warren, Pa.-N. Y., by C. Butts. 1910.
[b]176. Sewickley, Pa., by M. J. Munn. 1911.
[b]177. Burgettstown-Carnegie, Pa., by E. W. Shaw and M. J. Munn. 1911.
[b]178. Foxburg-Clarion, Pa., by E. W. Shaw, E. F. Lines, and M. J. Munn. 1911.
[b]180. Claysville, Pa., by M. J. Munn. 1911.
[b]184. Kenova, Ky.-W. Va.-Ohio, by W. C. Phalen. 1912.

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[a] The price of folios named in this list is 5 cents each.
[b] Issued in two editions—library (18 by 22 inches) and field (6 by 9 inches). Specify edition desired. Price same for either edition.

STONE.

By Ernest F. Burchard.

INTRODUCTION.

The present report on the stone industry contains, in addition to the usual large amount of statistical data on the production of the various commercial types of stone, subdivided into the several forms in which the stone is marketed, the completion of the general discussion of the stone resources of the United States which was begun in the report for 1911. The report for 1911 dealt with the stone quarried in the States east of Mississippi River and was illustrated by seven maps showing the location of the stone quarries by the types of stone. The report for 1912 was illustrated by six maps and was concerned with the 15 Middle States west of the Mississippi. The present chapter covers the stone resources of the States west of the Rocky Mountains, including Arizona, California, Idaho, Nevada, Oregon, Utah, and Washington, and is illustrated by three quarry maps. The maps and text relating to California, Idaho, and Utah were prepared by G. F. Loughlin, of the U. S. Geological Survey.

The value of the stone output for 1912 showed an increase of 1.4 per cent, with decreases of from 1 to 12 per cent for three of the varieties of stone under which data are grouped and with increases of from 3 to 8 per cent for the other two varieties. The statistics for 1913, however, showed certain increases ranging from 1 to 22 per cent in value, with a total average increase of 7.08 per cent. Of the most important stone products, stone for exterior building and for curbing showed considerable decreases, while the other important products, as monumental stone, paving stone, crushed stone, limestone for flux, riprap, etc., showed increases. It is well known that stone has suffered severe competition for several years past from various types of cheaper structural materials, and a large number of owners of small quarries who were accustomed to quarry stone for foundation and rough rubble work have closed their quarries on account of lack of demand, this stone having been replaced by concrete and brick. The demand for the more expensive grades of building stone has continued fairly regular, and the decrease caused by the closing of quarries furnishing the cheaper stone has been offset in the grand total by the increase in the output of crushed stone, which at one time was considered only a by-product.

The stone industry outside of regular quarry centers shows great irregularity in its fluctuations, being influenced largely by local demand. Construction of seawalls, river improvement work, ballasting of railroad tracks, construction of roads, reservoirs, and dams, repairing and constructing locks on canals, and other similar structural work may call for the opening of a quarry in the vicinity of the work, and for the abandonment of this quarry as soon as the work is completed. This naturally causes a large increase and corresponding decrease in the output of those States where there is no regularly defined quarry region, and even in States having regular quarry centers a contract for a large public building or any extra construction work influences the output of the region.

In the statistical part of this report, which is entirely the work of Miss A. T. Coons, of the United States Geological Survey, new tables are added nearly every year which give not only the value of the stone production but the quantity of stone quarried as well, and it is hoped in this way to increase the value of the statistics from year to year by the inclusion of quantitative data. This improvement is hindered by the lack of uniform units of measurement in the reports of the quarrymen and in many cases by their omission of any quantities whatever.

The figures presented in the following report, as in previous years, have to do with the stone produced and sold, or used by the quarrymen, and include only such manufactured product as is put on the market by the quarrymen themselves. This applies especially to rough and dressed building stone, rough and dressed monumental stone, crushed stone, flagstone, curbstone, and paving blocks. The value given to the manufactured product is the price received by the producer free on board at point of shipment, and includes, therefore, the cost of labor necessary to dress the stone. The stone reported as sold rough includes stone sold as rough stock to monumental works and to cut-stone contractors for building purposes and stone sold as riprap, rubble, and flux; the value includes the cost of only such labor as is required to get the stone out of the quarry in the shape required by the purchaser. The value given to this stone is the price received by the quarryman free on board at point of shipment. In case the stone is sold to local trade the value is given as the quarryman sells the material, generally at the quarry, but in some cases delivered, if this is done by the producer. In some places a long haul to market or to the railroad increases the cost of the material and therefore the selling price.

For simplicity of treatment the kinds of stone covered by the statistics in this report are classified as granite, trap rock, marble, limestone, and sandstone.

Granite includes true granite as well as monzonite, syenite, gneiss, and schist, and certain other crystalline rocks which are quarried by too few producers to permit their production to be shown separately. The varieties of crystalline rocks thus occasionally included under "granite" are mostly of the light volcanic type, such as tuff, rhyolite, trachyte, and andesite, but from time to time small quantities of dark crystalline and volcanic rocks, such as basalt, diorite, diabase, gabbro, and dolerite, are necessarily included with granite. The trap rock output for California, Hawaii, Massachusetts, New York, New Jersey, Oregon, Pennsylvania, and Washington represents an important industry, and it is therefore possible to show the value of this stone separately. The trap rock from these States consists largely of basalt. The separation of basalt in Oregon and Washington from granite is made for the first time in this report. In order to make the figures for 1912 comparable they have been changed for these States to conform with the 1913 figures. In the discussion of the stone resources of the States west of the Rocky Mountains the deposits of granitic rock, dark volcanic rocks, and light volcanic rocks have been considered separately, and the quarries in these three classes of rocks are indicated by distinctive symbols.

Marble includes a small quantity of serpentine quarried and sold as marble in California, Georgia, Maryland, Pennsylvania, and Vermont, and also a small quantity of the so-called "onyx" marble or travertine obtained from caves and other deposits in Kentucky and other States.

Limestone does not include limestone burned into lime, bituminous limestone, nor limestone entering into the manufacture of Portland cement. It includes, however, a small quantity of stone sold locally as marble.

Sandstone includes the quartzites of South Dakota, Minnesota, and Wisconsin and the fine-grained sandstones of New York and Pennsylvania, known to trade as bluestone. As bluestone is the product of a distinct local industry, its production is also shown separately from that of the other sandstones. Bluestone is also quarried in New Jersey and West Virginia, but this product is small and is not separated from sandstone. In Kentucky most of the sandstone quarried and sold is known locally as freestone. The figures given for sandstone do not include the value of the grindstones, whetstones, and pulpstones made from sandstones quarried in Michigan, Ohio, and West Virginia; nor does the total sandstone value include sandstone crushed into sand and used in the manufacture of glass and as molding sand. The production of these materials is published in other reports in Mineral Resources.

UNIT OF MEASUREMENT.

Owing to the variety of uses to which stone is put, there is no regular unit of measurement employed by the quarrymen, the stone being sold by the cubic yard, the cubic foot, the ton, cord, perch, rod, square foot, square yard, square, etc. Building and monumental stone, especially the dressed product, is usually sold by the cubic foot or the cubic yard, although this unit varies with the class of stone and with the locality; a large quantity of the rough stone is sold by the perch, cord, and ton. Rubble and riprap, including stone for such heavy masonry as breakwater and jetty work, are generally sold by the cord and ton. Fluxing stone and stone for chemical use—as for alkali works, sugar factories, carbonic-acid plants, paper mills—are sold by the long ton. Flagstone and curbstone are sold by the square yard and the square foot, the thickness being variable and dependent on the orders received. Granite paving blocks are sold invariably by number of blocks, and as such have been tabulated and published for several years; these blocks, however, are not of uniform size, the value depending on the size and the labor necessary to cut the block into the shape desired. Other paving material is sold by various units, as ton, cubic yard, etc. Crushed stone is reported as sold by the cubic yard or ton, the short ton being more generally used. The weight of a cubic yard of crushed stone varies from 2,300 to 3,000 pounds, the average weight being about 2,500 pounds. In certain localities this crushed stone is sold by the "square" of 100 square feet by 1 foot, or 100 cubic feet to a square. It is also of interest to note the selling of crushed stone by the bushel, 21½ bushels representing a cubic yard of about 2,700 pounds. As most of the crushed-stone producers report the quantity according to some unit, it has been possible to convert the crushed stone into short tons, which unit represents the larger number of producers and is the most convenient.

On the statistical inquiry cards asking for the production of stone according to various stone products, the producers do not always report the quantity, but it has been possible to publish in this report the quantity as well as the value of the granite production of Maine, New Hampshire, Minnesota, Vermont, and Wisconsin. The value of the granite production of Massachusetts is given for the first time by counties and uses, although it was found impossible to give the figures of quantity. The report includes also the limestone production in the Bedford, Ind.; Carthage, Mo.; and Bowling Green, Ky., limestone districts; the marble production of California, Georgia, Massachusetts, New York, Tennessee, and Vermont; and the quantity of the total marble output.

PRODUCTION.

The total value of the stone produced in the United States in 1913 was $83,732,995, as compared with $78,193,220 in 1912, an increase of $5,539,775, or 7.08 per cent. The year surpassed all previous years in the value of its stone output, the value of granite, trap rock, sandstone, marble, and limestone increasing 8.17, 22.88, 2.02, 1.08, and 5.49 per cent, respectively, over the value for 1912.

The following table shows the value of the different kinds of stone produced in the United States from 1901 to 1913, inclusive:

Value of the different kinds of stone produced in the United States, 1901–1913.

Year.	Granite.	Trap rock.	Sandstone.[a]	Marble.	Limestone.	Total.
1901	$14,266,104	$1,710,857	$8,138,680	$4,965,699	$18,202,843	$47,284,183
1902	16,083,475	2,181,157	10,594,483	5,044,182	20,895,385	54,798,682
1903	15,703,793	2,732,294	11,262,259	5,362,686	22,372,109	57,433,141
1904	17,191,479	2,823,546	10,273,891	6,297,835	22,178,964	58,765,715
1905	17,563,139	3,074,554	10,006,774	7,129,071	26,025,210	63,798,748
1906	18,562,806	3,736,571	9,169,337	7,582,938	27,327,142	66,378,794
1907	18,064,708	4,594,103	8,871,678	7,837,685	31,737,631	71,105,805
1908	18,420,080	4,282,406	7,594,091	7,733,920	27,682,002	65,712,499
1909	19,581,597	5,133,842	8,010,454	6,548,905	32,070,401	71,345,199
1910	20,541,967	6,452,141	7,930,019	6,992,779	34,603,678	76,520,584
1911	21,194,228	6,739,141	7,730,868	7,546,718	33,897,612	77,108,567
1912	19,223,302	7,560,049	6,893,611	7,786,458	36,729,800	78,193,220
1913	20,793,800	9,289,809	7,033,067	7,870,890	38,745,429	83,732,995
Percentage of increase (+) or decrease (−) for 1913	+8.17	+22.88	+2.02	+1.08	+5.49	+7.08
Percentage of total	24.83	11.10	8.40	9.40	46.27	100.00

[a] Includes bluestone.

The foregoing table shows the following relations between the values of the various classes of rock and the changes that occurred in the totals from 1912 to 1913:

Granite.—The value of granite represented 24.83 per cent of the total value of stone for 1913. The increase in value was $1,570,498, from $19,223,302 in 1912 to $20,793,800 in 1913, or 8.17 per cent. Granite for building, monumental, crushed stone, paving blocks, riprap, and rubble increased in value, but there was a decrease in the value of granite for curbing and flagging.

Trap rock.—Trap rock showed the largest increase, $1,729,760, of all the varieties of stone, from $7,560,049 in 1912 to $9,289,809 in 1913, or 22.88 per cent. The trap rock output is chiefly crushed stone.

Marble.—Marble represented 9.40 per cent of the total stone value in 1913 and increased from $7,786,458 in 1912 to $7,870,890 in 1913, a gain of $84,432, or 1.08 per cent.

Limestone.—The value of limestone represented 46.27 per cent of the total value of stone produced in 1913. It increased from $36,729,800 in 1912 to $38,745,429 in 1913, a gain of $2,015,629, or 5.49 per cent.

Sandstone.—Sandstone, including quartzite, and bluestone increased in value from $6,893,611 in 1912 to $7,033,067 in 1913, a gain of $139,456, or 2.02 per cent.

The value of bluestone, included with standstone, decreased from $1,505,763 in 1912 to $1,280,862 in 1913, a decrease of $224,901, or 14.9 per cent.

The following table shows the rank of States and Territories in 1912 and 1913, according to value of production of stone, and the percentage of the total produced by each State or Territory.

Rank of States and Territories in 1912 and 1913, according to value of production of stone, and percentage of total produced by each State or Territory.

1912.

Rank of State.	State or Territory.	Total value.	Percentage of total.	Number of plants.
1	Pennsylvania	$9,144,214	11.69	700
2	Vermont	6,554,851	8.38	56
3	New York	6,415,015	8.20	255
4	Ohio	6,197,388	7.92	245
5	Indiana	5,091,924	6.51	131
6	California	3,902,313	4.99	150
7	Illinois	3,841,504	4.91	106
8	Massachusetts	3,663,279	4.68	137
9	Missouri	2,486,505	3.18	194
10	Wisconsin	2,211,847	2.83	186
11	Georgia	1,983,016	2.54	42
12	Minnesota	1,845,746	2.36	74
13	Maine	1,810,590	2.31	79
14	New Jersey	1,716,829	2.19	102
15	Tennessee	1,656,812	2.12	85
16	Connecticut	1,467,458	1.88	65
17	Colorado	1,420,607	1.82	47
18	New Hampshire	1,311,488	1.68	36
19	Kentucky	1,282,148	1.64	100
20	Michigan	1,192,204	1.52	62
21	Washington	1,174,047	1.50	32
22	West Virginia	1,164,877	1.49	70
23	Maryland	1,054,872	1.35	42
24	North Carolina	1,032,022	1.32	67
25	Iowa	946,436	1.21	95
26	Virginia	877,746	1.12	63
27	Alabama	842,300	1.08	26
28	Rhode Island	768,067	.98	19
29	Kansas	763,228	.98	97
30	Texas	680,365	.87	37
31	Arkansas	513,844	.66	20
32	Oklahoma	429,788	.55	32
33	Nebraska	336,189	.43	13
34	New Mexico	335,937	.43	7
35	Oregon	268,002	.34	22
36	South Carolina	263,905	.34	13
37	Utah	249,782	.32	27
38	Hawaii	231,351	.30	9
39	Montana	216,079	.28	18
40	Delaware	193,074	.25	5
41	South Dakota	162,295	.21	21
42	Alaska	(a)	....	....
43	Florida	(a)	....	....
44	Wyoming	68,479	.09	10
45	Arizona	67,124	.09	18
46	Idaho	63,974	.08	11
47	Louisiana	(a)	....	....
48	Nevada	(a)	....	....
	Other States	b 293,699	.38	11
	Total	78,193,220	100.00	3,637

a Included in "Other States." b Includes Alaska, Florida, Louisiana, and Nevada.

Rank of States and Territories in 1912 and 1913, according to value of production of stone, and percentage of total produced by each State or Territory—Continued.

1913.

Rank of State.	State or Territory.	Total value.	Percentage of total.	Number of plants.
1	Pennsylvania	$10,117,469	12.08	624
2	Vermont	7,313,355	8.73	57
3	New York	7,185,493	8.58	189
4	Ohio	6,261,338	7.48	234
5	Indiana	4,676,689	5.58	127
6	Illinois	4,140,953	4.94	109
7	California	4,118,935	4.92	150
8	Massachusetts	4,096,372	4.89	138
9	Missouri	2,538,699	3.03	179
10	Wisconsin	2,157,980	2.58	198
11	Georgia	2,105,366	2.51	36
12	Tennessee	2,062,686	2.46	76
13	Minnesota	1,952,686	2.33	93
14	Maine	1,792,079	2.14	71
15	New Jersey	1,772,832	2.12	90
16	Connecticut	1,603,663	1.91	65
17	Michigan	1,520,133	1.82	35
18	New Hampshire	1,482,771	1.77	36
19	Washington	1,399,475	1.67	36
20	Alabama	1,285,944	1.54	35
21	North Carolina	1,212,501	1.45	37
22	West Virginia	1,193,323	1.43	64
23	Maryland	1,153,115	1.38	63
24	Kentucky	1,150,205	1.37	92
25	Virginia	1,063,782	1.27	77
26	Colorado	985,817	1.18	52
27	Kansas	825,607	.99	84
28	Iowa	805,294	.96	83
29	Texas	725,106	.87	39
30	Rhode Island	643,995	.77	16
31	Arkansas	525,050	.63	17
32	Utah	415,471	.50	20
33	South Carolina	360,476	.43	14
34	Oregon	357,498	.43	24
35	Montana	343,516	.41	17
36	Nebraska	327,187	.39	15
37	Delaware	289,987	.35	6
38	Oklahoma	278,600	.33	25
39	Hawaii	249,390	.30	10
40	New Mexico	219,566	.26	9
41	Florida	207,420	.25	10
42	Alaska	(a)	....	....
43	South Dakota	172,736	.21	19
44	Idaho	152,390	.18	13
45	Wyoming	109,784	.13	7
46	Arizona	107,989	.13	15
47	Louisiana	(a)	....	....
	Other States [b]	272,272	.32	3
	Total	83,732,995	100.00	3,409

[a] Included in "Other States." [b] Includes Alaska and Louisiana.

Pennsylvania has always held first rank among the stone-producing States—except in the year 1908 when Vermont reported the largest production—and in 1913 it produced 12.08 per cent of the total of the entire United States, Vermont being second, with 8.73 per cent. Other large stone-producing States following in order of rank of output are New York, Ohio, Indiana, Illinois, California, Massachusetts, Missouri, Wisconsin, Georgia, and Tennessee, each of whose production was valued at more than $2,000,000. In 1912 the leading States were Pennsylvania, Vermont, New York, Ohio, Indiana, California, Illinois, Massachusetts, Missouri, Wisconsin, and Maine. In 1913 Illinois supplanted California, and Georgia and Tennessee went with the States producing more than $2,000,000. Fourteen States in 1912 produced stone valued at between $1,000,000 and $2,000,000, and 13 States in 1913 fell between these limits.

Of 48 States reporting in 1912, 37 States showed an increased production in 1913 and 10 a decrease. Nevada dropped out in 1913.

The number of active operations in 1913 was 3,409, compared with 3,637 in 1912, a decrease of 228 operations, although the value of the output increased over 7 per cent. A number of causes contributed to this decrease, the chief of which was the tendency of small producers to abandon their quarries on account of lack of demand for foundation stone. Also the high cost and scarcity of labor was a strong factor against the small quarryman. Combination of properties and the regular fluctuations of demand also have considerable influence on the increase or decrease of operations.

The following table shows the value of the stone used for various purposes in 1912 and 1913. Only such values are given as are for uses common to two or more varieties of stone.

Value of granite, trap rock, sandstone, limestone, and marble used for various purposes in 1912 and 1913.

1912.

Kinds.	Building (rough and dressed).	Monumental (rough and dressed).	Flagstone.	Curbstone.	Paving stone.	Crushed stone.
Granite	$6,125,841	$4,643,919	$41,640	$898,209	$2,562,005	$3,465,678
Trap rock	93,988				265,635	6,341,625
Sandstone	2,263,289		721,069	1,108,545	585,275	1,165,634
Limestone	5,051,896		14,393	153,015	278,930	17,619,599
Marble [a]	2,771,645	2,115,200				
Total	16,306,659	6,759,119	777,102	2,159,769	3,691,845	28,592,536

1913.

Kinds.	Building (rough and dressed).	Monumental (rough and dressed).	Flagstone.	Curbstone.	Paving stone.	Crushed stone.
Granite	$6,661,415	$4,715,084	$13,172	$814,290	$2,755,995	$3,850,887
Trap rock	83,078				204,346	7,506,516
Sandstone	1,860,924		553,129	1,154,836	736,767	1,248,244
Limestone	4,509,339		7,337	108,793	239,340	19,072,224
Marble [a]	1,822,458	2,497,564				
Total	14,937,214	7,212,648	573,638	2,077,919	3,936,448	31,677,871
Percentage of increase (+) or decrease (−) over 1912.	−8.40	+6.71	−26.18	−3.94	+6.63	+10.79

[a] Marble for exterior building only.

This table, besides showing the comparative value of the different varieties of stone according to their common usage, shows the changes for the total output with respect to the different stone products.

A comparison of the figures for 1912 and 1913 shows decrease in the totals for building stone, flagstone, and curbstone, with increase for monumental, paving, and crushed stone.

Building stone decreased in value from $16,306,659 in 1912 to $14,937,214 in 1913, a loss of $1,369,445, or 8.4 per cent. The only increase shown was in the granite production.

Monumental stone increased in value $453,529, or 6.71 per cent. Marble and granite are the only varieties of stone representing this product, although a small quantity of limestone is used for this work, and an inconsiderable quantity of sandstone is reported as sold locally for tombstone bases. The total output was valued at $7,212,648 in 1913, as compared with $6,759,119 in 1912.

Flagstone decreased $203,464, or 26.18 per cent, in 1913. The decrease was general for all kinds of stone, but sandstone, which included chiefly the bluestone of Pennsylvania and New York, showed the largest decrease. The use of concrete for this purpose instead of stone is the principal cause of the loss.

Curbstone decreased in value $81,850, or 3.94 per cent, from $2,159,769 in 1912 to $2,077,919 in 1913.

Stone for paving increased in value from $3,691,845 in 1912 to $3,936,448 in 1913, a gain of $244,603, or 6.63 per cent. Limestone and trap rock showed a slight decrease, which was more than balanced by the increase in granite and sandstone.

Crushed stone, which is the largest product common to more than one variety of stone, showed the largest increase in value—from $28,592,536 in 1912 to $31,677,871 in 1913, a gain of $3,085,335, or 10.79 per cent.

The following table shows the quantity and value of crushed stone produced in the United States in 1912 and 1913, by uses and kinds of stone:

Quantity and value of crushed stone produced in the United States in 1912 and 1913 by uses and by kinds of stone, in short tons.

Kind.	Road making.		Railroad ballast.		Concrete.		Total.		Average price per ton.
	Quantity.	Value.	Quantity.	Value.	Quantity.	Value.	Quantity.	Value.	
1912.									
Granite	1,558,893	$1,218,108	1,360,985	$797,854	1,689,127	$1,449,716	4,609,005	$3,465,678	$0.75
Trap rock	3,910,817	2,868,093	1,755,066	1,012,948	3,536,951	2,460,584	9,202,834	6,341,625	.69
Limestone	13,292,935	7,130,843	10,560,779	4,854,301	9,268,928	5,634,455	33,122,642	17,619,599	.53
Sandstone	477,780	281.414	313,515	170,646	776.725	713,574	1,568,020	1,165,634	.74
Total	19,240,425	11,498,458	13,990,345	6,835,749	15,271,731	10,258,329	48,502,501	28,592,536	....
Average price per ton	....	$0.60	....	$0.49	....	$0.67	....	$0.59	....
1913.									
Granite	1,800,687	$1,552,062	1,176,879	$743,642	1,904,858	$1,555,183	4,882,424	$3,850,887	$0.79
Trap rock	5,033,071	3,662,834	2,182,987	1,408,954	3,469,959	2,434,728	10,686,017	7,506,516	.70
Limestone	13,296,377	7,353,665	11,774,121	5,551,415	10,099,030	6,167,144	35,169,528	19,072,224	.54
Sandstone	398,806	300,442	311,585	186,043	870,605	761,759	1,580,996	1,248,244	.79
Total	20,528,941	12,869,003	15,445,572	7,890,054	16,344,452	10,918,814	52,318,965	31,677,871	....
Average price per ton	....	$0.63	....	$0.51	....	$0.67	....	$0.61	....
Percentage of increase (+) compared with 1912	+6.70	+11.92	+10.40	+15.42	+7.02	+6.44	+7.87	+10.79	....

As shown by this table, the quantity and value of the crushed-stone output in 1913 was 52,318,965 short tons, valued at $31,677,871, as compared with 48,502,501 short tons, valued at $28,592,536, in 1912, an increase of 3,816,464 tons, or 7.87 per cent, in quantity and of $3,085,335 in value. The average price per ton was 59 cents for 1912 and 61 cents for 1913.

Crushed granite decreased 273,419 short tons in quantity and $385,209 in value. The average price per ton increased from 75 cents in 1912 to 79 cents in 1913.

Crushed trap rock increased 1,483,183 short tons in quantity and $1,164,891 in value. The average price per ton was reported as 70 cents in 1913 compared with 69 cents in 1912.

Crushed limestone increased 2,046,886 short tons in quantity and $1,452,625 in value. The average price per ton increased from 53 cents in 1912 to 54 cents in 1913.

Crushed sandstone increased 12,976 short tons in quantity and $82,610 in value. The average price per ton increased from 74 cents in 1912 to 79 cents in 1913.

Crushed stone used for road making increased 1,288,516 short tons in quantity and $1,370,545 in value. The average price per ton 63 cents in 1913, compared with 60 cents in 1912.

Crushed stone for railroad ballast increased 1,455,227 short tons in quantity and $1,054,305 in value. The average price per ton increase from 49 cents in 1912 to 51 cents in 1913.

Crushed stone for concrete increased 1,072,721 short tons in quantity and $660,485 in value. The average price per ton was the same as for 1912, 67 cents.

The following table shows the quantity and value of crushed stone produced in the United States in 1912 and 1913, by States and Territories and by uses:

Production of crushed stone in 1912 and 1913, by States and Territories and by uses, in short tons.

1912.

State or Territory.	Road making.		Railroad ballast.		Concrete.		Total.	
	Quantity.	Value.	Quantity.	Value.	Quantity.	Value.	Quantity.	Value.
Alabama	85,754	$54,270	30,298	$14,093	65,144	$38,235	181,196	$106,589
Arizona	1,875	2,250	14,950	13,000	11,703	20,956	28,528	36,206
Arkansas	129,577	104,258	177,295	115,725	125,236	107,605	432,108	327,588
California	1,451,487	964,300	948,046	548,578	1,157,665	808,847	3,557,198	2,321,725
Colorado	14,860	15,350	1,222	376	2,945	3,149	19,027	18,875
Connecticut	441,828	288,548	211,460	89,645	314,605	194,119	967,893	572,312
Delaware	30,614	27,861	20,100	14,070	29,533	24,536	80,247	66,467
Florida	84,224	57,836	43,500	15,000	23,514	25,646	151,238	98,482
Georgia	35,621	33,927	42,695	53,223	206,818	199,754	285,134	286,904
Hawaii	105,147	128,854	....	....	75,595	94,140	180,742	222,994
Idaho	14,978	10,131	25,000	16,000	5,750	4,600	45,728	30,731
Illinois	2,643,251	1,083,803	960,602	368,349	2,035,113	963,617	5,638,966	2,415,769
Indiana	1,771,521	1,033,673	286,186	102,841	72,603	45,197	2,130,310	1,181,711
Iowa	37,567	30,821	601,137	235,326	422,332	404,877	1,061,036	671,024
Kansas	126,078	95,642	560,322	274,176	317,112	234,261	1,003,512	604,079
Kentucky	514,124	319,057	1,024,538	473,023	200,209	109,355	1,738,871	901,435
Louisiana	10,197	8,158	15,351	12,281	47,776	38,221	73,324	58,660
Maine	7,090	5,062	18,666	14,000	6,627	5,075	32,383	24,137
Maryland	359,921	295,726	383,371	212,879	144,634	133,674	887,926	642,279
Massachusetts	460,564	431,162	14,651	13,985	934,432	741,835	1,409,647	1,186,982
Michigan	625,358	313,815	54,327	28,368	196,778	106,638	876,463	448,821
Minnesota	76,783	65,952	59,905	40,642	328,445	287,600	465,133	394,194
Missouri	333,591	262,438	599,799	387,449	837,096	674,986	1,770,486	1,324,873
Montana	4,141	1,365	184	101	30,593	18,115	34,918	19,581
Nebraska	40	20	9,037	5,985	275,430	252,063	284,507	258,068
New Hampshire	5,270	2,875	2,022	2,527	24,178	20,228	31,470	25,630
New Jersey	855,537	679,768	417,482	266,136	515,311	395,142	1,788,330	1,341,046
New Mexico	....	....	710,149	326,022	15,325	7,950	725,474	333,972
New York	1,978,666	1,256,354	1,441,326	742,156	2,333,612	1,466,316	5,753,604	3,464,826
North Carolina	76,746	70,985	116,664	33,254	209,265	206,579	402,675	310,818
Ohio	3,595,221	1,675,300	2,093,441	787,486	600,729	305,267	6,289,391	2,768,053
Oklahoma	89,413	60,862	340,936	178,440	183,680	111,435	614,029	350,737
Oregon	150,587	128,272	28,028	14,636	176,070	102,013	354,685	244,921
Pennsylvania	1,506,457	948,364	1,249,713	723,476	1,205,257	754,231	3,961,427	2,426,071
Rhode Island	58,577	64,777	....	....	19,508	24,140	78,085	88,917
South Carolina	40,719	41,252	22,926	21,234	68,035	67,878	131,680	130,364
South Dakota	3,875	4,160	....	....	67,671	54,598	71,546	58,758
Tennessee	325,964	268,509	267,267	114,011	214,007	127,076	807,238	509,596
Texas	79,694	52,753	110,212	49,956	633,301	434,332	823,207	537,041
Vermont	2,700	1,975	5,000	2,000	21,396	15,007	29,096	18,982
Virginia	140,697	112,496	300,240	166,856	222,684	156,889	663,621	436,241
Washington	166,926	96,775	5,645	2,847	40,659	29,591	213,230	129,213
West Virginia	40,938	27,440	700,669	328,871	234,883	100,855	976,490	457,166
Wisconsin	755,795	370,559	75,983	26,726	612,741	335,568	1,444,519	732,853
Wyoming	452	703	....	....	5,731	6,133	6,183	6,836
Total	19,240,425	11,498,458	13,990,345	6,835,749	15,271,731	10,258,329	48,502,501	28,592,536

Production of crushed stone in 1912 and 1913, by States and Territories and by uses, in short tons—Continued.

1913.

State or Territory.	Road making.		Railroad ballast.		Concrete.		Total.	
	Quantity.	Value.	Quantity.	Value.	Quantity.	Value.	Quantity.	Value.
Alabama	88,330	$47,237	14,633	$7,187	395,727	$255,695	498,690	$310,119
Arizona			1,200	265	7,169	5,735	8,369	6,000
Arkansas	207,110	177,476	103,879	74,961	98,303	80,051	409,292	332,488
California	1,409,976	853,990	845,641	514,120	1,185,017	763,627	3,440,634	2,131,737
Colorado	24,450	33,000			612	522	25,062	33,522
Connecticut	578,547	366,306	95,518	55,694	495,481	304,534	1,169,546	726,534
Delaware	39,837	37,522	30,467	21,327	12,552	10,496	82,856	69,345
Florida	34,664	32,632	96,882	40,006	152,286	117,874	283,832	190,512
Georgia	60,569	49,950	57,466	55,884	134,938	115,959	252,973	221,793
Hawaii	103,542	97,826	24,793	25,747	50,147	52,851	178,482	176,424
Idaho	7,858	15,043	110,250	70,560	18,000	27,000	136,108	112,603
Illinois	1,958,482	921,340	1,405,688	592,210	2,376,700	1,246,042	5,740,870	2,759,592
Indiana	1,736,744	956,284	514,745	203,431	53,876	29,985	2,305,365	1,189,700
Iowa	136,848	81,351	513,531	218,573	464,280	301,305	1,114,659	601,229
Kansas	64,130	49,074	511,370	283,435	350,799	264,854	926,299	597,363
Kentucky	468,135	286,407	995,908	422,864	201,498	104,615	1,665,541	813,886
Louisiana	9,733	7,787	22,455	17,964	50,030	40,240	82,218	65,991
Maine	2,745	2,055	432	324	18,852	16,262	22,029	18,641
Maryland	417,807	373,904	408,507	230,687	213,699	178,065	1,040,013	782,656
Massachusetts	952,707	794,415	112,944	71,882	940,691	824,320	2,006,342	1,690,617
Michigan	557,231	289,685	124,330	56,892	301,612	154,705	983,173	501,282
Minnesota	74,070	64,920	53,816	32,374	504,714	408,467	632,600	505,761
Missouri	488,325	342,849	605,441	405,665	779,846	636,148	1,873,612	1,384,662
Montana	11,410	2,812	1,307	485	27,306	14,480	40,023	17,777
Nebraska			68,938	38,178	275,693	231,626	344,631	269,804
New Hampshire	8,276	6,415	129	129	11,900	10,297	20,305	16,841
New Jersey	916,679	735,926	468,891	317,744	445,437	346,387	1,831,007	1,400,057
New Mexico			384,561	148,016	54,000	54,000	438,561	202,016
New York	2,674,209	1,608,083	1,768,306	951,672	2,372,771	1,509,244	6,815,286	4,068,999
North Carolina	77,071	73,062	137,331	67,828	242,316	235,887	456,718	376,777
Ohio	3,230,300	1,598,434	2,036,173	806,590	692,450	357,568	5,958,923	2,762,592
Oklahoma	5,171	4,384	208,021	98,134	121,316	77,702	334,508	180,220
Oregon	248,423	182,471	113,468	59,873	130,340	83,524	492,231	325,868
Pennsylvania	2,039,553	1,510,849	1,574,561	1,015,796	1,370,611	871,706	4,984,725	3,398,351
Rhode Island	48,500	58,500	1,500	3,000	8,660	7,996	58,660	69,496
South Carolina	56,989	47,776	60,412	43,950	68,298	61,757	185,699	153,483
South Dakota	2,600	1,670			62,169	48,630	64,769	50,300
Tennessee	298,226	212,004	339,768	142,289	199,678	123,945	837,672	478,238
Texas	244,267	145,747	294,476	132,699	324,156	255,782	862,899	534,228
Vermont	4,275	3,783	1,500	664	22,906	15,942	28,681	20,389
Virginia	207,728	151,395	570,517	291,876	248,751	157,470	1,026,996	600,741
Washington	170,952	122,579	11,706	9,998	9,134	4,508	191,792	137,085
West Virginia	104,752	55,882	588,995	284,364	180,451	90,255	874,198	430,501
Wisconsin	757,720	466,178	165,116	74,717	659,932	408,390	1,582,768	949,285
Wyoming					9,348	12,366	9,348	12,366
Total	20,528,941	12,869,003	15,445,572	7,890,054	16,344,452	10,918,814	52,318,965	31,677,871

According to this table nine States in 1913 produced crushed stone valued at more than $1,000,000, as follows, by rank: New York, Pennsylvania, Ohio, Illinois, California, Massachusetts, New Jersey, Missouri, and Indiana.

Besides the stone reported above as crushed for road making, a large quantity of other material answering practically the same purpose as crushed stone is used in construction of roads. In almost all the States a large quantity of gravel, often crushed gravel, is used for road material. In Missouri a considerable amount of road material is obtained from the tailings of the concentrating mills at the zinc mines. This is put on the market as "chats" and consists of small angular fragments of chert and limestone. The zinc companies are very glad to get rid of this waste material, which is loaded on the cars by the various railroads of the district at a cost of about 6 or 8 cents a ton. It makes more than ordinarily good roads and is widely distributed all through the Middle West, and sells at prices ranging from 50 cents to $1 a ton. In the neighborhood of the mines the material sells for about 15 cents a ton. It is used for railroad ballast as well as road making. The annual output amounts to about 1,300,000 tons. In Tennessee and Alabama a quantity of chert is used for road metal, and crushed slag from the blast furnaces of the various States furnishes a valuable road material. In Alabama, one of the large iron-producing States, over 2,000,000 short tons of furnace slag was crushed and put on the roads, the average value of which was about 25 cents a ton. Crushed slag is also used as railroad ballast and for concrete and roofing material.

Crushed stone is the largest factor in the stone industry at the present time. In 1898 the first figures of the value of crushed stone were published and amounted to $4,031,445. Crushed stone, chiefly for road making and railroad ballast, was reported previously to that time, but was not separated from other products. The growth of the crushed-stone industry is well shown in the following table, which gives the output of exterior building stone, monumental stone, and crushed stone, from 1900 to 1913, the year 1900 being the first year for which exactly comparable tables are available. Prior to the advent of crushed stone, building and monumental stone were considered the chief stone products. The stone crushed for concrete and cement took the place of a large quantity of building and foundation stone.

Value of exterior building stone and of crushed stone, 1900–1913.

Year.	Monumental stone (rough and dressed).	Building stone (rough and dressed).	Crushed stone.	Year.	Monumental stone (rough and dressed).	Building stone (rough and dressed).	Crushed stone.
1900....	$3,618,316	$10,672,598	$6,525,368	1907....	$6,978,949	$16,675,811	$22,054,297
1901....	4,734,699	15,112,600	8,560,432	1908....	6,948,841	16,040,630	20,262,012
1902....	5,941,585	20,790,341	11,480,959	1909....	6,104,190	17,594,455	24,078,780
1903....	5,767,360	19,795,491	13,188,938	1910....	6,887,542	16,105,856	27,264,535
1904....	5,991,714	18,883,455	15,530,122	1911....	6,985,416	16,443,758	28,426,375
1905....	6,112,585	20,240,809	16,419,614	1912....	6,759,119	16,306,659	28,592,536
1906....	6,773,478	20,681,625	17,467,486	1913....	7,212,648	14,937,214	31,677,871
Percentage of increase (+) or decrease (−) in 1912 and 1913....					+6.71	−0.840	+10.79

It is noticeable that whereas the values for building and monumental stone show considerable fluctuation, those for crushed stone show continued increase except for the year 1908, when a sharp decrease was shown, with entire recovery in 1909.

EXPORTS AND IMPORTS.

The following figures compiled from statistics furnished by the Bureau of Foreign and Domestic Commerce of the Department of Commerce, give the value of the exports and imports of stone for the calendar years 1912 and 1913:

Exports of stone from the United States in 1912 and 1913.

Kind.	1912	1913
Marble and stone, unmanufactured....	$645,889	$606,745
All others....	1,193,989	1,250,147
Total....	1,839,878	1,856,892

Imports of stone into the United States in 1912 and 1913.

Kind.	1912		1913	
	Quantity.	Value.	Quantity.	Value.
Marble:				
In block, rough, etc.......cubic feet..	636,843	$1,001,703	643,225	$1,024,595
Sawed or dressed.......do....	117	148	221	606
Slabs or paving tiles.......sup. feet.	311,895	79,577	275,888	50,788
All other manufactures.......	....	249,008	....	242,674
Mosaic cubes (loose).......pounds..	2,156,611	29,551	[a] 3,660,280	48,944
Total.......	....	1,359,987	....	1,367,607
Onyx:				
In blocks, rough, etc.......cubic feet..	13,029	49,237	10,067	34,518
All other manufactures.......	....	713	....	1,803
Total.......	....	49,950	....	36,321
Granite:				
Dressed.......	....	108,917	....	110,451
Rough.......cubic feet..	9,467	3,421	13,701	5,074
Total.......	....	112,338	....	115,525
Stone (other):				
Dressed.......	....	16,951	....	23,422
Rough.......cubic feet..	54,012	23,005	125,085	63,260
Total.......	....	39,956	....	86,682
Grand total.......	....	1,562,231	....	1,606,135

[a] Quantity estimated for last three months of 1913.

The export table shows the slight increase of $17,014, or 0.92 per cent, in the export trade in stone for 1913. The total exports for 1913 were valued at $1,856,892. The value of the stone imported also increased somewhat, or from $1,562,231 in 1912 to $1,606,135 in 1913, a gain of $43,904, or 2.81 per cent.

TARIFF.

The tariff act of October, 1913, made some changes in the duty imposed on imported stone, and the following table shows the duty prior to October, 1913, and the present duty.

Duty imposed on stone imported into the United States prior to and after the tariff act of October, 1913.

Stone.	Duty.	
	Prior to act of October, 1913.	After act of October, 1913.
Marble:		
In block, rough, etc.......cu. ft..	$0.65	$0.50
Sawed or dressed.......do....	1.00	.75
Slabs or tiles—		
Not over 1 inch thick—unrubbed.......sup. ft..	.08	.06
Not over 1 inch thick—rubbed.......do....	.10	.08
Over 1 inch and not over 1½ inches thick—		
Unrubbed.......do....	.10	.08
Rubbed.......do....	.12	.10
Over 1½ inches and not over 2 inches thick—		
Unrubbed.......do....	.12½	.10
Rubbed.......do....	.14½	.12
All other marble manufactured.......ad valorem..	50 per cent.	45 per cent.
Mosaic cubes, loose.......do....	½ cent per pound +20 per cent.	20 per cent.

Duty imposed on stone imported into the United States prior to and after the tariff act of October, 1913—Continued.

Stone.	Duty. Prior to act of October, 1913.	Duty. After act of October, 1813.
Onyx:		
In block, rough, etc........cu. ft..	$0.65	$0.50
All other manufactured........ad valorem..	50 per cent.	45 per cent.
Granite:		
Dressed........do....	50 per cent.	25 per cent.
Rough........cu. ft..	$0.10	$0.03
Freestone, sandstone, limestone, lava, and all other monumental or building stone, except granite, marble, breccia not specially provided for:		
Dressed........ad valorem..	50 per cent.	25 per cent.
Rough........cu. ft..	$0.10	$0.03
Freestone, granite, sandstone, and limestone unmanufactured and unsuitable for monumental or building stone.	....	Free.

GRANITE.

PRODUCTION.

The figures given in this report as representing the value of the granite production in the United States include also the value of small quantities of syenite, gneiss, schist, basalt, tuff, trachyte, andesite, and other crystalline and igneous rocks. The quantities of these allied rocks quarried are too small to tabulate separately, and the production of the igneous rocks other than granite would have to be concealed for certain States because there are less than three producers reporting. The quarrying of trap rock, consisting largely of basalt and diabase in California, Connecticut, Hawaii, Massachusetts, northern Michigan, New Jersey, New York, Oregon, Pennsylvania, and Washington, represents, however, an industry sufficient by itself to make it practicable to tabulate this stone separately, and therefore its value is not included in the grand total of granite.

For the first time the statistics of basalt quarried in Oregon and Washington have been separated from the granite figures and included under trap rock. This was done for the 1912 figures as well as for those for 1913 in order to make the two years comparable and accounts for the changes made in the 1912 figures as published in the present report.

The value of granite produced in the United States in 1913 was $20,793,800, an increase of $1,570,498, or 8.17 per cent, as compared with $19,223,302, the value in 1912. Granite for all purposes except curbing, flagging, and railroad ballast increased in value in 1913.

Fourteen States reported a granite production valued at more than $500,000 in 1913 in the following order: Vermont, Massachusetts, Maine, New Hampshire, California, North Carolina, Pennsylvania, Minnesota, Wisconsin, Georgia, Maryland, Connecticut, New York, and Rhode Island. In 1912 the order was as follows: Vermont, Massachusetts, Maine, California, New Hampshire, Wisconsin, North Carolina, Minnesota, Georgia, Rhode Island, Connecticut, Maryland, and Pennsylvania.

In 1913 the first eight States produced granite valued at more than $1,000,000; in 1912, the first six. In 1913, Vermont, New Hampshire, North Carolina, Pennsylvania, and Minnesota showed an increase in value of output; in 1912, these States were Vermont, New Hampshire, North Carolina, Minnesota, Connecticut, and Pennsylvania. The large increase in Pennsylvania was due to increased activity in the use of crushed stone for road material quarried in the vicinity of Philadelphia. In New York a considerable quantity of stone from excavations in New York City was used for riprap and crushed for use in concrete work.

The following table shows the value of the production of granite, including a small output of other igneous rocks, in the United States from 1909 to 1913, inclusive:

Value of granite, etc., produced in the United States, by States and Territories, 1909–1913.

State or Territory.	1909	1910	1911	1912	1913
Alabama			(a)		
Arizona	(a)	(a)	$13,105	$26,501	$13,270
Arkansas	$150,179	$226,690	354,041	366,354	378,110
California	1,310,520	1,520,299	1,738,094	1,583,583	1,451,149
Colorado	74,326	93,679	137,356	55,010	84,497
Connecticut	610,514	410,535	574,673	761,757	765,334
Delaware	456,328	357,708	218,234	193,074	289,987
District of Columbia			(a)		
Georgia	843,542	1,049,186	847,023	823,207	906,470
Hawaii	68,955	139,724	(b)	(b)	(b)
Idaho	(a)	(a)	(a)	30,300	113,710
Maine	1,939,524	2,315,730	2,257,034	1,803,679	1,796,279
Maryland	771,224	982,746	845,936	749,555	806,259
Massachusetts	2,164,619	1,567,754	2,361,624	2,220,279	2,133,407
Michigan	c 660,823	c 858,734			
Minnesota			797,244	950,033	1,000,917
Missouri	155,717	120,663	139,070	97,776	42,484
Montana	(a)	(a)	29,670	28,666	31,520
Nevada		(a)	(a)	(a)	
New Hampshire	1,215,461	1,239,656	1,017,272	1,311,488	1,482,771
New Jersey	60,175	80,105	167,112	142,515	62,637
New Mexico	(a)	(a)	(a)	(a)	(a)
New York	443,910	330,716	344,038	431,910	746,826
North Carolina	743,876	839,742	772,685	983,615	1,116,475
Oklahoma	67,584	102,566	20,244	14,460	30,678
Oregon	d 284,135	d 1,080,009	d 580,978	e 16,721	e 37,807
Pennsylvania	507,814	478,919	491,428	575,680	1,102,206
Rhode Island	933,053	521,490	957,743	767,507	642,375
South Carolina	218,045	369,448	335,617	263,905	360,476
South Dakota			(a)	(a)	(a)
Texas	173,271	66,909	70,488	67,613	76,067
Utah	7,525	6,783	5,209	8,975	(a)
Vermont	2,811,744	2,694,474	2,730,719	3,047,954	3,782,235
Virginia	488,250	503,106	420,611	470,657	462,162
Washington	d 742,878	d 642,992	d 1,345,551	e 140,581	e 140,279
Wisconsin	1,442,305	1,475,342	1,382,309	1,179,018	927,616
Other States	235,300	466,262	239,120	110,929	15,797
Total	19,581,597	20,541,967	21,194,228	19,223,302	20,793,800

a Included in "Other States."
b Basalt, included under trap rock.
c Includes a small value for trap rock in Michigan and Minnesota.
d Includes basalt or trap rock.
e Exclusive of basalt or trap rock.

The following table shows the value of the granite, including small values for trap and other igneous rocks, produced in the United States in 1912 and 1913, by States and Territories and uses:

Value of granite and other igneous rocks in the United States in 1912 and 1913, by States and Territories and uses.

1912.

State or Territory.	Sold in the rough.					Dressed for—		Made into paving blocks.
	Building.	Monumental.	Rubble.	Riprap.	Other.	Building.	Monumental.	
Arizona	$325	$1,720				$1,000	$4,650	
Arkansas			$126,460					
California	32,935	53,929	6,919	$111,717	$2,904	307,997	90,825	$115,650
Colorado	10,300	35,260	900					
Connecticut	53,168	34,099	934	298,224	827	203,739	50,454	48,209
Delaware	5,243			109,699	15	419		8,617
Georgia	15,930	41,385	31,541	31,080	50	140,396	700	58,289
Idaho	700							
Maine	307,422	40,875	17,815	836	1,302	563,482	65,722	670,520
Maryland	95,570	14,826	76,336	83	888	39,210	17,797	60,853
Massachusetts	190,585	424,813	21,706	107,425	48,005	778,403	20,700	358,876
Minnesota	19,018	61,995	7,609	30,610	290	229,048	430,982	75,820
Missouri	5,629	35,273	1,816	2,518		700	9,900	5,927
Montana	809	500	500			15,164	7,242	1,695
Nevada								
New Hampshire	70,533	66,879	5,845	6,052	4,006	571,661	168,784	297,256
New Jersey	25,880	15,200	380	2,115	400	450		
New Mexico								
New York	25,329	5,541	23,731	32,071	1,890	160,959	10,265	
North Carolina	52,265	27,800	8,884	3,050	1,014	216,523	18,500	212,990
Oklahoma	2,000	8,450					2,610	
Oregon		1,700				2,230	12,791	
Pennsylvania	243,506	10,560	7,840	93,729	29,399	64,211	44,300	13,442
Rhode Island	14,331	178,565	1,514	512	55	164,752	269,074	37,449
South Carolina	5,450	70,273	1,658	8,300		300	42,245	166
South Dakota								
Texas	8,058	30,880		9,445		800	5,000	
Utah	5,500	3,400					75	
Vermont	34,433	1,367,149	2,830		6,680	1,323,787	286,563	12,016
Virginia	28,617	8,820	32,554	59,575		3,852	7,526	79,046
Washington	583	1,628	13,180			30,822	10,501	7,877
Wisconsin	1,018	13,076	1,575	168	188	49,499	500,177	497,307
Other States[a]						1,300	12,000	
Total	1,255,137	2,554,596	392,527	907,209	97,913	4,870,704	2,089,323	2,562,005

State or Territory.	Curbing.	Flagging.	Crushed stone.			Other.	Total.
			Road making.	Railroad ballast.	Concrete.		
Arizona					$18,806		$26,501
Arkansas			$101,917	$96,858	41,119		366,354
California	$109,810	$175	301,304	183,789	250,256	$15,373	1,583,583
Colorado			6,750		1,800		55,010
Connecticut	33,359	814	14,512		12,149	11,269	761,757
Delaware	2,435	179	27,861	14,070	24,536		193,074
Georgia	231,897	8,070	26,542	47,223	188,254	1,850	823,207
Idaho			9,000	16,000	4,600		30,300
Maine	105,649	4,860	5,062	14,000	5,075	1,059	1,803,679
Maryland	5,900	584	207,089	129,347	97,251	3,821	749,555
Massachusetts	108,304	2,750	94,555	3,985	51,629	8,543	2,220,279
Minnesota	23,470		33,607	15,000	22,400	184	950,033
Missouri	2,950				33,063		97,776
Montana	635				2,121		28,666
Nevada							(b)
New Hampshire	63,728	16,610	2,875	2,527	20,228	14,504	1,311,488
New Jersey			35,585	55,085	6,520	900	142,515
New Mexico							(b)
New York	3,111		41,553		127,220	240	431,910
North Carolina	130,506	4,510	60,691	33,254	206,579	7,049	983,615
Oklahoma					1,400		14,460
Oregon							16,721
Pennsylvania	3,941	100	16,522	17,573	28,867	1,690	575,680
Rhode Island	7,891		64,777		24,140	4,502	767,507
South Carolina	2,535		41,252	21,234	67,878	2,559	263,905
South Dakota							(b)
Texas	700				12,730		67,613
Utah							8,975
Vermont	912		100	2,000	11,544		3,047,954
Virginia	16,774	438	54,540	49,480	115,427	14,008	470,657
Washington	40,596	450	797,854		11,188	780	140,581
Wisconsin	2,106	1,900	49,038		62,936	30	1,179,018
Other States[a]	1,000	200		96,429			110,929
Total	898,209	41,640	1,218,108	797,854	449,716	88,361	19,223,302

[a] Includes Nevada, New Mexico, and South Dakota. [b] Included in "Other States."

Value of granite and other igneous rocks in the United States in 1912 and 1913, by States and Territories and uses—Continued.

1913.

State or Territory.	Sold in the rough.					Dressed for—		Made into paving blocks.
	Building.	Monumental.	Rubble.	Riprap.	Other.	Building.	Monumental.	
Arizona	$2,700	$3,570					$1,000	
Arkansas	63		$58,005	$37,000				
California	90,548	44,054	6,846	61,096	$1,204	$416,125	61,215	$109,902
Colorado	8,353	45,730	414			2,000		
Connecticut	35,292	40,352	8,375	340,080	952	141,214	94,456	46,640
Delaware	13,880	270	191,480	5,691		3,931		1,696
Georgia	14,446	29,043	30,266	21,141	50	200,496	42,886	172,831
Idaho	750		100			300		
Maine	208,028	39,224	26,526	18,707	21,104	633,140	27,189	702,318
Maryland	89,849	14,474	61,062	7,627	500	7,700	27,555	41,152
Massachusetts	197,961	400,652	27,619	46,251	52,631	730,404	30,246	395,390
Minnesota	14,279	76,644	9,581	60,695		146,352	490,564	85,150
Missouri	869	16,552		1,691		1,425	360	4,882
Montana	770	500	100			22,850	2,000	
New Hampshire	51,961	93,662	33,228	1,561	2,589	553,333	194,995	451,545
New Jersey	672	547	2,400	1,342	620		4,081	
New Mexico								
New York	11,990	3,832	25,981	259,148	600	30,871	8,754	28,000
North Carolina	62,103	18,571	36,916		50	304,642	23,615	215,133
Oklahoma	6,200	18,150	128			600	2,000	
Oregon	80	1,500				200	10,015	
Pennsylvania	333,598	4,035	10,871	180,901	33,418	53,179	39,865	49,440
Rhode Island	38,631	154,453	279	1,014	100	67,041	230,440	66,018
South Carolina	440	86,247	2,752	37,883	150	690	59,589	8,844
South Dakota								
Texas	6,453	33,946		28,918			6,000	
Utah								
Vermont	43,621	1,453,818	4,566	124	13,522	2,008,240	239,18[illegible]	3,162
Virginia	47,980	11,797	38,854	42,000	58	4,200	3,294	73,795
Washington	2,211	1,674		9,568		29,167	9,335	20,632
Wisconsin	1,451	18,843	2,082	400	342	10,829	486,913	279,465
Other States[a]	7,057	1,167		1,100		2[illegible]0	6,223	
Total	1,292,236	2,613,307	573,431	1,163,938	127,890	5,369,179	2,101,777	2,755,995

State or Territory.	Curbing.	Flagging.	Crushed stone.			Other.	Total.
			Road making.	Railroad ballast.	Concrete.		
Arizona				$265	$5,735		$13,270
Arkansas			$159,423	60,493	63,126		378,110
California	$92,745		222,259	186,125	156,143	$2,887	1,451,149
Colorado			28,000				84,497
Connecticut	25,265	$284	16,511		12,550	8,363	765,334
Delaware	3,659		37,522	21,327	10,496	35	289,987
Georgia	189,736	720	32,100	49,884	98,726	24,145	906,470
Idaho			15,000	70,560	27,000		113,710
Maine	84,686	6,754	2,055	324	16,262	3,962	1,790,279
Maryland	6,820	685	256,958	136,485	149,820	5,572	806,259
Massachusetts	132,646	1,870	46,612	4,408	48,030	18,687	2,133,407
Minnesota	18,976		19,806	600	78,220	50	1,000,917
Missouri					12,712	3,993	42,484
Montana	1,800		500		3,000		31,520
New Hampshire	70,498	1,175	6,415	129	10,297	11,383	1,482,771
New Jersey			7,680	44,373	922		62,637
New Mexico							(b)
New York			32,900		342,170	2,580	746,826
North Carolina	92,240		57,888	67,828	235,548	1,941	1,116,475
Oklahoma					3,600		30,678
Oregon			26,000		12		37,807
Pennsylvania	9,353	159	327,129	12,311	33,822	14,125	1,102,206
Rhode Island	11,000		58,500	3,000	7,996	3,903	642,375
South Carolina	9,560		47,776	43,950	61,757	838	360,476
South Dakota							(b)
Texas			[illegible]50				76,067
Utah							(b)
Vermont	1,737		1,877	664	11,717		3,782,235
Virginia	11,681		86,618	34,916	94,969	12,000	462,162
Washington	51,478		6,980	6,000		3,234	140,279
Wisconsin	410	1,525	54,803		70,553		927,616
Other States[a]							15,797
Total	814,290	13,172	1,552,062	743,642	1,555,183	117,698	20,793,800

[a] Includes New Mexico, South Dakota, and Utah. [b] Included in "Other States."

Building stone.—About 32 per cent of the value of granite output is represented by building stone, which, including rough and dressed stone, was valued at $6,661,415 in 1913, of which nearly one-fifth was the value of rough stone and four-fifths the value of the dressed stone sold. In 1912 this value was $6,125,841, or an increase of $535,574 in 1913. Over 30 per cent of the building stone value is represented by Vermont's output, which is chiefly dressed stone. Massachusetts, Maine, and New Hampshire follow next in order, producing respectively 14, 13, and 9 per cent of the granite used for building, the stone in these States also being sold chiefly as dressed stone. Pennsylvania contributes most of the rough stone.

Monumental stone.—Nearly 23 per cent of the value of granite in 1913 was for monumental stone (rough and dressed), the total value of which was $4,715,084, an increase of $71,165, or 1.53 per cent, over the value for 1912, which was $4,643,919. The total value is almost equally divided between rough and dressed stone, both of which increased in value in 1913. Vermont's output was nearly 36 per cent of the total monumental stone, representing both rough and dressed stone. The next State in rank was Minnesota, producing, however, only 12 per cent.

Rubble.—Rubble increased in value $180,904 in 1913, or from $392,527 in 1912 to $573,431 in 1913.

Riprap.—Stone for riprap increased in value $256,729 in 1913, or to $1,163,938 from $907,209 in 1912.

Paving blocks.—Paving blocks represent over 13 per cent of the value of the granite output. Maine, New Hampshire, Massachusetts, Wisconsin, North Carolina, Georgia, and California, in the order named, are the largest producers of this material.

The following table shows the quantity and value of granite paving blocks produced in the United States in 1912 and 1913 by States:

Number and value of granite paving blocks produced in 1912 and 1913, by States and Territories.

State.	Paving blocks.			
	1912		1913	
	Number.	Value.	Number.	Value.
California	2,228,835	$115,650	2,096,567	$109,902
Connecticut	968,640	48,209	992,509	46,640
Delaware	211,180	8,617	46,430	1,696
Georgia	2,324,900	58,289	4,910,958	172,831
Maine	12,795,125	670,520	13,266,644	702,318
Maryland	1,030,331	60,853	681,000	41,152
Massachusetts	7,070,082	358,876	7,885,001	395,390
Minnesota	1,097,700	75,820	1,126,000	85,150
Missouri	95,400	5,927	104,175	4,882
Montana	17,472	1,695		
New Hampshire	8,153,800	297,256	10,979,474	451,545
New York			400,000	28,000
North Carolina	5,079,343	212,990	4,415,311	215,133
Pennsylvania	280,205	13,442	1,041,718	49,440
Rhode Island	780,382	37,449	1,128,581	66,018
South Carolina	5,600	166	231,710	8,844
Vermont	344,015	12,016	70,654	3,162
Virginia	1,980,943	79,046	1,595,628	73,795
Washington	98,000	7,877	182,092	20,632
Wisconsin	9,974,076	497,307	5,308,092	279,465
Total	44,536,029	2,562,005	56,462,544	2,755,995
Average price per thousand		$57.53		$48.81
Percentage of increase in 1913 as compared with 1912			26.78	7.57

These figures give the quantity and value of paving blocks quarried and sold by the quarrymen. In some of the States, notably Vermont, a considerable quantity of stone is sold to paving block manufacturers, who manufacture the blocks and market them. As these firms have no connection with the quarries, and the stone purchased by them is already reported by the quarrymen as sold rough, the blocks manufactured are not included in the figures of the paving-block industry. This output in Vermont, however, amounted to about 1,400,000 blocks, valued at about $56,000, in 1912, and about 2,800,000 blocks, valued at about $109,000, in 1913. A change was made in the Vermont 1912 figures to conform to those for 1913. In Massachusetts the quarrymen themselves sell the paving blocks manufactured by the "motion" men, who manufacture the blocks from their stone, and these blocks are included in the total.

The paving-block business showed a decided increase in quantity in 1913 as compared with 1912, but, while the value of the output also increased, the average price per thousand decreased. The increase in quantity was from 44,536,029 blocks in 1912 to 56,462,544 blocks in 1913, a gain of 11,926,515 blocks, or 26.78 per cent. The increase in value was from $2,562,005 in 1912 to $2,755,995 in 1913, a gain of $193,990, or 7.57 per cent. The average price per thousand was $47.99 in 1911, $57.53 in 1912, and $48.81 in 1913, a decrease of $8.72 for 1913, although practically the price was the same for 1913 as for 1911. The value of the blocks varies with the size and with the dressing, and ranges from about $25 to $100 per thousand.

A large proportion of the output from Minnesota and Wisconsin supplies the Chicago market. The blocks for Baltimore, New York, Philadelphia, and other large eastern cities as well as for the central and southern cities are supplied by Massachusetts, Maine, North Carolina, New Hampshire, New Jersey, Georgia, Pennsylvania, and other granite-producing States of the Atlantic seaboard. The Pacific coast demand is met by the quarries in the States situated on that coast.

Curbing.—Granite for curbing decreased in value $83,919, or from $898,209 in 1912 to $814,290 in 1913. Georgia, Massachusetts, California, North Carolina, and Maine are the largest producers of this material.

Flagging.—But a small part of the total granite output is used for flagstone, and this was one of the three products in which the granite output showed a decrease. The decrease amounted to $28,468, or from $41,640 in 1912 to $13,172 in 1913.

Crushed stone.—Granite in the form of crushed stone represents a little more than 18 per cent of the value of the total granite output and 12 per cent of the value of the crushed stone produced in the United States.

There was an increase in 1913 of 273,419 short tons in quantity and $385,209 in value of the crushed granite, or from 4,609,005 short tons, valued at $3,465,678, in 1912 to 4,882,424 short tons, valued at $3,850,887, in 1913. About 75 per cent of this crushed stone is used for road making and concrete—nearly equally divided between the two—and the remaining 25 per cent for railroad ballast. Road making and concrete increased in output, while stone for railroad ballast decreased somewhat. The average value per short ton was 75 cents in 1912 and 79 cents in 1913, an increase of 4 cents per short ton.

Other purposes.—Rough stone sold for a variety of purposes not given on the statistical card increased from $97,913 in 1912 to $127,890 in 1913, a gain of $29,977; and worked stone sold for a variety of purposes increased $29,337, or from $88,361 in 1912 to $117,698 in 1913.

GRANITE IN INDIVIDUAL STATES.

GENERAL STATEMENT.

It is always recognized that statistics are of much greater service when both the quantity and the value are given, and the Survey has endeavored to render the stone statistics as complete as possible by publishing such figures of quantity as can be compiled from the data reported by the quarrymen. Owing to the various units of measurement used and to the lack of uniformity of some of the units, and also because many operators give no unit, it is difficult to compile figures of quantity. However, the majority of producers in several of the larger granite States report quite conformable figures of quantity, and below is given the output of Maine, Minnesota, New Hampshire, Vermont, and Wisconsin, showing the quantity and the distribution of the output by counties. No county figures are published unless there are three or more producers in the county. As requests have been made for the output of Massachusetts according to the distribution of the output, the figures of value are given by counties as far as they can be made available. It is to be regretted that the quantities for this State can not also be published.

MAINE.

Much of the granite quarried in Maine is shipped in large blocks for cyclopean masonry. The largeness of this stone renders it somewhat difficult to handle, but on account of the nearness of much of it to water transportation and because of the fewer number of pieces to handle it does not command as high a value per cubic foot as some of the other granites. For the same reason, and because there is often so little carving on the larger blocks, the dressed stone does not show such a high average price per cubic foot. The dressed stone also varies considerably in average price, depending on the terms of the contract.

The figures below show the output by groups rather than by individual counties, the small number of producers in each county rendering this necessary.

Production of granite in Maine in 1912 and 1913, by counties and uses.

County.	Number of operators.	Building.				Monumental.				Paving.		Crushed stone.		Curbing and flagging.		Other.	Total value.
		Rough.		Dressed.		Rough.		Dressed.									
		Quantity (cubic feet).	Value.	Quantity (cubic feet).	Value.	Quantity (cubic feet).	Value.	Quantity (cubic feet).	Value.	Quantity (number of blocks).	Value.	Quantity (short tons).	Value.	Quantity (lineal feet).	Value.	Value.	
1912.																	
Cumberland, Franklin, Oxford, Somerset, and York	19	48,534	$10,159	77,130	$231,727	23,171	$11,300	3,438	$2,889	1,357,552	$60,818	31,051	$22,792	19,150	$5,565	$1,338	$348,964
Hancock	32	858,083	280,237	27,727	46,553	3,130	1,085	6,050	8,700	2,002,879	97,834	1,007	995	192,136	101,118	2,607	539,129
Kennebec, Knox, Lincoln, and Waldo	17	18,243	10,245	110,246	283,652	42,291	22,635	10,877	44,766	9,369,694	508,643	325	350	1,616	1,450	17,067	888,808
Washington and Aroostook	9	7,305	6,781	475	1,550	4,885	5,855	4,851	9,367	65,000	3,225	....	....	5,621	2,376	....	26,778
Total	77	932,165	307,422	215,578	563,482	73,477	40,875	25,216	65,722	12,795,125	670,520	32,383	24,137	218,523	110,509	21,012	1,803,679
Average price	....	....	$0.33	....	$2.61	....	$0.56	....	$2.61	Per M, $52.40		....	$0.75	....	$0.51	....	....
1913.																	
Cumberland, Franklin, Oxford, Somerset, and York	18	55,188	$10,322	31,866	$200,414	17,206	$11,827	3,885	$3,775	1,235,775	$61,730	21,891	$18,541	13,625	$5,335	$9,213	$321,157
Hancock	30	577,067	173,282	207,765	251,977	18,469	4,125	10,020	7,740	2,592,794	130,323	....	....	180,211	86,105	42,105	695,657
Kennebec, Knox, Lincoln, and Waldo	15	50,173	24,424	94,603	178,799	11,948	8,795	2,451	7,270	9,431,875	509,921	138	100	....	....	18,981	748,290
Washington and Aroostook	7	....	....	705	1,950	19,263	14,477	2,852	8,404	6,200	344	....	....	....	....	....	25,175
Total	70	682,498	208,028	334,939	633,140	66,886	39,224	19,208	27,189	13,266,644	702,318	22,029	18,641	193,836	91,440	70,299	1,790,279
Average price	....	....	$0.30	....	$1.89	....	$0.59	....	$1.42	Per M, $52.94		....	$0.85	....	$0.47	....	....

Maine was one of the larger States which showed a decreased granite production, although this decrease was only $13,400, or from $1,803,679 in 1912 to $1,790,279 in 1913. The only products which increased were dressed building stone and paving blocks. The building stone, however, decreased considerably in average price, while paving blocks increased 54 cents in average price per thousand.

MASSACHUSETTS.

It has not been found possible to show the quantity of granite quarried in Massachusetts, but the figures given below serve to show the distribution of the product and the principal uses. Massachusetts, like Maine, was one of the larger granite-producing States showing a decrease in output. This decrease was small, from $2,220,279 in 1912 to $2,133,407 in 1913, and amounted to only $86,872, or less than 4 per cent.

Value of granite produced in Massachusetts in 1912 and 1913 by counties and uses.

1912.

Number of operations.	County.	Building.		Monumental.		Paving blocks.	Crushed stone.	Other.[a]	Total value.
		Rough.	Dressed.	Rough.	Dressed.				
6	Berkshire, Franklin, Hampden, and Hampshire	$750	$93,200	$28,466	$50	$13,000	$22,108	$19,817	$177,391
12	Bristol and Plymouth	37,115	32,205	649	....	38,065	14,214	34,002	156,250
17	Essex	106,195	190,901	41,064	....	241,593	34,895	123,234	737,882
19	Middlesex	7,742	155,120	....	....	47,105	22,466	52,612	285,045
17	Norfolk	7,681	7,537	354,494	20,650	8,850	36,000	54,380	489,592
10	Worcester	31,102	299,440	140	....	10,263	20,486	12,688	374,119
81	Total	190,585	778,403	424,813	20,700	358,876	150,169	296,733	2,220,279

1913.

Number of operations.	County.	Building.		Monumental.		Paving blocks.	Crushed stone.	Other.[a]	Total value.
		Rough.	Dressed.	Rough.	Dressed.				
5	Berkshire, Franklin, Hampden, and Hampshire	$75	$60,096	$39,981	$2,000	$1,800	$15,190	$14,004	$133,146
13	Bristol and Plymouth	55,662	13,583	400	250	11,896	13,879	27,153	122,823
14	Essex	84,003	128,296	34,228	....	285,843	35,025	77,698	645,093
21	Middlesex	2,707	61,368	80	4,681	85,335	12,445	75,639	242,255
15	Norfolk	45,174	4,310	325,763	23,265	4,000	....	47,395	449,907
11	Worcester	10,340	462,751	200	50	6,516	22,511	37,815	540,183
79	Total	197,961	730,404	400,652	30,246	395,390	99,050	279,704	2,133.407

[a] Other includes stone sold for riprap, rubble, curbing, flagging, and other minor uses.

MINNESOTA.

Minnesota showed the small increase of $50,884 in value of granite output in 1913, from $950,033 in 1912 to $1,000,917. The increase was distributed over all uses except building stone, which decreased in quantity, value, and average price per ton. There was a notable increase of $6.55 in the average price per thousand of the paving blocks, or from $69.07 per thousand in 1912 to $75.62 per thousand in 1913. To prevent publishing individual figures the productions of neighboring counties are combined, and for the same reason the rough stone and the dressed stone are given together. Minnesota has attained considerable importance as a granite-producing State, especially in the vicinity of St. Cloud the granite is a source of wealth to the State.

The stone quarried in Lake and St. Louis counties is trap rock rather than granite. The following table shows the quantity and value of the granite output of Minnesota in 1912 and 1913 by counties and uses:

Quantity and value of granite produced in Minnesota in 1912 and 1913, by counties and uses.

1912.

County.	Number of plants.	Building (rough and dressed).		Monumental (rough and dressed).		Paving blocks.		Crushed stone.		Other value.	Total value.
		Quantity (cubic feet).	Value.	Quantity (cubic feet).	Value.	Number of blocks.	Value.	Quantity (short tons).	Value.		
Lac qui Parle, Redwood, and Renville	3	925	$595	5,175	$8,444	....	....	....	....	$107	$9,146
Benton and Kanabec....	5	22,000	40,536	15,200	39,200	50,000	$3,500	....	....	7,950	91,186
Sherbourne....	5	41,250	37,127	3,862	3,189	913,700	62,545	13,462	$14,900	9,950	127,711
Stearns........	15	78,101	169,808	157,642	442,144	134,000	9,775	....	....	16,987	638,714
Lake and St. Louis [a]......	3	....	....	....	....	....	....	66,462	56,107	27,169	83,276
Total....	31	142,276	248,066	181,879	492,977	1,097,700	75,820	79,924	71,007	62,163	950,033
Average price.	....	....	$1.74	....	$2.71	Per M, $69.07		....	$0.89	....	....

1913.

County.	Number of plants.	Building Quantity (cubic feet).	Building Value.	Monumental Quantity (cubic feet).	Monumental Value.	Paving Number of blocks.	Paving Value.	Crushed Quantity (short tons).	Crushed Value.	Other value.	Total value.
Benton, Redwood and Renville.....	5	2,880	$1,875	9,350	$27,419	....	....	....	....	$8,379	$37,673
Sherbourne....	5	51,762	40,369	4,870	4,240	712,000	$54,350	10,628	$13,110	5,575	117,644
Stearns........	18	61,354	118,387	193,327	535,549	414,000	30,800	80	40	13,018	697,794
Lake and St. Louis [a]......	3	....	....	....	....	....	....	99,844	85,476	62,330	147,806
Total....	31	115,996	160,631	207,547	567,208	1,126,000	85,150	110,552	98,626	89,302	1,000,917
Average price..	....	....	$1.38	....	$2.73	Per M, $75.62		....	$0.89	....	....

[a] Trap rock.

NEW HAMPSHIRE.

In compiling a detailed statement of the granite output of New Hampshire it was found that Cheshire and Hillsboro were the only counties that could be published separately, and for 1913 it was necessary to combine all of the others, although the counties were not in close proximity. The total value of the output increased from $1,311,488 in 1912 to $1,482,771 in 1913, a gain of $171,283, or 13 per cent.

The following table shows the quantity and value of the granite produced in New Hampshire in 1912 and 1913 by counties and uses:

Quantity and value of granite produced in New Hampshire in 1912 and 1913 by counties and uses.

Number of operators.	County.	Building.				Monumental.				Paving.		Curbing and flagging.		Crushed stone.		Other value.	Total value.
		Rough.		Dressed.		Rough.		Dressed.									
		Quantity.	Value.	Quantity.	Value.	Quantity.	Value.	Quantity.	Value.	Number of blocks.	Value.	Quantity.	Value.	Quantity.	Value.		
	1912.																
		Cu. ft.		*Cu. ft.*		*Cu. ft.*		*Cu. ft.*				*Linear feet.*		*Short tons.*			
6	Carroll and Merrimack	19,378	$7,446	174,431	$460,436	32,453	$16,670	7,024	$27,642	2,439,315	$87,131	12,197	$5,981	14,891	$14,219	$2,974	$622,499
7	Cheshire	37,237	13,040	25,691	77,657	18,575	18,706	16,267	49,847	700,235	29,288	36,115	13,758	12,109	9,176	7,088	218,560
3	Coos, Grafton, and Strafford	9,900	750	....	....	....	....	....	....	....	....	....	....	4,470	2,235	14,000	16,985
19	Hillsboro	94,809	49,297	28,480	33,568	33,132	31,503	21,923	91,295	5,014,250	180,837	157,549	60,599	....	....	6,345	453,444
35	Total	161,324	70,533	228,602	571,661	84,160	66,879	45,214	168,784	8,153,800	297,256	205,861	80,338	31,470	25,630	30,407	1,311,488
	Average price	....	$0.44	....	$2.50	....	$0.80	....	$3.73	Per M,	$36.46	....	$0.39	....	$0.81	....	....
	1913.																
9	Carroll, Grafton, Strafford, and Merrimack	27,990	$10,351	146,592	$458,842	35,064	$18,199	13,838	$53,099	2,986,720	$124,700	8,989	$4,638	17,574	$15,468	$17,257	$702,754
9	Cheshire	77,079	24,102	33,534	85,786	24,345	19,794	6,917	19,851	1,425,475	56,572	175	44	731	373	26,654	233,176
18	Hillsboro	56,514	17,508	8,894	8,705	60,343	55,669	32,028	122,045	6,567,279	270,273	208,316	66,991	2,000	1,000	4,650	546,841
36	Total	161,583	51,961	189,020	553,333	119,752	93,662	52,783	194,995	10,979,474	451,545	217,480	71,673	20,305	16,841	48,761	1,482,771
	Average price	....	$0.32	....	$2.93	....	$0.78	....	$3.69	Per M,	$41.13	....	$0.33	....	$0.83	....	....

VERMONT.

The granite output of Vermont represents over 18 per cent of the total granite output of the United States, and in 1913 the State produced $1,648,828 more granite than its closest competitor, Massachusetts. Vermont's output in 1913 was valued at $3,782,235 and that of Massachusetts at $2,133,407. The total for Vermont represented an increase of $734,281, or 24 per cent, over the value for 1912, which was $3,047,954.

As the granite industry is one of the principal sources of the State's wealth, the following detailed statement of output is of interest. The following table shows the production of granite in Vermont in 1912 and 1913, by counties and uses:

Production of granite in Vermont in 1912 and 1913, by counties and uses.

1912.

County.	Number of active firms reporting.	Building.				Monumental.				Paving.		Other uses.	Total value.
		Rough.		Dressed.		Rough.		Dressed.					
		Quantity (cubic feet).	Value.	Quantity (cubic feet).	Value.	Quantity (cubic feet).	Value.	Quantity (cubic feet).	Value.	Quantity (number of blocks).	Value.	Value.	
Washington, Orange, and Windsor	24	29,388	$25,474	389,028	$1,322,567	1,320,744	$1,325,794	72,306	$252,103	216,015	$7,020	$20,013	$2,952,971
Essex and Orleans	6	5,309	2,659	1,500	750	35,405	16,405	5,000	12,000	....	....	3,080	34,894
Windham	3	5,500	2,500	172	470	....	....	....	....	126,000	4,920	973	8,863
Caledonia	7	9,000	3,800	....	....	53,618	24,950	28,000	22,400	2,000	76	....	51,226
Total	40	49,197	34,433	390,700	1,323,787	1,409,767	1,367,149	105,306	286,503	344,015	12,016	24,066	3,047,954
Average price per cubic foot	....	....	$0.70	....	$3.39	....	$0.97	....	$2.72	Per M,	$34.93	....	....

1913.

County.	Number of active firms reporting.	Building Rough Quantity (cubic feet).	Building Rough Value.	Building Dressed Quantity (cubic feet).	Building Dressed Value.	Monumental Rough Quantity (cubic feet).	Monumental Rough Value.	Monumental Dressed Quantity (cubic feet).	Monumental Dressed Value.	Paving Quantity (number of blocks).	Paving Value.	Other uses Value.	Total value.
Washington, Orange, and Windsor	24	44,803	$38,639	546,335	$2,004,724	1,377,974	$1,403,090	67,253	$235,087	....	....	$30,930	$3,712,465
Orleans	5	20	210	3,040	3,040	25,140	12,520	3,000	2,100	....	....	900	18,505
Windham	5	8,844	4,272	190	476	150	75	....	....	70,654	$3,162	2,647	10,632
Caledonia	6	2,000	500	....	....	79,228	38,133	800	2,000	....	....	....	40,633
Total	40	55,667	43,621	549,565	2,008,240	1,482,492	1,453,818	71,053	239,187	70,654	3,162	34,477	3,782,235
Average price per cubic foot	....	....	$0.78	....	$3.65	....	$0.98	....	$3.37	Per M,	$44.75	....	....

As previously stated in this report and in former reports, the value represents the value of the stone as sold by the quarrymen, the value being given for rough stone if sold rough and for dressed stone if sold after cutting by the quarrying firm. In Vermont the greater part of the granite is sold to granite manufacturers in the rough, and, although some of the stone is shipped in the rough, the greater part is cut in the vicinity of Barre and other centers, and this manufacturing industry forms a distinct, though dependent, source of wealth to the State. Dressed stone, including monumental and building stone, as quarried and sold by the quarrymen, amounted to only 620,618 cubic feet compared with 1,538,159 cubic feet sold rough. The dressed stone, however, was valued at $2,247,427, or an average price of $3.62 per cubic foot, while the rough stone value was reported at $1,497,439, or 97 cents per cubic foot.

If the rough stone be considered as sold in the manufactured state at the average price of dressed stone, after allowing 10 per cent for waste, the total value for Vermont, including stone sold for paving blocks, curbing, rubble, crushed stone, etc., would represent an industry amounting in 1913 to nearly $6,000,000.

The most notable feature of the granite production in Vermont in 1913 was the increase in the stone used for building purposes, which, including rough and dressed stone, amounted to 439,897 cubic feet in 1912 and increased to 605,232 cubic feet in 1913.

The paving-block industry in Vermont has never been of especial importance when compared with the size of this industry in the nearby States of Maine, New Hampshire, and Massachusetts. The greater number of blocks made in this State are not made by the quarrymen, but made from stone sold by them to firms who manufacture and sell the finished product. For this reason the stone sold by the quarrymen for paving blocks is included under rough stone, and the table of production does not include the entire number of blocks manufactured in the State. Owing to a misconception, the figures given in previous years did not represent the correct quantity and value of the blocks as sold by the quarrymen, but in this report the 1912 figures have been changed to conform with those collected in 1913. Besides the blocks reported in the table of production, there were made by paving-block contractors in 1912 about 1,400,000 blocks, valued at about $56,000, and in 1913 about 2,800,000 blocks, with an approximate value of $109,000.

WISCONSIN.

To prevent disclosure of individual figures, it was found necessary, in compiling a detailed statement of the granite production in Wisconsin, to class together the counties of Douglas, Green Lake, Oconto, and Waupaca, although these counties are not in the same part of the State. It was also necessary to include under building and monumental stone both the rough and the dressed stone, although it will readily be seen that the figures represent mostly dressed stone.

The following table shows the output of granite in Wisconsin in 1913 by counties and uses:

Quantity and value of granite produced in Wisconsin in 1913 by counties and uses.

Number of operators.	County.	Building (rough and dressed).		Monumental (rough and dressed).		Paving blocks.		Crushed stone.		Other.	Total value.
		Quantity.	Value.	Quantity.	Value.	Quantity (number of blocks).	Value.	Quantity.	Value.	Value	
		Cubic feet.		*Cubic feet.*				*Short tons.*			
6	Douglas, Green Lake, Oconto, and Waupaca	....	....	1,000	$1,300	631,073	$31,423	72,766	$65,756	$685	$99,164
5	Marathon	794	$1,119	42,850	178,033	....	....	....	....	....	179,152
3	Marinette	1,920	6,600	25,343	89,676	....	....	....	....	....	96,276
10	Waushara and Marquette	2,120	4,561	32,745	236,747	4,677,019	248,042	74,535	59,600	4,074	553,024
24	Total	4,834	12,280	101,938	505,756	5,308,092	279,465	147,301	125,356	4,759	927,616
Average price		....	$2.54	....	$1.96	Per M. $52.65		....	$0.85	....	....

TRAP ROCK.

Besides the "trap rock" (basalt, and other dark volcanic rocks) reported in the following tables, there is a small quantity included in the figures for granite under those States in which trap rock does not form enough of an industry to warrant the separate publication of the figures.

In the value of trap rock produced in Massachusetts is included the value of slate quarried in the vicinity of Boston, which, on account of lack of fissility, is rendered unsuitable for any of the purposes for which slate is used; therefore, it is crushed and used entirely for road making.

The trap-rock industry in the Pacific coast States is known as the basalt-quarrying industry, and as stated previously in this report, the basalt quarried in Oregon and Washington has for the first time been separated from granite and included with trap-rock figures. The greater part of the production from the Washington quarries was used both in 1912 and 1913 in riprapping at the mouth of Columbia River. Also in California a large increase in the riprap production was for work done in Humboldt Bay.

There was a large increase in the value of the total output in 1913, from $7,560,049 in 1912 to $9,289,809 in 1913, an increase of $1,729,760 or 22.88 per cent.

With the exception of Washington, each of the producing States showed a considerable increase in value of output, but the rank of States changed considerably. In 1912 only two States produced trap rock valued at more than $1,000,000, California and New Jersey; in 1913 California, Massachusetts, New Jersey, Pennsylvania, and New York, in order named, each contributed more than $1,000,000 to the total. Stone used for riprap, road making, and ballasting of railroads showed the largest increase.

The following table shows the value of the trap-rock production in the United States in 1912 and 1913, by States and uses:

Value of trap rock produced in the United States in 1912–13, by States and uses.

1912.

State.	Building.	Riprap and rubble.	Paving.	Crushed stone.			Other.	Total.
				Road-making.	Railroad ballast.	Concrete.		
California	$500	$214,438	$229,261	$591,036	$340,561	$543,254	$7,297	$1,926,347
Connecticut	15,683	17,066	3,081	274,036	89,645	180,370	1,189	581,070
Hawaii	2,607			128,854		94,140	5,750	231,351
Massachusetts	30,614	6,000		303,007	10,000	564,706	914	915,241
Michigan		8,500		18,366		9,340		36,206
New Jersey	9,213	4,357	31,646	616,674	189,641	342,079	8,787	1,202,397
New York	20,000			376,460	39,106	396,101		831,667
Oregon	755	4,721	300	128,272	14,636	102,013	70	250,767
Pennsylvania	14,458	1,860	1,347	359,844	326,512	210,331	2,031	916,383
Washington	158	575,029		71,544	2,847	18,250	792	668,620
Total	93,988	831,971	265,635	2,868,093	1,012,948	2,460,584	26,830	7,560,049

1913.

State.	Building.	Riprap and rubble.	Paving.	Road-making.	Railroad ballast.	Concrete.	Other.	Total.
California	$208	$626,477	$141,332	$507,258	$321,500	$531,009	$4,461	$2,132,245
Connecticut	9,152	7,967	1,759	349,795	55,694	288,629	327	713,323
Hawaii	750	66,478	483	97,826	25,747	52,851	5,255	249,390
Massachusetts	24,988	1,000		702,803	67,474	698,424	2,500	1,497,189
Michigan		51,600		23,369	8,492	8,740		92,201
New Jersey	18,856	4,976	50,949	701,494	250,571	322,598	10,487	1,359,931
New York	12,000			520,666	102,939	242,085	200,000	1,077,690
Oregon	2,265	6,228	7,658	156,471	59,873	83,512		316,007
Pennsylvania	5,731	1,175	2,165	492,183	512,666	202,452	2,546	1,218,918
Washington	9,128	504,392		110,969	3,998	4,428		632,915
Total	83,078	1,270,293	204,346	3,662,834	1,408,954	2,434,728	225,576	9,289,809

The following table shows the quantity and value of trap paving blocks produced in the United States in 1912 and 1913, by States:

Number and value of trap paving blocks produced in the United States, 1912–13, by States.

State.	Paving blocks.			
	1912		1913	
	Number.	Value.	Number.	Value.
California	4,906,889	$229,261	2,237,971	$141,332
Connecticut	78,600	3,081	44,250	1,759
Hawaii			36,250	483
New Jersey	1,015,841	31,646	1,470,648	50,949
Oregon	10,000	300	218,800	7,658
Pennsylvania	33,673	1,347	51,400	2,165
Total	6,045,003	265,635	4,059,319	204,346
Average price per thousand		$43.94		$50.33

MARBLE.

The figures for marble production here presented include, for some of the States, the value of serpentine (verde antique marble) and "onyx" marble. The serpentine included is that form which, from its use as ornamental stone for interior decorative work in buildings, answers the purpose of marble. The California, Georgia, Pennsylvania, and Vermont figures in this report include this stone. Onyx marble, or cave onyx, is included in the production of Kentucky and New Mexico.

In 1913 the commercial output of marble came from the following States, arranged according to value of output:

Vermont: Bennington, Franklin, Grand Isle, Rutland, and Washington counties.
Tennessee: Blount, Knox, Loudon, and Union counties.
Georgia: Cherokee and Pickens counties.
Colorado: Gunnison County.
Alabama: Talladega County.
Massachusetts: Berkshire and Hampden counties.
New York: Dutchess, St. Lawrence, Warren, and Westchester counties.
Pennsylvania: Montgomery and Northampton counties.
Alaska: Near Tokeen, Ketchikan mining district, southeastern Alaska.
California: Amador, Los Angeles, Tulare, and Tuolumne counties.
Maryland: Baltimore and Harford counties.
North Carolina: Cherokee County.
Utah: Utah County.
Arkansas: Searcy County.
New Mexico: Otero County.
Washington: Chelan County.
Virginia: Loudoun County.
Oregon: Josephine County.

The value of the marble produced by Vermont in 1913 was $3,513,405, or 44.64 per cent of the total; by Tennessee, $1,416,952, or 18 per cent of the total; and by Georgia, $1,101,997, or 14 per cent of the total for the United States. With reference, however, to quantity, the total number of cubic feet reported was 3,606,818, to which Vermont contributed 1,183,400 cubic feet, or 32.81 per cent; Tennessee, 754,234 cubic feet, or 20.91 per cent; and Georgia, 1,031,373 cubic feet, or 28.6 per cent. The average price per cubic foot shown for Vermont was $2.97; for Tennessee, $1.88; for Georgia, $1.03. The differences in average price per cubic foot for these three leading marble States are due to the fact that most of the Vermont producers mill and sell their stone as dressed stone. The Tennessee producers sell much of their stone to mills in the vicinity or ship as finished or partly finished material from their own mills. The Georgia marble is practically all sold as rough stone.

The marble output in the United States was valued in 1912 at $7,786,458 and in 1913 at $7,870,890, a gain of $84,432, or 1.08 per cent. Most quarrymen report their output from year to year, using the same unit, so that a comparison of the cubic feet and value of the same is possible, or of the square feet or tons sold, and their corresponding value. The greater part of the marble quarried is sold by the cubic foot. In 1912 there was reported 3,370,626 cubic feet of marble, valued at $7,559,574, or $2.24 per cubic foot; in 1913, 3,606,818 cubic feet, valued at $7,605,271, or $2.11 per cubic foot, a gain for 1913 of 236,192 cubic feet and $45,697. Besides this there was produced in 1913, 376,648 square feet of sawed marble, valued at $139,260, and 106,084 short tons of marble, valued at $126,359; in 1912 the figures were 115,018 square feet, valued at $85,428, and 158,005 short tons, valued at $141,456.

Owing to the small number of producers in many of the marble-producing States, it is not possible to compile a satisfactory table showing the marble production, by States. The figures are given, however, as far as they are available.

The following table shows the value of the marble produced in the United States from 1909 to 1913, by States:

Value of marble produced in the United States, 1909–1913, by States and Territories.

State or Territory.	1909	1910	1911	1912	1913
Alabama	(a) $212,462	(b) $255,664	(c) $335,005	(d)	(d)
Alaska	(a) 46,900	(b)	(c)	(d)	(d)
Arizona	(a)		(c)		
California	89,392	(b) 112,339	29,964	$76,424	$72,768
Colorado	(a) 488,311	(b) 488,173	(c) 1,010,840	(d)	(d)
Georgia	766,449	953,917	1,088,422	1,096,622	1,101,997
Kentucky	(a)	(b)	(c)	(d)	
Maryland	(a)	(b)	(c) 73,300	(d)	(d)
Massachusetts	243,711	224,088	219,445	213,939	276,819
New Mexico	(a) 5,390	(b)	(c)	(d)	(d)
New York	402,729	484,732	379,670	291,210	252,982
North Carolina	(a)	(b)	(c)	(d)	(d)
Oklahoma			(c)		
Oregon	(a)				(d)
Pennsylvania	186,037	(b) 182,514	214,913	267,242	(d)
South Carolina			(c)		
Tennessee	613,741	728,502	700,229	974,733	1,416,952
Texas	(a)	(b)			
Utah	(a)	(b)	(c)	(e)	(d)
Vermont	3,493,783	3,562,850	3,394,930	3,494,253	3,513,405
Virginia				(e)	(d)
Washington	(a)	(b)			(d)
West Virginia	(a)	(b)			
Other States				1,372,035	1,235,967
Total	6,548,905	6,992,779	7,546,718	7,786,458	7,870,890

a Alabama includes Kentucky, Maryland, North Carolina, and West Virginia; Alaska includes Washington; New Mexico includes Arizona and Texas; Colorado includes Oregon and Utah.
b Alabama includes Kentucky, North Carolina, and West Virginia; California includes Alaska and Washington; Colorado includes Arizona and New Mexico; Pennsylvania includes Maryland.
c Alabama includes Kentucky and Oklahoma; Colorado includes Alaska, Arizona, New Mexico, Oregon, and Utah; Maryland includes North Carolina and South Carolina.
d Included in "Other States."
e Included in limestone.

The following table shows the value of marble quarried from 1908 to 1913, according to uses:

Distribution and value of the output of marble, 1908–1913, among various uses.

Use.	1908	1909	1910	1911	1912	1913
Sold by producers in rough state.....	$1,455,980	$2,330,336	$2,098,480	$3,182,620	$3,358,536	$3,645,863
Dressed for—						
Building (exterior)................	2,329,438	1,293,019	1,463,749	1,220,635	1,396,254	829,244
Ornamental purposes............	25,506	24,695	37,950	71,000	134,826	34,850
Monumental work................	1,843,426	1,184,672	1,279,985	1,368,430	720,464	1,135,658
Interior decoration in buildings..	1,943,750	1,557,783	2,001,646	1,545,963	1,944,161	1,869,262
Other uses not specified..........	135,820	158,400	110,969	158,070	232,217	356,013
Total............................	7,733,920	6,548,505	6,992,729	7,546,718	7,786,458	7,870,890

The chief uses of marble are as exterior and interior building stone and for monuments. Dressed monumental stone was the only one of these products that had an increase in value, according to the preceding tables. A consideration of the figures, including both rough and dressed stone, shows the following results:

Building stone (exterior work).—Marble as building stone is sold for two different uses—one on the exterior of buildings and the other in the interior, as wainscoting, paneling, mantels, floors, stairs, balustrades, etc. The total value of building marble in 1913 was $4,982,463, or 63.3 per cent of the entire marble output. In 1913 this value included 1,667,725 cubic feet of rough stone, valued at $2,277,752, or $1.36 per cubic foot; also 6,300 short tons, valued at $4,205; and 1,000 square feet, valued at $2,000; 598,129 cubic feet of dressed stone, valued at $2,561,246, or $4.28 per cubic foot; also 375,648 square feet, valued at $137,260.

The value of marble produced in 1913 for exterior building purposes (including rough and dressed stone) and either sold or used by the producer was $1,822,458, a decrease of $949,187, compared with 1912, when this value was $2,771,645. The total for 1913 included $993,214 for rough and $829,244 for dressed building stone; in 1912 the rough building marble sold was valued at $1,375,391 and the dressed building stone at $1,396,254, a decrease in 1913 of $382,177 for rough stock and of $567,010 for dressed marble.

The quantity of marble sold in 1913 rough for exterior building was 809,114 cubic feet, valued at $989,814, or $1.22 per cubic foot, and 4,000 tons, valued at $3,400. There was 288,754 cubic feet of dressed stone, valued at $829,244, or $2.87 per cubic foot.

In 1912 the quantity of marble sold rough for building stone was 945,728 cubic feet, valued at $1,369,213, or $1.45 per cubic foot; 5,009 square feet, valued at $4,828; and 450 tons, valued at $1,350. There was 478,361 cubic feet of dressed building stone quarried, valued at $1,396,254, with an average price of $2.91 per cubic foot.

Interior decoration work.—The total value of marble for interior work in buildings (including stone sold rough and dressed) in 1913 was $3,160,005, a gain of $1,215,844, when compared with $1,944,161 in 1912. The stone sold for this work in 1913 was 1,167,986 cubic feet, valued at $3,019,940, or $2.59 a cubic foot; 376,648 square feet, valued at $139,260; and 2,300 short tons, valued at $805.

The production of this stone was 858,611 cubic feet, valued at $1,287,938, or $1.50 per cubic foot; 1,000 square feet, valued at $2,000; and 2,300 short tons, valued at $805, sold as rough stone for interior work; and 309,375 cubic feet, valued at $1,732,002, or $5.60 per cubic foot, and 375,648 square feet, valued at $137,260, sold in the manufactured state for this purpose. In 1912 only dressed stone was reported for interior work. This amounted to 364,769 cubic feet, valued at $1,863,561, or $5.11 a cubic foot, and 110,009 square feet, valued at $80,600, a total value of $1,944,161. In 1912 this stone as sold rough for interior building was not separated from that sold rough for exterior building, which accounts for the large difference in average price.

Monumental stone.—Monumental marble (including rough and dressed stone) was valued at $2,497,564 in 1913 and at $2,115,200 in 1912, an increase of $382,364 in 1913. In 1912 the value of rough stock was $1,394,736 and of dressed monumental stone $720,464; the corresponding figures for 1913 are $1,361,906 for rough monumental stock and $1,135,658 for dressed monumental stone, a decrease in 1913 of $32,830 in value of rough stock and an increase of $415,194 for dressed stone. In 1913 the stone sold rough for monumental use was 912,792 cubic feet, valued at $1,361,592, or $1.49 per cubic foot, and 32 tons, valued at $314. The dressed monumental stone sold amounted to 256,300 cubic feet, at $4.43 per cubic foot.

In 1912 the quantity of stone sold rough for monumental work was 867,716 cubic feet, at $1.61 per cubic foot; and that for dressed monumental work was 214,326 cubic feet, at $3.36 per cubic foot.

Other marble.—Rough stone for other uses includes waste marble sold to lime burners, to carbonic-acid factories, to pulp mills, to iron furnaces for flux, and that used for road making, etc.; the dressed stone includes stone for mosaics, electrical work, etc.

As the form of the requests to the producers for the reports of their marble output in 1912 and 1913 was slightly different, it is impossible to make a direct comparison of the marble sold in the different States in these years according to uses. The following statements of the marble output in the United States show the quantity and value of this material and the form in which it was sold by the producer in 1912 and 1913:

Total quantity and value of marble produced in the United States in 1912 and 1913, according to the use for which the stone was intended.

1912.

Form in which sold by producer.		Quantity.	Value.
In rough blocks or rough sawed:			
To dealers or manufacturers	cubic feet	403,025	$588,409
Rough:			
Direct for—			
Monumental work	do	867,716	1,394,736
Buildings	do	945,728	1,369,213
	square feet	5,009	4,828
	short tons	450	1,350
As finished work:			
Direct for—			
Monumental work	cubic feet	214,326	720,464
Buildings (exterior)	do	478,361	1,396,254
Interior decoration	do	364,769	1,863,561
	square feet	110,009	80,600
Ornamental purposes	cubic feet	76,013	134,826
As crushed stone	short tons	32,789	23,156
As ground limestone	do	8,085	26,542
For other purposes	do	116,681	90,408
	cubic feet	20,688	92,111
Total	do	3,370,626	7,559,574
	square feet	115,018	85,428
	short tons	158,005	141,456
			7,786,458

Total quantity and value of marble produced in the United States in 1912 and 1913 according to the use for which the stone was intended—Continued.

1913.

Form in which sold by producer.		Quantity.	Value.
In rough blocks, rough sawed, or rough dressed:			
To dealers or manufacturers—			
For monumental work	cubic feet	889,048	$1,311,846
	short tons	30	300
Building—Exterior work	cubic feet	759,910	928,226
	short tons	4,000	3,400
Building—Interior decorative work	cubic feet	682,611	1,087,938
	square feet	1,000	2,000
	short tons	2,300	805
Direct for—			
Monumental work	cubic feet	23,744	49,746
	short tons	2	14
Building—Exterior work	cubic feet	49,204	61,588
Building—Interior work	do	176,000	200,000
Dressed:			
Direct for—			
Monumental work	do	256,300	1,135,658
Building—Exterior work	do	288,754	829,244
Building—Interior work	do	309,375	1,732,002
	square feet	375,648	137,260
Ornamental purposes	cubic feet	2,650	34,850
As ground limestone or crushed stone	do	37,100	17,500
	short tons	22,529	57,215
For other purposes	cubic feet	132,122	216,673
	short tons	77,223	64,625
Total	cubic feet	3,606,818	7,605,271
	square feet	376,648	139,260
	short tons	106,084	126,359
			7,870,890

The following table shows the quantity and value of the marble sold by the producers in the most prominent marble States:

Quantity and value of marble produced in California, Georgia, Massachusetts, New York, Tennessee, and Vermont in 1912 and 1913.

State.	1912		1913	
	Quantity.	Value.	Quantity.	Value.
California:				
Short tons	479	$2,874	478	$2,990
Cubic feet	28,429	73,550	37,155	69,778
Total		76,424		72,768
Georgia:				
Short tons	17,676	29,286	20,293	35,484
Cubic feet	928,191	1,067,336	1,031,373	1,066,513
Total		1,096,622		1,101,997
Massachusetts:				
Short tons	9,217	12,360	9,557	13,014
Cubic feet	104,228	197,175	92,137	176,545
Square feet	28,615	4,404	342,648	87,260
Total		213,939		276,819
New York:				
Short tons	62,219	57,243	49,014	50,301
Cubic feet	144,105	233,967	122,063	202,681
Total		291,210		252,982
Tennessee:				
Short tons	16,478	6,315		
Cubic feet	605,198	968,418	754,234	1,416,952
Total		974,733		1,416,952
Vermont:				
Short tons	600	295	6,300	4,205
Cubic feet	1,105,022	3,464,534	1,183,400	3,509,200
Square feet	54,203	29,424		
Total		3,494,253		3,513,405

LIMESTONE.

An increase of $2,015,629, or 5.49 per cent, marks the limestone production of the United States in 1913 in comparison with 1912. The increase in value from $36,729,800 in 1912 to $38,745,429 in 1913 was almost entirely in the various branches of the crushed stone industry. The higher grades of stone for building, paving, and curbing decreased in value, as did also rubble stone. Stone for riprap, sugar factories, fluxing, and for use in the manufacturing industries, as alkali works, glass factories, paper mills, carbonic acid plants, etc., showed considerable increase.

The value given for the limestone production does not include the value of a large quantity of limestone burned into lime and sold as a manufactured product, except in cases of alkali works, sugar factories, and, to a small extent, at steel works and smelting plants where lime instead of stone is used as a flux, and the only record kept is of stone used rather than lime burned. Also a quantity of stone sold to manufacturers of lime who may require a certain kind of stone that they do not produce is here included as well as a small quantity of stone sold to farmers for burning into lime for farm use, whose record can not otherwise be obtained. The commercial output of lime is given in another chapter of Mineral Resources.

A large quantity of limestone used in the manufacture of Portland cement is also excluded from these figures; the value of this stone enters into and is included in the value of the cement, the statistics of which are also given in another chapter.

The chief States producing limestone in 1913, according to rank in value, were Pennsylvania, Ohio, Indiana, Illinois, New York, Missouri, Michigan, Kentucky, West Virginia, and Wisconsin, the first six producing over $2,000,000 each, and the last four over $1,000,000 each. In 1912 the rank was Pennsylvania, Indiana, Ohio, Illinois, New York, Missouri, Kentucky, and Michigan. Ohio took second place from Indiana in 1913, and West Virginia and Wisconsin joined the States having a production of limestone valued at more than $1,000,000. Each of these leading States, except Indiana and Kentucky, showed an increase in 1913. Pennsylvania, the largest producer of limestone, produced nearly 16 per cent of the total output, and about 68 per cent of the stone from Pennsylvania was fluxing stone and the rest chiefly crushed stone. Ohio produced nearly 13 per cent of the limestone output, of which nearly 55 per cent was for crushed stone and most of the remainder for flux. The production in Indiana represented 12 per cent of the total limestone output, and nearly 70 per cent of the output of the State was for building stone.

The following table shows the value of limestone, by States, from 1909 to 1913, inclusive.

Value of limestone from 1909 to 1913, by States and Territories.

State or Territory.	1909	1910	1911	1912	1913
Alabama	$700,642	$714,516	$571,798	$531,085	$812,664
Arizona	(a)	(b)	8,676	19,099	6,328
Arkansas	112,468	84,280	c 136,007	66,952	52,220
California	283,869	590,990	576,701	245,235	323,287
Colorado	355,136	415,523	341,798	365,004	428,736
Connecticut	a 5,023	b 9,062	c 21,040	17,924	(d)
Florida	a 49,856	b 84,457	97,520	60,524	156,589
Georgia	34,593	24,236	31,632	53,187	83,899
Hawaii	(a)	....	....	....	....
Idaho	(a)	19,423	c 19,497	19,791	18,569
Illinois	4,234,927	3,847,715	3,436,977	3,808,784	4,112,172
Indiana	3,749,239	4,472,241	4,406,577	5,066,337	4,649,597
Iowa	525,277	543,600	679,895	944,885	803,682
Kansas	892,335	768,739	789,448	757,197	824,005
Kentucky	903,874	978,809	1,124,170	1,160,148	1,069,034
Louisiana	(a)	(b)	(c)	(d)	(d)
Maine	(a)	(b)	(c)	(d)	(d)
Maryland	197,939	154,370	218,636	228,713	282,241
Massachusetts	....	(b)	(c)	(d)	(d)
Michigan	750,589	842,126	1,001,535	1,139,560	1,408,708
Minnesota	698,309	654,833	612,915	546,650	636,620
Missouri	2,111,283	2,360,604	2,179,767	2,373,725	2,486,020
Montana	154,064	169,836	148,126	154,133	260,915
Nebraska	293,830	338,731	263,459	335,369	326,287
Nevada	....	....	(c)	(d)	....
New Jersey	224,017	224,709	138,148	205,334	280,680
New Mexico	a 140,801	b 227,657	243,119	237,543	148,266
New York	2,622,353	2,813,476	2,857,797	3,208,911	3,539,043
North Carolina	(a)	(b)	30,278	39,864	67,132
Ohio	4,020,046	4,357,432	4,461,882	4,885,088	4,945,310
Oklahoma	450,055	509,344	594,664	409,994	246,912
Oregon	....	3,594	(c)	(d)	(d)
Pennsylvania	5,073,825	5,394,611	5,243,045	6,017,308	6,189,145
Rhode Island	(a)	(b)	(c)	(d)	(d)
South Carolina	....	(b)	(c)	....	....
South Dakota	a 49,328	17,150	6,250	10,628	4,098
Tennessee	a 589,949	b 747,162	c 798,369	673,329	643,586
Texas	341,528	447,239	490,289	530,251	590,289
Utah	169,700	389,603	168,145	208,245	368,007
Vermont	18,839	25,250	19,702	12,644	17,715
Virginia	342,656	471,903	369,872	403,069	598,032
Washington	38,269	36,186	32,478	20,370	62,913
West Virginia	864,392	841,064	902,077	981,467	1,046,625
Wisconsin	1,047,044	979,522	848,363	853,477	1,017,135
Wyoming	24,346	43,687	36,960	64,749	108,234
Other States	....	....	....	73,227	130,734
Total	32,070,401	34,603,678	33,897,612	36,729,800	38,745,429

a New Mexico includes Arizona; South Dakota includes Hawaii and Idaho; Connecticut includes Maine and Rhode Island; Florida includes Louisiana; Tennessee includes North Carolina.
b New Mexico includes Arizona; Connecticut includes Maine, Massachusetts, and Rhode Island; Florida includes Louisiana; Tennessee includes North Carolina and South Carolina.
c Arkansas includes Louisiana; Connecticut includes Maine, Massachusetts, and Rhode Island; Idaho includes Nevada and Oregon; Tennessee includes South Carolina.
d Included in "Other States."

Value of the production of limestone in the United States in 1912 and 1913, by States and uses.

1912.

State.	Rough building.	Dressed building.	Paving.	Curbing.	Flagging.	Rubble.	Riprap.
Alabama			$15,900				$81,361
Arizona							
Arkansas	$5,887	$9,936				$963	166
California	136						
Colorado							
Connecticut							
Florida							
Georgia	828					414	2,518
Idaho	12					250	
Illinois	15,413	19,293	53,169	$33,063	$356	187,478	58,545
Indiana	1,329,620	2,173,267	230	75,697	1,481	21,335	11,407
Iowa	44,979	9,830	4,600	580	50	43,347	112,698
Kansas	46,222	29,219	15,062	1,032	982	29,188	20,997
Kentucky	86,977	101,224	198	17,660	397	13,186	32,511
Louisiana							
Maine							
Maryland	10,719						
Massachusetts							
Michigan	9,997					380	75
Minnesota	65,216	145,354		245	1,971	35,096	43,751
Missouri	139,416	310,276	26,601	6,170	2,928	203,672	289,999
Montana	2,653					70	6
Nebraska	448					4,088	64,824
Nevada							
New Jersey	625						
New Mexico							
New York	112,736	27,013		2,877	912	13,798	5,769
North Carolina							
Ohio	59,842	12,475	5,560	550		37,822	242,742
Oklahoma	8,692	27,731	360			1,325	22,374
Oregon							
Pennsylvania	144,424	1,258	149,079	1,465		8,730	1,745
Rhode Island							
South Dakota						600	621
Tennessee	5,965	1,685	150	275	11	910	53,726
Texas	13,144	7	6,000	1,111		2,624	20,650
Utah	23,961	1,100		200		150	8,932
Vermont	2,760					50	
Virginia	6,457					197	
Washington							
West Virginia	354					4,000	5,445
Wisconsin	40,497	3,358	2,021	12,090	5,305	30,101	101,383
Wyoming	740						
Other States	150						206
Total	2,178,870	2,873,026	278,930	153,015	14,393	639,674	1,182,451

Value of the production of limestone in the United States in 1912 and 1913, by States and uses—Continued.

1912—Continued.

State.	Crushed stone.			Flux.	Sugar factories.	Other.	Total.
	Road making.	Railroad ballast.	Concrete.				
Alabama	$54,270	$14,093	$26,235	$339,166		$60	$531,085
Arizona				6,400	$12,450	249	19,099
Arkansas			50,000				66,952
California	51,128	24,000	9,133	62,210	73,834	24,794	245,235
Colorado		376		313,237	46,189	5,202	365,004
Connecticut			1,600	1,524		14,800	17,924
Florida	27,500	15,000	8,750			9,274	60,524
Georgia	7,385	6,000	11,500	6,636		17,906	53,187
Idaho	1,131				18,398		19,791
Illinois	1,054,676	368,349	963,617	951,733	6,441	96,651	3,808,784
Indiana	1,033,673	102,841	45,197	216,275	3,152	52,162	5,066,337
Iowa	30,821	235,326	404,302	2,928	8,128	47,396	944,885
Kansas	95,642	274,176	234,261	178		10,238	757,197
Kentucky	298,057	473,023	106,890	9,670		20,355	1,160,148
Louisiana							(a)
Maine							(a)
Maryland	88,637	83,532	36,423	8,364		1,038	228,713
Massachusetts							(a)
Michigan	295,449	28,368	97,298	137,812	36,944	533,237	1,139,560
Minnesota	23,410	25,642	195,545	1,235	4,400	4,785	546,650
Missouri	260,198	387,449	641,798	38,937	7,270	59,011	2,373,725
Montana	1,365	101	15,994	99,896	34,048		154,133
Nebraska		5,985	252,043		7,308	673	335,369
Nevada							(a)
New Jersey	19,509	21,410	9,014	122,943		31,833	205,334
New Mexico		229,593	7,950				237,543
New York	828,682	701,932	811,187	535,159		168,846	3,208,911
North Carolina	10,294					29,570	39,864
Ohio	1,671,990	782,486	269,015	1,698,237	12,562	91,807	4,885,088
Oklahoma	60,862	178,440	110,035	150		25	409,994
Oregon							(a)
Pennsylvania	490,342	285,312	407,445	4,361,677		165,831	6,017,308
Rhode Island							(a)
South Dakota	560		3,663		5,184		10,628
Tennessee	268,509	114,011	127,076	88,789		12,222	673,329
Texas	52,753	49,956	349,602	33,094		1,310	530,251
Utah				170,642		3,260	208,245
Vermont	1,875		3,463	665		3,831	12,644
Virginia	56,506	115,576	41,192	130,916		52,225	403,069
Washington	2,255		153	10,718		7,244	20,370
West Virginia	24,352	292,317	87,775	546,511		20,713	981,467
Wisconsin	310,151	26,726	263,626	36,219		22,000	853,477
Wyoming	703		4,452		58,800	54	64,749
Other States	8,158	12,281	38,221	5,851		8,360	73,227
Total	7,130,843	4,854,301	5,634,455	9,937,772	335,108	1,516,962	36,729,800

a Included in "Other States."

Value of the production of limestone in the United States in 1912 and 1913, by States and uses—Continued.

1913.

State.	Rough building.	Dressed building.	Paving.	Curbing.	Flagging.	Rubble.	Riprap.
Alabama	$9,517	$27,020	$189			$188	$58,850
Arizona							
Arkansas	5,901	39,384				408	1,627
California							
Colorado							
Connecticut							
Florida							
Georgia	360		1,875			175	
Idaho						200	
Illinois	14,806	11,911	9,734	$262	$205	131,194	113,083
Indiana	1,265,323	1,842,682	2,463	73,050	1,660	7,520	19,797
Iowa	33,266	8,155	16,713	750	238	30,723	97,619
Kansas	24,112	32,879	17,280	4,198	30	13,873	95,273
Kentucky	69,673	75,230	37	6,014		4,358	73,197
Louisiana							
Maine							
Maryland	7,024	125	4,350			3,400	145
Massachusetts							
Michigan	8,274					3,511	610
Minnesota	46,477	155,592	218	750		32,408	46,839
Missouri	110,080	268,970	14,596	9,296	3,328	127,683	473,399
Montana	2,874					25	17
Nebraska	1,008					1,121	52,080
New Jersey	185						
New Mexico	250						
New York	75,278	29,737	7,750	2,861		16,600	10,594
North Carolina							
Ohio	47,127	4,587	2,650			23,187	83,358
Oklahoma	985	50,030				64	16,066
Oregon							
Pennsylvania	106,690	840	129,440	3,170	85	8,600	8,391
Rhode Island							
South Dakota	40						788
Tennessee	7,292	4,208	15,100	153		2,100	59,429
Texas	36,508	11,979	7,800	547		698	8,824
Utah	23,188	1,278				50	26,057
Vermont	665					2,500	425
Virginia	771	1,668				197	
Washington							
West Virginia			800			750	
Wisconsin	40,840		8,345	7,742	1,791	28,947	68,189
Wyoming	950						
Other States	3,600						16,766
Total	1,943,064	2,566,275	239,340	108,793	7,337	440,480	1,331,423

Value of the production of limestone in the United States in 1912 and 1913, by States and uses—Continued.

1913—Continued.

State.	Road making.	Railroad ballast.	Concrete.	Flux.	Sugar factories.	Agri-cultural.	Other.	Total value.
Alabama	$47,237	$7,187	$168,195	$487,078	....	$7,203	....	$812,664
Arizona	....	....	....	3,628	$2,700	....	....	6,328
Arkansas	....	....	4,000	....	....	900	....	52,220
California	95,793	3,971	68,645	42,274	93,950	1,500	$17,154	323,287
Colorado	....	....	....	333,609	93,875	....	1,252	428,736
Connecticut	....	....	....	....	....	....	....	(a)
Florida	29,749	37,500	72,432	....	....	16,908	....	156,589
Georgia	17,850	6,000	17,233	7,056	....	30,850	2,500	83,899
Idaho	43	....	....	....	18,326	....	....	18,569
Illinois	895,352	592,210	1,245,829	979,303	2,000	78,278	38,005	4,112,172
Indiana	956,234	203,431	29,985	199,955	1,554	20,124	25,819	4,649,597
Iowa	81,351	218,573	300,767	4,866	5,900	3,089	1,672	803,682
Kansas	49,074	283,435	264,854	170	....	1,500	37,327	824,005
Kentucky	286,407	422,864	101,948	12,368	....	10,582	6,356	1,069,034
Louisiana	....	....	....	....	....	....	....	(a)
Maine	....	....	....	....	....	....	....	(a)
Maryland	116,946	94,202	28,245	23,723	....	....	4,081	282,241
Massachusetts	....	....	....	....	....	....	....	(a)
Michigan	266,316	48,400	145,965	494,495	38,215	7,048	395,874	1,408,708
Minnesota	32,771	31,774	283,947	540	720	2,287	2,297	636,620
Missouri	338,849	405,665	623,436	35,874	3,992	8,297	62,555	2,486,020
Montana	2,312	485	11,480	230,097	13,625	....	....	260,915
Nebraska	....	38,178	231,626	....	2,274	....	....	326,287
New Jersey	15,377	22,800	12,579	178,233	....	44,844	6,662	280,680
New Mexico	....	148,016	....	....	....	....	....	148,266
New York	1,047,216	804,296	759,814	562,669	....	67,441	154,787	3,539,043
North Carolina	15,174	....	339	11,269	....	40,350	....	67,132
Ohio	1,596,796	790,004	318,097	1,934,734	15,393	29,255	100,122	4,945,310
Oklahoma	4,384	98,134	74,102	....	....	60	3,087	246,912
Oregon	....	....	....	....	....	....	....	(a)
Pennsylvania	585,004	419,579	531,889	4,206,797	....	51,416	137,244	6,189,145
Rhode Island	....	....	....	....	....	....	....	(a)
South Dakota	1,670	....	1,400	....	....	....	200	4,098
Tennessee	212,004	142,289	123,945	64,825	....	9,413	2,828	643,586
Texas	138,747	132,699	218,282	29,928	....	500	3,777	590,289
Utah	....	....	....	317,316	....	....	118	368,007
Vermont	1,906	....	4,225	677	....	....	7,317	17,715
Virginia	64,327	256,960	62,201	185,052	....	19,236	7,620	598,032
Washington	4,630	....	80	47,107	....	696	10,400	62,913
West Virginia	51,129	250,082	76,202	663,892	....	550	3,220	1,046,625
Wisconsin	391,230	74,717	329,723	42,119	....	4,704	18,788	1,017,135
Wyoming	....	....	12,084	....	95,200	....	....	108,234
Other States	7,787	17,964	43,595	4,335	....	36,687	....	130,734
Total	7,353,665	5,551,415	6,167,144	11,103,989	387,724	493,718	1,051,062	38,745,429

a Included in "Other States."

Building stone.—Over 11 per cent of the limestone output is represented by building stone, which, including both rough and dressed stone, decreased in value from $5,051,896 in 1912 to $4,509,339 in 1913, a loss of $542,557, or 10.7 per cent. Indiana and Missouri are the largest producers of building limestone, and the output of Indiana, amounting to $3,108,005, represented 68.9 per cent of the building limestone quarried in the United States. Most of the product of this State is quarried in Lawrence and Monroe counties and is well known to the trade as Bedford oolitic limestone, from the town of Bedford, Lawrence County, which, with Bloomington, Monroe County, forms the shipping center of this stone. This Bedford stone is chiefly used for building stone, although some is sold for flagstone, curbstone, monumental stone, crushed stone, ground limestone, furnace flux, and some—not included in this report—is used for lime and cement.

As this stone is so large a factor in the building limestone trade, the following tables are given to show the details of the production of Bedford oolitic limestone in Lawrence and Monroe counties, Ind., from 1901 to 1913 and by uses in 1912 and 1913:

Quantity and value of Bedford oolitic limestone quarried in Lawrence and Monroe counties, Ind., 1901–1913.

Year.	Lawrence County.		Monroe County.		Total.	
	Quantity.	Value.	Quantity.	Value.	Quantity.	Value.
1901		$1,365,875		$421,599		$1,787,474
1902		1,207,497		439,902		1,637,399
1903		1,088,477		487,662		1,576,139
1904		1,054,302		589,672		1,643,974
1905		1,550,076		843,399		2,393,475
1906		1,460,743		1,162,062	a 9,282,004	2,622,805
1907		1,413,280		908,612	a 7,849,027 b 256,960	2,321,892 110,525
1908	a 5,199,996 b 93,085	1,498,822 42,150	a 3,147,097 b 8,260	880,218 1,719	a 8,347,093 b 101,705	2,379,040 43,869
1909	a 6,441,483 b 145,672	1,678,195 71,637	a 2,970,388 b 106,600	801,436 56,925	a 9,411,871 b 252,272	2,479,631 128,562
1910	a 5,778,660 b 131,590	1,841,233 75,906	a 3,960,148 b 70,655	1,265,287 44,224	a 9,738,808 b 202,245	3,106,520 120,130
1911	a 6,612,988 b 53,242	2,171,148 27,842	a 2,915,444 b 50,914	859,580 45,112	a 9,528,442 b 104,156	3,030,728 72,954
1912	a 7,066,496 b 71,124	2,622,648 37,894	a 3,375,808 b 76,532	824,594 60,629	a 10,442,304 b 147,656	3,447,242 98,523
1913	a 5,737,303 b 91,034	2,095,461 50,092	a 3,273,369 b 67,035	992,286 41,508	a 9,010,672 b 158,069	3,087,747 91,600

a Cubic feet. b Short tons.

Production of Bedford oolitic limestone in Lawrence and Monroe counties, Ind., in 1912 and 1913, by uses.

1912.

County.	Building.						Other uses.[a]		Total value.
	Rough.		Dressed.		Total.				
	Quantity (cubic feet).	Value.	Quantity (cubic feet).	Value.	Quantity (cubic feet).	Value.	Quantity (short tons).	Value.	
Lawrence	4,024,487	$942,180	3,042,009	$1,680,468	7,066,496	$2,622,648	71,124	$37,894	$2,660,542
Monroe	2,182,862	361,942	1,192,946	462,652	3,375,808	824,594	76,532	60,629	885,223
Total	6,207,349	1,304,122	4,234,955	2,143,120	10,442,304	3,447,242	147,656	98,523	3,545,765
Average price		$0.21		$0.50		$0.33		$0.67	

1913.

County.	Rough quantity (cubic feet).	Rough value.	Dressed quantity (cubic feet).	Dressed value.	Total quantity (cubic feet).	Total value.	Other uses quantity (short tons).	Other uses value.	Total value.
Lawrence	3,881,072	$915,001	1,856,231	$1,180,460	5,737,303	$2,095,461	91,034	$50,092	$2,145,553
Monroe	1,948,892	344,097	1,324,477	648,189	3,273,369	992,286	67,035	41,508	1,033,794
Total	5,829,964	1,259,098	3,180,708	1,828,649	9,010,672	3,087,747	158,069	91,600	3,179,347
Average price		$0.22		$0.57		$0.34		$0.58	
Percentage of increase (+) or decrease (−) as compared with 1912	−6.08	−3.45	−2.49	−14.67	−13.71	−10.43	+7.05	−7.03	−10.33

a Includes stone used for rubble, riprap, curbstone, flagstone, glass making, sugar factories, ground limestone, etc.

These figures do not indicate a very thriving condition of the industry, but most of the operators report better prospects for 1914. It is noticeable that although the output for Lawrence County decreased, the output for Monroe County increased. The total decrease for the two counties was $366,418, or 10.33 per cent, from $3,545,765 in 1912 to $3,179,347 in 1913. Building stone decreased from 10,442,304 cubic feet, valued at $3,447,242, in 1912 to 9,010,672 cubic feet, valued at $3,087,747, in 1913, a loss of 1,431,632 cubic feet in quantity and of $359,495 in value. The average price per cubic foot increased slightly in 1913, or from 21 cents in 1912 to 22 cents in 1913 for stone in rough blocks and from 50 cents in 1912 to 57 cents in 1913 for milled stone.

Missouri ranked next to Indiana in the output of building limestone, the value of the output in 1913 being $379,050, in comparison with $449,692 for 1912, a decrease in 1913 of $70,642.

About 68 per cent of the Missouri building stone in 1913 was a strong, light-gray crystalline limestone from Carthage, Jasper County, and the following table shows the details of production in this district for the last six years:

Production of limestone at Carthage, Jasper County, Mo., in 1908–1913, by uses.

Year.	Number of producers.	Building stone.		Curbing.	Flagging.	Rubble.	Other.[a]	Total value.
		Quantity.	Value.	Value.	Value.	Value.	Value.	
		Cubic feet.						
1908	8	431,576	$280,249	$5,238	$3,602	$2,682	$17,826	$309,597
1909	8	481,274	334,715	1,263	6,232	3,791	24,001	370,002
1910	10	502,161	347,244	1,767	7,229	2,945	23,571	382,756
1911	9	427,974	293,470	2,427	2,431	2,596	23,865	324,789
1912	8	404,685	268,930	670	2,878	4,885	28,087	305,450
1913	7	346,421	236,524	....	2,367	1,500	18,564	258,955

[a] Includes stone used for monumental work, crushed stone, stone sold to glass factories, blast furnaces, sugar factories, etc.

From this table it will be seen that the limestone production in 1913 for this district decreased $46,495, or over 15 per cent. Stone for all purposes showed a general decrease, both in quantity and value. The average price per cubic foot for building stone was 68.6 cents in 1911, 66.5 cents in 1912, and 68 cents in 1913.

Another limestone of increasing importance to the building trade in the Central States is the oolitic limestone quarried near Bowling Green, Warren County, Ky. The following table shows the quantity and value of this limestone from 1909 to 1913:

Production of limestone in Warren County, Ky., by uses, 1909–1913.

Year.	Rough building.		Dressed building.		Crushed stone.		Other.[a]	Total value.
	Quantity.	Value.	Quantity.	Value.	Quantity.	Value.	Value.	
	Cubic feet.		*Cubic feet.*		*Short tons.*			
1909	203,120	$60,936	74,482	$62,989	46,725	$22,013	$33,704	$179,642
1910	204,602	56,141	90,100	57,350	108,183	47,532	5,584	166,607
1911	134,291	45,792	103,220	76,589	57,720	25,921	250	148,552
1912	148,711	51,638	114,308	100,774	38,495	17,563	1,890	171,965
1913	110,576	36,388	95,915	74,250	37,972	20,476	2,045	133,159
Average price	....	$0.33	....	$0.77	....	$0.54	....	....

[a] Curbing, flagging, fluxing, and monumental stone.

Building stone as shown in this table represented nearly 92 per cent of the total production of limestone for building in Kentucky. Building stone in this district also suffered a decrease in output. The average price per cubic foot was 33 cents for rough stone and 77 cents for dressed stone. Stone sold as crushed stone decreased in quantity and increased in value of output.

Paving.—Limestone for paving decreased in value from $278,930 in 1912 to $239,340 in 1913, or $39,590. Pennsylvania, Kansas, Iowa, Tennessee, and Missouri produced most of the limestone used for paving in 1913.

Curbing.—There was a decrease of $44,222 in the value of the output of limestone for curbing, from $153,015 in 1912 to $108,793 in 1913. Indiana furnished almost all of this material in 1913.

Flagging.—A decrease of $7,056 marked the limestone output of flagging, from $14,393 in 1912 to $7,337 in 1913. Most of the stone was from Missouri.

Rubble.—Rubble decreased in value $199,194, from $639,674 in 1912 to $440,480 in 1913. Illinois, Missouri, Minnesota, and Iowa reported the largest production.

Riprap.—Riprap increased in value $148,972, from $1,182,451 in 1912 to $1,331,423 in 1913. Missouri, Illinois, Iowa, and Kansas produced most of this stone in 1913.

Crushed stone.—Crushed limestone used in road making, railroad ballast, concrete, etc., had a larger value than any other limestone product. In 1913 this output was 35,169,528 short tons, valued at $19,072,224, an increase of 2,046,886 short tons in quantity and of $1,452,625 in value for 1913, as compared with 1912, when the figures of output were 33,122,642 short tons, valued at $17,619,599. This was a notable increase, and the largest increase, both in quantity and in value, was shown in the stone sold for railroad ballast.

In 1913 the total output was divided into 13,296,377 short tons, valued at $7,353,665, for road making; 11,774,121 short tons, valued at $5,551,415, for railroad ballast; and 10,099,030 short tons, valued at $6,167,144, for concrete, which compared with the itemized output for 1912—road making, 13,292,935 tons, valued at $7,130,843; railroad ballast, 10,560,779 tons, valued at $4,854,301; concrete, 9,268,928 tons, valued at $5,634,455—was an increase of 3,442 tons in quantity and $222,822 in value for road making, of 1,213,342 tons in quantity and $697,114 in value for railroad ballast, and of 830,102 tons in quantity and $532,689 in value for concrete. It is possible that the stone for road making includes some stone used for concrete, some of the operators reporting that they were unable to subdivide, except approximately, their total output of crushed stone, not knowing the exact use which was to be made of the stone. The average price per short ton was 54 cents in 1913 compared with 53 cents in 1912.

Ohio, Illinois, New York, Pennsylvania, Indiana, and Missouri were ranking States in 1913 according to quantity of crushed limestone sold, and the rank according to value was Illinois, Ohio, New York, Pennsylvania, Missouri, and Indiana.

Furnace flux.—Next to crushed stone, limestone sold for furnace flux showed the largest value and a larger increase in production in 1913 than any other limestone product. The production in 1913 was 22,620,961 long tons, valued at $11,103,989; in 1912 it was

20,190,554 long tons, valued at $9,937,772, an increase in 1913 of 2,430,407 tons in quantity and of $1,166,217 in value. The average price per ton was 49 cents in 1913, the same as in 1912. Pennsylvania, Ohio, Illinois, West Virginia, New York, Michigan, Alabama, and Colorado were the principal producers. The increase in the production of furnace flux in 1913 is comparable with the increase in pig iron manufactured in 1913.

The following table shows the production of limestone for smelter, open-hearth, and blast-furnace flux in 1912 and 1913, by States, in long tons:

Production of furnace flux, etc., in 1912 and 1913, by States, in long tons.

State.	1912		1913	
	Quantity.	Value.	Quantity.	Value.
Alabama	582,904	$339,166	841,477	$487,078
Arizona	7,035	6,400	3,596	3,628
California	54,868	62,210	39,520	42,274
Colorado	534,224	313,237	552,413	333,609
Connecticut	2,774	1,524	(a)	(a)
Georgia	11,622	6,636	10,813	7,056
Illinois	2,747,284	951,733	2,790,245	979,303
Indiana	481,950	216,275	407,414	199,955
Iowa	5,500	2,928	6,387	4,866
Kansas	177	178	241	170
Kentucky	14,527	9,670	19,117	12,368
Maine			(a)	(a)
Maryland	14,978	8,364	46,860	23,723
Massachusetts	(a)	(a)	(a)	(a)
Michigan	295,941	137,812	1,202,817	494,495
Minnesota	1,257	1,235	479	540
Missouri	42,533	38,937	40,757	35,874
Montana	259,193	99,896	782,017	230,097
New Jersey	230,822	122,943	330,352	178,233
New York	981,670	535,159	972,529	562,669
North Carolina			18,781	11,269
Ohio	3,334,126	1,698,237	3,822,762	1,934,734
Oklahoma	100	150		
Oregon	(a)	(a)		
Pennsylvania	8,540,211	4,361,677	8,180,056	4,206,797
Rhode Island	(a)	(a)	(a)	(a)
Tennessee	156,732	88,789	117,156	64,825
Texas	48,161	33,094	44,427	29,928
Utah	295,670	170,642	499,406	317,316
Vermont	604	665	413	677
Virginia	254,108	130,916	343,382	185,052
Washington	17,484	10,718	35,546	47,107
West Virginia	1,179,708	546,511	1,420,979	663,892
Wisconsin	83,840	36,219	85,589	42,119
Other States	10,551	5,851	5,430	4,335
Total	20,190,554	9,937,772	22,620,961	11,103,989
Average price per ton		$0.49		$0.49
Per cent of increase			12.04	11.74

a Included in "Other States."

Other uses.—Limestone reported as sold to sugar refiners increased in value from $335,108 in 1912 to $387,724 in 1913, a gain of $52,616. Stone for other uses included stone quarried and used by alkali works in New York and Michigan; stone sold to glass factories, to paper mills, and to carbonic-acid plants; stone for making whiting and mineral wool; and also a small quantity sold to farmers for burning into lime to be used as a fertilizer, it being impossible to get the lime value for this stone. The total output of stone for these various uses decreased in value $465,900, from $1,516,962 in 1912 to $1,051,062 in 1913.

A value of $493,718 was reported as the value of ground limestone, used to spread on the soil for a soil sweetener or enricher, in the place of lime. This represents 408,627 short tons of the material and shows an average price of $1.21 per ton. In 1913 there was reported for this purpose, but included with other uses, about 200,000 tons, valued at $311,702, or $1.56 per ton. This product has only been used for three or four years. In 1911 the first record of production was made which amounted to 174,290 short tons.

SANDSTONE.

There was an increase of $139,456, or 2.02 per cent, in the value of the sandstone output in 1913; nevertheless this stone has taken a less prominent position than any other variety of stone. All the other varieties have in the last 10 years increased considerably in value of output, but sandstone has showed a decided falling off. In 1904 the total value of the output, including bluestone and quartzite, was $10,273,891; in 1913 it was $7,033,067, a decrease of $3,240,824, or over 31 per cent for the 10 years. During that same period granite increased about 21 per cent; trap rock 230 per cent; marble nearly 25 per cent; limestone about 75 per cent; and the entire stone output increased over 42 per cent.

One of the chief causes of decrease in the sandstone industry has been a strong factor in the increase of the other kinds of stone. This is the use of crushed stone, which at first was used chiefly for road making and ballast, then as an aggregate in concrete for paving, sidewalks, bridge piers, and abutments, foundations, steps, and house trimmings, which are the principal uses besides building stone for sandstone. Sandstone is not so much used for crushed stone as the other varieties of stone, and the decrease caused by the use of concrete was not made up by increased production of crushed sandstone, as with some of the other varieties of stone. Not included in the sandstone figures is the value of a considerable quantity of sandstone chiefly from Ohio and Michigan, manufactured into grindstones, scythestones, and other abrasives and included in the report on abrasives. Some sandstone is also ground into sand for glass-making and other purposes, and is included in the chapter in Mineral Resources on sand and gravel.

The value of sandstone in 1913 was $7,033,067. In 1912 it was $6,893,611. Had it not been for a decrease in the output of the sandstone known to the trade as "bluestone," quarried in eastern New York and northeastern Pennsylvania, there would have been a larger increase. The decrease in bluestone production in New York was especially noticeable and was occasioned by the curtailment or the finishing of work done by the State on public construction, as well as decreased output of the regular products. This stone forms such an important industry for these two States that a separate table is given to it. New York, Pennsylvania, and Ohio in the order named are the most important sandstone-producing States; of these Ohio was the only one showing an increase for 1913, but the increase was not considerable. Much of the sandstone reported from Minnesota, South Dakota, and Wisconsin is a quartzite, locally often called granite or jasper and used largely for paving.

The following table shows the value of the sandstone production in the United States from 1909 to 1913, inclusive, by States:

Value of sandstone (including quartzite and bluestone) production in the United States 1909–1913, by States.

State.	1909	1910	1911	1912	1913
Alabama	$77,327	$109,063	$73,195	$27,596	$151,111
Arizona	298,335	131,716	[a] 57,100	21,524	88,391
Arkansas	67,956	71,641	85,529	80,538	89,395
California	290,034	113,488	176,213	70,724	139,486
Colorado	197,105	189,603	135,673	108,169	96,964
Connecticut	(b)	(c)	(a)	(d)	(d)
Florida	....	....	(a)	(d)	(d)
Georgia	....	....	....	(d)	(d)
Idaho	29,263	34,070	40,097	13,883	20,111
Illinois	26,891	5,710	30,953	32,720	28,781
Indiana	4,119	4,141	7,078	(d)	(d)
Iowa	2,443	14,456	56,312	1,551	1,612
Kansas	19,560	25,691	13,774	6,031	1,602
Kentucky	90,835	90,729	97,439	114,650	81,171
Maryland	10,584	18,226	10,097	15,950	16,435
Massachusetts	[b] 457,962	[c] 424,485	[a] 406,072	307,838	188,919
Michigan	36,084	31,233	12,985	16,438	19,224
Minnesota	299,358	483,578	292,366	349,063	315,149
Missouri	28,763	39,398	19,748	15,004	10,195
Montana	73,443	59,019	34,437	33,280	51,081
Nebraska	....	....	(a)	(d)	(d)
Nevada	(b)	(c)	....	....	....
New Jersey	189,098	112,650	155,765	166,583	69,584
New Mexico	4,963	1,402	4,085	(d)	66,700
New York	[e] 1,430,830	[e] 1,810,770	[e] 2,353,995	[e] 1,651,317	[e] 1,568,952
North Carolina	....	(c)	[a] 10,385	(d)	(d)
North Dakota	(b)	....	....	....	....
Ohio	1,639,006	1,402,131	1,334,947	1,312,300	1,316,028
Oklahoma	59,855	19,801	90,971	5,334	1,010
Oregon	[b] 4,811	[c] 30,375	[a] 1,668	....	(d)
Pennsylvania	[e] 1,637,794	[e] 1,595,070	[e] 1,333,309	[e] 1,367,601	[e] 1,359,533
South Dakota	[b] 118,029	156,576	141,615	139,167	163,165
Tennessee	(b)	(c)	(a)	(d)	(d)
Texas	61,600	40,471	28,000	82,501	58,750
Utah	71,235	43,589	41,953	32,562	23,965
Virginia	28,574	25,080	31,315	4,020	(d)
Washington	335,470	438,581	301,843	344,476	560,468
West Virginia	[b] 201,038	[c] 212,308	203,935	183,410	146,698
Wisconsin	204,959	189,654	144,430	179,352	213,229
Wyoming	13,130	5,314	3,584	3,730	(d)
Other States	....	....	....	206,299	185,358
Total	8,010,454	7,930,019	7,730,868	6,893,611	7,033,067

[a] Arizona includes Florida; Massachusetts includes Connecticut; Oregon includes Nebraska; North Carolina includes Tennessee.
[b] Massachusetts includes Connecticut; Oregon includes Nevada; South Dakota includes North Dakota; West Virginia includes Tennessee.
[c] Massachusetts includes Connecticut; Oregon includes Nevada; West Virginia includes Tennessee and North Carolina.
[d] Included in "Other States."
[e] Includes bluestone.

Value of production of sandstone (including quartzite and bluestone) in the United States in 1912 and 1913, by States and uses.

1912.

State.	Rough building.	Dressed building.	Ganister.	Paving.	Curbing.	Flagging.	Rubble.
Alabama			$45				$4,866
Arizona	$924	$2,700				$200	300
Arkansas	1,205	350		$4,032	$5,905	2	4,770
California	34,338	3,668			2,845		500
Colorado	14,154	23,023	14,278	25,955	8,362	4,289	4,540
Connecticut							
Florida							
Georgia							
Idaho	11,630	2,063					40
Illinois	644	564	2,250				135
Indiana							
Iowa	818	14					104
Kansas	5,063				42	926	
Kentucky	23,071	59,492		140		1,118	5,350
Maryland	6,500		5,250	2,400			550
Massachusetts	70,038	76,725					
Michigan	4,844	9,985					1,132
Minnesota	7,591	52,695		180,894	17,074		6,339
Missouri	1,921	4,078			40	100	1,375
Montana	725	23,554				2,144	2,777
Nebraska							
New Jersey	55,609	49,665		925	7,670	450	2,884
New Mexico							
New York	74,392	300,098		226,581	530,980	325,577	18,259
North Carolina							
Ohio	122,248	389,899	4,000		337,110	278,887	28,432
Oklahoma	1,600	17					3,717
Oregon							
Pennsylvania	221,467	239,424	206,728	31,634	189,696	100,339	38,442
South Dakota	23,619	18,440		29,413			2,669
Tennessee							
Texas	147				994		
Utah	5,966	13,146		5,500		2,837	4,613
Virginia							500
Washington		67,532		40,201			1,828
West Virginia	76,034	20,620			6,577	1,400	20,169
Wisconsin	10,249	28,675	47,384	37,100			10,322
Wyoming	2,049						
Other States [a]	83,417	16,599	10,000	500	1,250	2,800	35,692
Total	860,263	1,403,026	289,935	585,275	1,108,545	721,069	200,305

[a] Includes Connecticut, Florida, Georgia, Indiana, Nebraska, New Mexico, North Carolina, and Tennessee.

Value of production of sandstone (including quartzite and bluestone) in the United States in 1912 and 1913, by States and uses—Continued.

1912—Continued.

State.	Riprap.	Crushed stone.			Other.	Total.
		Road making.	Railroad ballast.	Concrete.		
Alabama	$10,685			$12,000		$27,596
Arizona		$2,250	$13,000	2,150		21,524
Arkansas	26,500	2,341	18,867	16,486	$80	80,538
California	43	20,832	228	6,204	2,066	70,724
Colorado	3,619	8,600		1,349		108,169
Connecticut						(a)
Florida						(a)
Georgia						(a)
Idaho	150					13,883
Illinois		29,127				32,720
Indiana						(a)
Iowa	40			575		1,551
Kansas						6,031
Kentucky	2,014	21,000		2,465		114,650
Maryland	1,250					15,950
Massachusetts	1,975	33,600		125,500		307,838
Michigan	140				337	16,438
Minnesota	540	8,935		69,655	5,340	349,063
Missouri	4,280	2,240		125	845	15,004
Montana	2,015				2,065	33,280
Nebraska						(a)
New Jersey	792	8,000		37,529	3,059	166,583
New Mexico						(a)
New York	5,685	9,659	1,118	131,808	27,160	1,651,317
North Carolina						(a)
Ohio	90,189	3,310	5,000	36,252	16,973	1,312,300
Oklahoma						5,334
Oregon						(a)
Pennsylvania	34,200	81,656	94,079	107,588	22,348	1,367,601
South Dakota	10,491	3,600		50,935		139,167
Tennessee						(a)
Texas	9,360			72,000		82,501
Utah					500	32,562
Virginia		1,450	1,800	270		4,020
Washington	234,915					344,476
West Virginia	5,858	3,088	36,554	13,080	30	183,410
Wisconsin	25,241	11,370		9,006	5	179,352
Wyoming				1,681		3,730
Other States [b]	5,855	30,356		16,916	2,914	[b] 206,299
Total	475,837	281,414	170,646	713,574	83,722	6,893,611

[a] Included in "Other States."
[b] Includes Connecticut, Florida, Georgia, Indiana, Nebraska, New Mexico, North Carolina, and Tennessee.

Value of production of sandstone (including quartzite and bluestone) in the United States in 1912 and 1913, by States and uses—Continued.

1913.

State.	Rough building.	Dressed building.	Ganister.	Paving.	Curbing.	Flagging.	Rubble.
Alabama	$37,500						$9,055
Arizona	2,275	$8,520					7,356
Arkansas	325			$2,035	$8,240	$39	1,030
California	7,514	69,220		16,000	435		1,050
Colorado	10,808	23,746	$10,353	31,509	9,995	2,088	2,931
Connecticut							
Florida							
Georgia							
Idaho	12,979	6,859					273
Illinois	428	120	2,000				32
Iowa	500	450			6		80
Indiana							
Kansas	916					322	364
Kentucky	16,022	56,135				1,264	80
Maryland	450		782	1,480			3,805
Massachusetts	34,068	30,111					1,874
Michigan	5,580	7,380					3,125
Minnesota	1,379	47,629		184,573	9,863		7,808
Missouri	2,070	2,839		185	74		970
Montana	3,992	44,139					800
Nebraska							
New Jersey	32,848	5,487		325	350	450	1,520
New Mexico	800	200					11,700
New York	65,254	212,000		288,648	525,209	211,047	9,326
North Carolina							
Ohio	102,413	345,638	4,200		450,839	239,675	11,616
Oklahoma							1,000
Oregon							
Pennsylvania	188,986	210,192	283,056	49,174	144,725	95,479	70,744
South Dakota	17,179	19,377		65,708			708
Tennessee							
Texas	4,250						
Utah	1,861	4,073		15,659			2,372
Virginia							
Washington	1,410	58,626		20,672			5,240
West Virginia	25,347	27,663		12	3,800	660	11,871
Wisconsin	10,478	23,261	63,384	60,287		13	23,928
Wyoming							
Other States	64,205	5,522	13,000	500	1,300	2,092	10,164
Total	651,837	1,209,087	376,775	736,767	1,154,836	553,129	200,822

Value of production of sandstone (including quartzite and bluestone) in the United States in 1912 and 1913, by States and uses—Continued.

1913—Continued.

State.	Riprap.	Road making.	Railroad ballast.	Concrete.	Other.	Total value.
Alabama	$17,056			$87,500		$151,111
Arizona	60,240				$10,000	88,391
Arkansas	32,205	$18,053	$14,468	12,925	75	89,395
California	813	28,680	2,524	7,830	5,420	139,486
Colorado	12	5,000		522		96,964
Connecticut						(a)
Florida						(a)
Georgia						(a)
Idaho						20,111
Illinois		25,988		213		28,781
Iowa	38			538		1,612
Indiana						(a)
Kansas						1,602
Kentucky	5,003			2,667		81,171
Maryland	2,698				7,220	16,435
Massachusetts		45,000		77,866		188,919
Michigan	3,127				12	19,224
Minnesota		12,343		46,300	5,254	315,149
Missouri	57	4,000				10,195
Montana	50				2,100	51,081
Nebraska						(a)
New Jersey	4,648	11,375		10,288	2,293	69,584
New Mexico				54,000		66,700
New York	19,676	7,301	44,437	165,175	20,879	1,568,952
North Carolina						(a)
Ohio	82,862	1,638	16,586	39,471	21,090	1,316,028
Oklahoma					10	1,010
Oregon						(a)
Pennsylvania	28,126	106,533	71,240	103,543	7,735	1,359,533
South Dakota	12,423			47,230	540	163,165
Tennessee						(a)
Texas	10,750	6,250		37,500		58,750
Utah						23,965
Virginia						(a)
Washington	474,520					560,468
West Virginia	23,507	4,753	34,282	14,053	750	146,698
Wisconsin	2,873	20,145		8,114	746	213,229
Wyoming						(a)
Other States	32,500	3,383	2,506	46,024	4,262	185,348
Total	813,184	300,442	186,043	761,759	88,386	7,033,067

a Included in "Other States."

Building stone.—The largest product of the sandstone industry is building stone, and this showed a decrease of $402,365, or more than 17 per cent. The value in 1913, including rough and dressed stone, was $1,860,924; in 1912, $2,263,289. Ohio, Pennsylvania, and New York produced most of the building stone.

Ganister.—Ganister reported from Pennsylvania, Wisconsin, Georgia, Colorado, Ohio, Illinois, and Maryland was valued at $376,775 in 1913, an increase of $86,840 over 1912.

Paving.—The total value of the paving stone (blocks, slabs, etc.) increased $151,492—from $585,275 in 1912 to $736,767 in 1913. New York and Minnesota were large producers.

Curbing.—Sandstone for curbing was valued at $1,108,545 in 1912; in 1913 its value was $1,154,836, an increase of $46,291. New York, Ohio, and Pennsylvania were the principal producers.

Flagging.—Ohio, New York, and Pennsylvania were the chief States producing sandstone flagging, and this product was the only one besides building stone that declined in value of output. The total decrease amounted to $167,940—from $721,069 in 1912 to $553,129 in 1913.

Rubble.—The value of rubble remained practically the same—$200,822 in 1913 and $200,305 in 1912.

Riprap.—Sandstone sold for riprap increased in value from $475,837 in 1912 to $813,184 in 1913, a gain of $337,347. Over half of this output was produced in Washington and was used for the protection of the Northern Pacific Railway tracks in the vicinity of Tacoma.

Crushed stone.—There was an increase in value in crushed sandstone of $82,610—from $1,165,634 in 1912 to $1,248,244 in 1913. The quantity increased from 1,568,020 short tons in 1912 to 1,580,966 tons in 1913, a gain of 12,976 tons. The average price per ton in 1912 was 74 cents; in 1913 it was 79 cents.

BLUESTONE.

A fine-grained, compact dark blue-gray argillaceous sandstone is quarried in eastern and southeastern New York and in northeastern Pennsylvania. The figures of production for this stone are included in those of sandstone, but on account of the local importance of the material, the value is also given separately. This stone is marketed under peculiar conditions. Almost all the owners of land in this district have small deposits of the stone on their property and quarry small quantities of it annually, which they sell to agents of large dealers who market the stone. As many of these dealers also quarry the stone, it has been found that the best figures of production are obtained from the dealers, who are better able to give the entire quantity of stone bought and sold than are the small producers. This stone is used chiefly for flagging, curbing, and for sills, lintels, steps, and house copings. In recent years, however, much of this stone for these purposes has been replaced by cement concrete. For the last few years some of this stone has been crushed and used in the concrete work of the New York City water-supply system. The output in 1913 was valued at $1,280,862, in 1912 at $1,505,763, a decrease of $224,901, or 14.9 per cent, in 1913.

The following table shows the value of the bluestone produced from 1906 to 1913:

Value of bluestone produced from 1906 to 1913.

Year.	Value.	Year.	Value.
1906	$2,021,898	1910	$1,535,187
1907	2,117,916	1911	1,876,473
1908	1,762,860	1912	1,505,763
1909	1,446,402	1913	1,280,862

The following table shows the value and uses of the bluestone produced in New York and Pennsylvania in 1912 and 1913:

Value and uses of bluestone produced in New York and Pennsylvania in 1912 and 1913.

State.	Building purposes.	Flagging.	Curbing.	Crushed stone.	Other purposes.	Total value.
1912.						
New York	$310,797	$325,210	$404,203	$102,905	$9,187	$1,152,302
Pennsylvania	114,296	95,223	116,647	9,593	17,702	353,461
Total	425,093	420,433	520,850	112,498	26,889	1,505,763
1913.						
New York	$201,032	$200,588	$327,694	$199,210	$15,775	$944,299
Pennsylvania	118,988	93,198	94,625	23,306	6,446	336,563
Total	320,020	293,786	422,319	222,516	22,221	1,280,862

STONE RESOURCES IN THE STATES WEST OF THE ROCKY MOUNTAINS.

QUARRY MAPS.

Within the last few years the United States Geological Survey has received many requests for maps showing areas of stone suitable for building and other purposes in the United States. Such a set of maps is doubtless very desirable, and their preparation may be considered a goal to be attained at some future time, but not under present conditions, as the preparation of such a publication would entail an expense not compatible with the funds at present available. The compilation of a reconnaissance geologic map of the United States, recently issued, occupied the time of a geologist for several years. This geologic map shows, for the most part, the rocks subdivided on the basis of age—not on a lithologic basis—and therefore, in order to make it a serviceable stone map, it would be necessary so to resubdivide and reclassify all the cartographic units that the character and accessibility of the rock might be indicated, a task which would require many years of additional work in field and office. This reconnaissance geologic map of the United States is now available; it is contained in the geologic map of North America, issued as part of Survey Professional Paper 71,[1] in 1912, and may be obtained free of charge from the Director of the United States Geological Survey, Washington, D. C. This map shows on a scale of approximately 80 miles to 1 inch the main subdivisions of rocks by geologic systems, and in some places by series, but it does not show the rock formations, such as limestones, sandstones, granites, etc., that are suitable and available for quarry products. The Survey has issued, from time to time, special reports on certain types of stone within limited areas, as, for instance, on granite in certain States, on marble or limestone, or structural materials in general in certain districts; and occasionally a note on stones suitable for building purposes is included in a geologic folio text; but, taken altogether, the work done on this subject is hardly more than begun. In most of the States, especially those east of Mississippi River, the locations of the stone quarries already opened outlined in a general way the areas underlain by suitable stone, although, of course, suitable stone may extend far beyond the areas actually developed. Markets and transportation are the two factors that exert the greatest influence on the development of stone, even though the stone may be admittedly of an excellent quality and may be in a convenient position for quarrying. With all these limitations in mind, it was decided that the most practicable maps bearing on the stone industry that could be prepared by the Survey in the short time available for the work should indicate the locations of quarries by classes of stone. Accordingly maps having a scale of approximately 40 miles to 1 inch showing quarries throughout the United States by classes of stone have been completed. Sections comprising the States east of Mississippi River were published in the report on stone in Mineral Resources for 1911, and sections comprising the States west of Mississippi River to and including the Rocky Mountain States were issued with the report on stone in Mineral Resources for 1912. The final sections comprising the quarries in the States west of the Rocky

[1] Willis, Bailey, Index to the stratigraphy of North America: U. S. Geol. Survey Prof. Paper 71, 894 pp., 1 wall map, 1912.

Mountains are included in the present report on the stone industry in 1913. The statements in this chapter with regard to the ages of the rocks under discussion have been made with reference to the classification and geologic mapping in Professional Paper 71. Many facts are also drawn from State reports and other sources credited in the footnotes, and notes made by the writers in the course of visits to quarries in the western States have also contributed to the data. If these stone-quarry maps are studied in connection with the geologic map of the United States mentioned above, many interesting, economic, and scientific relations between the stone industry and areal geology may be observed.

A few notes in general explanation of the maps should be included here. It was the aim in the preparation of these maps to present an outline of quarry areas in so far as practicable without special reference to the magnitude of the output of stone from any given area. For instance, if there are many quarries at or near one place it is impracticable on account of the scale of the maps to represent each quarry by a separate symbol, and only one symbol is given; on the other hand, in an isolated place there may be but one quarry and that a small one, yet the fact that quarriable stone occurs at that place has been regarded as the important point to be brought out by these maps, and the isolated quarry is therefore indicated by the appropriate symbol. Naturally, where the quarry industry predominates in a county or a district these maps readily indicate that fact, as inspection of Plates V, VI, and VII shows at a glance that there are several granite quarries near Rocklin, Cal., many trap-rock quarries in the vicinity of San Francisco, Cal., and Portland, Oreg., and several limestone quarries in Sanpete County, Utah, but equally interesting and possibly of even more importance to the matter of distribution of stone resources is the demonstration that there is also quarriable granite in Baker County, Oreg., limestone in Blaine County, Idaho, volcanic tuff in Cochise County, Ariz., and marble in Stevens County, Wash. A provision has been made in the directories accompanying the maps which shows the number of quarries represented by a single symbol. For instance, with regard to granite symbol No. 18, on the map of California, Plate VI, the directory gives "18—Rocklin (24)"—indicating that 24 granite quarries are represented by the single granite symbol near Rocklin, Cal. The limestone quarrying industry and the manufacture of lime are so intimately associated, practically every lime manufacturer at times selling some crushed stone or other form of stone not burned and many stone producers making lime as an adjunct to their stone business, that the locations of limekilns have also been given on these maps, by simply modifying the triangular limestone symbol into a double triangle which indicates "limestone and limekiln." On the other hand, limestone quarries operated as a source of material for the manufacture of cement have not been included, because, as a rule, they are operated solely for cement material, the sale of stone from them being negligible. Besides this, the location of cement plants has been shown on maps accompanying the chapters on the cement industry in Mineral Resources for 1910 and 1911.

The advisability of giving a complete tabulation of such chemical analyses of stones as are available has been considered; but, since analyses of stones other than limestones are of rather doubtful value, except from a scientific viewpoint, this matter has been disposed of by giving in the chapter in Mineral Resources on the production of lime in 1911,[1] a few copies of which are still available for free distribution, an extensive tabulation of chemical analyses of both limestone and limes from all parts of the country, including both high-calcium and high-magnesian materials. In a few instances, however, both chemical and physical data with regard to rocks of particular interest have been included in the present report.

Under marbles no distinction has been made in the quarry symbols between true metamorphic marbles and crystalline limestones susceptible of a high polish, since the latter class includes some very valuable marbles of commerce. Onyx marble in Arizona and California is also indicated by the marble symbol.

The preparation of these quarry maps was begun in 1911 on the basis of the Survey's list of stone producers in 1910. Before the chapters for 1911 and 1912 went to press some revision was made in order to bring the maps up to date, and the maps for the 1913 chapter have been completely revised, but it has been unavoidable to include some quarries now inactive, and probably it has been impossible to include every place in which stone is quarried. However, the first fault is not a disadvantage, because, although a quarry may have been abandoned temporarily, it by no means follows that the quarriable stone has been exhausted, and the symbol stands not wholly to show the location of a quarry but also the existence of a certain type of stone at that place.

There are certain limitations to the accuracy of these maps which should be mentioned here. The scale of the maps is approximately 40 miles to 1 inch. On this scale the quarry symbols, which have been made as small as is compatible with convenient reading and interpretation, are still so large that each one covers much more area than an average-sized quarry. Where quarry areas are close together, it has therefore been necessary to place the symbol as near the determined locality as possible, without running the symbols together or superimposing one upon another. In the great majority of counties the only town shown on the base map is the county seat. Therefore the location of all other places where quarries are situated has been of necessity interpolated from other Government maps, commercial atlases, and railroad maps. Not all these maps are agreed in all details, and many of the locations resulting from comparisons of these various sources of information are to some extent compromises. One other unavoidable source of error is that the exact location of a quarry may not have been given by the stone producer in his reports to the Survey. All quarries have therefore been plotted with reference to the nearest railroad station or post office, according to the reports of the producer, unless, as in many cases, special information in the possession of the writers has been drawn upon to determine doubtful locations. In view of the small scale of the map and the purposes which it is intended to fulfill it is believed that these errors will not detract seriously from its value.

The treatment of the subject in the following discussions has, on account of limitations of time and space, been more or less generalized, although the present chapter treats of the stone resources of the sev-

[1] Burchard, E. F., The production of lime: U. S. Geol. Survey Mineral Resources for 1911, pt. 2, pp. 658-707, 1912.

eral States concerned in much greater detail than have previous chapters. In the case of the directories locations only have been given, without reference to ownership of quarries, since it is planned to treat this subject in an entirely impersonal way, and also because the ownership of quarries changes more or less frequently.

Readers who are interested in further details concerning the stone resources of the country will find much local information in the Survey reports listed in the bibliography at the end of this chapter, especially the works of Dale and Watson, and in a textbook by G. P. Merrill, "Stones for building and decoration," published by John Wiley & Sons, New York.

ARIZONA.

By E. F. Burchard.

The stone resources of Arizona, which are comparatively little developed, comprise granite, basalt, tuffs, and other igneous rocks, slate, marble, onyx, limestone, and sandstone. Sedimentary rocks predominate in the northeastern third of the State, although there are in this portion many areas of volcanic rocks. Across the middle of the State from northwest to southeast extends an irregular belt of volcanic, intrusive, and metamorphic rocks. The southern portion of the State is largely covered by "desert wash," a more or less loosely consolidated deposit which partly fills the desert basins, and through which protrude many isolated areas of igneous and a few areas of sedimentary rocks. The sedimentary beds of the northern and northeastern parts of the State range in age from the Algonkian sandstone and limestone of the Grand Canyon to the Upper Cretaceous sandstone and shale of the plateau country in Navajo and Apache counties, although there are breaks in the sequence of the deposits. These sedimentary rocks consist of sandstone, shale, and limestone, and contain also important beds of gypsum.

Granite.—Granite and related rocks occur in several widely separated areas in Arizona. According to the geologic folios [1] that have been published by the United States Geological Survey, granites occur in the Bradshaw Mountains, at and near Prescott, in the Mule Mountains near Bisbee, in the mountains surrounding Globe, and in the vicinity of Clifton. According to Blake [2] there is a broad central area of coarse-grained porphyritic granite, generally gray in color, outcropping in the Santa Rita Mountains at Helvetia; on the east side of the Huachuca Mountains facing the San Pedro Valley; in the northern end of the Santa Catalina Range near Oracle; and extending northward toward the Superstition Mountains and to Salt River east of Florence. Blake states that in the Tombstone area gray medium-grained granodiorite occurs which weathers in such a way as to leave large globular masses or bowlders of disintegration confusedly piled on the surface. Another outcrop on a large scale of similar granodiorite is found in the Dragoon Mountains. Quartz diorite is available in inexhaustible quantities in the Bradshaw Mountains.

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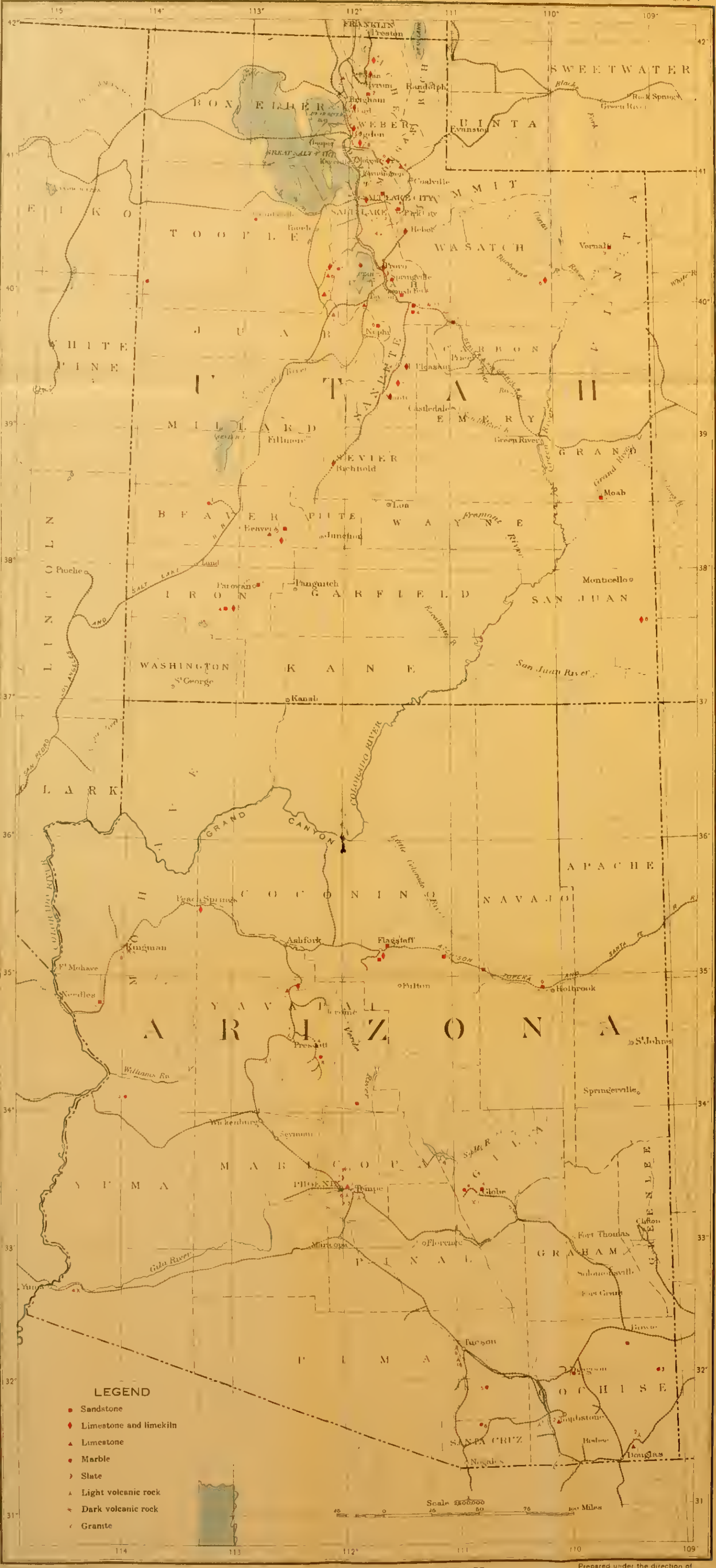
[1] Geol. Atlas, folios 111, 112, 126, 129.

[2] Blake, Wm. P., Geology of Arizona: Rept. Governor of Arizona to the Secretary of the Interior, for 1903, pp. 131–132.



MAP OF ARIZONA AND UTAH

Showing location of limekilns and quarries of limestone, sandstone, marble, slate, light volcanic rock, dark volcanic rock, and granite

Prepared under the direction of E. F. Burchard

The granite output of Arizona is not large at present and is confined chiefly to supplying local demands for monumental work and for an occasional building. Quarries are situated near Phoenix, Maricopa County; Globe, Gila County; and Prescott, Yavapai County.

The quarries near Phoenix are about 7 miles south of the city. Two varieties of granite are produced here, both gneissoid. The finer grained of the two is of a gray color and is noticeably porphyritic, with white crystals of orthoclase in contrast to the finer-grained gray mass of the rock. The coarser-grained variety is of lighter color and with biotite having a linear arrangement. A local light-gray granite, resembling the latter of these two, has been used in the walls of the first story of the State Capitol at Phoenix.

The quarries near Prescott are 1½ to 2 miles northwest of the city on the north side of the Santa Fe, Prescott & Phoenix Railway tracks and about one-fourth of a mile from a siding where blocks may be loaded for shipment. The rock is obtained from large bowlders, which form a low ridge. These bowlders are of all sizes up to 30 feet in diameter, and represent the residual portions of the rock that lay between the joint planes. Weathering along the joint planes and exfoliation of the blocks have reduced the surface granite generally to a bowldery condition. The surface of the bowlders is oxidized to a light pink color, which extends generally to a depth of only one-eighth to one-half inch, and below which the color of the granite is light gray. The grain of the stone is medium and fairly even. Small faint, light-brown spots are scattered uniformly through the mass. These spots appear to be stains in the quartz and feldspar grains, produced by the oxidation of minute specks of iron pyrite. Pyrite is not common in this granite, however, and the staining appears to have reached its maximum. This granite polishes fairly well, but does not show a marked contrast between hammered and polished surfaces. It is reported to work favorably and to possess good rift and grain. Conditions in this vicinity do not favor opening quarries in the rock below the bowldery zone, and since the bowldery material is fairly satisfactory, besides being cheaply quarried, it is probable that it will continue to be utilized as a source of granite for several generations.

A gray, partially disintegrated granite is quarried about 2 miles east of Dome, Yuma County, for use as railroad ballast.

A crystalline andesite porphyry, termed commercially "white granite," and a granodiorite, or "black granite," are found in the Santa Rita Mountains, about 5 miles northeast of Helvetia, Pima County.[1] The andesite porphyry occurs as a nearly perpendicular dike about 100 feet thick cutting granite. The material is strong and durable and of low specific gravity.

Dark volcanic rocks.—There are vast areas of basaltic lava flows in Arizona, mostly of Tertiary and later age. They are found in all parts of the State and are associated with the sedimentary rocks as well as with granites, schists, and tuffs. Locally they are termed "malpais" rocks. From an economic viewpoint this type of rock is of very little importance at present in this area. Because of its somber colors and its rough texture it does not make a desirable building and ornamental stone, and, although it makes good crushed

[1] Personal communication from C. F. Tolman, jr., Palo Alto, Cal.

stone for concrete and railway ballast, it is not yet in great demand for these purposes. An interesting type of basaltic rock is obtained from bowlders about 12 miles north of Phoenix which is worked into rough blocks for foundations and is also trimmed into dimension blocks for fireplaces and mantels. This rock is of a brownish-purple color, of medium grain, is rather vesicular, and contains calcite in many of the small cavities. A dark-gray, more or less vesicular basalt is associated with the red sandstone near Flagstaff, and production of basalt has been reported from the vicinity of Kingman. Basalt is also quarried in a small way from surface material a few miles southwest of Tucson.

Light volcanic rocks.—The most common rocks of this type that are quarried for structural purposes in the Western States are tuffs of various kinds, and Arizona is most bountifully supplied with them. Tuff is generally well suited to building purposes in arid, warm regions, and where it can be used it possesses advantages over other kinds of stone in its lightness of weight and in the ease and cheapness with which it may be quarried and trimmed. Generally it is possible to quarry tuff in blocks as large as are needed. Evidence of the appreciation of the value of tuff as a building stone in Arizona is shown by the opening of tuff quarries in such widely scattered parts of the State as Kingman, Flagstaff, Kirkland, Phoenix, Tempe, Tucson, Huachuca, and Tufa, near Douglas. The tuff near Kingman [1] is fawn-colored or mouse-colored, with small fragments of white or cream-colored pumice stone. The rock is largely composed of pumice, and contains also grains of transparent sanidine. The material is obscurely stratified, and, although soft enough to be readily cut with a saw or other tools in any direction, it does not crumble and is strong enough for ordinary building purposes. The specific gravity is 1.72; the weight per cubic foot, 107.36 pounds; and the absorption is 23½ per cent.

Rhyolite tuff and rhyolite porphyry are quarried within 2 to 5 miles west and southwest of Tucson, mostly from surface and bowlder material. According to Blake, the principal varieties are white and pink in color, the white variety having no perceptible rift, so that it cuts or chips well in any direction. Some inclusions are present which detract from the homogeneity of the stone. The university dormitory and several residences and terrace walls in Tucson are built of the white tuff. The pink tuff consists largely of silica. It possesses a uniform, pleasing rose-pink tint, and has fewer inclusions than the white tuff. This rock breaks with a conchoidal fracture equally well in any direction, can be easily cut and chiseled, yet is firm and strong. The rock has a specific gravity of 2.55, and the weight per cubic foot is 159.17 pounds, which is greater than that of most tuffs. The absorption is less than the normal, being only a little more than 5 per cent. The tuff from near Phoenix is reported as a friable variety,[1] of white and gray color, sufficiently compact to be cut in blocks of considerable size, and to have been used to some extent for building purposes. The form of occurrence is reported to be in "blankets," 3 to 15 feet thick, more or less tilted, and the constituent material to be mainly pumice fragments of about 0.25 millimeter in greatest diameter.

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[1] Blake, Wm. P., Rept. Governor of Arizona for 1899, p. 131, 1899.

A light-gray rhyolitic tuff is quarried from bowlders 5 or 6 miles east of Flagstaff, near Cliffs station. This is a granular and rather porous rock, not very hard, but blocks of it are capable of being trimmed evenly on the edges. Locally it is called "malpais." It has been used in many of the older buildings of Flagstaff, including the post-office block, a bank, several business buildings and residences, and it is used considerably at present as a foundation stone.

The tuff quarried near Kirkland is, when fresh, of an attractive cream shade which weathers to pinkish buff. The groundmass is soft, being composed in large part of pumice, but there are small inclusions of dark crystalline material that are much harder than the surrounding rock. These inclusions, or "knots," render the rock less desirable to work than a more homogeneous material would be, and since they come out easily they produce a slightly pitted surface in dimension stone. Notwithstanding this disadvantage, this tuff was used for the exterior of the upper two stories of the State capitol at Phoenix. Five columns and six pilasters, each with carved capital and base, were cut from the tuff. The ornamental blocks about the windows and cornices are sawed, while the walls are mainly of rock-faced tuff. The tuff stonework surmounts and harmonizes well with the gneissoid granite which was used to the top of the basement story. This capitol is a fine example of what may be done with tuff as a building stone in the southwestern United States.

One of the most promising deposits of tuff in Arizona is situated about 2 miles northwest of the station of Tufa on the El Paso & Southwestern Railroad. This rock has a fine-grained, stony groundmass in which a few small bright phenocrysts of feldspar may be seen, and a very few inclusions or knots of coarser textured material as much as three-fourths of an inch in diameter. The rock is all of a light shade, but there are various pleasing tints developed from place to place in the deposit, such as white, cream, light blue, pink, and light brown. The rock is rather soft and breaks easily in the quarry, but is reported to harden in the walls of buildings. It appears to trim evenly, and also is fully as susceptible of tooling and carving as a fine-grained sandstone. A favorite way of finishing the stone for trimming is to rub it to a plane surface. The deposit is extensive and is reported to cover 100 acres or more in this vicinity. It appears to have been deposited on an eroded surface, and is in places 25 feet or more in thickness. In places the surface is bare, but in others there is a little soil or gravel. At one place a few inches of tuffaceous sandstone was noted overlying the tuff.

The tuff from near Tufa is practically the only natural building stone that has been used in the city of Douglas and vicinity. Foundations, trimmings, and walls of business blocks, churches, and residences are built of this rock, and it is reported to have been shipped to El Paso and other cities.

Rhyolite occurring in a large bluff on the west side of the river near Clifton[1] has been used for building purposes. Dacite, which occurs in inexhaustible quantity and in a readily accessible situation near Globe,[2] affords an easily worked and durable material and has

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[1] Lindgren, Waldemar, U. S. Geol. Survey Geol. Atlas, Clifton folio (No. 129), p. 13, 1905.
[2] Ransome, F. L., U. S. Geol. Survey Geol. Atlas, Globe folio (No. 111), p. 17, 1904.

been used locally for walls and foundations. The green rhyolite tuff which occurs abundantly in the valley of Castle Creek, Yavapai County, has been used in building the hotel at Castle Creek Hot Springs.[1] This stone is said to be soft and easily worked when fresh and to harden on exposure. It is considered a handsome building stone.

Slate.—According to Blake [2] large areas of mica slate and clay slate occur in Arizona in the pre-Cambrian rocks in the mountainous region from the Yuma ranges to the Bradshaw Mountains; in an extensive region of argillaceous slate on Cave Creek, Maricopa County; near Walnut Grove in Yavapai County; and on the eastern side of the Rincon Mountains, about 6 miles north of Dragoon Summit station. This last slate occurs in close association with the gneissic rocks in which the quartz veins carrying wolframite occur.

One slate quarry is reported as operated occasionally about 7 miles north of Phoenix. The product resembles a mica schist rather than a slate, and is used chiefly for foundations. The foundation of the State Capitol is reported to have been built of this rock.

A large part of the Yavapai schist as mapped in the Bradshaw Mountains folio is reported to consist of phyllites with slaty cleavage, but they are not known to be of sufficiently fine and even grain nor to have sufficiently perfect cleavage to be properly termed slates. No records of the use of this rock for roofing purposes are available.

Marble.—Notes are available concerning many deposits of marble in Arizona, and it is apparent that there is no lack in this State of suitable marble of various shades, or of onyx. A variety of types is found in one locality about 5 miles northeast of Helvetia,[3] in the Santa Rita Mountains, Pima County, including fine and coarse grained black marble, fine and coarse grained dark blue marble, and coarse-grained white marble. Blake [4] mentions marble from this locality having been used at Tucson for monumental purposes, and also states that remarkably fine white statuary marble occurs in large masses on Marble Peak on the northeast side of the Santa Catalinas. Three areas of calcite marble on the east side of the Chiricahua Mountains are described by Paige.[5] Two of the areas lie about 14 miles S. 22° E. from Bowie, a station on the Southern Pacific Railroad, and the third lies about 18 miles N. 50° W. of Rodeo, N. Mex., a station on the El Paso & Southwestern Railroad, and about 5 miles northwest of Paradise, Ariz. The two marble deposits that can be reached from Bowie lie, one just west of Fort Bowie and the other about 3 miles east of the same place. The western deposit is of medium-grained, crystalline-granular structure, and is mostly of a pure white color with pinkish tones. Thin seams of red iron oxide are abundant but enhance rather than decrease the beauty of polished surfaces. On the borders of the ledge gray and blue shades are developed. This rock is severly fractured at the surface and had not been sufficiently prospected when examined in 1908 for its real worth to be determined. The marble east of Fort Bowie is a massive, even, crystalline-granular

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[1] Jaggar, T. A., jr., and Palache, Charles, U. S. Geol. Survey Geol. Atlas, Bradshaw Mountains folio (No. 126), p. 11, 1905.
[2] Blake, Wm. P., Geology of Arizona: Rept. Governor of Arizona for 1903, pp. 127-128.
[3] Personal communication from C. F. Tolman, jr., Palo Alto, Cal.
[4] Blake, Wm. P., Rept. Governor of Arizona for 1899, p. 132.
[5] Paige, Sidney, Marble prospects in the Chiricahua Mountains, Ariz.: U. S. Geol. Survey Bull. 380, pp. 299-311, 1909.

medium-grained aggregate of calcite crystals. Its dominant color is white, or pinkish, or grayish white, with irregular black markings. Gray, dove-colored, and blue varieties also are present, and some is pure white. The marble zonês are metamorphic developments in limestone strata, and in places contain siliceous bands, which must be avoided in quarrying, running parallel with the stratification of the limestone. The joints vary in abundance and distribution and are far enough apart in places to permit good bodies of rock to be quarried. The most southern area of the three examined by Paige lies near the head of Whitetail Canyon. The ledge can be traced for a mile and is a band in a series of northwest-southeast trending Carboniferous (?) limestones. This is a coarsely crystalline-granular white marble without markings. A few limonite stains are present and silica bands are abundant in places, although thicknesses of stone, respectively 100 feet and 50 to 60 feet, were observed to be free of this impurity.

Tests made on marble samples from near Fort Bowie at the structural materials laboratory of the Survey at St. Louis show an average strength of 10,300 pounds per square inch; weight ratio of absorption, 0.0011; volume ratio of absorption, 0.0029; and weight per cubic foot, 168.91 pounds. Considerable marble is reported to have been shipped from this quarry for use in a recently constructed Federal building.

Marble deposits of great variety and beauty are reported to occur 2 miles southeast of Dragoon station. White marble, golden-yellow marble, and marble veined with green, yellow, and other shades, all of fine grain, as well as conglomerate showing marked contrasts of color, are among the samples sent to the Survey from this deposit. All of these samples are susceptible of a high polish. Undeveloped, coarsely crystalline marbles are reported to occur in the Colorado River region south of the mouth of Williams River, and it is understood that some prospecting has been done about 10 miles north of the station of Bouse.

Onyx marble.—Some of the onyx deposits in Arizona are already well known. Near Mayer, on the left bank of Bigbug Creek, about 26 miles southeast of Prescott, is a deposit of onyx marble reported to cover about 200 acres, small portions of which are of a quality suitable for decorative purposes, although but little commercial exploitation has yet been possible. This deposit varies from 1 foot to 25 feet in thickness. The material is variable in color and texture. Most of it is white or pale green where fresh, but oxidation of iron contained in ferrous carbonate has produced brown limonite and deep red hematite, and these minerals in the form of powder are suspended in the calcite, giving brilliant color contrasts with the white or green material. Lack of space prohibits extended description of this material here, but the interested reader will find detailed discussions in the references cited below.[1]

A second deposit of onyx marble in Yavapai County is in the southern part of the county at Cave Creek, about 45 miles northeast of Phoenix.[2] The prevailing colors of this onyx are similar to those at

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[1] Merrill, G. P., U. S. Nat. Mus. Rept., 1893, pp. 539–585; Stones for building and decoration, 3d ed., pp. 263–266, Wiley & Sons, 1903.
Blake, Wm. P., Rept. Governor of Arizona for 1899, pp. 132–133.
Jaggar, T. A., jr., and Palache, Charles: U. S. Geol. Survey Geol. Atlas, Bradshaw Mountains folio (No. 126), pp. 3 and 11, 1905.
[2] Blake, Wm. P., op. cit., p. 133. Merrill, G. P., op. cit., pp. 266–267.

Mayer, viz, greenish and yellowish with veins of brown and red, and are said to be very beautiful. The onyx used in the counter of the Annex Hotel in Chicago is reported to have been produced from the deposit at Cave Creek. This deposit is intimately associated with basalt, and is more or less shattered, so that it has been difficult to extract large blocks of material of fine quality.

One more important deposit of onyx marble in Arizona remains to be mentioned, that situated in Santa Cruz County, about 4½ miles south of Greaterville, Pima County. This deposit is found in a cave which has been developed in limestone in Cave Hill on the east side of the Santa Rita Mountains. According to Willis,[1] this onyx marble is travertine, of considerable homogeneity of texture and of color. The color is brown of various shades, and it is reported that cracks in the material are so rare that the size of blocks that are obtainable is limited only by the equipment that may be installed to handle the stone and by the transportation facilities.

In addition to these deposits Blake mentions samples of black and white banded onyx having been brought to Tucson from some place in Arizona, but neglects to state the exact locality.

Limestone and lime.—Two extensive limestone formations of Carboniferous age, the Redwall limestone and the Kaibab limestone, occur in north-central Arizona, and to the south large masses of limestone, in large part Carboniferous and Devonian in age, have been infolded among the intrusive and sedimentary rocks of the mountainous districts. The Redwall limestone is reported to range from 800 to more than 2,000 feet in thickness, but includes much calcareous shale and some sandstone. The Kaibab limestone is generally about 800 feet thick where fully developed, but contains considerable chert in its upper portion. Lime is burned and crushed stone is produced in places from the Carboniferous limestone in northern Arizona, as at Flagstaff, Puntenney, and Delrio. In the Clifton-Morenci district the upper 100 feet of the Modoc limestone is composed of limestone carrying about 95 per cent of calcium carbonate. Near Morenci a nearly pure dolomite underlies this limestone. The limestone is quarried for smelter flux on Modoc and Shannon mountains. In the Bisbee district the Escabrosa limestone would probably yield stone suitable for crushing and possibly of fair quality for building. The Naco limestone is quarried for flux near the smelters, and there is a vast supply of limestone suitable for this purpose in this district.

Sandstone.—The principal areas of sandstone in Arizona in which quarries have been opened are in the northern part of the State along the Atchison, Topeka & Santa Fe Railway, but there are other localities where sandstone or quartzite is quarried, as, for example, near Globe. Near Haviland, Mohave County, a tuffaceous sandstone is reported to be quarried. Probably the best-known sandstone of Arizona is that quarried about 1¼ miles east of Flagstaff. This is a fine, angular-grained stone of several dull shades of light red. Calcium carbonate and argillaceous material are readily detectable in the cementing material. According to Merrill [2] the stone contains 79.19 per cent silica and insoluble matter, 3.75 per cent iron and aluminum oxides, and 13.11 per cent calcium carbonate. The stone is only moderately hard. About 65 feet of sandstone are exposed in the

[1] Willis, C. F., Arizona (magazine published at Phoenix), pp. 14–15, November, 1913.
[2] Merrill, G. P., op. cit., p. 516.

vicinity of the quarry, besides about 25 feet of shaly sandstone and sandy shale. The rock has been included by Darton[1] in the Moencopie formation, probably of Permian age. Below the shaly layers, which are in the upper part of the exposure and which show laminations of color, the sandstone is mainly massive and of a uniform shade. Two sets of nearly vertical joints are prominent, but their spacing is wide enough to permit the quarrying of good-sized blocks. Much of the red sandstone from Flagstaff is used in California cities. Among the buildings in which it may be seen are the Federal buildings in Sacramento and Los Angeles. The stone can be sawed and tooled readily, but does not seem capable of retaining sharp lines and angles for long periods.

About 3 miles south of Flagstaff a light-gray sandstone has been quarried to a small extent for local use. This is a stone of very pleasing shade. The grains are subangular to round, and there are a few flakes of mica visible. The rock contains a little calcium carbonate, but not so much as the red stone. But little has been produced thus far on account of the long haul necessary.

The red sandstone of the Moencopie formation has been quarried also at three places farther east along the line of the Santa Fe Railway, viz, at Sunshine, Winslow, and Penzance. The stone at Sunshine is very similar to that at Flagstaff. It is used for masonary dams, riprap, foundations, and general building work. South and east of Winslow there are beds of a lighter red color than at Flagstaff that have been quarried in a small way, and on the northwest edge of the town several shaly buttes are capped with reddish-brown flaggy sandstone, a little harder than the light-red stone. This flaggy stone has been used for sidewalks, curbs, retaining walls, foundations, and to some extent for walls of buildings. The stone at Penzance is also of a reddish shade and has been used for purposes similar to those of the stone at Sunshine.

In the vicinity of Bisbee rough blocks have been quarried from the Bolsa quartzite and used chiefly for foundations and walls. The stone is said to be hard and durable but not to be suitable for cut-stone work. About 1½ miles east of Globe, in Rocky Gulch, some beds of red quartzitic sandstone belonging to the Apache group have been quarried to a small extent for building stone. Dark-brown, banded quartzite belonging to the Coronado quartzite has been quarried about three-fourths of a mile south of Morenci and used in the construction of large buildings in the town and also for lining copper converters.

Production.—The total production of stone in Arizona in 1913 was valued at the quarries at $107,989, as compared with $67,124 in 1912.

Directory.—Quarries of all the kinds of rock quarried in Arizona are listed below by class of rock, county, and town (or post office):

[1] Darton, N. H., Reconnaissance of parts of New Mexico and Arizona: U. S. Geol. Survey Bull. 435, Pl. I, 1910.

Directory of stone quarries in Arizona.

GRANITE.

Gila County: 1. Near Globe (in Russell Gulch).
Maricopa County: 2. Phoenix (2).
Yavapai County: 3. Prescott.
Yuma County: 4. Dome (about 2 miles east of).

DARK VOLCANIC ROCK (BASALT, ETC.).

Maricopa County: 1. Phoenix (12 miles north of).
Mohave County: 2. Kingman (near).

LIGHT VOLCANIC ROCK (TUFF, ANDESITE, RHYOLITE, ETC.).

Cochise County:
1. Huachuca.
2. Tufa.
Coconino County: 3. Flagstaff (6 miles east of).
Gila County:
4. Roosevelt.
5. San Carlos.
Maricopa County:
6. Phoenix (near).
7. Tempe (near).
Mohave County: 8. Kingman
Pima County:
9. Tuscon (near).
10. Tuscon (6 miles southwest of).
Yavapai County: 11. Kirkland.

SLATE.

Maricopa County: 1. Phoenix (about 7 miles north of).

MARBLE AND ONYX.

Cochise County:
1. Bowie (2) (12 miles southeast of).
2. Dragoon (2 miles southeast of).
3. Paradise (5 miles northwest of).
Gila County: 4. Globe (10 miles west of, at foot of Sleeping Beauty Mountain).
Pima County: 5. Helvetia (6 miles northeast of).
Santa Cruz County: 6. Greaterville (4½ miles south of) (onyx).
Yavapai County:
7. Cave Creek.
8. Mayer.
Yuma County: 9. Bouse (10 miles north of).

LIMESTONE.

Cochise County:
1. Lee.
2. Charleston (near).
Maricopa County: 3. Phoenix (2) (near).
Yavapai County:
4. Humboldt.
5. Delrio (near).

LIMESTONE AND LIME KILNS.

Coconino County: 1. Flagstaff (2).
Yavapai County:
2. Puntenney.
3. Nelson.

SANDSTONE.

Coconino County:
1. Flagstaff (1¼ miles east of).
2. Flagstaff (3 miles south of).
3. Sunshine.
Gila County: 4. Globe (2).
Mohave County: 5. Haviland.
Navajo County:
6. Penzance.
7. Winslow.

UTAH.

By G. F. Loughlin.

The writer has visited only a few of the quarries in Utah and is indebted to Prof. F. J. Pack of the University of Utah, and to certain stone companies for much of the brief information here presented. It is hoped that a more thorough account can be given later.

Utah is divided geologically into three sharply contrasted parts. The western half of the State consists almost entirely of the Great

Basin Ranges, which are composed for the most part of Paleozoic quartzite and limestone cut and overlain in places by Tertiary volcanic rocks. The Wasatch Mountains, which mark the east boundary of the Great Basin, are also composed mostly of Paleozoic quartzite and limestone overlain in places by Mesozoic strata, with local bodies of pre-Cambrian rocks, and in the Cottonwood region of a large intrusive granite body of probably late Cretaceous age. The formations of the Wasatch Mountains are continued eastward along the Uinta Range. The southeastern quarter of the State is composed almost entirely of Mesozoic, largely sandstones with local developments of gypsum and salt, and include the important coal beds. The northeastern quarter, with the exception of the Uinta Range, is almost entirely covered with early Tertiary conglomerates and sandstones. Tertiary volcanic rocks are well distributed over the western half of the State, and are especially abundant in the southwestern part.

Granite.—Granite and closely associated rocks have been quarried both from pre-Cambrian exposures and from the late Cretaceous intrusive body of the Cottonwood region, but only the latter has been worked on anything like an extensive scale. The quarries at Willard and Ogden have furnished gray to pink and red granite or granite gneiss largely from bowlders for local use, including monument bases. The exposures in places are badly shattered and streaked with pegmatite ("giant granite") veins and greenish seams of epidote and chlorite, and even moderately good quarry sites are very few. This statement holds true for the pre-Cambrian exposures along both the northern and the southern parts of the Wasatch Mountains.

The biotite granite of the Cottonwood region was first quarried at Wasatch in Little Cottonwood Canyon to furnish stone for the Mormon Temple in Salt Lake City. It has also been quarried near Alpine and Midway. Diorite, closely associated with the granite, is quarried to some extent for monumental stone on the west side of Clayton Peak near the head of Big Cottonwood Canyon. There are two quarries at Wasatch in Little Cottonwood Canyon. The older quarry is composed mostly of large glacial bowlders, the stone is gray to pale pinkish, coarse grained, and porphyritic, with feldspar crystals ranging from less than half an inch to 2 inches in length. Black inclusions, composed largely of hornblende, are prominent in the quarry, and may be seen in dressed blocks of the stone used in Salt Lake City; for example, in the steps of the post-office building. The newer quarry, situated on the north side of the canyon, is in a coarse, but more evenly grained gray to pinkish stone, and is said to be freer from the black inclusions. Stone from this quarry has been used for the main body of the new State capitol in Salt Lake.

Light and dark volcanic rocks.—Although volcanic rocks, including rhyolites, andesites, basalts, and other less commonly known types, are widely distributed throughout a great part of the State and occur in large quantities, they have been quarried only to a very small extent. The only quarry of which the United States Geological Survey has any record is at Beaver. The rock quarried there, and known by some as the "Beaver granite," is a porphyritic rhyolite of green and brown colors, with feldspar phenocrystals up to half an inch or more in length.[1]

[1] Oral information by Prof. F. J. Pack, Salt Lake City, Utah.

There are no data at hand on the quarrying of dark volcanic rocks. Crushed stone for road building and concrete aggregate has been derived largely from limestone and quartzite. The convenient location of these rocks with respect to the larger cities and the unfavorable location of basalt or other volcanic rock of suitable quality for road building has evidently prevented the development of the latter.

Slate.—According to Eckel,[1] deposits of slate believed to be of workable extent and good quality have been described as occurring on the islands in Great Salt Lake.

The only locality on which there is more definite information is in Slate Canyon, about 2 miles southeast of Provo. This is described by Eckel as follows:

> The slate here covers a considerable area, but that exposed at the surface is so badly broken up that large slabs can not be obtained. It is possible, however, that this condition will disappear if the deposits are worked deeper. Deposits of slate believed to be of workable extent and of good quality, have been described as occurring on the islands in Great Salt Lake, and some attempt has been made to develop them.
>
> The Provo deposits furnish green and purple slates, the latter being apparently present in greater quantity. The green slates show little tendency to cleavage in their surface outcrops, and will probably be less satisfactory for roofing purposes than the purple. The green slates rub very smooth, however, and would make good slabs or mill stock if obtainable in masses of sufficient size.
>
> The purple slates split well, with a surface about as smooth as that of Peach Bottom slate (of Pennsylvania and Maryland). From samples seen it appears that they also bear punching well.

The following is a partial analysis of a sample of the purple slate, collected by Eckel and analyzed by W. T. Schaller of the United States Geological Survey:

Silica (SiO_2)	54.05	Magnesia (MgO)	9.12
Alumina (Al_2O_3)	20.95	Carbon dioxide (CO_2) and water (H_2O)	3.90
Iron oxides (Fe_2O_3 and FeO)	.28		
Lime (CaO)	0.28		

Of 36 slate analyses discussed by Eckel, this one quoted is lowest in the percentages of silica and magnesia and is very far below the average in lime.

Marble.—Limestones of more or less crystalline texture are very abundant throughout the western half of the State, especially among Paleozoic and also among Mesozoic and early Tertiary formations, but by far the greater part of them are of dark monotonous color and would probably be of unattractive appearance, even with well-polished surfaces. At certain localities, however, especially where the limestones have undergone recrystallization without the development of metamorphic silicate minerals, near intrusive contacts of granite or monzonite, outcrops may be found where the texture, color, and composition of the stone are well suited for building and decorative purposes. The deposit near Newhouse in Beaver County is one of this type and lies on both the north and the south sides of a granite (quartz monzonite) intrusion. The best exposure is said to be about 2 miles southeast of Newhouse. It is a brecciated marble, whose colors in some beds vary from white to gray, with intermediate mottled and banded varieties, and in other beds from pink to red, the latter of very beautiful appearance.[2]

[1] Eckel, E. C., in Dale, T. N., Slate deposits and slate industry of the United States: U. S. Geol. Survey Bull. 275, p. 89, 1906; Bull. 586, p. 119, 1914.
[2] Oral information from Prof. F. J. Pack.

There is said to be a large mountain of marble at Ibapah near the southwest corner of Tooele County, remote from any railroad lines, but no further information regarding the deposit is at hand.

At Pelican Point on the west shore of Utah Lake, and near Five Mile Pass, 5 miles southwest of Fairfield in Tooele County, are prospects of black marble of Carboniferous (upper Mississippian) age. The stone is said to be rather soft, but to take a brilliant polish, yielding polished surfaces even blacker than the famous Belgian black marble. It is easily accessible and occurs in well-defined beds, which dip westward at a low angle and range in thickness up to 8 or 10 feet.[1]

An attempt was made in recent years to develop a deposit on the northern fork of Logan River, about 30 or 35 miles northeast of Logan; but the high cost of transportation and of development work in so isolated a place rendered the enterprise a failure. A little of the stone was shipped, and a sample may be seen in a small public drinking fountain on Main Street, Logan, close by the Eagle Hotel. The stone is of whitish color, irregularly mottled and streaked with reddish material.

East of the southern Wasatch Mountains, the early Tertiary formations include an impure limestone full of large oölitic concretions up to an inch or two in diameter. Marble quarries in this formation have been opened in Hobble Creek, 7 miles east of Springville and about 1 mile east of Clinton station, which is 5 miles south of Thistle Junction. The deposit at Springville is said to cover 1,200 acres, to average 200 feet in thickness, and to afford blocks of any desired size. Its colors vary from deep brown, through light brown, to straw color, and from pink to red. The variation in color is almost entirely in the cementing material, the nodules or concretions maintaining a brown color.[1]

The stone from the Clinton quarry, judging from material seen in Salt Lake City, is of prevailingly brown color, and the nodules in it are less abundant and irregularly distributed. Stone from this quarry commercially known as "bird's-eye marble," has been furnished for the interior of the Farmers & Stockgrowers Bank and the interior of the new State capitol in Salt Lake City.

Onyx marble.—"Onyx marble," or travertine, has been quarried at Pelican Point on the west shore of Utah Lake and at a point in Tooele County about 4 miles due south of Low station on the Western Pacific Railway and 60 miles west of Salt Lake City. Other prospects have been reported from Bull Valley in Washington County and from Redmond in Sevier County.

The deposits at Pelican Point consist of a series of veins, varying from a few inches to 10 and even 20 feet in thickness, cutting Carboniferous limestone.[1]

The colors of stone include dark and light amber, chrome yellow, lemon, orange, dark buff, and white. According to Merrill,[2] the stone is beautifully translucent and the colors are of astonishing depth and brilliancy. The stone may be seen in the interior of the City and County Building, Salt Lake City.

The deposit south of Low station, Tooele County, consists of a series of north-south vertical veins, ranging in width up to as much as 300 feet and in total length to 4,500 feet. The stone is said to be free from excessive fracturing and to occur in a series of vertical

[1] Oral information from Prof. F. J. Pack.
[2] Merrill, G. P., Stones for building and decoration, p. 274, 1903.

bands which present a great variety of colors and textures. Colors range from flaky whites, through creams, pinks, and lavenders, to yellows, shaded with brown, the lighter colors predominating. Banded and beautifully clouded varieties are also present.[a] In view of the scarcity of desirable "onyx marble" in the United States, this unusually large deposit seems worthy of the attention of marble dealers.

There are two quarry properties in the district, one embracing the bulk of the deposits and the other containing a vein 4 to 8 feet thick. Stone from the latter property is being furnished for the new State capitol in Salt Lake City.

Limestone.—With limestone so abundant throughout much of the State, only deposits within short distance of commercial centers have been worked to any extent. The Paleozoic limestones comprise a considerable quantity of argillaceous limestones relatively low in lime, and large quantities of magnesian or dolomitic as well as of high calcium limestones. They are prevailingly of dark bluish color, but drab and light ash-gray colors are also conspicuous, and textures vary from dense to finely and occasionally coarsely crystalline. The dolomitic limestones are commonly finely crystalline, but texture alone is not a certain means of identification. The high-calcium limestones vary from dense to coarsely crystalline.

The quarries in Paleozoic limestone are mostly located near the larger towns along the Wasatch Range, from the Idaho boundary southward to Santaquin. Both magnesian and high-calcium rocks have been burned, but relatively few analyses of the rocks burned are available. At Smithfield and Logan, in the north, bowlders have been broken and burned for lime. Little or no rock there has been quarried from the ledge. No analyses of the rock or the burned product have been reported, and it is not known whether the lime is of reasonably uniform composition or not. The rock seen by the writer in that district is of dolomitic appearance. In Ogden Canyon bluish-black Cambrian limestone from beds just above the Cambrian quartzite is burned for lime. The limestone burned at Morgan is bluish gray and finely crystalline rock of Carboniferous age. The limestone at Devils Slide is quarried principally for Portland cement manufacture, but a small amount is used as needed for local road building. Its composition varies as shown in the following analyses, all of which are well within the limits required of ingredients in Portland cement, but are of rather low grade for lime burning.

Analyses of limestone from Devils Slide, Utah.[b]

	1	2	3	4	5	6	7
Silica (SiO_2)	8.02	31.96	6.20	7.18	27.90	25.20	12.08
Alumina (Al_2O_3)	2.29	7.97	} 4.00	4.04	3.16	} 11.32	6.48
Ferric oxide (Fe_2O_3)	.63	3.45			9.84		
Magnesia (MgO)	2.45	2.57	1.66	2.81	2.41	3.12	3.00
Lime (CaO)	46.62	26.63	47.98	46.21	29.23	30.47	41.87
Carbon dioxide (CO_2)	39.05	26.06	[c] 39.57	[c] 39.51	[c] 26.68	[c] 29.10	[c] 35.95
Total	99.06	98.64	99.41	99.75	99.22	99.21	99.38

[a] Condensed from a report by Prof. F. J. Pack.
[b] Analyses made for Union Portland Cement Co. of Ogden, Utah—Nos. 1 and 2 by company chemist, Nos. 3 to 7 by F. H. Rouk; 3-4, "High rock;" 5-6, "Low rock;" 7, "Straight rock."
[c] Loss by ignition.

No less than 11 quarries have been operated at different times in the vicinity of Salt Lake City. The rocks quarried are in part or wholly of Paleozoic though some may be of Mesozoic age. The principal quarries are in the foothills just to the north of Salt Lake City, and in Mill Creek and Parley Canyon. The following table shows that samples analyzed of the Mill Creek and Parley Canyon quarries are of high calcium composition, whereas those of the Salt Lake City quarry represent beds of both high calcium and high magnesia rock.

Analyses of limestone near Salt Lake City.

	1	2	3	4	5	6
Silica (SiO_2)	1.00	3.00	1.20	2.60	....	2.50
Magnesia (MgO)	15.00	....	13.00	....	....	1.20
Lime (CaO)	32.00	53.00	38.80	53.00	....	49.20
Carbon dioxide (CO_2)	a 52.00	a 44.00	a 47.00	44.40	....	a 47.10
Magnesium carbonate ($MgCO_3$)	....	....	....	....	2.00	....
Calcium carbonate ($CaCO_3$)	....	....	....	....	98.00	....
Total	100.00	100.00	100.00	100.00	100.00	100.00

a By difference.

Nos. 1 to 4, Langton Lime & Cement Co., Crossman & Nichols, analysts.
No. 5, Union Lime & Stone Co., R. H. Officer & Co., analysts.
No. 6, Utah Lime & Cement Co.

At Provo a bluish-gray limestone of probable Cambrian age is burned for lime in the foothills just east of the city. About 1½ miles west of Santaquin in Utah County, limestone, also of probable Cambrian age, is quarried for use in sugar refining, and limsetones of Carboniferous age were formerly quarried for the same purpose near Lehi, Utah County, and at Topliff, Tooele County. The following analyses of these rocks have been made, and illustrate the composition of limestone suitable for use in beet-sugar manufacture:

Analyses of limestone from Utah and Tooele counties, Utah.

	Santaquin.		
	1	2	3
Insoluble	2.88	2.77	3.00 (Insoluble and soluble silica)
Soluble silica	.12	.22	
Alumina and ferric oxide	.60	.40	....
Magnesia	1.31	.68	....
Lime	53.10	53.70	54.00
Sulphuric anhydride (SO_3)	.06	.04	....
Ignition loss	42.64	42.60	43.00
Total	100.71	100.41	100.00
Calcium carbonate	94.82	95.89	97.00

	Topliff.	Lehi.
	4	5
Insoluble	2.70	0.45
Silica	....	....
Alumina and ferric oxide	.22	.15
Magnesium carbonate	.65	1.06
Calcium carbonate	96.01	96.00
Moisture	.12	.08
Sulphur	....	.12
Undetermined	.30	.70
Total	100.00	98.65

Paleozoic limestones are, or have been, quarried for smelter flux at the west side of the East Tintic range near Topliff, Rush Valley, and Doremus stations in Tooele County and at Mammoth in Juab County. The stone at the first three localities is of Carboniferous and that at Mammoth is of Cambrian age.

The rock quarried and burned along the east side of San Pete Valley from Ephraim to Manti is white, or nearly white, oolitic limestone of Eocene age. No analyses of it have been reported. The same stone is also quarried for use in building and may be seen in the Mormon Temple at Manti, in the central building of the University of Utah, and in several private dwellings in Salt Lake City. A considerable quantity has also been shipped to San Francisco, Cal. The stone is of creamy white texture and soft, composed of fine oolitic particles in an abundance of cementing material. The rubbed or tooled surfaces are nearly pure white. It appears well suited for interior work similar to that for which the well-known Caen stone of France has been used. Its exterior use should probably be limited to regions of mild climate.

Bowlders of a Tertiary oolitic limestone, locally called sandstone, were formerly worked at Collinston, Box Elder County, for monument bases, but none have been worked for several years.

Sandstone.—The sandstones of Utah which have been worked for more than local use are the Nugget sandstone of Mesozoic (Jurassic or Triassic) age, quarried in Emigration Canyon, around Park City, in Diamond Fork Canyon, and at Thistle, and a sandstone of Tertiary (Eocene) age quarried near Kyune station, which is about 5 miles east of Colton on the Denver & Rio Grande Railroad.

Two varieties are quarried in Emigration Canyon about 12 miles east of Salt Lake City. The more common variety is light reddish brown, banded with lines of darker brown, and very fine grained. It is a rather porous rock, composed mostly of quartz grains in a cement colored by ferric oxide, and it emits a rather pronounced argillaceous odor. It occurs in layers up to 2 or 3 feet in thickness, and blocks 10 feet or more in length can be obtained; but most of the dressed blocks seen in buildings are a foot or less in thickness and less than 3 feet in length. The stone has been used in several buildings in Salt Lake City and good examples may be seen in dwellings in the eastern part of the city.

The other variety quarried in Emigration Canyon is of light-gray to pale-buff color, but sometimes designated as "white." Its beds vary from a few inches to 5 feet in thickness, and blocks measuring as much as 10 to 15 feet in length, 5 to 10 feet in width, and 5 feet in thickness have been loosened; but, as in the red sandstone, small blocks greatly predominate. The stone is of uniform fine grain and is composed of quartz grains cemented with silica and a little clay. A little ferric oxide is also present, giving faint yellowish-brown bands in some places, and in others a more uniform buff color.

Several years ago, red sandstone belonging to the Nugget sandstone and generally similar to that in Emigration Canyon was quarried just east of Salt Lake City in what is now the Fort Douglass Reservation. This sandstone is displayed in several of the older buildings in Salt Lake City. During the few years after these quarries were included in the reservation and before those in Emigration Canyon were opened, red sandstone belonging to the Nugget sandstone was quarried, chiefly for Salt Lake City trade, a few miles north of Park City. At present the principal quarrying near Park City is at Metropolitan Spur, about 2 miles northwest of Park City. The material is light gray to reddish siliceous Nugget sandstone, occurring in thin beds 5 to 6 or more inches in thickness, and is used principally for paving blocks and flagstones in Salt Lake City.

The sandstone at Diamond Fork Canyon in Utah County is of brown rather than red color. Specimens from Thistle, Utah County, are red, fine, even grained, and their cementing matter contains more or less argillaceous material. Some contain small greenish-gray spots where ferric oxide is locally absent. They resemble in this respect the Portage entry, Michigan, sandstone.

The sandstone of Tertiary age quarried near Kyune station, about 5 miles east of Colton, in Utah County, is gray with a faint purplish tint, medium to fine grained, and consists of quartz with considerable feldspar and white and black mica. The mica flakes are the more prominent on surfaces parallel to bedding planes. Small dark brownish mud flakes are occasionally present. This stone is represented in the city and county building of Salt Lake City.

Production.—The total production of stone in Utah in 1913 was valued at $415,471, as compared with $249,782 in 1912.

Directory.—Quarries of all kinds of rock quarried in Utah are listed below by class of rock, county, and town (or post office).

Directory of stone quarries in Utah.

GRANITE.

Box Elder County: 1. Willard.
Salt Lake County:
2. Claytons Peak.
3. Little Cottonwood Canyon (2).
Utah County: 4. Alpine.
Wasatch County: 5. Midway.
Weber County: 6. Ogden.

LIGHT VOLCANIC ROCKS.

Beaver County: 1. Beaver.

SLATE.

Utah County: 1. Provo.

MARBLE.

Beaver County: 1. Newhouse.
Tooele County:
2. Ibapah.
3. Low (4 miles south of).
Utah County:
4. Clinton.
5. Pelican Point.
6. Five Mile Pass.
7. Springville.

LIMESTONE.

Beaver County: 1. Greenville.
Box Elder County: 2. Deweyville (2).
Juab County: 3. Mammoth.
Morgan County: 4. Devils Slide.
Tooele County:
5. Doremus.
6. Rush Valley.
Utah County: 7. Santaquin.

LIMESTONE AND LIMEKILNS.

Beaver County: 1. Beaver.
Box Elder County: 2. Geneva.
Cache County:
3. Logan.
4. Smithfield.
Iron County: 5. Cedar City (2).
Morgan County: 6. Morgan.
Salt Lake County: 7. Salt Lake City (11).
San Juan County: 8. Grayson (2).
Sanpete County:
9. Ephraim (3) and Sanpete.
10. Manti.
11. Spring City (Mill City).
Sevier County: 12. Richfield.
Tooele County: 13. Topliff.
Utah County: 14. Provo.
Wasatch County:
15. Midway.
16. Myton.
Weber County:
17. North Ogden.
18. Ogden.

SANDSTONE.

Beaver County: 1. Beaver.
Cache County: 2. Paradise.
Grand County: 3. Moab.
Iron County:
 4. Cedar City.
 5. Parowan (Kane Springs).
Juab County: 6. Cooper (Mount Nebo).
Salt Lake County: 7. Emigration Canyon (2).
Summit County: 8. Park City (3).
Uinta County: 9. Vernal.
Utah County:
 10. Diamond Fork Canyon (Castilla).
 11. Colton (Kyune station).
 12. Thistle.
 13. Thistle Junction.

CALIFORNIA.[1]

By G. F. Loughlin.

The Coast Range and the Sierra Nevada contain a vast quantity of various kinds of stone suitable for building, but large areas of these ranges are too remote from transportation lines to be of economic importance. A comparison of the quarry map (Pl. VI) with a geologic map of California will show that, although the different kinds of stone are widely distributed, most of the quarries are located in the vicinity of railroads within reasonable distances from the largest cities.

The stone-producing formations of California comprise rocks of Paleozoic (?), Jurassic, Cretaceous, and Tertiary ages, and include both intrusive and effusive igneous rocks of different kinds, sandstones, limestones, marbles, and slates.

Granite.—The granites and related rocks of California form the greater part of the central and southern parts of the Sierra Nevada and of the Coast Range southeast of Los Angeles. Smaller, though considerable areas are found in the Coast Range near San Luis Obispo, east and west of the lower part of Salinas River, near Santa Cruz, and at several places in the Klamath Mountains in the northwestern part of the State. The granites of California are nearly all of light to dark gray color, some with a pale pinkish tint. There are no pink and red granites similar to those of the Northeastern States and of certain Central States. Some, of dark-bluish to black color, are not granites in the geologic sense, but monzonites, diorites, and gabbros. They are known commercially, however, as "blue granite" and "black granite." Many of the light-colored granites are granodiorites and quartz monzonites, strictly speaking, but their differences from true granite are usually microscopic. All gradations in color and composition may be found from light-gray true granite to gabbro or "black granite," but the darker varieties are quarried only to a limited extent. In texture the granites vary from very fine to coarse grained, the medium to rather coarse grained varieties greatly predominating. A favorable feature common to most of the granites is their remarkably good rift and grain, which allows large blocks to be split evenly with a minimum amount of labor. Another feature which seems especially characteristic of California granites is the quantity of stone quarried from large residual bowlders, not only for

[1] Folios Nos. 3, 5, 11, 15, 17, 18, 31, 37, 39, 41, 43, 51, 66, and 138 of the Geologic Atlas of the United States describe the geologic distribution of the different formations in the eastern half of California from Redding southward to Mariposa. Folio No. 101 describes the geology around San Luis Obispo, and Folio No. 163 the geology from Santa Cruz northward to Redwood. Much of the information on the building stones of California has been taken from Bulletin No. 38 of the California State Mining Bureau (The structural and industrial materials of California), by L. E. Aubury.

MAP OF CALIFORNIA AND NEVADA

Showing location of limekilns and quarries of limestone, sandstone, marble, slate, light volcanic rock, dark volcanic rock, and granite

Prepared under the direction of E. F. Burchard

local but for more extensive use. These bowlders represent the remnants left from prolonged disintegration of large granite masses, but after removal of a thin weathered coating, they yield sound stone.

The most important quarry districts are in Madera, Placer, Riverside, and San Diego counties.

At Raymond, in Madera County, are two large quarries of biotite muscovite granite which have furnished stone for the post office, the Fairmont Hotel, the Mercantile Trust Co., and other buildings, and for the Dewey and McKinley monuments in San Francisco. The principal granites used in San Francisco are those from Raymond, Rocklin, and Penryn. Granite from the latter two localities, which are in Placer County, may be seen in the State Capitol at Sacramento, and in the Hibernia Bank and the Crocker Building in San Francisco. Most of the 24 quarries at Rocklin are small, though the largest in 1904 had a depth of 100 feet. They all are said to lie within an area not more than a mile square. The stone is of light-gray color and of medium to rather coarse grain. Quartz is abundant, more so than in most of the California granites, in colorless rounded grains. Soda-lime feldspar as a rule is dominant over the potash variety, and is of opaque, white color, giving contrast to the quartz. Black mica, the only other conspicuous mineral, occurs for the most part in fine unaltered scales. Where weathered it has yielded small quantities of iron oxide, which may appear as yellowish brown specks or may have filtered into the cleavage cracks of the translucent potash feldspar grains, giving them a pale flesh-colored tint. This color, however, is too slight to affect noticeably the general gray color of the stone. The stone is said to work well and to take a good polish. Its crushing strength, an average of three tests, is reported to be 21,104 pounds to the square inch.

The Penryn quarries also have been in operation since the early sixties. Bowlders as well as ledges have been quarried, and the stone has been used extensively in San Francisco. The granite is of gray (mottled white and black) color, and of coarse-grained appearance, with a slightly developed gneissoid structure. The light-colored minerals, which make up two-thirds of the rock, include both kinds of feldspar and a little quartz. The feldspars are translucent, colorless to pale flesh-colored, and free from alteration. The black minerals, which comprise the remaining third of the rock, are chiefly hornblende and biotite, intimately intergrown, and of brilliant black color. The apparent coarse grain of the rock is due to the tendency of the black minerals to segregate into small, nearly pure groups, which gives the rock an appearance very distinct from that of the majority of California granites.

Besides the granite just described there is, 1 mile east of Penryn, a "black granite," near gabbro in mineral composition, which has been quarried for monumental stone.

At Loomis, 3 miles south of Penryn, a biotite granite, intermediate in color and texture between the stones at Rocklin and Penryn, is quarried. It was used in the extension of the Hibernia Bank Building, San Francisco.

In Riverside County granite has been quarried on a large scale at Casa Blanca for rubble, used in the San Pedro breakwater, and for building and ornamental use at Corona, Riverside, and Temecula. At Corona both bowlders and ledges of a biotite muscovite granite are quarried, the former especially for paving blocks, a large number of which are made. In addition to building stone, a considerable quantity has given general satisfaction as monumental stone in Los Angeles, Riverside, and elsewhere in southern California.

At Temecula the granite is largely quarried from bowlders, since these are more easily worked than the ledges, which are for the most part covered with bowlders and residual soil. Paving blocks and dimension stone are produced. The rock is a biotite granite of light-gray color with a pale-reddish tint.

The quarries at Riverside and West Riverside have yielded a large quantity of granite for buildings in Los Angeles and vicinity. Two varieties have been noted by the writer: One a light-gray, medium-grained biotite muscovite granite, somewhat resembling the well-known Concord, N. H., stone; the other a medium-gray, medium-grained rather gneissoid biotite granite, in which the biotite tends to segregate into spots or bunches a quarter of an inch in diameter. In both varieties, the minerals are free from conspicuous alteration.

At the Casa Blanca quarries, the granite quarried for rubble contains a large number of dark blotches, but stone of uniform color is said to be available for building. Other quarries in Riverside County have yielded large quantities of stone for paving, road ballast, and concrete.

In San Diego County, Foster and Santee are the principal quarry centers, though granite for local use is quarried at a number of places. The granite from Foster has been used in the Government buildings at Fort Rosecrans on Point Loma, west of San Diego. Two varieties of granite are quarried at Foster. One is a medium gray fine-grained biotite granite, resembling rather closely the well-known gray granite from Westerly, R. I. The soda-lime feldspar is the most conspicuous of the light-colored minerals, owing to its white color, whereas the quartz and potash-feldspar are colorless. The soda-lime feldspar is somewhat altered, and some of its crystals have a greenish tint due to the presence of secondary epidote. A few of its crystals have been softened by weathering, but such crystals are too small to have any noticeable effect on the appearance and durability of the stone. The other variety is a light-gray medium to rather coarse grained gneissoid biotite granite of the same composition as the fine-grained variety; all its minerals are free from megascopic alteration. Associated with the gneissoid granite is a nearly white variety (aplite) containing only a very small quantity of biotite. It is not known whether this variety can be obtained in commercial quantities.

The granite from Santee is used largely for monumental work, also for building stone, and large quantities of it have been shipped to Los Angeles and other points in southern California. In monuments it resembles the widely used granite from Barre, Vt. The rock is of medium to rather dark gray color, distinctly darker than the average California granite, and of medium, even grain. It is composed essentially of bluish gray translucent feldspars and black intergrowths of hornblende, augite, biotite, and magnetite. All the minerals appear to be quite free from alteration. The rock takes a good polish, which, with its dark color, especially adapts it for monumental work.

At Dehesa, in San Diego County, there is an orbicular "black granite" or gabbro, that is well adapted for ornamental work, and would probably be unique among building and ornamental stones.

The rock is characterized by abundant rounded segregations of varying textures uniformly scattered through a medium to rather coarse-grained matrix, and several varieties, based on variations in texture, are said to be available. The orbicular rock has been found only as residual bowlders. Other orbicular "black granites" have been found at Rattlesnake Bar, Eldorado County, and in Sierra and Plumas counties, but none has been quarried.

In Butte County a large amount of granite is available, but lack of transportation facilities has prevented development. In Fresno County at Academy, a dark, medium-grained granite is quarried from bowlders. In Los Angeles County granite has been quarried largely for crushed stone and in recent years for the Los Angeles aqueduct. In Nevada County granite somewhat marred by streaks and black "knots" for local use has been quarried from bowlders at Grass Valley, Nevada City, and Rough and Ready. Some fine-grained "black granite" suitable for monumental work has been reported from Rough and Ready. In Sacramento County a large granite quarry is operated by the State prison at Folsom, chiefly for construction work by the State. In San Bernardino County granite occurs over large areas and is quarried near Crucero, Declez, Halleck, Oro Grande, and Victorville. The chief products are paving blocks and rubble, but some building and monumental stone also is quarried. The county jail in San Bernardino was built of stone from a Victorville quarry. In Shasta, Siskiyou, and Trinity counties there are large quantities of granite, but it is said to be jointed, shattered, or streaked to such an extent that a great deal of it is not suited for quarrying. Gray granite has been quarried in Siskiyou County for monumental work 4 miles southwest of Etna and a nearly black rock (uralitic gabbro) 16 miles north of that place. In Sierra County there are extensive areas of granitic rocks that have not been prospected. In Tulare County granite bowlders have been quarried near Portersville, and a gray syenitic rock at Rocky Point. In Tuolumne County a fine-grained gray biotite granite has been quarried at the head of Phoenix Lake.

Dark volcanic rock ("trap rock").—Published information on "trap rock," in distinction to other rocks of California, for use as crushed stone is very meager. Trap rock, or macadam, quarries represented on the accompanying map include not only diabase and basalt, the true trap rocks, but some other lavas, tuffs, granite, diorite, and possibly some sandstone, chert or jasper, limestone, shale, and gravel. In Solano and Sonoma counties the principal rock used is basalt; in Napa County, volcanic tuff. In Alameda, Marin, and San Francisco counties "blue rock" or metamorphic sandstone and chert or jasper are commercially termed trap rock, but in the present report certain of these quarries have been classed as sandstone. There is an abundance of basalt and diabase, as well as other suitable volcanic rocks in the State, though they are for the most part too far removed from the larger cities to be of value as crushed rock. In the vicinity of Santa Cruz basaltic rock is available, but it is said to be less suitable for road material than the chert layers which occur in the limestone formations.[1] The chert in this region is scarce. Red

[1] Branner, J. C., Newsom, J. F., and Arnold, Ralph, U. S. Geol. Survey Geol. Atlas, Santa Cruz folio (No. 163), 1909.

chert or jasper ("red rock") well suited for road material occurs in good quantity in the vicinity of San Luis Obispo.[1]

Light-colored volcanic rocks.—Volcanic rocks, both effusive and intrusive, and mostly light colored, cover practically the entire area of the northeastern part of the State, and considerable bodies of them are distributed in the Sierra Nevada range and along the eastern border of the State as far south as the Mohave Desert. They are also found extensively in counties just north of San Francisco Bay, and smaller bodies are found in the region around San Luis Obispo. The rocks quarried are largely tuffs of different kinds, but in places include considerable amounts of lavas. The tuffs as a rule are soft and easily worked when quarried, but harden on exposure. They are also refractory, and have been extensively used, especially in the northern counties, for chimneys, fireplaces, and for fire bricks in stoves. The lavas, as a rule, lack the pronounced rift so characteristic of the granites, and break with curved fractures, but they are easily dressed, though not in large blocks, such as may be obtained in the granite quarries. The most important quarries of volcanic rocks are in Napa, San Luis Obispo, Siskiyou, and Sonoma counties.

In Napa County, at Calistoga, a yellowish trachyte and trachyte tuff are quarried, mostly from bowlders. The tuff was used in the St. Helena post office. Near St. Helena reddish and yellowish trachyte tuffs have been quarried and used in several buildings, including the public school, in St. Helena. Other quarries of gray and red trachyte tuffs have furnished stone largely for bridge and foundation work. The red tuff is suitable for trimmings in structures built mainly of the lighter-colored stone. In Sonoma County, which adjoins Napa County on the west and is covered by the same volcanic formations, the principal quarries are near Agua Caliente, Santa Rosa, Sonoma, and Stony Point. The stone quarried is mostly light colored, but a dark-red rhyolite tuff is quarried near Sonoma that has a considerable local use for trimming. Some of the tuffs are locally called sandstone, which they closely resemble in color and texture. In Santa Rosa the Carnegie Library and the California Northwestern Railway station are built of stone quarried east of the town; in Petaluma, the Phoenix Building, Carnegie Library, and other buildings are constructed of trachytic tuff from Stony Point. The prevailing products, however, of these stones are paving blocks, curbing, flagging, and railroad ballast.

In San Luis Obispo County there is a series of dacite and andesite buttes extending northwestward from near San Luis Obispo to Morro Rock, on the coast. The stone has been quarried largely for rubble used in breakwater construction, but has also been used in building construction. The Presbyterian Church and the Free Library in San Luis Obispo contain stone from Bishops Peak. The stone at Los Berros has been used for building in San Luis Obispo, Arroyo Grande, and to a small extent even as far away as Los Angeles.

In Siskiyou County a light-yellowish tuff, with narrow bands and patches of brown ("sap" stains) and white, has been quarried east of Montague and used in some of the buildings of Yreka. Quarries of a similar rock and of blue-gray to brick-red tuffs have been quarried near Little Shasta, and also used for building in Yreka.

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[1] Fairbanks, H. W., U. S. Geol. Survey Geol. Atlas, San Luis Obispo folio (No. 101), 1904.

Near Macdoel a pumice has been quarried and shipped to San Francisco as an ingredient for cement. There is some indication at present that pumice and other highly-porous rocks of low specific gravity may be in considerable demand as fillers in concrete mixtures where a minimum of dead weight is required, thus opening a much more extensive market than has heretofore existed for such types of stone.

The other counties in which volcanic rocks find a local use are given in the quarry list on page 1365. One of the most important formations not previously mentioned is that known as the Tuscan tuff, of Pliocene age, which occurs extensively in the region east of Redding, Shasta County. The extent and distribution of this formation are given by J. S. Diller in the Lassen Peak (No. 15) and Redding (No. 138) folios of the Geologic Atlas of the United States Geological Survey. According to Diller, this rock varies in texture from very coarsely fragmental to fine grained. The fine-grained variety is gray and usually distinctly stratified, and is composed of small fragments of andesite, in part pumiceous, with broken crystals of soda-lime feldspar and hornblende embedded in a fine gray matrix composed of minute angular particles of volcanic glass, which constitute the major part of the rock. Regarding its economic value, Diller says:

The Tuscan tuff stands fire well, and being soft is easily hewn into shape. It is commonly used for chimneys and fireplaces, and in the vicinity of Millville a small church and several smokehouses are made of it. The Tuscan tuff is similar to the trass of the Rhine Valley, which is so extensively used in the manufacture of puzzolan cement, and there appears no good reason why it might not be used in the Redding region for the same purpose, especially since the necessary lime for admixture is abundant.[1]

Slate.[2]—California is the only one of the Pacific States that has produced slate. The slate quarried has all come from the Mariposa slate. The only important production has been in Eldorado County, but small quarries and prospects have been opened in Amador, Glenn, Mariposa, and Merced counties. Black slate has been the principal product, but a limited deposit of grayish-green slate has also been worked.

The black slate in the principal quarry, at Slatington, has a black or blue-black color, splits very finely and regularly with a smooth glistening surface, and resembles the slates of Bangor and Slatington, Pa. "Ribbons," or thin highly siliceous bands, are of frequent occurrence, and in some places pyrite is an objectionable impurity. Where quarries and prospects have proved unsuccessful, the rock exploited in some cases was weathered surface rock of poor quality, which may have capped slate of good quality; in others the slate was cut by numerous veins; in others the slate, after exposure for a few years, changed color owing to oxidation either of pyrite or some other iron compound, possibly a carbonate.

The green slate, an unusual alteration product of an igneous rock, forms a band (dike) several feet wide crossing the black slate obliquely to its ribbon structure in the principal Slatington quarry. It works satisfactorily as a roofing slate, though its cleavage surfaces are not as smooth as those of the black slate. It has been used for trimming and lettering on black slate roofs.[3]

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[1] U. S. Geol. Survey Geol. Atlas, Redding folio (No. 138), p. 14, 1906.

[2] More complete accounts of the slates of California, by E. C. Eckel, may be found in U. S. Geol. Survey Bull. 275, Slate deposits and slate industry of the United States, pp. 56-58, 1906; Bull. 586, pp. 65-70, 1914.

[3] A special description of the green slate by E. C. Eckel may be found in the Jour. Geology, vol. 12, pp. 15-29, 1904.

Marble.—The marbles of California have mostly been quarried from crystalline dolomite and limestone strata of Paleozoic age, although the limestones of Triassic, Jurassic, and early Tertiary ages afford in places more or less suitable materials. The outlines of certain limestone and marble deposits of the State have been shown in a recent Survey bulletin.[1] Limited quantities of "onyx marble" and "verde antique" or serpentine marble, have also been produced. Marble deposits of greater or less extent have been reported from at least 28 counties, but many of them are too inaccessible to be of any present importance. Others are too thoroughly fractured or of insufficient attractiveness to give promise of successful development. Many of the "onyx marble" deposits are of too limited extent to be profitably worked.

One of the most interesting deposits reported, not only in California but in all the Pacific States, is that exposed along the southwest base of the White Mountain and Inyo Range, between Keeler and Lone Pine, in Inyo County. It has been quarried on a commercial scale only at Inyo. The marble is a dolomite, generally fine grained and rather hard. Several varieties are available: Pure white; white mottled with yellow, gray, and black and penetrated by black dendritic markings of manganese oxide; yellow, similar to the Siena marble of Italy, but more distinctly granular and more closely resembling the Estromoz or so-called Lisbon yellow marble of Portugal; black, suitable for floor tilings. These marbles are distinctly harder than many eastern marbles and the foreign marbles which they resemble.[2]

Another deposit containing a variety of colored marbles is worked at Columbia, Tuolumne County, and produces fine-grained marbles of pale pinkish, yellowish, and very light to medium gray colors, and coarser-grained marbles of medium to dark gray color. The degree of darkness increases with the percentage of graphite, which occurs in thin seams, irregular streaks, and patches.

At Neenach, close to the boundary between Los Angeles and Kern counties, a white marble with reddish-brown and heavy blue veins is quarried. At Colton, in San Bernardino County, a bluish-gray marble has been quarried for ornamental building and monumental purposes. Both of these marbles are represented in several buildings of San Francisco and Los Angeles. A nearly black variegated marble, rather distinct from most American marbles, is reported near Cadiz, and a brecciated marble of mottled green, black, and white appearance but rather excessively fractured is being worked near Barstow.[3] A deposit of fine-grained hard marble, mostly of gray or black and white colors but with strata of pink, yellowish, and reddish shades, has been prospected on the east edge of the Coyote Mountains in San Diego County. In the western part of Siskiyou County there is an extensive belt of white and gray marble. A pure-white coarse-grained variety is said to be especially abundant, though finer-grained marble is also present. A great variety of colored marbles have been reported from this belt but no further information on them is available. Informa-

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[1] Eckel, E. C., Portland cement materials and industry in the United States, with contributions by E. F. Burchard and others: U. S. Geol. Survey Bull. 522, pl. 4, 1913.

[2] This paragraph is abstracted from G. P. Merrill's Stones for building and decoration, pp. 206-207, 1903. A brief account of the geology of the deposit is given by R. T. Hill in the Min. and Sci. Press, p. 86, July 20, 1912.

[3] Pack, R. W., Ornamental marble near Barstow, Cal.: U. S. Geol. Survey Bull. 540, pp. 363-368, 1913.

tion is also scarce on other dolomite and calcite marbles from various counties not mentioned above. Some idea of their general locations and extents may be gained from the accompanying map.[1]

The most important deposit of "onyx marble" is at Musick in San Luis Obispo County. The deposit is composed of aragonite (the orthorhombic form of calcium carbonate) and forms layers 1 to 10 and in one place 30 inches in thickness. It is a translucent stone partly banded and variegated, partly white and massive, and takes a brilliant polish. Blocks from 3 to 6 feet square have been quarried, and larger ones are said to be obtainable.[2] At Cement, near Suisin City, in Solano County, a resinous travertine, through which are scattered veinlike and pocket-like deposits of a dark brown banded material, has been worked intermittently and used for decorative purposes in San Francisco. According to Merrill,[3] some beautiful material was obtained here, but slabs of any considerable size could not be found free from porous layers or much unattractive coloring. A small deposit of attractive deep brown "onyx marble" has been worked on Sulphur Creek, Colusa County. It formed a vein consisting of two seams, each about 5 inches thick. Small deposits of light brown veined "onyx" are found and occasionally worked in the marble quarries at Colton, San Bernardino County. Many other deposits have been found in the State, but most, if not all, are too small to be of any commercial importance.

Serpentine is widely distributed in California but most of it lacks the necessary qualities in structure and appearance to find favor as a marble. Only one quarry of any consequence has been worked—the "verde antique" marble quarry situated about 16 or 17 miles east of Victorville, in San Bernardino County. The stone is an irregular mixture of yellowish to dark-green serpentine and rather coarse-grained calcite. In places practically pure serpentine is said to be 5 to 10 feet thick; in others, white and bluish gray limestone with no serpentine is 10 to 20 feet thick. The handsomest stone is said to be that in which the bright yellowish green serpentine is banded with the dark green and with white limestone.[4] It has been used for interior decorations in San Francisco and Los Angeles.

At Empire Landing, on Santa Catalina Island, a very dark green serpentine is reported as forming bunches in association with soapstone. The one specimen from this locality seen by the writer is dark greenish rock, nearly black on polished surface, spangled with gray to green, more or less altered, tremolite crystals. It appears from megascopic inspection, to consist essentially of talc, chlorite, and serpentine, the latter occurring both in the groundmass and with talc, as partial to complete pseudomorphs after tremolite. Fine, scattered grains of pyrite are also present.

It may be appropriate to mention here a deposit of olive to grass-green vesuvianite (californite) rock, suitable for ornamental work, which has been prospected on the South Fork of Indian Creek, in Siskiyou County. The rock is said to occur as bowlder-like masses

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[1] More definite data may be found in Bulletin 38 of the California State Mining Bureau, pp. 95–114, 1906, and on Eckel's map cited on page 1360.

[2] For detailed descriptions of this and other onyx marbles here mentioned the reader is referred to California State Mining Bur. Bull. 38, pp. 111–114, and to G. P. Merrill's Stones for Building and Decoration, pp. 268–271, ed. 1903.

[3] Op. cit., p. 269.

[4] California State Mining Bur. Bull. 38, pp. 147–148, 1906.

in serpentine, and as loose bowlders in the creek bed. A full description of this unique stone has been given by Kunz.[1]

Soapstone.—Talc and soapstone are also widely distributed in the State, but are not extensively worked. Soapstone for local uses, largely firebacks, has been quarried in Butte, Los Angeles (Santa Catalina Island), Sierra, Siskiyou, Trinity, and Yuba counties, but no production was reported in 1912 and 1913. The production of talc and soapstone is considered by J. S. Diller in another chapter of the Mineral Resources of the United States.

Limestone.—Limestone and dolomite, mostly crystalline, are widely distributed in California and are quarried at different places for use as local building stone, for lime burning, sugar refining, cement manufacture, and other uses. Much stone of suitable composition is too far removed from important lines of transportation to be of more than local importance. The following paragraphs are intended to give the locations and, where possible, the characters of the most extensive deposits.

The most abundant supply in the State according to Diller[2] is in the Redding district, Shasta County. Here a thick belt of limestone of Triassic age, generally pure, is exposed east of Furnaceville, and forms Brock Mountain and may be traced for many miles to the north. A belt of more prominent limestone ridges and peaks, of Carboniferous age, extends northward from Lilienthal along the McCloud for many miles. Where best developed it is over 1,000 feet thick. A third belt of limestone of Devonian age is exposed near Kennett. Though not so extensive as the others, it is more accessible. The first two limestones have been quarried for flux, and the last is extensively quarried and burned for lime at Kennett. Limestone of Paleozoic age also occurs extensively in Siskiyou and Trinity counties, but none is quarried in the latter county.

The limestone lenses in the Calaveras formation (Carboniferous) afford an abundance of limestone, and have been quarried in Amador, Eldorado, Placer, and Sierra counties, as indicated on the quarry map. In Kern County, a broad belt of coarsely crystallized blue and white limestones, generally much shattered, extends along the north border of Tehachapi Valley and supplies material for the important lime industry at Tehachapi. Crystalline limestone, mostly coarse grained and as a rule almost pure calcium carbonate, is also quarried in Monterey, Riverside, San Bernardino, and Santa Cruz counties. In the last-named county large persistent beds of shattered blue and white limestone are entensively quarried northwest of the city of Santa Cruz and at Felton.

In Santa Clara County, on Black Mountain, a thin-bedded, shattered limestone, colored dark gray to nearly black, has been quarried; 2 miles southeast of Los Gatos a fine-grained, thin-bedded cherty limestone has been worked. In Santa Barbara County a soft, fossiliferous Triassic limestone, chalky in places, and much shattered, has been worked 6 miles southwest of Lompoc for use in sugar refining.

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[1] Kunz, G. F., Californite (vesuvianite), a new ornamental stone: Am. Jour. Sci., 4th ser., vol. 16, pp. 397-398 1903.

[2] Diller, J. S., Limestone of the Redding district, California, U. S. Geol. Survey Bull. 213. p. 365, 1903. See also U. S. Geol. Survey Bull. 225, pp. 176-177, 1904; and U. S. Geol. Survey Geol. Atlas, Redding folio (No. 138), 1906.

In San Joaquin and Contra Costa counties travertine or aragonite has been quarried for lime. The deposit in the former county was worked three-quarters of a mile south of Carnegie, and comprises a series of veins varying from 3 inches to 3 feet in thickness.

In addition to the quarries indicated on the map the following deposits are known to be available:[1] In Kern County, 18 miles east of Cantil, and 15 miles west and south of Mohave; in Monterey County, 26 miles south of Monterey; in Riverside County, half a mile to a mile south of Whitewater (suitable for beet-sugar refining and cement manufacture), 14 miles southwest of Mecca, and 5 miles northwest of San Jacinto; in San Benito County, in the mountains south and east of San Juan and 9 miles south of Hollister (suitable for lime and cement manufacture); in San Bernardino County, near Hinkley and 9 miles southeast of Kelso (both suitable for lime and cement manufacture); and in Tulare County, 9 miles east and a little south of Portersville station (suitable for lime and cement manufacture).

Sandstone.—Sandstones suitable for building are mostly limited to the Cretaceous and Tertiary formations, which cover extensive areas in the Coast Range and border the northern and central parts of the Sierra Nevada. The prevailing colors are yellow to buff, bluish or greenish gray, and brown. Many of the sandstones, like the volcanic tuffs, are soft when quarried but harden on exposure.

The sandstones which have attracted most attention are quarried in Colusa, Los Angeles, San Luis Obispo, Santa Clara, and Ventura counties. That from Colusa County is quarried near Sites. It occurs in massive beds of bluish or greenish gray to buff color, and is composed chiefly of quartz and feldspar grains in a greenish argillaceous and somewhat calcareous matrix. Tests of the Colusa Sandstone Co.'s stone gave the following results: Specific gravity, 2.56; water absorbed in 24 hours, 3.03 per cent; crushing strength, 8,440 to 8,940 pounds per square inch. Its behavior when subjected to fire and to other sudden temperature changes was generally satisfactory.

In Los Angeles County the principal sandstone quarries are at Chatsworth Park, near Chatsworth station. The stone is fine grained and rather heavily bedded, tawny yellow near the surface, but bluish gray at greater depth where it is unaffected by oxidation. It consists of grains chiefly of quartz and feldspar with some of black and white micas in an argillaceous matrix. It has been used in San Bernardino, Santa Ana, and Los Angeles.

Sandstone in Santa Clara County has been quarried at Graystone and elsewhere. The Graystone quarries furnish a yellowish to buff, medium to fine-grained stone, composed of quartz, feldspar, and a few mica grains in an argillaceous and calcareous cement. Tests have yielded the following results: Weight per cubic foot, 165 pounds; absorption of water, 5.13 per cent; crushing strength (of a single specimen), 2,400 pounds per square inch. Its resistance to fire and to other severe temperature changes was generally good. The buildings of Leland Stanford Junior University, at Palo Alto, are built of this stone. The Carnegie Library of Santa Cruz is constructed of sandstone quarried near Los Gatos, Santa Clara County.

In Ventura County brown sandstone has been quarried, mostly from large bowlders, in Sespe Canyon, 5 or 6 miles from Brownstone

[1] Information furnished by J. A. Taff, geologist Southern Pacific Co., San Francisco, Cal.

station. The stone is rather fine grained, and consists chiefly of white quartz and feldspar grains in a brown matrix, which contains considerable calcium carbonate. Tests have resulted as follows: Specific gravity, 2.65; weight per cubic foot, 165.6 pounds; absorption of water, 1.53 per cent; crushing strength, 4,122 pounds per square inch (load applied normal to bedding) and 3,892 pounds per square inch (load applied parallel to bedding). The stone has been found of considerable use in San Francisco, Los Angeles, and Pasadena.

In San Luis Obispo County Cretaceous and Tertiary sandstones have both been quarried, but no explicit information concerning them has been obtained. Other sandstones of interest are the very fine-grained red and pure white argillaceous sandstones near Ione, Amador County; light blue and buff fine-grained sandstone in Contra Costa County; green, blue, red, dark yellowish, and drab sandstones quarried 6 miles south of Tehachapi and used in Los Angeles and Pasadena; bluish or greenish gray, fine-grained, argillaceous sandstone quarried on Angel Island, Marin County, and used in San Francisco; light buff, rather coarse-grained sandstone of Miocene age, quarried in the Santa Ynez Mountains near Santa Barbara and used in Santa Barbara and Los Angeles; tawny colored sandstone of the Chico formation (Upper Cretaceous), quarried near Redding, Shasta County, and used considerably in northern California; and the tawny and gray sandstones, the latter closely resembling the sandstone quarried near Henley and Yreka, in Siskiyou County.

Production.—The total production of stone in California in 1913 was valued at the quarries at $4,118,935, compared with $3,902,313 in 1912.

Directory.—The quarries of all kinds of rock quarried in California are listed below by class of rock, county, and town (or post office):

Directory of stone quarries in California.

GRANITE.

Amador County: 1. Jackson.
Calaveras County: 2. Milton (Gopher Ridge) (porphyrite).
Fresno County: 3. Academy (Clovis) (2).
Humboldt County:
4. Arcata (3).
5. Eureka.
Lassen County: 5a. Susanville.
Los Angeles County: 6. Azusa.
7. Hollywood (Independent station, Los Angeles).
8. Monrovia
9. Pacoima or San Fernando (2).
Madera County: 10. Raymond (3).
Mariposa County: 11. Jasper Point.
Napa County: 12. Napa (2).
Nevada County:
13. Grass Valley.
14. Nevada City.
15. Rough and Ready.
Placer County:
16. Lincoln.
17. Penryn (2) and Loomis.
18. Rocklin (24).
Plumas County: 19. Chilcoot and Cuba (3).
Riverside County: 20. Corona (6).
21. Elsinore (4).
22. Perris (2).
23. Riverside (8) and West Riverside.
24. Temecula Station (5).
Sacramento County: 25. Represa (Folsom).
San Benito County: 26. Logan.
San Bernardino County:
27. Crucero.
28. Declez (3).
29. Halleck (2).
30. Hesperia.
31. Victorville (4).
San Diego County:
32. Campo.
33. Dehesa.
34. Escondido.
35. Foster (2).
36. San Diego and Helix (3).
37. Santee.
San Luis Obispo County: 38. Port San Luis (Port Hartford)
Santa Clara County: 39. San Jose.
Sonoma County: 40. Santa Rosa (3).
Tulare County: 41. Portersville (3).

DARK VOLCANIC ROCK (BASALT, ETC.)

Alameda County: 1. Berkeley.
Butte County: 5. Oroville.
Contra Costa County: 6. Richmond (4) (includes 1 at Point Richmond).
Fresno County: 7. Reedley.
Humboldt County: 8. Eureka.
Kern County: 9. Caliente.
Los Angeles County:
10. Acton (2).
11. Redondo Beach.
12. South Pasadena.
13. Spadra.
Marin County: 14. San Rafael (2).
Napa County: 16. Napa (3).
Sacramento County:
17. Dredge (mail Mills).
18. Folsom City (State Prison Quarry).
19. Natoma.
San Luis Obispo County: 21. Santa Margarita.
San Mateo County:
22. Belmont.
23. San Mateo (2).
Siskiyou County: 25. Dietz.
Solano County:
26. Benicia.
27. Cordelia.
28. Vacaville.
Sonoma County:
29. Anadel and Kenwood (2).
30. Melitta (3).
31. Petaluma (4) and Pengrove.
32. Santa Rosa (2).
33. Sonoma (5).

LIGHT-COLORED VOLCANIC ROCKS.

Alameda County: 1a. San Leandro.
Butte County: 1. Pentz (Curtis ranch).
Calaveras County:
2. Jackson (Mokelumne Hill).
3. Vallicita.
4. Valley Springs.
Eldorado County: 5. Smith Flat (near Placerville).
Inyo County: 6. Laws (6 miles west of.)
Los Angeles County: 7. Avalon (between Avalon and Empire Landing).
Merced County: 7a. Merced Falls.
Napa County:
8. Calistoga (5).
9. Napa (4).
10. St. Helena (4).
San Luis Obispo County:
11. Arroyo Grande.
12. Bishops Peak (Cerro Obispo) (2).
San Luis Obispo County—Continued.
13. Los Berros.
14. Morro Rock.
Siskiyou County:
15. Little Shasta (2).
16. Macdoel.
17. Montague (8 miles east of).
Solano County: 18. Winters (southwest of).
Sonoma County:
19. Agua Caliente.
20. Santa Rosa (2).
21. Sonoma (3).
22. Stony Point (2).
Sutter County: 23. Sutter City (Marysville Buttes).
Tehama County:
24. Paskenta (north of).
25. Red Bluff (20 miles west of).

SLATE.

Eldorado County:
1. Placerville (2).
2. Slatington.
Mariposa County: 3. Hornitos.
Merced County: 4. Planada (11 miles east of).

MARBLE.

Amador County:
1. Plymouth (2).
2. Sutter Creek.
Butte County:
3. Pentz.
4. Oroville.
5. Pulga.
Calaveras County:
6. San Andreas (3).
7. Vallicita.
Inyo County:
8. Inyo.
9. Swansea.
Los Angeles County:
10. Avalon.
11. Neenack (includes adjacent deposit in Kern County).
Mono County: 12. Topaz.
Riverside County:
12a. Eolom station (6 miles south of).
12b. Eolom station (7 miles southwest of).
San Bernardino County:
13. Baker.
14. Barstow.
15. Mentone.
16. Victorville (2).
San Luis Obispo County: 17. Musick (Arroyo Grande).
Siskiyou County: 18. Indian Creek.
Tuolumne County:
19. Columbia (2).
20. Sonora.

LIMESTONE.

Calaveras County:
1. Campo Seco (3).
2. Fosteria (4).
3. Murphy.
Modoc County: 4. Cedarville.
Monterey County: 4a. Salinas (6 miles southeast of).
Nevada County: 5. Grass Valley.
Riverside County:
6. Corona (Orange).
7. Riverside.
8. San Jacinto.
San Bernardino County:
9. Cajon.
10. Colton.
San Mateo County: 11. Rockaway.
Santa Clara County: 12. Mountain View.
Shasta County: 13. Ingot.
Tulare County: 13a. Lemon Cove (2 miles northeast of).

LIMESTONE AND LIMEKILNS.

Alameda County:
1. Berkeley.
2. Pleasanton.
Amador County: 3. Ione.
Contra Costa County:
4. Concord.
5. Cowell (mail Clayton).
Eldorado County:
6. Cool and Auburn.
6a. Cothrin (2 miles north of).
Kern County: 7. Tehachapi (5).
Los Angeles County: 8. Los Angeles (2).
Mono County: 9. Mono Lake.
Monterey County: 10. Monterey.
Orange County: 10a. Capistrano.
Placer County.
11. Colfax.
12. Newcastle.
San Benito County:
13. Hollister (3).
14. San Juan.
San Bernardino County:
15. Oro Grande (Halleck post office) (3).
16. Victorville.
San Luis Obispo County: 17. Adelaide.
Santa Barbara County: 18. Lompoc (2).
Santa Clara County: 19. Los Gatos.
Santa Cruz County:
20. Davenport.
21. Felton and Rincon (2).
22. Santa Cruz (4).
Shasta County:
23. Kennett (5).
24. Redding (2).
Siskiyou County:
25. Callahan.
26. Fort Jones.
27. Gazelle (2).
28. Greenview.
Solano County: 29. Cement.
Sonoma County: 30. Geyserville.
Tuolumne County:
31. Jacksonville.
32. Sonora (2).
Ventura County:
33. Oxnard.
34. Ventura

SANDSTONE.

Alameda County:
1a. Oakland (8).
1b. Piedmont.
Amador County:
1. Ione.
2. Lancha Plana.
Calaveras County: 3. Valley Springs.
Colusa County: 4. Sites (2).
Contra Costa County:
5. Clayton.
6. Martinez (2).
7. Stege (2).
Del Norte County: 8. Crescent City.
Kern County: 9. Tehachapi (6 miles south of).
Los Angeles County: 10. Chatsworth (3).
Napa County:
11. Napa (2)
12. St. Helena.
Orange County:
13. El Modeno.
14. Santa Ana (2).
San Francisco County: 14a. San Francisco (5).
San Luis Obispo County:
15. Berros.
16. Edna (near).
17. Santa Margarita (near).
San Mateo County:
18. Colma.
18a. San Pedro Point.
Santa Barbara County:
19. Montecito.
20. Santa Barbara (14).
Santa Clara County:
21. Graystone.
22. Los Gatos (10 miles from).
Shasta County:
23. Redding (northeast of) (2).
24. Texas Spring.
Siskiyou County:
25. Henley (2).
26. Yreka (2).
Sonoma County:
27. Coast Bluffs.
28. Freestone (2).
29. Petaluma (2).
Stanislaus County: 30. Knights Fery (Wright ranch).
Ventura County:
31. Camarillo.
32. Santa Susana.
33. Sespe.
Yolo County: 34. Winters (2).

NEVADA.

By E. F. Burchard.

The larger part of the area of Nevada is occupied by Tertiary effusive rocks, consisting of rhyolite, andesite, and related types, and tuffaceous rocks. There are in the extreme western part of the State in the Sierra Nevada, and at a few places in the interior, small areas of post-Cambrian intrusives which include granite and diorite. There are also, on the flanks of the mountain ranges, most of which have a general north-south trend, areas of sedimentary rocks of Ordovician, Devonian, Carboniferous, Triassic, and Jurassic age, including limestone, sandstone, and shale, in part metamorphosed. In the basins between the mountains are Tertiary sediments and wash of Quaternary age. The State is therefore bountifully supplied with stone of all kinds, but it is not likely that important quarrying industries will be built up except in the vicinity of the larger towns. The writer has had no opportunity to make field investigations of the stone resources of Nevada. Prof. J. C. Jones of the Mackay School of Mines, University of Nevada, has kindly furnished notes on the general features of the quarry industry and has made certain additions and corrections on the quarry map, and the writer herewith expresses his appreciation for this courteous assistance.

According to Prof. Jones nearly every town of any size in Nevada has its local "quarry" where stone is obtained from time to time for foundations and other rough work, as it is customary for builders to go out into the hills and get stone when any is needed rather than to maintain a regular and continuous quarry. Considerable stone has been obtained from a quarry in hornblende andesite about a mile north of Reno, and the stone for the water table of the new library building of the University of Nevada at Reno was obtained from a quarry in rhyolitic tuff about 2 miles southwest of the town. Several other small quarries in similar stone are reported to have been opened in that vicinity. The quarries near Merrimac and Tonopah are also in rhyolitic tuff. At Reno granite is obtained from bowlders that have been washed down from the Sierra by Truckee River. Stonecutters report that these bowlders yield fresher and sounder rock than can be obtained from rock in situ. Of the marble quarries the one at Carrara is the only one in active operation at present (Jan. 30, 1914), though the quarry at Mina is to resume operation soon. There is no question as to the quality of the marble in the Nevada quarries. The retardation in their development has been due in most instances to lack of capital to push their product. There is an abundance of suitable stone in Nevada, but the small demand and consequent scarcity of stonecutters make it cheaper to import stone, unless there happens to be a large building or contract that makes it possible to bring in the necessary skilled labor. Practically all the stone used in trimming is imported from other States, much of it coming from Bedford, Ind. Such granite as is used comes from across the Sierra, chiefly from Rocklin, Cal.

The following notes are abstracted from a bulletin of the Department of Geology and Mining, University of Nevada, entitled "Preliminary report on the building stones of Nevada," by John A. Reid, published in 1904. Prof. Reid's notes fortunately deal with the undeveloped stone resources as well as with those that are quarried.

Granite.—The east flank of the Sierra and the area along the foothills is characterized by an abundance of crystalline rocks, all more or less connected in origin yet varying from those termed granite to those of dioritic nature. The term granite is, however, used here for such rocks as might commercially be included in this class.

Granite occurs in the immediate vicinity of Laughtons station, to the north of the Southern Pacific Railroad track, about 5 miles west of Reno. Considerable rough stone has been taken out at the outcrop directly on the railroad, but no real quarry face has been opened. In color this granite is a medium to light gray, with occasional splotches of a darker shade. The rock is susceptible of a good polish, quite in contrast to the rough finish. Considerable joint structure is developed on a large scale, sufficient to make quarrying easy, and yet not enough to preclude the possibility of extracting large blocks. The texture is of medium fineness in the main phase of the stone, but varies considerably. The normal rock has much more white mineral than dark, but often rounded spots occur which contain a much larger percentage of black constituents. Little or no pyrite is present. The stone, because of its location on the railroad, is available at once and in large quantity. It can be used for ornamental work if no variations in texture are present, and for all the more common structures, such as foundations, curbing, walks, and the like, it will give satisfaction.

In the vicinity of the town of Verdi, about 10 miles west of Reno on the Southern Pacific Railroad, considerable areas of granite exist. Much of it is directly on the railroad, south of the town, along Truckee River. There are two types of granite here. The first type is that which makes up most of the mass. The color is a rich dark gray, with a faint trace of pink, giving as a result a very handsome stone. It is susceptible of a high polish, showing quite dark in comparison with the rough surface. As to the structure of the rock, some faulting has occurred, and joint planes are probably developed. From the outcrops existing, the texture appears fairly constant, there being a slight change in color in widely separated localities. The sulphides are in very small quantity. The stone seems to be remarkably free from imperfections in this respect. Like the Laughton stone, it is so situated that it is available at any time with lowest possible cost of handling. For monumental work, as well as for all the best uses, this granite should find a ready market. The second variety of granite from Verdi is found at present only in bowlders lying on the worn surface of the other granite. It undoubtedly occurs as veins in the main mass, and should properly be called a pegmatite. The color is either a light red ground through which are irregularly dispersed black shining crystals of tourmaline, or more rarely, a white ground with the dark mineral. The general effect is very pleasing to the eye. The quartz and feldspar are of fine grain, while the black mineral, in coarser crystals, is in spots in size from a quarter of an inch up to a foot or more. The stone will take a high polish, differing little from the unfinished surface in shade. It should meet with favor for some kinds of ornamental work, as well as for building material, if it can be obtained in large enough quantity.

Granite outcrops west of the old town of Washoe, on the Virginia & Truckee Railway, and is a part of the great granite mass occurring at the east base of the Sierra. A quarry is opened about a mile west of the town, and the stone has been shown to be of fairly uniform color and grain. The color is a medium dark gray, with a very faint pinkish tinge, lighter than the rock near Verdi. There appear to be few or no imperfections in structure debarring the extraction of large pieces for use, but, in common with most of these rocks, the texture varies somewhat. The sulphide minerals are rare, as in all of these rocks. A good polish is taken, quite dark compared with the unfinished stone. The granite is used for monuments and ornamental purposes.

Granite is well exposed at Ophir, about a mile northwest of Franktown, on the Virginia & Truckee Railway. A little preliminary quarrying has been done at a point just south of the wood flume, on the small creek here draining down from the mountains. The stone rises about 100 feet above the creek, giving opportunity for working. The color is the lightest of all those described, being, in the average, a very light gray. Some varieties, small in amount, are darker in shade. A good polish is possible, which is little darker than the rough surface. Jointing is well developed, insuring ease in quarry work while not preventing the extraction of large blocks. In texture the rock as a whole varies considerably, though the main mass is fairly constant. Normally the crystals of the compartment minerals are fine in grain.

Granite is well shown in the railroad cuts south of the station of Lakeview, 3 miles northwest of Carson. The color is a light gray, similar to but darker than the Ophir granite. In the exposed outcrop many little dots of red are to be seen on careful inspection. The mass of the rock is quite faulted and jointed, but blocks of large size can be taken out, judging by the weathered portion. The texture is rather coarse because of the large size of the hornblende crystals; the light colored constituents are of finer grain. Magnetite shows quite plentiful under the microscope. Such a rock as this is limited in usefulness to the commoner demands, and it is also possible, on account of the mineral content, to use it as a road metal. Its vast quantity, ease of access, small mica percentage, and comparatively large percentage of iron, make it possible that it might prove a success as a material for macadamized roads. On the Prison Hill at Carson, a similar granite outcrops from beneath the andesite flows. This locality is not on the line of the railroad, but is easily approached by teams.

Near the town of Luning, Esmeralda County, 5 miles from the railroad, is an occurrence of fine-grained white granite. No real quarrying has been done, and only a small quantity of stone has been extracted. Small pieces show a finer grain than the other granites described.

Granite occurs near Mason Valley, in Hudson Pass, Lyon County, about 18 miles from the railroad. As with most of the other rocks, little quarrying has been done. The color is rather striking, being a light mottled pink-gray. On close inspection three distinct colors are noticeable—white, pink, and dark green. The polished surface brings these out well, and presents a considerable and pleasing contrast with the rough finish. The grain is medium and even, with an occasional large white crystal. This stone can be used for ornamental work and buildings, and should find a ready market.

Two varieties of granite are used in Winnemucca. The first is quarried 12 miles north of the town, and hauled in by teams. It is a medium light gray stone, taking a fine polish, and is sufficiently good for the best class of work. The grain is medium coarse, with little variation in color or mineral content. The second granite used in Winnemucca is taken from bowlders found on the lower slopes of Winnemucca Mountain. In color and general appearance it is much like the first, but takes a poorer polish. It also has found some demand for monuments and buildings, but is inferior to the first because of longer exposure in fragments. However, it is well adapted to all the commoner uses.

Much granite exists both north and south of the town of Elko but at some distance. At present one variety is quarried, about 30 miles north, and is used in the town for nearly all purposes.

The mass of Mount Davidson, upon whose eastern flanks Virginia City lies, is chiefly of a dioritic rock. This rock may not make a first-class building material, for its color is a somber gray, its grain fine, and the whole aspect is uninviting. It is mentioned because of its possible use as a road metal. Its constituents are feldspar and hornblende, with usually some iron pyrite. The texture is one of interlocking crystals, causing very great toughness.

Light volcanic rocks.—There are two stones used in Nevada which are classed with this group of rocks. Both are from the region just south of Virginia City, near the American Flat tunnel, on the line of the Virginia & Truckee Railway, in Lyon County. Both are quartz porphyrites in a general sense, though there are variations from a true quartz porphyry or rhyolite to a quartz andesite, or dacite, based on the nature of the included feldspars. Rhyolite is quarried from the great mass covering many acres, at a point on the railroad one-fourth of a mile west of the American Flat tunnel. The color is yellowish white, a suitable shade for a dry, dusty climate. The texture is porphyritic and even throughout larger masses. The general effect is good. Rather large glassy quartz grains give the rock a distinct individuality. The hardness is high, the toughness a little less, and both rank with the best. The rock shows much resistance to atmospheric changes, so that long life to a structure of this material is assured. This stone was much used in the early days on the Comstock, chiefly for foundations. It shows no evidence of change where so used. The railroad now constructs of it abutments, culverts, retaining walls, and other similar structures.

Another quartz porphyry is quarried five-eighths of a mile east of the tunnel already mentioned. The color in the mass is a medium-dark purplish. The texture is porphyritic, with well-developed crystals of quartz, feldspar, and dark mica. The color is due to the purplish-gray groundmass, in which the other minerals show distinctly. The main difference between these two rocks is in the color and the increase in the proportion of mica in the purplish variety. This latter stone is decidedly pleasing to look upon and should find favor for buildings. Its hardness, toughness, and other characteristics are favorable, and it is quarried by the railroad and used in some of its culverts and abutments. It has been used in one of the railroad crossings at Steamboat Springs and makes a fine appearance.

There are several quite important building stones among the andesites, including some of great promise. As the demand for such materials of construction increases, these stones should all find ready markets, particularly as they are easy of access and near the centers of population.

Andesite is the stone used largely in the erection of the new Carnegie Library building in Reno. It is locally called a sandstone. It comes from one of the Recent large andesite flows on the lower eastern flanks of the Sierra. The quarry is situated at a point about 4 miles southwest of Reno, though nearly 2 miles farther by road. The quarry shows well the flow structure of the mass; the planes of motion lie nearly horizontal, greatly facilitating the extraction of large blocks. The color is a medium light red or red-gray, similar to but redder than the tint of the quartz porphyry at Virginia City. The texture is porphyritic, showing white feldspar crystals with smaller ones of mica and hornblende in the red-gray groundmass. The white feldspar is all that shows on a cursory examination, and as much of this mineral is present the popular term sandstone has been employed. The hardness and toughness are low for a rock of this type and are little better than in an average sandstone, sufficient, perhaps, for all ordinary demands but not enough for the very largest buildings now erected. It will withstand much in the nature of temperature changes, as will all the rocks of this group.

On the western side of the ridge on which this quarry is situated is a second outcrop of similar rock, gray in color. The lasting qualities of the gray rock are much better. The two stones are in pleasing contrast and will undoubtedly find favor.

There are two varieties of andesite at Huffaker, 5 miles south of Reno. The railroad here skirts the foot of a rather low hill on which the rocks in question outcrop. They are both part of the same mass.

The first is a red stone, a shade darker than the library andesite. It forms most of the surface material and can be obtained in quite large quantity. It has no flow planes like the first-mentioned andesite. It is porphyritic in texture, showing well-formed crystals of black hornblende, red discolored lath-shaped crystals of feldspar, all in the red groundmass. The hardness is medium, the toughness somewhat less. The availability of the material is a strong point in its favor, as it outcrops less than 100 feet from the railroad track. The second variety is a granitic rock and popularly might be called a granite. It is a medium light gray stone, apparently showing quartz, feldspar, and hornblende. Careful study, with and without the microscope, shows it to be a truly porphyritic rock of medium grain and even texture. The general aspect of the rock is decidedly in its favor. The Huffaker residence, a large two-story structure, is made of this material, which shows no change in its 30 years of service.

Andesite exists north of Reno over considerable territory. A quarry in the best material is about 2 miles north of the University campus, just above the railroad. The color is a light greenish gray in the mass, a restful one in the glare of the sunlight in a hot, dry climate. The rock is rather strikingly porphyritic on close inspection, though of even appearance at a little distance. Large glassy feldspar crystals half an inch in length are abundant. Also many flakes of dark mica are present, with a little hornblende, all set in the compact, greenish-gray groundmass. In selected pieces the texture is fairly constant, but as a mass much variation occurs. Inclusions of other materials are found, and small cavities are plentiful, so that careless work may result in unsightly spots in buildings. The hardness and toughness are fair, and the resistance to weather changes is good. As it is on the railroad, it is easily available, and there is a vast quantity in sight. The stone has been used considerably in Reno. Several of the newer University buildings, the gymnasium and Lincoln Hall, contain it, and a few structures in the business part of town are made wholly, or nearly so, of the material. Another possible use is that of road metal.

About 2 miles east of the old town of Virginia City runs a ridge approximately north and south. Sugar Loaf peak is part of this ridge, which is cut in two by Sixmile Canyon and Creek. Two varieties of andesite are found in this ridge. The first of these is quarried at a point just east of the Brunswick Lode, on the east side of a small hill rising from the ridge. Considerable rock has been taken out here, yet no well-cut face is shown. The structure of the mass is columnar. The columns, averaging 2 feet or more in diameter, pitch to the northwest at a low angle, aiding quarrying. This stone is the most striking in appearance of all those described in these notes, and is very handsome. The texture is porphyritic, and large rounded feldspar crystals often half an inch across, with smaller prisms of hornblende and flakes of dark mica appear in a blue-gray or steel-blue groundmass. The feldspar is quite glassy, much in contrast to the lusterless colored ground. There is some variation in texture which must be guarded against by selecting only the best. Frequently small inclusions with slightly different color and grain occur, which spoil the even effect. The hardness, toughness, and other characteristics are good and need little consideration under ordinary circumstances. The stone is easily obtained, the quarry being less than 2 miles from the railroad. It was used extensively in the early days of the town for foundations for large machinery. The second variety of these andesites occurs in Sugar Loaf and in the exposed places in the immediate vicinity. It has not yet been quarried nor used. A fine exposure is present southwest of the road in Sixmile Canyon where the bridge spans the creek at the base of Sugar Loaf. This rock is very similar to the first, yet distinct in its general appearance. The groundmass is a very light gray, with a faint tinge of blue, and the well-formed minerals are white feldspar, in smaller crystals than in the first phase, with black hornblende more plentiful than before, and a little dark mica. The other qualities are about the same as those of the first variety and are good.

There are three tuffs now in use in the State. They are softer than the average consolidated tuff, yet this lack does not prevent their being used in many important ways. They fill a want for certain kinds of materials better than any other stone and at times rank with the best sandstones. Tuff outcrops in the Virginia Range in the canyon of Carson River, at Merrimac station, within easy reach of all important points. The quarry is on the south bank of the river, and is one of the very few well-opened quarries in Nevada. The color of the stone is a light pink, almost a flesh color, and does not vary throughout the mass. As it is composed of volcanic ash, with some mineral fragments, its texture might be taken to indicate a very fine-grained sandstone. The fragmental character is clearly shown, and the absence of stratification planes or layers indicates to the unaided eye the nature of the material. The ash is largely glass, in minute fragments, in which are imbedded a few angular pieces of mica, quartz, and feldspar. The grain is very even for such a stone, and its general effect is very good. Its hardness and toughness are low, about equal to a soft sandstone and too low to warrant its use under much stress. It tempers a little on standing, but not sufficient to increase its strength greatly. It is rather porous, as are all the tuffs, yet withstands temperature changes well because of its internal structure. It has been used very largely in and about Carson and Reno chiefly for copings, cornices, lintels, arches, and for other purposes requiring little strength. When used with brick or with any other material harmonizing with it in color a very pleasing contrast is presented. The Gymnasium and Lincoln Hall of the University Buildings both contain it; some brick residences in Reno are much improved by its use; and the new Elk's Hall shows it to advantage.

Tuff occurs in a mass of consolidated ash almost 20 miles northeast of Reno, on the Spanish Springs Valley road. A little stone has been quarried and used in Reno in ways similar to the rock at Merrimac station. Its color is a light pink, a little lighter than the first material. These two stones are very similar in their features and can be used in precisely the same ways and for the same demands. This second tuff, however, is more irregular in texture, containing angular fragments of other rocks, largely andesite and granite, thereby appearing somewhat mottled when closely inspected. It tempers slightly better than the other. Careful selection should eliminate the unsightly stone from that quarried.

Tuff occurs in the hills northeast of the town of Lovelock, on the line of the Southern Pacific Railroad. Some has been obtained about 4 miles from the station. The color is a purplish gray, of a medium depth of tint. The structure and texture are in general the same as in the other tuffs. Many small fragments of volcanic rocks are interspersed throughout the mass, and small glassy crystals of feldspar are quite noticeable on careful inspection. The rock inclusions are dark gray, so that a close view exhibits many seeming imperfections in grain. Used in a building these are not apparent, and the whole aspect is a very pleasing one. The usual shade of purple will give a pretty contrast with other stones whose color blend with its own. The hardness and strength are good, ranking well up with that of the best sandstones, while at the same time it is resistant to atmospheric changes. A vast quantity is in sight here.

A volcanic agglomerate or a consolidated volcanic mud is found on the railroad at Washoe. Several of the old abandoned buildings of the once thriving town are made wholly of this stone, an unusual material for purposes of construction. The color is mottled light and medium dark gray and the surface usually appears dusty. The texture is quite porous. Nothing in the way of definite substances or minerals can be easily determined or distinguished. Its lasting qualities rank with an average sandstone, but its strength is less.

Marble.—The marbles are well represented in Nevada, although little has been done to develop them. Only a few are quarried, owing to the irregular demand and the difficulty of gaining a market against other stone now used.

On the borders of La Moille Valley, in Elko County, exists a vast quantity of a fairly good variety of marble. No quarrying has been done, but some stone has been taken out to show its character. The color is white in one variety, and a gray, or a laminated gray and white, in another. The white is clear, not marked by yellowish spots or flaws. The stone is rather finely crystalline, and takes a good polish. The marbles are all hard and brittle. The rock is not very far from transportation facilities and should meet with some demand. The uses are mainly interior ones, such as tiling for floors, mantles, and mosaic work. In the Humboldt Mountains a considerable quantity of coarsely crystalline marble exists, which may prove of some value upon more careful investigation. What rock has been seen shows a pure white color with few impurities appearing on weathering. Gray and white marble exist in the region in the vicinity of Luning, Mineral (formerly Esmeralda) County. Some of this has been quarried and used in Carson and it ranks with the others mentioned. It outcrops on the railroad; hence is easy of access.

In addition to the marbles mentioned by Reid, marble has been discovered about 14 miles north of Las Vegas, and near the Las Vegas & Tonopah Railroad, about halfway between Las Vegas and Tonopah. Here the town of Carrara has been established and quarries have been opened. Several varieties of marble are found here. The grain is generally very fine and uniform, and the stone is susceptible of a high polish. One sample sent to the University of Nevada is of an olive-green shade. Prof. Jones considers that the color may be due in part to serpentine and in part to organic matter. The variety "Pavonazzo" is of a light cream color, with a few irregular suture-like veins colored yellow to yellowish brown. This yellow stain is due to the oxidation of iron pyrite, minute grains of which can be seen along the veins with the aid of a lens.

In White Pine County, about 4 miles west of the Nevada-Utah State line, beginning about 5 miles west-southwest of Gandy, Utah, is an extensive deposit of marble. This marble has been studied and described by Darton,[1] who finds the marble formation to be about 150 feet thick and to extend up a canyon for 2 miles, constituting the greater part of the walls of the main canyon and of several of its branches. The marble is completely crystalline and is in large part dark bluish gray in color, banded or mottled with light gray or white, although a great variety of other colors may be seen. Some beds show regular alternations of white and gray marble in thin wavy or contorted layers, and there is also a portion, about 35 feet thick, of massively bedded creamy-white marble near the top of the deposit. The rock is variable in grain and large quanties of both fine and coarse grained material are available. The rock is mainly a calcite marble carrying small quantities of magnesia, ranging from 1.35 to 5.66 per cent, and less than 1 per cent each of such impurities as silica, iron oxide, and alumina. No pyrite were observed. The rock is reported to be susceptible of a beautiful polish. Physical tests show that the rock possesses a high crushing strength and a low percentage of absorption and should therefore be well suited to exterior structural work as well as interior decoration. Only surface samples had been obtained at the time Darton examined this deposit, the long haul to a railroad having precluded commercial development.

[1] Darton, N. H., Marble of White Pine County, Nev., near Gandy, Utah: U. S. Geol. Survey Bull. 340, pp. 377-380, 1908.

Limestone.—Limestone, although found in many localities in Nevada, is quarried in only four counties. The chief demand for limestone in this State is for the manufacture of lime, and limekilns have been erected at the places mentioned in the list of limestone quarries. At Dayton the stone is fairly high in calcium carbonate and carries 2.15 to 3.85 per cent iron and aluminum oxides and 4.39 to 7.22 per cent silica. Near Carson City the rock is also a high-calcium limestone, but averages lower in impurities, such as the metallic oxides and silica.

Sandstone.—Nevada has had developed up to the present time only a few rocks of this type, and none of them can be called first class. According to Reid, they are all of Recent geologic age. The first and most important sandstone is the well-known one at the State prison, near Carson. The sandstone beds or strata occupy the site of an extinct lake and exhibit the famous animal tracks on the present floor. The color is a yellowish gray, a gray, unfortunately, streaked with a light yellow, and not uniform. The rock is rather heavily bedded, with the bedding planes nearly horizontal. The mineral content shows the stone to be derived from the weathering and decomposition of a granite, the yellowish tinge being due to the oxidation of the iron-bearing substances. The constituent grains are cemented by a secondary silica. The average grain of the rock is of medium fineness, but in places becomes quite coarse, containing pebbles half an inch in size. The hardness and strength are medium, sufficient for all ordinary needs, and the resistance is good. There is much material in sight. The stone has been used largely in Carson and Reno. The new chemistry building at the university is constructed wholly of it, and presents a very satisfactory appearance. A small quantity has been used in the stone entrance to the university grounds.

Sandstone occurs near the town of Fallon, Churchill County. Little quarrying has been done, but samples of the rock show its main features. In color it is a cream-white very uniform in the small pieces shaped for exhibition. The grain is uniform, and quite fine. Its hardness and strength are about equal to those of the stone near Carson and satisfactory. It should resist the weather well, and appears to be a very fair stone for building purposes.

There are two varieties of sandstone quarries near and used in Winnemucca. Neither is first class in any respect, though they do well enough for local uses. They are taken from the old lake beds, to the northeast of the town. One stone is quarried 9 miles from the railroad station and hauled in by team. The color is a light drab and quite uniform. The minerals and substances comprising the stone do not show, on account of the fineness of the grain. Nothing but black flakes of mica are noticed. The hardness and strength are too low for anything but small structures. It stands temperature changes well, and were its strength higher would be an admirable building stone. Some new buildings have recently been erected in Winnemucca composed largely of this stone. The second variety of sandstone occurs at a point 4 miles from town, and is much more available. There are numerous faults and breaks in the material, which render the cost of obtaining stone fit for building almost prohibitive. The color is light gray; the texture is coarser than in the first variety, and somewhat variable. The hardness and strength are also considerably greater. The new fire company house in Winnemucca shows a handsome front of this material.

At Elko there is a sandstone much like the first one described from Winnemucca. As with the rest of the soft materials, its use is limited to small buildings, where the strain upon it is light. The local demands are met sufficiently well by it, but it can never have wide use. There is surely much first-class building material to be developed in this part of the State as the population increases.

Production.—The production of stone in Nevada is not published separately for either 1913 or 1912.

Directory.—The quarries of the kinds of rock quarried in Nevada are listed below by class of rock, county, and town (or post office):

Directory of stone quarries in Nevada.

GRANITE.

Mineral County: 1. Luning.

Washoe County:
  2. Washoe.
  3. Reno (5 miles west of).

LIGHT VOLCANIC ROCK.

Esmeralda County: 1. Near Tonopah, Nye County.

Ormsby County: 2. Merrimac.

Washoe County:
  3. Reno (1 mile north of.)
  4. Reno (2 miles southwest of.)

MARBLE.

Clark County: 1. 14 miles north of Las Vegas.

Mineral County:
  2. Luning (2).
  3. Mina (2).

Nye County: 4. Carrara.

LIMESTONE AND LIMEKILNS.

Clark County: 1. Sloan.

Lyon County:
  2. Dayton.

Lyon County—Continued.
  3. Wabuska.

Ormsby County: 4. Carson City.

SANDSTONE.

Ormsby County: 1. Carson City.

IDAHO.

By G. F. Loughlin.

Idaho, as shown on the geologic map of North America, may be divided geologically into seven parts. The part north of the latitude of Moscow consists mostly of an extensive area of the Algonkian Belt series, and includes in its western part a considerable area of metamorphic Paleozoic strata. These formations at many places are cut by bosses of granitic rocks and by sills and dikes of diabase and amphibolite. The central part of the State is covered by an immense batholith of granite or granodiorite, of late Cretaceous age, which incloses several areas of pre-Cambrian gneiss and schist. Paleozoic rocks occur extensively east of the southern end of the granite batholith, and also in the Great Basin ranges which occupy the southeastern part of the State. They are also exposed in limited areas along Snake River and certain tributary canyons, where overlying formations

MAP OF IDAHO, OREGON, AND WASHINGTON

Showing location of limekilns and quarries of limestone, sandstone, marble, slate, light volcanic rock, dark volcanic rock, and granite

Prepared under the direction of E F Burchard

have been removed by erosion. Triassic and Jurassic formations occur to a considerable extent along Snake and Salmon River basins in the western part of Idaho County, and also near the eastern boundary of the State from St. Anthony southward, where they are accompanied by Cretaceous rocks. Tertiary sediments, for the most part only imperfectly consolidated, are present along the valleys of Snake and Payette rivers near Boise, and also in Lemhi Valley from Salmon southward. Light volcanic rocks of early Tertiary age, rhyolitic and andesitic flows and tuffs, are known to be abundant in the mountains between the Snake River valley and the south and east boundaries of the State. The great Columbia River basalt field, of late Tertiary age, occurs in the western part of the State north of Lewiston and as far south as Weiser. It is present near Nampa in the southwestern part of the State, extending eastward along the Snake River valley to and beyond Pocatello, and is also exposed in the valley at Idaho Falls. Most of these formations have been quarried to some extent, but thus far only two or three quarries in the whole State have furnished stone for more than local use.

Granite.—In Idaho the word granite has been commercially used to include basalt and light volcanic rocks, but in this report these will be considered separately. Besides the immense batholith of central Idaho, granite and the closely related types granodiorite and monzonite are present in relatively small intrusive bodies cutting Paleozoic and older rocks in the northern part of the State and at several places along canyons in the western part, where they are exposed beneath the overlying basalt; but at only a few places are there exposures of granite of good quality near enough to lines of transportation to be of any present commercial value. It is in large part of similar character to the granite so widely distributed in the Pacific States, and for this reason is not likely to find more than a local market.

No granite quarries in the State have been steadily or extensively worked. The only quarry prospects of which the United States Geological Survey has any record are those situated along Snake River about 25 miles above Lewiston, or 6 or 8 miles above the mouth of Grande Ronde River, and one at the head of Hulls Gulch, 5½ miles east of Boise. According to Russell[1] the stone on Snake River, which has been quarried at two or three localities, is a fine-grained granite (diorite or monzonite) of excellent quality, and occurs in unlimited quantities. The limited excavations seen were not sufficient to demonstrate the full value of the quarries, but they indicated that large-sized blocks of homogeneous stone could probably be obtained. Others who have seen the quarries state that fracturing is so abundant that quarrying must be expensive and involve the handling of a large quantity of waste. The quarries, located on each side of the river, close to its margin, are favorably situated in reference to water transportation at periods of high water, but are 2 miles or more above the present limits of permanent navigation. Attempts to market some of the stone in recent years have involved a cost far in excess of the selling price. Conditions in the future may be made more favorable if a proposed railroad is finally built along the Snake

[1] Russell, I. C., Geology and water resources of Nez Perce County, Idaho: U. S. Geol. Survey Water-Supply Paper 54, p. 119, 1901.

River canyon. The rather dark-gray color of the stone practically limits it to monumental work, for which it appears very well adapted, provided blocks of desirable size and free from black knots or blotches can be obtained.

Russell also mentions a rather coarse-grained diorite of good quality on Mission Creek, where it cuts through Craig Mountain and near Kippen, 20 to 25 miles southeast of Lewiston, but both of these localities lack transportation facilities. He describes a similar diorite as occurring in vast quantities in Clearwater Canyon, from near Orofino to a point above Kamiah. It is easily available for rough masonry, but is too jointed and veined to afford large blocks of uniform color and texture. Transportation facilities, however, are favorable, and rock suitable for building and monumental work may be discovered.[1]

The southwestern portion of the great central batholith extends to within a few miles of Boise, but, according to Lindgren,[2] it is rarely available as building stone on account of its deep disintegration and the extensive joint systems traversing it. At most places where it is well exposed the remoteness of the locality renders it of small value. A small quantity has been quarried at the head of Hulls Gulch, 5½ miles east of Boise, and may be seen in use at the side entrance to the post office and the entrance of the Commercial Club in Boise. It is a gray medium to rather coarse grained granite, more or less porphyritic. Only a few residual bowlders and superficial joint blocks in ledges have been worked thus far, but the quality of these and favorable transportation costs justify further development The stone in sight will mostly afford rather small blocks, but blocks up to 8 or 10 feet in length and 2 feet square in cross section are obtainable.

Another occurrence which deserves mention because of its favorable location and architectural value is that of a rather coarsely porphyritic granite, which is exposed at a number of places on the Great Northern and the Northern Pacific railways, southwest of Sandpoint, in Bonner County. It is characterized by feldspar phenocrysts from half an inch to 1½ inches long, in a medium to rather dark gray groundmass of quartz, feldspar, and considerable biotite. It is of generally similar appearance to the granite in the post-office building at Spokane, Wash.

Diorite or "black granite" forms numerous intrusive sheets in the slates and sandstones along the Great Northern Railway, between Bonners Ferry and Lenia, but its architectural value has not been investigated. It is very dark, somewhat greenish, and rather coarse to fine grained. Greenish black hornblende, somewhat fibrous, is the most conspicuous mineral, and feldspar and quartz are also prominent.[3]

Dark volcanic rocks (basalt).—Basalt occurs so extensively in Idaho, Washington, and Oregon, and is so restricted by its structure and appearance to use for rough building and crushed stone, that it has been most economical for users of this stone to open temporary quarries within easy reach of the point of use. There are no permanently

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[1] Russell, I. C., op. cit., p. 119.
[2] Lindgren, Waldemar, U. S. Geol. Survey Geol. Atlas, Boise folio (No. 45), 1898.
[3] Calkins, F. C., A geological reconnaissance in northern Idaho and northwestern Montana: U. S. Geol. Survey Bull. 384, p. 45, 1909.

active quarries in Idaho, and the symbols on the accompanying map only serve to show the places of which the Geological Survey has record where basalt has been used at one time or another. The stone used is typical basalt. Some is rather highly vesicular, some is dense, with only occasional rather larger vesicles. By far the greater part has been used as crushed stone in concrete work and road building. For the latter use there may be considerable variation in the quality of the stone; some is rather brittle, owing to its texture or to minute fractures, and some is soft in places owing to decomposition and causes the road surface to wear unevenly, whereas the best stone is of practically ideal toughness and homogeneity and wears with an even surface. Good stone is doubtless abundant everywhere, but experience has shown that care must be used in the selection of stone for high-class road work.

Basalt has been extensively used as rubble and in the side and rear walls of many buildings, where the colors and shapes of the blocks were of no great consequence. Dressed blocks have also been used in a few cases. The Zion Cooperative Mercantile Institution building at Idaho Falls, built in 1884, has a front entirely of basalt in dressed blocks, with both rock face and finely tooled surface; some blocks are 6 feet long. The stone is of nearly black color and contains several small to large irregularly spaced vesicles. It gives a somber appearance, but shows no weathering effects after 30 years of exposure, and door sills where loaded trucks have been passing back and forth have not suffered any noticeable abrasion. Basalt has also been used, and with good effect, in the base of the Methodist Episcopal church, at Lewiston, erected in 1907. Here the blocks are mostly small, with rock face exposed.

Light volcanic rocks.—Light volcanic rocks, called sandstones in some places, have been used considerably for building in the southeastern part of the State, and are well illustrated by buildings in Pocatello, Blackfoot, Idaho Falls, and Rexburg. The stones used are mostly rhyolite, but a little andesite (and trachyte) as well as volcanic tuffs have been worked. The quarries between Blackfoot and Rexburg are mostly of rhyolite, which occurs in residual bowlders of gray and pink colors. It affords mostly stone of small dimensions, but can yield blocks as much as 10 feet in length and 3 to 4 feet in width and thickness. There has been, however, little demand for such large blocks, and most of the stones in use range from less than 2 to 4 and occasionally 5 or 6 feet in length, the latter forming sills and copings. Scattered vesicles and occasional included spots of flinty matter and rather pumicious material are commonly present, and are to be expected in this type of rock; but they give no seriously objectionable appearance to stone with rock face or coarsely pointed surface. Tuffs are quarried at Sunnydell in Madison County and near Albion in Cassia County, and have also been worked at Goshen, south of Idaho Falls. In most cases both the true rhyolites and the tuffs work very easily when quarried, but gradually harden on prolonged exposure, and in the favorable climate of southeastern Idaho they have withstood the weather from 15 to over 20 years with no evidence of disintegration. A few of the tuffs, however, are so poorly consolidated in the first place and undergo so little hardening on exposure that they have crumbled considerably in the walls of buildings, or have been deeply worn where subjected even to slight abrasion, and have suffered transverse breaks even under a light load.

Light volcanic rocks of these types should not be expected to give as high results in testing as do granite, marbles, and the stronger sandstones; but building experience in southeastern Idaho has proved that the better grades, both of the flow rocks (true rhyolites, andesites, etc.) and of the tuffs are quite adequate for all the demands that have been made upon them. They, furthermore, are so cheaply worked, rough stone selling as low as $2 a perch (16½ cubic feet) and dressed stones from 20 to 35 cents a cubic foot, according to size, that they seem worthy of more than local consideration.

A little rhyolite, which forms sills or contemporaneous flows in the Tertiary sands (Payette formation) around Boise, has been used to a limited extent for local buildings and also for roads, but none has been quarried for several years.

A basaltic tuff of brownish-yellow color, and therefore classed with the light volcanic rocks has been used in several buildings in Lewiston. It is, however, quarried on the west side of Snake River and is described with the volcanic rocks of Washington on page 1401.

Slate.—According to Russell:[1]

> Slate of pleasing reddish color, of easy cleavage, and so far as can be judged from natural exposures, of good quality, occurs on the eastern side of Cottonwood Butte (about 40 miles southeast of Lewiston), and is well located for quarrying. This material should be thoroughly tested as soon as transportation facilities admit of its being put on the market, to ascertain whether sheets of the desired size can be obtained.

Russell's statement was made before the railroad from Joseph to Orangeville had been constructed. The deposit is now only about 5 miles west of Cottonwood station. It is of interest in this connection to note that no red slate quarries have been developed in the Western States.

Slate occurs abundantly in the Belt series of northern Idaho, but none of it has been found to possess the necessary qualities of roofing slate.[2]

Marble.—Crystalline limestone and dolomite occur at several places in Idaho, but the exposures thus far noted are either too badly fractured or are too remote from transportation lines to be of present commercial interest as marbles. Only two marble prospects in the State have been reported to the United States Geological Survey. One of these is situated on Snake River about 25 miles south of Lewiston. Small samples seen by the writer consist of white coarse-grained calcite, irregularly streaked with dark graphitic bands and lenses, and resembling the darker varieties of the well-known marble from Georgia. The rocks in this vicinity are much disturbed, and it is not known whether blocks of sufficient size and quality for architectural use can be readily obtained. The deposit at present, as is the case with the granite in the vicinity, is not yet within reach of permanent water transportation.

The other marble prospect is located at Basin on a belt of crystalline limestone which extends along the range west of Albion in Cassia County. The nearest railroad point is Oakley, about 5 miles to the west. One block of it seen in Albion was a white, coarse-grained stone containing a large proportion of tremolite in single-bladed crystals and diverging groups up to an inch in length. This one sample, which may not fairly represent the whole deposit, is of quite as good appearance as some white tremolitic marbles that have found

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[1] Op. cit., p. 122. [2] Oral communication from F. C. Calkins, of the U. S. Geological Survey.

considerable use, but is hardly of sufficient quality to warrant extensive development under present conditions of transportation.

According to Russell,[1] the white to gray crystalline limestone at Orofino and vicinity polishes well and "should find a ready market for building and monumental purposes provided it can be had in blocks of desired size"; but so far as known no attempts to develop a marble quarry have been made. The deposit is close to the railroad and favorably situated for transportation to the large cities of the northwest.

Limestone.—Limestone is widely distributed in Idaho and has been quarried at a number of places, mostly for lime manufacture, but in a few places for sugar refining and for smelter flux, and in one instance for cement manufacture. Talus from shattered limestone has been used locally for road building.

The principal lime-producing point at present is at Bayview on the southwest shore of Pend Oreille Lake. The quarries are in shattered, white, coarsely crystalline limestone of probable Paleozoic age. Four quarries have been opened, but only one is being worked at present. Beds of high calcium and high magnesium content (the latter called "soft rock") alternate irregularly and are accompanied by thin beds and streaks of dark lime silicate rock. Only the high-calcium rock has been quarried thus far. The stone is white, rather coarse grained, and appears to be pure save for thinly but evenly disseminated specks of pyrite. When dissolved in weak hydrochloric acid it leaves a small residue which the microscope shows to consist chiefly of the lime-magnesia silicates, tremolite and diopside. The pyrite, during burning, oxidizes to brownish black specks, which are of insufficient quantity to affect the quality of the lime. The high magnesium rock is called "soft rock" because of its tendency to crumble on exposure to the air after burning. The following analysis, made for the Washington Brick, Lime & Sewer Pipe Co., of Spokane, Wash., shows the composition of both the high-calcium and the high-magnesium stones and the corresponding burned limes:

Analysis of limestones from Bay View, Idaho.

	1	2	3	4	5
Silica, mica, clay, etc	0.8	2.3	2.2	5.1	2.4
Iron oxides and alumina	None.	0.2	Trace.	Trace.	None.
Calcium carbonate	93.2	60.0	56.0	60.5	92.3
Magnesium carbonate	5.8	37.7	43.5	34.6	5.6
	99.8	100.2	101.7	100.2	100.3

Approximate composition of lime burned from limestone, Bay View, Idaho.

	1	2	3	4	5	6
Silica, mica, clay, etc	1.4	4.3	2.2	9.3	4.2	2.08
Iron oxides and alumina	None.	0.4	Trace.	Trace.	None.	0.76
Calcium oxide (CaO)	93.5	62.3	58.5	60.3	90.3	87.61
Magnesium oxide (MgO)	5.4	33.0	38.2	30.0	5.6	6.48
Ignition loss	....	....	....	....	....	3.40

1. Top of quarry at the kiln.
2. Ten feet down on face "soft rock."
3. Side of quarry 20 feet down, "soft rock."
4. Blue rock. Forms thin bed at or near bottom of high-calcium bed.
5. From old quarry, near lake shore.
6. Location not given. Presumably an average sample of burned lime.

Analyses 1-5, by T. R. Ernst, 1911; analysis 6 by the C. M. Fassett Co.

[1] Russell, I. C., U. S. Geol. Survey Water-Supply Paper 54, p. 120, 1901.

As many as five kilns have been operated in the past, but present demands require the operation of only one. The lime is loaded on cars at the kiln and shipped over the Spokane International Railway, which has a branch terminus at Bayview. Across Pend Oreille Lake, about a mile northeast of Lakeview, an impure limestone is quarried, crushed, and loaded into cars, which are conveyed across the lake on a scow to Bayview and thence by rail to the International Portland Cement Co.'s plant east of Spokane. Shale for the cement plant is also quarried at the same locality as the limestone. At Lakeview limestone was formerly quarried, and the remains of two old kilns are still standing. Limestone outcrops at several other points along the shores of Lake Pend Oreille and has been quarried in a small way at a few places, but the present small demand for lime gives no incentive to work deposits situated so far from a railroad.

At Orofino lime has been burned in the past, but the property has recently (June, 1914) been taken over by a cement company, whose plant is not yet completed. The deposit is described by Russell [1] as follows:

Limestone occurs also at Orofino and at three or four localities on Orofino Creek within the first mile above its mouth, as well as on the southern side of Clearwater River about half a mile below Orofino. At each of these localities the well-defined beds are associated with schist; they strike about north-south and stand nearly vertical. The limestone has been metamorphosed and is now mostly a coarsely crystalline marble, varying in color from white to gray.

An analysis of this limestone is given in column 5 of the accompanying table.

Russell [2] states that limestone occurs in great quantities along the Snake River Canyon, 1 to 3 miles above the mouth of Grande Ronde River and also about 8 miles farther up stream (that is about 18 and 26 miles south of Lewiston, or 5 and 13 miles south of Taplin). The deposit near Grande Ronde River has been worked for limestone, and is at present in control of the Idaho Portland Cement Co., which has a partly erected cement plant at Asotin, Wash. Shale suitable for cement manufacture also occurs in the same locality. The deposit was examined in 1912 by H. S. Gale,[3] who took samples which yielded the analyses in columns 1 and 2 of the accompanying table. An analysis of a sample collected by Russell is given in column 3. All three analyses show the rock to be a high-calcium limestone of exceptional purity. Gale states that Snake River at this point is navigable for eight months in the year. Small boats may be able to reach it all the year around.

[1] Russell, I. C., op. cit., p. 120.
[2] Idem, pp. 120–121.
[3] Mr. Gale's report is included in U. S. Geol. Survey Bull. 522, pp. 136–138, 1913, on the Portland cement materials and industry in the United States.

Analyses of limestone near Snake River, Idaho.

	1	2	3	4	5
Silica (SiO_2)	0.48	0.34	0.39	1.08	0.37
Insoluble	....	....	....	.11	.27
Oxide of iron (Fe_2O_3)	Trace.	Trace.	.10	.19	.12
Alumina (Al_2O_3)	.48	.18	....	....	....
Lime (CaO)	55.52	55.72	55.34	54.75	51.96
Magnesia (MgO)	.17	.43	.10	.51	3.05
Carbon dioxide (CO_2)	43.07	43.20	43.59	43.50	44.08
Water (H_2O)	Trace.	Trace.	....	....	....
Alkalies and undetermined	.28	.13	....	....	....
	100.00	100.00	....	100.14	99.85

1. Average of 121 samples of limestone chipped at approximately uniform intervals throughout the length of a 160-foot tunnel.
2. Average of about 30 samples representing an outcrop at least 50 feet thick.

Samples Nos. 1 and 2 collected by H. S. Gale, U. S. Geol. Survey, and analyzed by A. B. Lort, Bur. Standards.

3. Sample from Snake River Canyon, collected by I. C. Russell and analyzed by George Steiger.
4. Sample from Mission Creek.
5. Sample from Orofino.

Samples 4 and 5 collected by I. C. Russell and analyzed by W. F. Hillebrand. The insoluble portions contained a trace of titanium oxide (TiO_2). Both analyses showed traces of organic matter.

Russell also gives the following description of a limestone on Mission Creek about 20 miles southeast of Lewiston:[1]

Limestone outcrops beneath the Columbia River lava on the right bank of Mission Creek, about half a mile above where it emerges from the deeper portion of its canyon in the Craig Mountains uplift, and also in a gulch about a mile to the west. Along Mission Creek, for a distance of approximately 300 feet, the limestone is admirably exposed in the precipitous canyon wall to a height of 500 feet. It is in general a hard grayish-blue rock containing a few obscure fossils. The strike of the beds is N. 50° E. (magnetic), and the dip is eastward at an angle of from 80° to 85°. Formerly it was burned in kilns which still remain, and it is said to have yielded a good lime.

An analysis of a typical sample of this rock is given in column 4 of the preceding table, and shows it to be, like the limestone in Snake River Canyon, a high-calcium rock of exceptional purity and to be well suited not only for lime burning but also for use in the manufacture of Portland cement and in the beet-sugar industry.

Transportation difficulties have been the chief obstacle to successful exploitation of this deposit.

North of Boise, on a point between the north and the south forks of Willow Creek, there is, in the Payette formation, a stratum of yellowish-gray oolitic limestone several feet thick which has been locally used for building stone. It consists almost exclusively of concentric spheroids of calcite about 1 millimeter in diameter, sometimes with small particles of foreign substances in the center.[2]

Limestone has been quarried at several places in the southeastern parts of the State mostly, or wholly, from Paleozoic formations, though limestones of Triassic and Jurassic age are available near the east boundary between Montpelier and St. Anthony. Of the quarries indicated on the accompanying map, those at Arco, in Blaine County, and at Franklin, in Franklin County, have been worked in connection with the beet-sugar industry, those at Hahn and Nicholia for smelter flux, and the others for lime burning. Most of the quarries are idle at present and but little information regarding these limestones could be obtained. A few analyses are, however, given below. In the vicinity of Montpelier and Georgetown in Bear Lake County both talus piles

[1] Op. cit., p. 121. [2] Lindgren, Waldemar, U. S. Geol. Survey Geol. Atlas, Boise folio (No. 45), 1898.

and outcrops of shattered limestone have been used for local road building. The stone is naturally broken into sizes desirable for macadam and has only to be shoveled into carts and conveyed to the point where it is to be used.

There are large areas of limestone in the vicinity of Mackay, Custer County, and of Hailey, Blaine County, but no quarries have been reported from them.

Small travertine deposits have been quarried at a few places and used for flux in smelters at Clayton, Lemhi County, and at Ketchum, Blaine County.[1]

Analyses of limestones from Blaine,[a] Cassia, and Franklin counties, Idaho.

	Arco (Blaine County).[b]			Franklin (Franklin County).[c]	Burley (Cassia County).[d]
Insoluble	1.90	2.04	1.34	....	....
Silica (SiO_2)	....	....	....	1.78	1.00
Soluble silica (SiO_2)	.06	.02	.09	....	....
Iron and aluminum oxides (Fe_2O_3 and Al_2O_3)	.28	.38	.34	.30	Trace of each.
Lime (CaO)	55.10	54.78	54.52	....	....
Magnesia (MgO)	.07	.13	.34	....	....
Sulphur trioxide (SO_3)	.10	.03	.10	....	....
Water (H_2O)	....	....	....	.08	....
Ignition loss	43.14	42.94	43.34	....	....
Undetermined	....	....	....	.40	....
	100.65	100.32	100.07	....	....
Calcium carbonate ($CaCO_3$)	98.4	97.8	97.40	93.56	97.20
Magnesium carbonate ($MgCO_3$)	....	....	....	3.88	....

[a] Limestones used in beet-sugar manufacture.
[b] Furnished by Utah-Idaho Sugar Co., Salt Lake City, Utah.
[c] Furnished by Amalgamated Sugar Co.
[d] Furnished by Barrett Lime Co.

Sandstone.—Although sandstone has been reported to be produced at several localities, most of the stone in question is in reality light volcanic rock. At only one locality, around Boise, has true sandstone been worked at all extensively, and at only one other locality, east of Dingle in Bear Lake County, has a sandstone prospect of any promise been brought to the Survey's attention.

The sandstone around Boise belongs to the Payette formation of Tertiary (Eocene ?) age, which consists for the most part of loosely consolidated sands and clays with some beds of hard sandstone. A detailed description of the formation has been given by Lindgren.[2]

The hard sandstone beds are found at several places and some of them are of excellent quality. Lindgren says:

> At all of the localities where good sandstone occurs the quality appears to be the result of the cementing action of hot siliceous springs on the sands. The principal locality near Boise is Table Rock, the sandstone occurring in the eroded hills of the Payette formation from Hot Springs on the south to a point northeast of Natatorium on the north. At Table Rock the facilities for quarrying are excellent, and many buildings at Boise are constructed of the material. There are two principal strata, 50 to 100 feet thick, one at the top of Table Rock, the other 400 or 500 feet below it, separated by less firmly cemented material. * * * The sandstone is of light gray, yellowish, or reddish color. The best quality is found in the lower strata, as the top layers are often somewhat too coarse. The rock is easily dressed and is well adapted for building purposes. It is composed of closely packed angular quartz and feldspar grains, the latter often filled with secondary mica. Foils of original biotite and muscovite also occur. There is little if any pyrite present. The rock is very porous, containing extremely little cementing material.

[1] Oral information by J. B. Umpleby, United States Geological Survey.

[2] Lindgren, Waldemar, U. S. Geol. Survey Geol. Atlas, Boise folio (No. 45), 1898, and Nampa folio (No. 103), 1904.

There is at present one quarry of considerable size at the south end of the top of Table Rock. The sandstone bed here consists of a 20-foot thickness of good stone capped by a varying thickness of coarse, hard, pebbly sandstone, and underlain by a poorly consolidated argillaceous stratum. The stone has been quarried for a total distance of a quarter of a mile along the south edge of the deposit and cubical blocks of good stone measuring as much as 20 feet on a side have been loosened. The blocks are bounded by vertical joints at approximately right angles and rather uniformly spaced. The present method of quarrying is to undermine a block by removal of the underlying material, and to allow it to fall over on the quarry floor. The force of the fall is sufficient to cause the top waste rock to separate from the block along a rather pronounced seam and to break into pieces small enough to be conveniently handled. The good stone is then divided by the Knox system of blasting into blocks of desired size, lengths usually ranging up to 10 feet and widths and thicknesses from 2 to 4 feet, and is shipped down the mountain on a gravity road a mile long to a spur track on the Oregon Short Line Railroad. The upper 6 or 8 feet of the 20 feet are rather conspicuously streaked with brown iron oxide and are called second-class stone; the lower 12 or 14 feet are relatively free from these streaks and are called first class. The difference in appearance, however, is conspicuous only in newly quarried stone, and the film of dust which has accumulated on the stone after only two or three years of exposure in the buildings of Boise is sufficient to conceal the difference between first and second class stone.

The following results of crushing tests on the sandstone at Boise have been furnished the writer by Prof. C. N. Little of the University of Idaho, Moscow:

Crushing tests of the sandstone at Boise, Idaho.

In 1911:
- One 2-inch cube, gray sandstone; crushing strength 5,600 pounds per square inch.
- One 2-inch cube, cream sandstone; crushing strength 5,500 pounds per square inch.
- Greatest difference in edge perpendicular to pressure, $\frac{1}{64}$ of an inch.

In 1912:
- Eight 2-inch cubes from same quarry; crushing strength ranging from 2,800 to 4,210 pounds per square inch.
- Average for light cream sandstone 3,650 pounds per square inch.
- Average for cold gray sandstone, 3,460 pounds per square inch.

Dimensions varied as much as 0.02 of an inch perpendicular to pressure face.

These figures may be rather low since the blocks tested were not perfect cubes. They serve, however, to give an approximate idea of the strength of the stone. It is weaker than several well-known sandstones, but the many buildings constructed of it in Boise show that it is quite strong enough to meet all the strength requirements thus far demanded of it. Its weathering qualities in the Boise climate are also very satisfactory.

Its use thus far has been largely local, and there are no data at hand regarding its durability in other regions. The stone in recent years has begun to find a more extended market, and some has been shipped as far as Los Angeles, Cal.

Besides the quarry just described, small quarries have been worked in the penitentiary grounds at Natatorium and in Curlew Gulch, 2 miles northeast of Boise. Other deposits, more or less remote from the railroad, are at Horseshoe Bend on Payette River, "Table Mountain" on the north side of Willow Creek, and southwest and south of Nampa.

The prospect near Dingle lies about 5 miles southeast of Dingle village and 3 miles southwest of Harer (Hear) siding on the Oregon Short Line, near the head of Pine Springs Gulch. The deposit is a part of the Nugget sandstone, of Jurassic or Triassic age, and is exposed along the north side of the gulch for a height of 400 or 500 feet, the beds striking a little west of north and dipping 35° to 50° W. The stone is fine, even grained, and nearly all of light reddish brown color, some of uniform appearance, and some with conspicuous thin bands of light and dark brown and occasionally of creamy white. At the east end of the exposure is a thin-bedded outcrop of creamy-white sandstone with little or no brown coloring matter. The constituent grains are quartz with considerable feldspar, and the principal cementing materials appear to be silica and ferric oxide. The outcrops are largely of thin-bedded appearance, owing to more pronounced weathering along certain seams or bedding planes. Single layers range from a few inches up to 1, 2, and 3 feet in thickness. It is probable that these seams will not be so conspicuous below the weathered surface and will not prevent the quarrying and use of thicker blocks. Near the west end of the property, blocks measuring 5 feet or more in thickness and 10 feet or more in length are exposed in the broken outcrops at three or more distinct horizons. Thus far only talus blocks have been quarried, furnishing mostly small blocks of less than 3 feet in length and a foot or less in thickness; but some finished blocks 6 feet or more in length have been dressed for steps, copings, and sills.

The only test thus far made on the stone was a crushing test of a 2-inch cube by Prof. Solon Shedd, at Pullman, Wash., which was found to have a crushing strength of 12,000 pounds to the square inch, a much greater strength than is possessed by several well-known sandstones. The only example of the stone seen in use is the dwelling house on Ream's ranch, Dingle, where the stone has been in place for 10 years with no sign of weathering. In view of the scarcity of stone of this color in the Northwest, this prospect is well worthy of consideration.

Production.—The total production of stone in Idaho in 1913 was valued at the quarries at $152,390, as compared with $63,974 in 1912.

Directory.—The quarries of all kinds of rock quarried in Nevada are listed below by class of rock, county, and town (or post office):

Directory of stone quarries in Idaho.

GRANITE.

Ada County: 1. Boise (5½ miles east of).

Nez Perce County: 2. Lewiston (25 miles south of).

DARK VOLCANIC ROCKS (BASALT).

Bonneville County: 1. Idaho Falls.
Canyon County: 2. Warren (near Nampa).
Idaho County: 3. Cottonwood.
Kootenai County: 4. Coeur d'Alene.
Nez Perce County: 5. Lewiston.
Twin Falls County: 6. Twin Falls.

LIGHT VOLCANIC ROCKS.

Ada County: 1. Boise (foothills east of).
Bonneville County:
2. Goshen.
3. Prospect and Rigby (2).
Cassia County:
4. Albion (6 miles southeast of).
5. Oakley.
Madison County:
6. Rexburg (5 miles southeast of).
7. Sunnydell (2).

MARBLE.

Cassia County: 1. Basin.
Nez Perce County: 2. Lewiston (25 miles south of).

LIMESTONE.

Blaine County: 1. Arco.
Bonner County: 2. Lakeview (3 miles northeast of).
Franklin County:
3. Franklin.
4. Mission Creek.
Nez Perce County: 5. Taplin (5 miles south of).

LIMESTONE AND LIMEKILNS.

Bannock County: 1. Pebble.
Bear Lake County: 2. Montpelier.
Cassia County:
3. Basin.
4. Burley (14 miles southeast of).
5. Marion.
Franklin County: 6. Clifton.
Fremont County:
7. St. Anthony.
8. Teton.
Kootenai County: 9. Bayview.
Lemhi County:
10. Hahn.
11. Lemhi.
12. Nicholia.
Nez Perce County: 13. Oro Fino (or Orofino).
Oneida County: 14. Malade City (2).

SANDSTONE.

Ada County: 1. Boise (4 miles southeast of) (2).
Bear Lake County: 2. Dingle.

OREGON.

By E. F. Burchard.

A strip along the Pacific slope, comprising less than one-fourth of the area of Oregon, is largely composed of sedimentary rocks, of which sandstone of Tertiary age is probably the predominant type. In southwestern Oregon Cretaceous and Jurassic rocks as well as Silurian and undifferentiated Paleozoic sediments occur, the Paleozoic sediments carrying in places valuable beds of limestone and marble. Two or three small areas of intrusive rocks including granite are found in southwestern Oregon. By far the greater part of the State east of the Pacific slope is underlain by effusive rocks of Tertiary and later age, although in the interior of the State, surrounded by the volcanic rocks, are large areas of Tertiary sediments, such as the John Day region, and of Quaternary deposits, such as the arid regions of south-central Oregon. A few small areas of Paleozoic sedimentary and intrusive rocks also occur within the volcanic field of northeastern Oregon.

The stone industry has not yet reached a high state of development in Oregon, although certain Tertiary sandstones have been quarried on a fairly large scale and have been shipped as far as San Francisco.

The granites of the southwestern part of the State are now attracting attention. Limestone is quarried in several places for crushed stone and at a few places for the manufacture of lime, and, according to recent reports, will soon be used for the manufacture of Portland cement. The output of basalt in the Willamette Valley is of growing importance, especially for road metal and concrete.

A few papers devoted particularly to stone resources of Oregon are available, among which are:

Stafford, O. F., Mineral resources and industries of Oregon: Oregon Univ. Bull., new ser., vol. 1, No. 4, pp. 105–111, May, 1904. (Stone notes mainly by C. W. Washburne.)

Darton, N. H., Structural materials in parts of Oregon and Washington: U. S. Geol. Survey Bull. 387, 1909.

Parks, H. M., Preliminary report on building stone in Oregon: The mineral resources of Oregon, vol. 1, No. 2, pp. 10–46, February, 1914.

From these papers, supplemented by data published by J. S. Diller in descriptions of the Roseburg, Coos Bay, and Port Orford quadrangles, United States Geological Survey folios Nos. 49, 73, and 89; and in a geological reconnaissance in northwestern Oregon in the Seventeenth Annual Report of the United States Geological Survey, pp. 441–520; by A. J. Collier, in the geology and mineral resources of the John Day region, in the mineral resources of Oregon, volume 1, No. 3, pages 3–47, March, 1914; and from field notes of the writer, the following notes on the stone resources of Oregon are derived:

Granite.—Important deposits of granite exist in several places in Jackson County within moderate distances of the main line of the Southern Pacific Railroad. A very excellent grade of granite outcrops on Neil Creek, about 1½ miles southwest of Ayers station. Granite underlies several square miles in this locality and is part of the granite intrusion of Mount Ashland. Much of this granite has been quarried from large bowlders high on the slopes of Neil Creek and worked into monumental stock at Ashland. Fine examples may be seen in the Ashland cemetery. This granite is medium fine grained, light bluish gray rock, and consists principally of orthoclase, plagioclase, and biotite. It is uniform in texture and color, fractures smoothly for granite, works well, and gives good contrasts between polished and hammered surfaces.

The rock has a sparkling or "lively" appearance, and is almost free of knots or other objectionable features, but contains here and there "salt streaks"—thin veins or dikes that resemble the aplite dikes in the granites of Maine. Joints cut the rock at intervals from a few inches to 6 feet apart, but mostly the spaces are 3 to 4 feet in one direction and much farther apart in another. This granite resembles the well-known Barre, Vt., granite and should prove a valuable resource when the demand for such a stone on the Pacific coast becomes sufficient to maintain a large quarrying industry.

In the vicinity of Medford are several granite quarries. One of these is favorably situated on the Southern Pacific line between Ray Gold and Tolo. A gray granite darker in color and coarser in grain than the stone of Mount Ashland is quarried here. Quartz, orthoclase, and plagioclase, biotite, and hornblende are present. Quarry operations are reported to have been handicapped by the irregularity of the jointing, but some building stone has been obtained here and used in the construction of a business block in Medford. The quarry is now operated by Jackson County as a source of road metal. Another gray granite is quarried at points respectively 5 and 6½ miles northwest of Medford. This granite is coarser grained than the stone near Ray Gold, and shows on polished surfaces a peculiar concentric structure in many of its feldspar crystals. A few "knots" or segregations of dark minerals are present in places in the quarry. The product of these quarries is hauled by wagon to Medford, where it is used mainly for monuments, although a small quantity is supplied for structural purposes.

Granite is quarried in eastern Oregon at only one place, viz, about 2 miles east of Haines, Baker County. According to Parks, this is a medium grained rather dark gray granite, the dark color being due to a considerable proportion of black minerals such as biotite and hornblende. Dark-colored knots occur in places in the quarry face. Joints are so spaced that single blocks 3 by 4 by 20 feet may be obtained. The stone is used principally for monuments and foundations, but it is suitable also for general structural purposes. Among the granitic rocks mentioned by Parks is an altered, medium-grained diabase, of a dull grayish-green color and a somewhat mottled appearance that outcrops about 6 miles north of Willamina, Yamhill County. This rock could be used locally to good advantage in piers, foundations, etc., but it is doubtful if it would meet the market requirements for a general building stone.

Physical tests of the Ashland, Ray Gold, and Haines granites showed them all to sustain a pressure of more than 13,000 pounds per square inch. None showed as much as 0.25 per cent of absorption, and no deterioration was apparent after repeated freezing and thawing.

Dark volcanic rocks (basalt, etc.).—Prior to 1913 in statistical tables in Mineral Resources on production of stone in Oregon, basalt, andesite, rhyolite, and all other igneous rocks of Oregon have been grouped under the general term "granite," and the totals for granite thereby greatly exaggerated. The fact is that the greater part of the stone output for the State during the last few years has really consisted of basalt and other dark volcanic rocks, which have been crushed for road making, concrete, and railroad ballast and also sold as rough, broken stone for riprap, chiefly along Columbia River. The statistics have been revised for this issue. As stated above, basalt flows cover a large part of the area of Oregon. The rock varies greatly in character from place to place and is, in general, suitable for the uses above mentioned rather than for dimension stone. According to Washburne, basalt is frequently used as a foundation stone in Oregon, but is undesirable for exterior use on account of the rapidity with which it weathers. He considers that the finest-grained basalts, which are usually somewhat glassy when fresh, are the most durable, but they are generally so fractured that large blocks can not be quarried. Basalt, especially in large columns, makes artistic fences, and when crushed and screened is better for macadam than any other rock in western Oregon. Washburne mentions a good basalt as quarried near Silverton, Marion County, and used in foundations of mills and stores; also a dark basic andesite quarried at Montavilla, near Portland, from which stone is shipped throughout the Willamette Valley for use chiefly as tombstone bases, but used also for building stone, although it does not well resist the weather. What is probably the same rock was determined by Johannsen for Darton to be basalt with dibasic texture, consisting of much plagioclase with some augite, magnetite, and phenocrysts of fresh olivine. The highlands west of Portland consist largely of basalt which outcrops extensively in their steep eastern slope and in all of their deeper canyons. The black "basalt" quarried on the banks of Columbia River at St. Helens may be classed as an augite andesite. Southward from Portland the basalt is extensively exposed along the sides of Willamette River beyond Oregon City, where the falls are formed by high ledges of basalt. Basalt occurs at many places farther south in Willamette Valley and is reported to be quarried at Lafayette, McMinnville, Dayton, Amity, Salem, and Cottage Grove. An old quarry at Eugene affords a fine example of columnar jointing.

At Astoria a dense, fine-grained blue-black to dark grayish-green basalt outcrops in the ridge bordering the city on the south. It is quarried near the head of Sixteenth Street. The structure is characterized by irregular vertical jointing and cross fractures, which split the rock near the surface into small fragments and blocks, but more massive rock may be obtained by deeper quarrying. At present this rock is for the most part crushed and screened to concrete sizes, but considerable quantities are used as rubble and dimension stone in foundations and retaining walls in Astoria. The basement walls of the high school building are of dimension stone from this quarry, and the main part of the building is constructed of concrete containing the basalt in the aggregate. The concrete is faced with white cement, which makes a striking contrast with the dark stone facing below. A large fireproof office building and other structures in Astoria are built of basalt concrete.

A greenish diabase is quarried at Miami, on Tillamook Bay, and in the Coos Bay region basalt outcrops on both sides of Coos River a short distance below the forks, where it can be conveniently obtained.

Several quarries are opened in basalt along Columbia River above the mouth of the Willamette, as at Warrendale, Hood River, Mosier, and The Dalles, and in other parts of the State the usefulness of the rock is equally well appreciated wherever the demand arises, as is shown by quarries at Klamath Falls, La Grande, and Baker City. In addition to the uses above noted paving blocks are made from basalt at certain quarries.

According to Collier, in the John Day region the Columbia River quarries have furnished basalt for a large store building at Heppner. The color of this basalt is not particularly pleasing, but otherwise the stone gives satisfaction. There is an abundance of basalt in this region suitable for roads and for concrete.

Light volcanic rocks.—There are no Survey data at hand concerning the relation of this type of rocks to the building trades in Oregon, but fortunately Parks has described the deposits at present of most importance, and the following notes are extracts and adaptations from his recent paper.[1]

Volcanic tuff, a rather unique building material which gives much promise, occurs over a wide area in eastern Oregon and is found also

[1] Parks, H. M., op. cit., pp. 37-40.

in some parts of western Oregon. The body of this rock is made up of volcanic ash particles, through which are scattered darker fragments of volcanic glass, broken pieces of feldspar crystals, and occasional masses of pumice. These particles vary from the size of fine-grained sand to that of the gravel pebble. The tuffs are probably formed by the accumulation of ash and other volcanic materials, which were ejected from some prehistoric volcano of the explosive type. It is likely that in most instances the deposition took place in much the same manner as the recent accumulation of volcanic ash over large areas in Alaska during the eruption of Katmai Volcano. Whatever its exact origin this deposit of fragmental materials was later buried by lava flows and sedimentary rocks, which consolidated it into a firm rock. At times the lava particles which were explosively projected into the atmosphere by the eruption may have fallen into bodies of water where they would become sorted to some extent into layers of coarse and fine material.

Volcanic tuff has been quarried and used in many places in the John Day Valley and in Wallowa, Baker, and other eastern Oregon counties. Very similar rock is also found in two or three localities in Marion County. In different places it varies materially in color, texture, and general qualities. The tuffs are very light in weight, being only about two-thirds as heavy as ordinary sandstone. The color is usually light, which gives a pleasing appearance for many purposes from an architectural standpoint. They can be worked very easily, sawed or carved into all kinds of shapes, and possess sufficient compressive strength to meet safely any proper conditions that will be imposed upon them even in our largest public buildings. The use of tuff in many places has demonstrated the adaptability of the stone to the climate of eastern Oregon. It is considerably less costly than some of the harder building stones, such as granite, sandstone, and limestone. Since this type of building stone has been most largely developed and more generally used in Baker County, only that general region will be discussed.

The two quarries from which the bulk of the Baker County stone is obtained are about 13 miles southeast of the city of Baker, on the Oregon-Washington Railway, near the station of Pleasant Valley One of these, known as the Ideal quarry, is less than half a mile north of the station, the other, the property of the Oregon Lava Stone Co., is about 1,000 feet south of the station. The rocks in the general region of Pleasant Valley are chiefly a series of lava flows, tuffs, and lake-bed deposits overlying the older greenstones. These rhyolitic flows and the deposition of the volcanic tuffs and lake sediments in this region seem to have taken place during about the same period. That is to say, volcanic eruptions of varying nature accompanied or succeeded each other, thus giving at times both solid and glassy rocks and also the loose-textured fragmental materials that are now consolidated into tuffs; while sediments were at the same time accumulating in the bottom of lakes that covered portions of that region. In very few of the quarries examined are any indications of bedding found. This shows that water probably had in most cases very little to do with the deposition of the rock strata. One exception to this rule is observed at the Ideal quarry, where the true lake beds are apparently overlain by volcanic tuff, which later also seems to show some bedding. These beds have a strike of N. 70° W. and a dip to N. 35°.

The Ideal quarry is opened on the south slope of the hill, the beds dipping directly against the slope. On account of this relation between the attitude of the beds and the slope of the land surface greater difficulties have to be met in quarrying, on account of the increasing overburden, than if the quarry could be located at a point where the dip and the surface slope are more nearly in the same direction. It seems probable that a more favorable site in this respect could be selected within a few hundred feet. The joints in this quarry are parallel to and at right angles to the bedding direction. More or less faulting and other evidences of movement since the rocks were consolidated are apparent in most exposures of the volcanic tuff and old lake bed deposits.

At the Oregon Lava Stone Co.'s quarry on the south side of the railroad the rocks are broken by a series of vertical joints and a second set of joint planes which are approximately parallel to the surface. These last occur much more plentifully and closer together within a few feet of the surface. The explanation seems to be that this series of shallow joints is entirely due to weathering agencies. Some of the joint planes are smooth curves instead of plane surfaces. No bedding whatever is evident in this quarry.

In both of the Pleasant Valley quarries stone can be gotten out in very large blocks, if desired, on account of the wide spacing between joints. Cubes as large as 8 feet in each dimension can be easily obtained. The rock in each of the quarries varies to some extent in different parts of the face, but is usually a light gray in color and for the most part quite fine grained in texture. In some parts of the exposures, and especially in the lighter gray stone, scattered irregular fragments of glass and pumice occur. Few of the glass fragments are over a quarter of an inch in diameter, but the inclusions of pumice are found at times to measure as much as an inch across. These larger fragments are often of a different color than the finer groundmass, sometimes lighter and sometimes darker. The glass particles are usually colored, sometimes black, while the pumice is more nearly the color of the groundmass.

According to tests made by the United States Bureau of Standards these tuffs have an absorption of something more than 25 per cent and an average crushing strength of nearly 2,000 pounds to the square inch, which last is amply sufficient for ordinary building purposes. It should be noted also that the strength of the volcanic tuff shows no deterioration from repeated freezing and thawing.

The available supply of volcanic tuff in Pleasant Valley area appears to be inexhaustible. The rock can be seen at the surface over an area of about 200 acres. The maximum depth is not known, but a thickness of over 100 feet can be observed in places. The amount of overburden encountered in quarrying will vary. In some places there is not more than 2 or 3 feet of waste rock, while in others as much as 10 or 15 feet of soil and weathered rock is present.

On the whole, volcanic tuff as a building stone has many features in its favor. Its conspicuous advantages are its light gray color, its light weight, and the ease with which it can be worked and handled. Because of its porosity and darker color when wet it has been questioned by some whether such stone can be used to advantage as a building material in a climate similar to that of the Willamette Valley where the winter rainfall is heavy. On drying, it of course resumes its original characteristic color. Whether its high porosity would be found objectionable in a climate so damp as this for several months of the year is a question which sufficient data are not at hand to answer definitely. Many common brick used in building walls everywhere are, however, fully as porous and as absorbent as the tests show this type of stone to be.

In his recent article on the geology and mineral resources of the John Day region Collier [1] gives data of value concerning the possibilities of rhyolite tuff as a building stone as follows:

This region is well supplied with building stones of various kinds, among the most promising of which is some rhyolite tuff, a prominent member of the Rattlesnake formation. As has been noted, the Rattlesnake formation lies in an almost horizontal position in the syncline in the southern part of the field. The rhyolite stands out as the capping rock for a great many mesas and shows by this that it is capable of resisting the weather in a notable way. Although this rock is to be seen along the valley all of the way from the town of John Day to and beyond Antone, the rock is most accessible near the town of Mount Vernon, where it is approximately 25 feet thick, and where there are several quarries from which small amounts have been taken at various times. A rock very similar to this, and possibly the same, is to be found scattered over the Mascall formation in large bowlders. The rock has been used for building smokehouses, cellars, and chimneys from Canyon City to Antone, and it can be seen in some larger buildings in John Day and Canyon City. It is light colored, pleasing to the eye, and in a climate as dry as that of the John Day region, its porous nature is not a disadvantage. Whether it would resist the weather as well in the Willamette Valley is an open question, but it probably will be found to work as well as in the John Day Valley.

The rock owes its origin to some violent volcanic eruption either in the Cascade Mountains or nearer at hand. The materials of which it is composed were thrown up into the air and settled over the land surface. While they are nearly all light pumicious fragments that could be carried for some distance by the winds, there are some fragments of more dense glass, the pressure of which would seem to indicate that water had been instrumental in bringing them to their present position.

Light volcanic rocks were noted by Stafford and Washburne [2] as follows: In Crook County volcanic tuff occurs along Des Chutes River which can be hewn into shape with an ax and which is used for fireplaces and other light building purposes. North of Alca station, Douglas County, green volcanic tuff has been worked by the Southern Pacific Railroad for revetment, fills, etc. This tuff continues north about 8 miles to Cottage Grove, where it was quarried in Cemetery Hill and used in foundations. Here it has a mottled yellow color, due to oxidation, and is not very suitable for building purposes. At Canyon City, Grant County, a soft, white volcanic ash, easily worked, was largely quarried for rebuilding part of the city after a disastrous fire in 1898. The stone makes a handsome building material, but is rather porous and has no mineral cement, the particles being held together by interlocking and by a paste of fine mud. Rhyolitic lavas said to be good for building purposes are reported from La Grande. Washburne considers that volcanic tuff and volcanic ash, unless cemented thoroughly by some insoluble substance, make poor building stones because of their absorptive properties, which cause flaking during frosts and hasten decomposition at all times.

Slate.—According to the Survey records there are no active slate quarries in Oregon. Records are few concerning slate deposits,

[1] Collier, A. J., op. cit., pp. 41–42. [2] Oregon Univ. Bull., new ser., vol. 1, No. 4, pp. 106–110.

consequently a note by Collier [1] is of interest here. In the John Day region, in the forks of Currant Creek, sec. 29, T. 8 S., R. 19 E.,[2] there is a large area of slate most of which lies west of the wagon road. This slate is noteworthy on account of having an almost perfect cleavage, a feature that is very desirable and not very common. The cleavage and quality of the rock appear suitable for roofing slate and warrant prospecting, but these conclusions are based on a rather hasty examination, due allowance being made for the fact that only the weathered outcrops could be examined.

Marble.—The occurrence of marble has been reported from Douglas, Jackson, Josephine, and Wallowa counties, Oreg., and quarries are now in operation in the last two counties. The marble in Douglas County occurs in several places about 8 miles, measured in an air line, east-southeast of Roseburg and belongs to limestone lentils (Whitsett limestone lentils of Diller) in the Cretaceous Myrtle formation. This marble is dense, rather fine grained limestone, variegated in color. Some is dove-colored, with white seams of calcite in the joint and fracture planes. Mottled gray shades are shown with white veins, while other portions are brecciated and show red and yellow shades with white and gray veins and areas. The quarry in this marble was abandoned many years ago. Some of the stone was used in the Douglas County courthouse at Roseburg, and some was used for monuments. Parts of the rock take a good polish, but, since different portions of the mass vary considerably in hardness, the rock is not easy to work. As shown by a monument about 20 years old the material does not weather well. The polished surface becomes rough and seams are opened.

A reference to marble in Jackson County is given by Diller [3] to the effect that marble is reported to occur near Rocky Point. A deposit of gray and white banded marble is reported to the writer to be situated about 15 miles west-southwest of Medford.

Deposits of marble occur in Josephine County about 24 miles south of Grants Pass. One deposit is near the head of Williams Creek, and another is about 15 miles farther west on Deer Creek. The stone of Williams Creek is in part limestone and in part coarse-grained variegated marble. The mass is lens-shaped, about 300 feet wide and more than 1,000 feet long, according to A. N. Winchell, who visited the deposit in 1913. The marble is in part a strikingly veined, black and white crystalline material, and there is also a light gray stone and some is nearly white. The stone takes a good polish and weathers as well as most marbles, to judge from tombstones in the Grants Pass cemetery. The quarry is so far from a railroad that it is worked only in a small way and intermittently for monument stock. Blocks are rolled down hill, then hauled about 6 miles to a cutting shop, and then about 20 miles to Grants Pass for finishing. The marble on Deer Creek is black and gray, veined with white calcite. It is not developed.

A study of a promising deposit of black marble about 5 miles southwest of Enterprise, Wallowa County, has recently been made by Parks, who has published a description of the material and its geologic

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[1] Collier, A. J., op. cit., p. 42.

[2] Regarding the location Collier cites J. C. Merriam, Contributions to the geology of the John Day Basin: California Univ. Dept. Geology Bull., vol. 2, p. 280.

[3] Diller, J. S., A geological reconnaissance in northwestern Oregon: U. S. Geol. Survey Seventeenth Ann. Rept., pt. 1, p. 514, 1896.

relations.[1] The marble outcrops about 2,000 feet above the level of Wallowa Valley and has been traced in an east-west direction, on the strike, more than 1,000 feet. The thickness of the bed is known to be more than 500 feet in some of the more favorable exposures. The individual beds vary in thickness from 2 to 6 feet, and are cut by joints 2 to 6 feet apart, but in the quarry at a depth of 16 feet from the surface blocks of 60 to 75 cubic feet can be obtained without difficulty. Intrusions of basic igneous rock cut the marble in places. The rock is dense and very fine grained, of a grayish-black color which becomes darker on polishing. Some beds are lighter colored, and some of the black stone contains here and there white spots of calcite which make a strong contrast in color. The lighter-colored beds might be quarried for building stone. The black material appears susceptible of a high polish.

Limestone and lime.—Limestone is found in all the counties which contain marble, since the marble beds are either dense limestones susceptible of a high polish, or else are metamorphosed phases of larger deposits of limestone. Lime is burned at most of the localities which produce limestone, but where the stone is not used for lime it is mostly crushed for concrete and road material. The stone near Roseburg is said to be excellent for lime. A chemical analysis of the black marble near Enterprise shows less than 5 per cent of impurity, and there are limekilns in operation both northwest and southeast of the town. About 4 miles southwest of Dallas, quarries have been opened in fine to coarse grained argillaceous limestone which varies in color from brownish green to dark grayish green. This stone has been used as monumental and also as building stone, the courthouse at Dallas having been constructed of it. An abundance of rock occurs here, and the thickness of the beds and the joint spacing is such that blocks of large size can be obtained. There is a possibility that the rock may be used for the manufacture of Portland cement at Oswego, by mixing with it a high-calcium limestone. Limestone deposits of considerable magnitude occur in Baker County, not far from Baker City, and also to the southeast in the vicinity of Huntington. Large limekilns are in operation at several points near the Oregon-Washington Railroad & Navigation Co. line. Grant and Union counties, also, in northeastern Oregon are reported to contain limestone deposits of considerable extent, and quarries have been opened at Prairie City and La Grande.

Sandstone.—The sandstones of Oregon that are at present of the greatest importance are chiefly in the Coast Range, and are of Tertiary age. These sandstones are quarried in several places for buildings, bridge piers, and for the construction of jetties. From the latitude of Portland southward deposits of sandstone are found in practically all the counties along the coast and in the Willamette, Umpqua, and Rogue River valleys, but south of the latitude of Eugene they are especially abundant. Near the coast the sandstone is generally a little softer than farther east.

In Washington County, 2½ miles west of Gaston, occurs a fine-grained sandstone, dark bluish gray when fresh, but lighter or greenish-gray when weathered. The stone is composed chiefly of quartz grains with some feldspar, muscovite, and olivine cemented by argillaceous material. Two quarry openings have been made here,

[1] Parks, H. M., op. cit., pp. 30-35.

the upper of which shows a thickness of 25 feet and the lower 50 feet of sandstone. The stone is reported to work easily, but is of a rather somber color. It has been used in a number of public buildings, among them the courthouse at Hillsboro. In Lincoln County, near Pioneer post office or Morrison station, a massive bedded medium fine-grained light-gray sandstone occurs in large quantities and for many years prior to 1898 was worked on an important scale; the stone was shipped to San Francisco, where the Call Building and the Emporium were built of it. Many buildings in the Willamette Valley, including two structures of the Oregon Agricultural College at Corvallis, the city hall and other buildings in Salem, and bank buildings in Eugene and Woodburn, also contain this stone. This sandstone is composed chiefly of fine grains of quartz with a few particles of feldspar, biotite, and hornblende. The cement is chiefly argillaceous, with a little calcium carbonate. The rock has an even texture, is soft enough to work easily, but possesses ample strength for building purposes and shows no deterioration in the freezing and thawing test. Just west of Monroe, Benton County, occurs a fine-grained, even-textured, grayish-green sandstone, consisting chiefly of quartz grains with a few particles of feldspar, olivine, and flakes of muscovite and films of secondary calcite. About 6 feet of beds are exposed in quarry openings at this place, and apparently blocks having a maximum dimension of 3 feet are obtainable. This stone has been used in the steps and trimming of the courthouse at Corvallis. Near Albany a greenish-gray to yellow sandstone has been quarried. In the Coos Bay region soft sandstone is found in abundance. On Coos River, near Marshfield, a micaceous sandstone has been quarried for jetty work. Lane County has several sandstone-bearing formations. Near Eugene, blue, fine and even-grained fossiliferous sandstone, greenish-gray in color, has been extensively quarried for local use. This sandstone is reported to be obtainable in blocks up to 5 feet long. A compact sandstone suitable for foundations has been quarried on the south side of Siuslaw River near Point Terrace. This outcrop is on tidewater, which facilitates shipment of the stone. At Loraine gray sandstone has been quarried for fireplaces, foundations, etc. Other sandstone quarries have been opened in Lane County, at Fairmount, and near Forest Grove and Turner. In Douglas County are a number of sandstone quarries, both active and inactive. Two and one-half miles north of Drain there is a large quantity of yellow sandstone suitable for bridge piers. The most important sandstone locality in Douglas County is east of the Southern Pacific Railroad between Roseburg and Sutherlin.[1] Quarries have been opened about 4 miles southeast of Sutherlin in gray, medium-grained, firmly cemented sandstone belonging to the Umpqua formation. The rock lies in beds 12 inches to 16 feet thick, separated by seams of shale. The jointing facilitates quarrying and permits blocks 5 to 10 feet long to be quarried. The rock is reported to work well and to be limited in available quantity only by the practical limitations of clearing and stripping. This stone is rather hard and dense, and shows a crushing strength of about 9,000 pounds to the square inch. It is reported to have been used in several buildings

[1] Notes from personal communication from L. G. Hicks, Roseburg, Oreg., also description by H. M. Parks, op. cit., pp. 27-28.

in Portland, including the Methodist Episcopal churches at Union Avenue and Multnomah Street, and Thirty-fifth and Yamhill Streets, a Congregational church at Thirty-second and Taylor Streets, a Presbyterian church at Fifty-fifth and Belmont Streets, and in the base course and steps of the Electric Building, also in a church in Albany and in a bank building in Sutherlin. Paving blocks from this sandstone have been laid in Russell Street, Portland. Other sandstones in this same area include a fine-grained, light-gray stone outcropping about 6 miles from Roseburg, and a medium-grained buff-gray sandstone about 4 miles north of Roseburg. These two deposits are but little developed.

In Jackson County, 5½ miles southwest of Medford, occurs a medium-grained bluish-gray to brown sandstone, composed largely of quartz grains with a few scales of black mica, and cemented in large part by calcium carbonate. This is a hard, massive sandstone, and appears to be a valuable stone although it has not been actively quarried for several years. Near Ayers station the Southern Pacific Railroad formerly operated a sandstone quarry.

Other sandstone deposits in Oregon that have attracted attention, but which are not at present being quarried, include a tawny yellow sandstone on the north side of Cape Blanco, Coos County, from which rock was formerly shipped to San Francisco; sandstone near Eagle Point and Gold Hill, Jackson County; sandstone near Scotts Mills, and Jefferson, Marion County; and sandstone near Bay City, Tillamook County. The sandstone from Jefferson is fine grained, dark gray in color, with calcareous cement, and is reported to be easily carved and to have been used for the Oregon stone in the Washington Monument at the National Capital.

Production.—The total production of stone in Oregon in 1913 was valued at the quarries at $357,498, as compared with $268,002 in 1912.

Directory.—Quarries of all kinds of rock quarried in Oregon are listed below by class of rock, county, and town (or post office):

Directory of stone quarries in Oregon.

GRANITE.

Baker County: 1. Haines.
Jackson County:
2. Ayers.
Jackson County—Continued.
3. Near Medford (2).
4. Near Ray Gold.

DARK VOLCANIC ROCK (BASALT, ETC.).

Baker County: 1. Baker (2).
Clatsop County: 2. Astoria (2).
Columbia County: 3. St. Helens.
Hood River County: 4. Hood River.
Klamath County: 5. Klamath Falls.
Lane County:
6. Cottage Grove.
7. Eugene.
8. Springfield.
Marion County: 9. Salem.
Multnomah County:
10. Portland (2).
11. Rocky Butte (2).
12. St. Johns.
13. Warrendale.
Tillamook County: 14. Tillamook Bay (Miami).
Union County: 15. Lagrande.
Wasco County:
16. The Dalles.
17. Mosier.
Washington County:
18. Cherry Grove.
19. Near Hillsboro.
Yamhill County:
20. Amity.
21. Carlton.
22. Dayton.
23. McMinnville.

LIGHT VOLCANIC ROCK (TUFF, ETC.).

Baker County: 1. Pleasant Valley (2).

MARBLE.

Douglas County: 1. Near Roseburg.
Josephine County: 2. Near Williams (25 miles south of Grants Pass).
Wallowa County: 3. Enterprise (5 miles southwest of).

LIMESTONE.

Douglas County: 1. Near Roseburg.
Grant County: 2. Prairie City.
Lane County:
3. Cottage Grove.
4. Eugene (near).
Marion County: 5. Salem.
Polk County: 6. Dallas (4 miles southwest of).
Union County: 7. Lagrande.

LIMESTONE AND LIMEKILNS.

Baker County:
1. Durkee.
2. Lime.
3. Pleasant Valley.
Grant County: 4. Canyon City.
Jackson County:
5. Goldhill (2).
6. Jacksonville.
Josephine County: 7. Wilderville.
Wallowa County:
8. Enterprise (6 miles southeast of).
9. Lostine (2).

SANDSTONE.

Benton County: 1. Monroe.
Coos County: 2. Marshfield.
Douglas County:
3. Roseburg (4 miles north of).
4. Sutherlin (3) (4 miles southeast of).
Jackson County:
5. Ayers.
6. Geary.
Lane County: 7. Eugene.
Lincoln County: 8. Pioneer.
Washington County: 9. Gaston (2½ miles northwest of).

WASHINGTON.

By E. F. Burchard.

Large areas of basalt cover the southern two-thirds of Washington and extend westward nearly to Puget Sound. As in Oregon, there are within the basalt area some Tertiary sediments. The northern portion of the State is largely underlain by Paleozoic metamorphic rocks with important areas of intrusive rocks of post-Cambrian age, and the western portion of the State is underlain principally by sediments of Jurassic, Cretaceous, Tertiary, and Quaternary age. Granites available for quarry purposes are found mainly in the intrusive areas north of the middle of the State, east of Puget Sound, but also in the southeastern part, near Snake River; marbles and limestones in the areas of Paleozoic and metamorphosed rocks in northeastern Washington; basalts and tuffs in the volcanic areas; and sandstone and limestone in the sediments of the Puget Sound and Olympic mountain regions. The following discussion of the stone resources of Washington has been derived in part from the paper by Prof. Solon Shedd on the Building and Ornamental Stones of Washington, published in the Annual Report of the Washington Geological Survey for 1902, pages 32 to 147, and in part from field notes by the writer, and from a few references in United States Geological Survey Geologic Atlas folios of central Washington by G. O. Smith. The paper by

Shedd contains tabulated data on chemical analyses and physical tests of many of the important granites, tuffs, marbles, and sandstones.

Granite.—Quarries of granitic rock are situated in King, Snohomish, Stevens, Spokane, and Whitman counties, Wash., although not all of them are active at present, and there are other counties which contain good granite for which there is no demand. The granite quarried in Washington is all of a light-gray color, and according to physical tests is slightly below the average in crushing strength, besides having a higher percentage of pore space and a higher ratio of absorption than many other granites. Nevertheless, these granites are all amply strong for any demands, and are otherwise durable and handsome. The largest granite quarrying center is at Index, Snohomish County. Here the rock is light-gray medium-grained hornblende-biotite granite. The mountains in this locality are largely of granite and the material adjacent to the railroad is in practically inexhaustible quantity, can be quarried economically in large blocks, and is a durable stone of pleasing appearance for structural work. It does not take a good polish, and is consequently not so suitable for work where polished stone is required. Careful selection is necessary in places if it is desired to obtain stone free from small black "knots" or segregations of dioritic composition, which are common to the granite in the vicinity of Index. Particles of iron pyrites are present in places, especially in the "knots." The crushing strength of this stone as shown by tests ranges from 13,900 pounds to 16,610 pounds to the square inch. The product of the quarries at Index is used largely in western Washington for dimension stone, trimming, sills, curbing, foundations, and for paving blocks.

In the vicinity of Spokane granite occurs in two areas, one about 9 miles north and a little west of the city near Little Spokane River, the other at Medical Lake and Silver Lake about 13 miles west of Spokane. The granite near Little Spokane River is of a light-gray color, of irregular, medium to coarse grain, and is composed principally of quartz, feldspar, and both biotite and muscovite. Large blocks are available here, and the granite is not difficult of access, but requires a haul of 10 miles to a railroad. This granite takes a good polish and is quarried intermittently for monumental purposes as well as for all kinds of work for which rough or dressed granite is suitable. Crushing strengths of 12,870 pounds and 15,800 pounds were shown by test. The granite at Medical Lake forms a low bluff on the west side of the lake where it has been exposed by erosion of basalt which once covered the area. This rock is medium coarse grained, light-gray stone, composed principally of quartz, feldspar, and biotite. Sheeting and jointing cut the rock into blocks 3 to 10 feet thick and 8 to 12 or 15 feet long. This granite takes a good polish and is used for both building and monumental work. Among the buildings constructed of it are the administration buildings of the State University at Seattle, the Agricultural College at Pullman, the Medical Lake Insane Asylum, the Fort Wright buildings, and the basement of the Lewiston, Idaho, post office.

The granite near Silver Lake is a light bluish-gray fine to medium grained rock. The stone is much jointed and fractured into irregularly sized and shaped blocks, but blocks 4 by 4 by 6 feet are easily obtained. The rock contains some dark "knots," but most of these can be avoided in procuring blocks for monuments, although, of course, the "knots" entail more or less waste. Although the material at present quarried is from near the suface, this granite is reported to be harder to work than many other granites. On account of this property and because it takes a good polish, it is used mainly for monuments. A wagon haul of about 1 mile to Medical Lake station is necessary. In southeastern Washington granite has been exposed at two places by Snake River where it has cut its canyon down through the basalt. One of these exposures is at Granite Point, about 2 miles above the mouth of Wawawai Canyon, 30 miles below Clarkston. Granite is exposed for about one-third of a mile along the river and rises to a maximum height of about 150 feet above the river. The stone is a light-gray, coarse-grained, biotite granite containing very little hornblende. The biotite occurs to a certain extent in layers and gives the granite a gneissoid appearance. The stone is reported to work well, to take a high polish, and to be suitable for buildings, curbing, bridge piers, and other heavy masonry. It was largely used in the construction of the customhouse at Portland, Oreg. At that time the stone had to be floated down Snake River to Riparia, but now a railroad passes the quarry and gives a better opportunity for shipping the stone. The second exposure in southeastern Washington is in Asotin County near the mouth of Grande Ronde River. Here the stone is darker gray and finer grained than that at Granite Point. It is reported to take a fine polish and to have been used for monumental purposes. At present, however, no regular quarry is maintained on account of the inaccessibility of the stone, since Snake River is seldom navigable above Asotin.

Dark volcanic rock (basalt, etc.).—The large areal extent of basalt in southern and southeastern Washington renders it available for local use more commonly than any other type of rock, and there are more than 20 basalt quarries scattered all the way from Puget Sound to Spokane, several being along Columbia River opposite areas where basalt is quarried also in Oregon. Heretofore the output of many of these basalt quarries was included with granite, but an attempt has been made in the present chapter to put these figures on a more logical basis. The basalt varies much in texture, from dense, fine-grained, columnar rock to coarse-grained, cellular material. The color is generally dark gray to black and not very attractive, yet some pleasing effects have been produced by the use of basalt as a building stone. Only a few quarries will be mentioned here, mainly for the purpose of illustrating the types of rock found, their occurrence, and uses. At Fisher, Clarke County, on Columbia River, a fine-grained, compact, gray stone is quarried, and large quantities have been used in jetties at the mouth of Columbia River and at Grays Harbor, and also for foundations and for bridge piers. Basalt has proved satisfactory for foundations and portions of the walls of certain buildings of the Washington Agricultural College at Pullman. Six miles west of North Yakima on the north side of Cowiche Creek a quarry has been opened at the top of the bluff in irregularly jointed dark-gray to black cellular andesite—designated as the Tieton andesite in United States Geological Survey geologic folio No. 86. The rock is somewhat porphyritic, containing numerous crystals of white feldspar. The quarry consists of a small irregular opening between 300 and 400 feet above the creek. Rough masses are blasted out and rolled down the hillside, at the base of which rough blocks, sills, etc., are cut and loaded on wagons. The material is not very hard, and splits irregularly, but can be trimmed fairly evenly. The Elks clubhouse, a handsome building at North Yakima, is built of rock of this type. A dark, finer grained rock is crushed for macadam at North Yakima. In 1910 the quarry and crusher were operated by the State with convict labor.

Dense, fine-grained, columnar, black basalt capping the bluffs about 3½ miles west of Spokane has been quarried to a considerable extent. The top 15 to 25 feet of the material is quarried by being pried loose or blasted out in blocks, which are then rolled down the bluff and at the base are broken into rubble or cut into paving blocks. The rock seems to be admirable for paving blocks, as it cuts easily into sound, even blocks about 4 by 5 by 9 inches, having good, sharp edges.

Light volcanic rocks (*tuff, etc.*).—Rocks of this class, most of which are composed of fragmental volcanic material, more or less consolidated, are widespread in Washington and have been demonstrated to be of considerably more value than has popularly been supposed, yet they have not been employed to any considerable extent for building purposes. According to Shedd an indurated dark-gray tuff of hornblende-pyroxene-andesite is quarried on the west side of Hoods Canal, about 2 miles northeast of Hoodsport, in the foothills of the Olympic Mountains. The material is stratified and has been mistaken for a sandstone. Crushing tests showed the stone to resist pressures of 10,300 pounds and 11,590 pounds to the square inch, which, while lower than that required to crush granite, is high for this type of rock. The ratio of absorption is low, and the effect of alternate freezing and thawing each day for 20 days was slight. The most significant results, however, were obtained from the fire and quenching test. Samples were heated gradually in a muffle furnace to temperatures of 800° F., 1,200° F., and 1,600° F., then plunged into cold water without apparent injury, except change of color to a brick red. Granites subjected to the same tests would be badly injured, if not completely destroyed. This deposit is extensive, easy of access, and is on a deep-water channel about 80 miles from Seattle. Other important areas of tuff are near Bossburg and China Bend of Columbia River, both in Stevens County. This rock is light gray, fine, indurated tuff of dacite material. The deposit is in layers varying in thickness, and like the stone near Hoodsport was formerly quarried as a sandstone. The crushing strengths of two samples of this rock were determined to be 7,730 pounds and 9,300 pounds to the square inch. Freezing and thawing affects this rock but little, and heating to 800° F. and cooling suddendly did not injure it perceptibly, but heating to temperatures of 1,200° F., and 1,600° F., and subsequent quenching affected this stone much more seriously than it did the rock near Hoodsport. About 1 mile north of North Yakima on a high ridge overlying dark basalt is a yellowish-gray tuff, probably water-laid and fairly well indurated, that is quarried for local building purposes. The rock might easily be mistaken for a sandstone. It is tough, but not very hard, and breaks with crumbling rather than sharp edges. No data are available concerning its service.

In Asotin County a peculiar deposit of basaltic tuff has come to the attention of both Mr. Loughlin and the writer. It is situated on the west side of Snake River valley about 2 miles north of Asotin. In this vicinity the rock is mainly of columnar and broken basalt and the deposit of tuff, which lies on the north side of a ravine cut in the basalt, is of limited extent. The tuff is of medium and generally uniform grains of basaltic material, loosely cemented and consequently very soft, and is generally of a greenish-yellow to yellowish-brown color, but some is dark gray. In places the rock contains "bombs" of vesicular basalt. No bedding is shown in places, but in others there is distinct crossbedding. The strength of the rock is very low and weathered pieces both in the quarry and in buildings are very soft and friable, yet it has been used in the construction of the Methodist Episcopal and Catholic churches and in a few dwellings and stone walls in Lewiston and in the front of a one-story bank building in Asotin. Cracks have appeared in places in structures built of this stone in Lewiston, evidently due to overloading. Notwithstanding the softness of the stone tool marks are preserved after 7 to 10 years in the favorable climate of Lewiston.

Mr. Loughlin reports the occurrence of a similar but finer grained stone at Asotin and Captain John creeks that has been used in the Lewiston National Bank Building. The sills below large windows all have one or more transverse cracks across them. This stone is very soft, but of a pleasing brownish yellow color.

Russell [1] noted this stone in early geologic studies, and though considering it of doubtful value for exterior work states that it has decided advantages for interior walls, especially of buildings designed to be fireproof.

Marble.—Shedd [2] makes the following statement concerning the occurrence of marble in Washington:

Marble is found in a number of places in Washington, but the principal deposits are in Stevens County. Marble, however, is found in the Snoqualmie Pass region of the Cascade Mountains, and to the north of there in some few places. The amount, however, so far as known is not very great. In Stevens County the deposits are quite numerous and in many cases very large. At the present time western Washington is not producing any marble and but very little is known to occur in that part of the State.

Detailed descriptions are given by Shedd of the properties of more than 20 companies that were prospecting and developing marble deposits in Stevens County prior to 1903. The localities at which promising prospects were opened are shown on the map (Pl. VII), but it must be borne in mind that few if any of these are producing quarries at the present time. Shedd's conclusions regarding the marble deposits of Stevens County are as follows: [3]

The marbles of Washington occur principally in Stevens County. They are of various colors and range in texture from those that are very fine to those that are very coarse. The composition is quite variable, in some cases being almost pure calcium carbonate, in others being magnesium carbonate with only traces of calcium carbonate, while in still others mixtures of calcium and magnesium carbonate are found in which there is more or less serpentine. The samples of marble used in making the physical tests shown in this report were perhaps hardly fair samples on account of the fact that many of the quarries are not developed to any extent as yet and the samples were necessarily from material that would not be as solid as it would be when a greater depth is reached. The results, however, of the tests of crushing strength show that the Stevens County marbles compare very favorably, as far as strength is concerned, with the best marbles from other parts of the United States. The specific gravity of these marbles is above the average, being as high as 2.908 in the case of the "Diamond Black" from the quarry of the United States Marble Co. [near Valley]. This same material also had the highest crushing strength of any sample tested, being 31,710

[1] Russell, I. C., Geology and water resources of Nez Perce County, Idaho: U. S. Geol. Survey Water-Supply Paper 54, pt. 2, p. 122, 1901.
[2] Shedd, Solon, Building and ornamental stones of Washington: Washington Geol. Survey Ann. Rept. for 1902, p. 76, 1903.
[3] Shedd, Solon, op. cit., pp. 146–147.

pounds to the square inch. The average specific gravity was about 2.75, which is about the same as that of the Georgia marbles. The porosity of the Washington marbles is low, being in all the samples tested, with the exception of two, less than 1 per cent.

In but very few cases have the marble deposits of Washington been developed to any very great extent, and in fact it has not been more than about a couple of years since active work was begun on most of the properties that are being worked at present [1902]. Since that time a very large number of marble claims have been staked and much of the material that has been located will never be of any value as marble. In some cases it is so hard that it will be too expensive to work it, in others the question of transportation will prevent the working of the deposits at a profit, while in other places the deposits are so badly broken and shattered that they will be of no value as marble for building or decorative material, except in a small way.

The general opinion seems to be that as depth is reached the seams that may occur on the surface will certainly disappear, and that no matter how badly the marble may be broken on the surface it will be solid when a comparatively short distance below the surface is reached. This disappearance of these seams, however, as has been already shown, is only an apparent one in most cases at least, unless a considerable depth has been reached, and may be only apparent even then.

There are, however, in Stevens County quite a number of very promising marble properties, both as regards the ordinary grades of marble as well as the more valuable decorative varieties.

At present most of the marble used for interior decoration in the modern buildings being erected in the Puget Sound cities is quarried at Tokeen, in southeastern Alaska. It is shipped in rough blocks to Tacoma, Wash., where it is prepared for market. Descriptions of the marble deposits in southeastern Alaska have recently been published by the Survey.[1]

Limestone and lime.—Important deposits of limestone are found in all the northern counties of Washington from the Idaho boundary to Puget Sound. The fact that certain of these deposits are on deep water greatly enhances their value, since these are the only large deposits of limestone along the Pacific coast of the United States so situated. The use of limestone as dimension stone for building purposes in Washington is probably very limited. Some limestone is crushed for use in concrete and macadam, and much is used in the manufacture of Portland cement, but by far the greater part of the output is converted into lime. The limestone used for Portland cement is restricted to low-magnesian stone, but limestone containing magnesia in any percentage may be used for making lime. Practically the only paper on the limestones of Washington is the much-quoted article by Landes,[2] which was reprinted in 1913 in Bulletin 522 of the United States Geological Survey. Both bulletins are now out of stock, therefore a brief résumé of the distribution of these limestone deposits will be given here. It should be borne in mind, however, that the discussion is from the viewpoint of the requirements of limestone for the manufacture of Portland cement, and that the deposits suitable for lime and macadam are still more widely distributed.

In San Juan County the deposits of most importance are at tidewater on San Juan and Orcas islands. The principal deposits on San Juan Island are at Roche Harbor, at which point the largest lime works on the northwest Pacific coast are located. The limestone is crystalline and metamorphic, and has been thought to be of pre-Cretaceous age. Adjacent to the limestone there are large deposits

[1] Burchard, Ernest F., Marble resources of Ketchikan and Wrangell districts, Alaska: U. S. Geol. Survey Bull. 542, pp. 52-77, 1913; Marble resources of Juneau, Skagway, and Sitka districts, Alaska: U. S. Geol. Survey Bull. 592, pp. 95-107, 1914.

[2] Landes, Henry, Cement resources of Washington: U. S. Geol. Survey Bull. 285, pp. 377-383, 1906.

of glacial sediments, which contain extensive beds of clay interbedded with sand. Some of the clay beds are known to be at least 40 feet in thickness, and are uncommonly free from gritty ingredients. In case these clays are not siliceous enough for use in cement manufacture, there are deposits of slate near at hand which might be utilized. In Whatcom County, in the vicinity of Kendall, there are a number of deposits of limestone and clay which afford the proper material for cement manufacture. An important outcrop of this limestone occurs in the form of a vertical cliff at a point about 3 miles from Kendall. The limestone is entirely crystalline and is a part of an extensive metamorphic series which has been greatly folded and crushed. A few miles west of the limestone deposits and along the railroad track are beds of glacial clay. One of these beds was drilled to a depth of 50 feet. The limestone is nearly pure, running 97.5 to nearly 99 per cent calcium carbonate, and the clay is apparently of a favorable composition for cement manufacture. In Skagit County large deposits of limestone and clay occur on the east side of Baker River, about three-fourths of a mile from its junction with Skagit River. This point is 40 miles from the mouth of the Skagit, a stream which is navigable at nearly all times of the year. The Seattle & Northern division of the Great Northern Railway also passes through this locality. The limestone is crystalline and nearly pure white in color. It is part of an extensive metamorphic series of unknown age. Slate adjoins the limestone, and these two formations strike a little west of north, the ledge of limestone dipping to the southwest at an angle of about 55 degrees. The outcrop is traceable for 600 feet along the strike and shows a width of 207 feet across the beds. The clay lies in horizontal beds in contact with the limestone, and is formed by silt brought down by Baker and Skagit rivers. It is well stratified and finely assorted, and rests upon beds of gravel. It is light blue in color, and has an average depth of 165 feet. There is also considerable limestone near Mount Sauk, on Jackman Creek and Baker River. In Snohomish County limestone occurs at a number of places in the eastern half of the county, and has been quarried at a point 3 miles east of Granite Falls. This stone is crystalline and is a member of an extensive metamorphic series extending in a broad north-south belt. The associated rocks are chiefly slate and schists. This rock has been quarried for the manufacture of lime and for use in flux and in paper making. The metamorphic series of rocks occurring in Whatcom and Snohomish counties continues into King County. In the vicinity of Snoqualmie Pass and at several points along the line of the Great Northern Railway, especially in the region about Baring, outcrops of crystalline limestone have been found. King County is particularly favored with clays of excellent quality. These clays occur chiefly in connection with the coal measures at Renton, Taylor, and Kummer. In the northern part of Okanogan County crystalline limestone has been discovered at many points, associated with slate, metamorphic sandstone, and conglomerate. The largest limestone areas are to the west and northwest of Riverside, where there are conspicuous cliffs of this rock covering an area of several square miles. On the eastern slope of Palmer Mountain are several prominent outcrops of light-gray limestone only partly crystalline. In Ferry County the largest limestone area is in the form of a long, narrow belt extending north-south across the country, and lies at the western foot of the granite divide separating Columbia and Kettle rivers from the streams to the west. This limestone is crystalline and associated with other metamorphic rocks, and near by clay and argillaceous limestone also occur, which might be utilized in cement manufacture. Stevens County contains large deposits of material necessary for cement manufacture. The rocks of the county are chiefly metamorphic in character, consisting mainly of limestone or marble, and slate and quartzite. The rocks have been greatly disturbed by folding as well as by intrusion of igneous rocks. The limestones are usually entirely crystalline, and in several places yield marble of excellent quality. The only evidence as to the age of the rocks has been noted near Springdale, where the semicrystalline limestone contains coral remains, which indicates that it is Paleozoic, probably of Carboniferous age. Many of the limestones in Stevens County are high in magnesia, and careful field work will be necessary in order to determine the location and extent of the high-calcium limestones.

Sandstone.—Sandstone deposits are found mainly in the western half of Washington and have been developed principally around Puget Sound and on the western and eastern slopes of the Cascades. Geologically these sandstones range from possibly as early as Carboniferous to late Tertiary. The oldest sandstones are on the east side of the Cascades in the northern part of the State, but there are no quarries in this area at present. Cretaceous sandstones occur on several islands in San Juan County, and Tertiary sandstones around the borders of Puget Sound and on the slopes of the Cascades. The Cretaceous sandstones are in many places coarse grained and range in color from gray to various shades of brown. The Tertiary sandstones are fine to coarse grained and vary in color from light gray to dark bluish and dark greenish shades. There are several large sandstone quarries in the State, among which are those at Chuckanut Bay, Whatcom County, Stuart Island and other islands of San Juan County, Wilkeson, Pierce County, and Tenino, Thurston County.

The sandstone at Chuckanut Bay is grayish blue to grayish green in color, inclining toward a dark rather than toward a light shade. The grain is fine and angular. Two grades of stone, according to fineness, are available. Analyses show that silica constitutes 90 per cent of the rock. The cement, which is mainly iron oxide, with a little alumina and magnesia and a trace of lime, holds the grains firmly. The beds that are quarried here are about 40 feet thick, rise with a dip of 55° to a height of more than 100 feet, and extend along the bay for several miles. Tests showed crushing strengths of 10,740 pounds and 11,070 pounds to the square inch, and the fire and quenching tests showed but little effect when heated to 800° F. and suddenly cooled. Freezing and thawing also had but little effect. The stone at Chuckanut Bay is well situated for shipment by rail or by water. It has been used in many Federal, county, and business buildings in the Puget Sound region, and for flagstone. The hardness and fine texture of the stone render it suitable for carved and ornamental work.

Sandstone has been quarried at several places around Reeds Harbor on Stuart Island. The stone varies from fine grained to a coarse conglomerate. The stone is dark colored and is composed of rounded quartz grains cemented by silica and iron oxide. One sample showed a crushing strength of 8,900 pounds to the square inch. Dark colored sandstone of medium grain has been quarried on Sucia Island, which is 3 miles north of East Sound. On Waldron Island a bluish hard sandstone has been quarried for paving blocks.

Light gray medium-grained sandstone, belonging to the Puget group, of Eocene age, is quarried 1 to 1½ miles northeast of Wilkeson. This rock consists mostly of even, angular to subangular quartz grains, but it contains generally a little mica, and in places small flakes of carbonaceous matter and a few grains of feldspar. Analysis shows it to contain 98.05 per cent silica, 0.89 per cent iron oxide, 0.27 per cent alumina, 0.22 per cent lime, and 0.12 per cent magnesia. Crushing tests of samples from the upper layer showed strengths of 7,680 pounds and 7,160 pounds to the square inch, and samples from the lower layer broke at 9,180 pounds and 10,840 pounds. Freezing and thawing tests affected the rock slightly, as did the fire and quenching tests. The darker sandstones were altered to a reddish color by the heat, but the color of the stone near Wilkeson remained unchanged. The rock is used for buildings, railroad work, riprap, and for paving block. The rock splits and trims well for pavers. Although rather soft the stone is tough and is serviceable as a paving block on hilly streets because it does not wear smooth as do some harder rocks.

A light-gray fine-grained sandstone composed mostly of rounded quartz grains with small flakes of mica has been quarried at Fairfax, 6 miles south of Wilkeson. This stone has been used for foundations for coke ovens. A light-colored medium-grained, firmly cemented sandstone with small flakes of muscovite and in places small seams of carbonaceous matter occurs near Cumberland, about 24 miles east of Tacoma. This rock was quarried for building stone about 20 years ago.

At Tenino, Thurston County, are large quarries in a fine, angular grained sandstone that is bluish gray where unweathered and grayish brown to buff where weathered. The stone consists principally of quartz grains with a few flakes of mica held together firmly by ferruginous cement. The rock contains about 90 per cent of silica and is very similar in chemical composition to the stone at Chuckanut Bay. The beds are massive and lie horizontal, so that the quarries are in the form of pits 75 feet or more in depth below the railroad level. Joints are rare and blocks as large as can be handled may be obtained. This sandstone is quarried on a large scale by modern quarrying machinery and is sawed, cut, grooved, planed, and turned in shops at the quarries. The stone is easily cut and is susceptible of delicate carving, and hence is much used for exterior decoration. The crushing strength as shown by records of tests ranges from 5,750 pounds to 6,879 pounds to the square inch. The fire and quenching test affected the coherence of the samples along the edges, and the color of the stone was changed to a brick red by the heat. The post office at Seattle is reported to have been constructed of sandstone from Tenino, and the stone is reported to have been used in the State Capitol at Olympia, the Bailey Building at Seattle, the Calvary Presbyterian Church in San Francisco, and in many other public buildings in the coast cities.

In the description of the Mount Stuart quadrangle Smith[1] gives the following notes on sandstones available for structural purposes:

> The sandstone of the Swank and Roslyn formations is fairly well adapted for construction work. The Swank sandstone is more thoroughly indurated than the Roslyn

[1] Smith, George Otis, U. S. Geol. Survey Geol. Atlas, Mount Stuart folio (No. 106), p. 10, 1904.

sandstone, but the more massive beds occur in localities which are not accessible. Sandstone from the productive portion of the Roslyn formation has been used somewhat in building, but no quarries have been opened. The tuffaceous sandstone of the Ellensburg formation has been used in buildings in Ellensburg, being obtained from a quarry a few miles beyond the southeast corner of the Mount Stuart quadrangle. Usually this stone is too soft and friable for use as a building stone.

Production.—The total production of stone in Washington in 1913 was valued at the quarries at $1,399,475, as compared with $1,174,047 in 1912.

Directory.—Quarries of all kinds of rock quarried in Oregon are listed below by class of rock, county, and town (or post office):

Directory of stone quarries in Washington.

GRANITE.

King County:
1. Baring.
2. Franklin.
3. Snoqualmie.
4. Veazie.

Snohomish County:
5. Granite Falls.

Snohomish County—Continued.
6. Index (4).

Spokane County:
7. Medical Lake (2).
8. Spokane (3) (9 to 12 miles north of).

Whitman County: 9. Granite Point.

DARK VOLCANIC ROCK.

(Basalt, etc.).

Clarke County:
1. Camas.
2. Fisher.

Cowlitz County:
3. Kelso.
4. Olequa.
5. Stella.

King County: 6. Riverton.

Kitsap County: 7. Charleston.

Klickitat County:
8. Goldendale.
9. Klickitat.

Lewis County: 10. Meskill.

Pierce County:
11. Electron.
12. Puyallup.

Skagit County:
13. Deception Pass.
14. Fidalgo.

Spokane County:
15. Marshall.
16. Spokane.

Thurston County: 17. Gate.

Walla Walla County: 18. Dixie.

Whitman County:
19. Colfax.
20. Palouse.
21. Pullman.

Yakima County:
22. North Yakima (4) (6 miles northwest of).
23. Selah.

LIGHT VOLCANIC ROCK.

(Tuff, etc.).

Asotin County: 1. Asotin (2 miles north of).

Mason County: 2. Hoodsport (or Lilliwaup).

Yakima County: 3. North Yakima (1 mile north of).

Stevens County: 4. China Bend and Bossburg.

MARBLE.

Chelan County:
1. Chelan.
2. Leavenworth.

Lincoln County: 3. Miles.

Spokane County: 4. Milan (8 miles north-northwest of).

Stevens County:
5. Addy (8 miles northwest of).
6. Bluecreek.
7. Bossburg.
8. Chewelah (3 to 5 miles east of).
9. Chewelah (2 to 5 miles southwest of).

Stevens County—Continued.
10. Colville (4 miles east-southeast of).
11. Mill Creek (15 miles east-southeast of).
12. Echo (7 miles northeast of).
13. Greenway Mountain.
14. Marble (1 mile northeast of)
15. Ryan.
16. Valley (2 miles east of).
17. Valley (5 miles northwest of).

Whatcom County: 18. Maple Falls.

LIMESTONE.

Chelan County: 1. Chelan.
Ferry County: 2. Keller.
Pend Oreille County: 3. Metaline.
Stevens County: 4. Northport.

LIMESTONE AND LIMEKILNS.

Chelan County:
1. Lakeside.
2. Wenatchee.
Ferry County: 3. Republic (2).
Okanogan County:
4. Chesaw.
5. Okanogan.
San Juan County:
6. Deer Harbor (2).
7. East Sound.
8. Roche Harbor.
9. Friday Harbor.
10. Orcas.
Stevens County: 11. Evans.
Whatcom County: 12. Sumas.

SANDSTONE.

Ferry County: 1. Republic.
Kitsap County: 2. Waterman.
Pierce County: 3. Wilkeson (2).
San Juan County:
4. Eastsound.
5. Stuart Island (5 miles from Roche Harbor).
San Juan County—Continued.
6. Waldron Island (2).
Skagit County: 7. Sedro Woolley.
Thurston County: 8. Tenino (2).
Whatcom County: 9. Chuckanut.

SURVEY PUBLICATIONS ON BUILDING AND OTHER STONE, SLATE, AND ROAD METAL.

The following list comprises the more important publications on stone, slate, and road metal by the United States Geological Survey. These publications, except those to which a price is affixed, can be obtained free by applying to the Director, United States Geological Survey, Washington, D. C. The priced publications may be purchased from the Superintendent of Documents, Government Printing Office, Washington, D. C. The annual volumes on Mineral Resources of the United States between 1882 and 1899 and for 1911, 1912, and 1913, contain besides the statistics of stone production discussions of available stone resources in various parts of the country. Many of the Survey's geologic folios also contain notes on stone resources that may be of local importance. A descriptive price list of folios may be obtained from the Survey.

MISCELLANEOUS PUBLICATIONS.

Alden, W. C., The stone industry in the vicinity of Chicago, Ill.: Bull. 213, pp. 357–360, 1903. 25c.
Bain, H. F., Notes on Iowa building stones: Sixteenth Ann. Rept., pt. 4, pp. 500–503, 1895. $1.20.
Bastin, E. S. (See Leighton, Henry, and Bastin, E. S.)
Burchard, E. F., Concrete materials produced in the Chicago district: Bull. 340, pp. 383–410, 1908. 30c.
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NATURAL GAS.

By B. Hill.

INTRODUCTION.

The year 1913 was the greatest in the history of the natural-gas industry in the United States, surpassing that of any previous year in both the quantity and the value of the gas produced. The returns show a decrease in the quantity and total value of the gas consumed in domestic use in 1913, as compared with 1912, but an increase in the average price per thousand cubic feet. This decrease in domestic consumption in 1913 was offset by the increase in the quantity and value of gas used for industrial purposes, for which there was at the same time an increase in the average price per thousand cubic feet. It will be seen from the reports of the last three years that the quantity and value of natural gas consumed for industrial purposes in the United States, as well as the average price, have been on the increase, and this greater consumption in 1913 indicates the general prosperity in the manufacturing industries of the country during that year.

One of the important features of the natural-gas industry in 1913 was the greater effort made to conserve the natural-gas resources of the country by saving the gas from oil wells by improved methods of drilling, by the installation of a greater number of plants for the extraction of gasoline from casing-head gas, and by the closing in of the "wild" well in Louisiana. Another important feature marking the progress of the natural-gas industry in 1913 was the completion of pipe lines and the successful introduction of gas into cities and towns of Indiana from the great gas fields of West Virginia; and, furthermore, the completion of the pipe line from the Midway field of California to southern California should be noted, and the successful introduction of natural gas into Los Angeles and surrounding cities and towns, the distance from the gas field to points of consumption being about 120 miles.

The total gas production in the United States in 1913 is estimated at 581,898,239,000 cubic feet, valued at $87,846,677, an average price of 15.10 cents per thousand cubic feet, as compared with a production of 562,203,452,000 cubic feet, valued at $84,563,957, an average price of 15.04 cents in 1912, this being an increase of 19,794,787,000 cubic feet in quantity and of $3,282,720 in value. Of this total product, about 32 per cent was utilized for domestic purposes, or 184,885,662,000 cubic feet, valued at $50,522,415, an average price of 27.33 cents per thousand cubic feet, and 68 per cent was utilized for industrial purposes, or 397,012,577,000 cubic feet, valued at $37,324,262, an average price of 9.4 cents per thousand cubic feet.

PRODUCTION AND CONSUMPTION.

The following table gives, by States, the total value of the natural gas produced in the entire country from 1885 to 1913, inclusive:

Approximate value of natural gas produced in the United States, 1885–1913, by States.

State.	1885	1886	1887	1888	1889	1890	1891
Pennsylvania	$4,500,000	$9,000,000	$13,749,500	$19,282,375	$11,593,989	$9,551,025	$7,834,016
New York	196,000	210,000	333,000	332,500	530,026	552,000	280,000
Ohio	100,000	400,000	1,000,000	1,500,000	5,215,669	4,684,300	3,076,325
West Virginia	40,000	60,000	120,000	120,000	12,000	5,400	35,000
Illinois	1,200	4,000	....	....	10,615	6,000	6,000
Indiana	....	300,000	600,000	1,320,000	2,075,702	2,302,500	3,942,500
Kansas	....	6,000	....	....	15,873	12,000	5,500
Missouri	....	....	....	....	35,687	10,500	1,500
California	....	....	....	....	12,680	33,000	30,000
Kentucky and Tennessee	....	....	....	....	2,580	30,000	38,993
Texas and Alabama	....	....	....	....	1,728	....	....
Arkansas and Wyoming	....	....	....	....	375	....	250
Utah	....	....	....	....	....	....	....
Colorado	....	....	....	....	....	....	....
South Dakota	....	....	....	....	....	....	....
Indian Territory and Oklahoma	....	....	....	....	....	....	....
Louisiana	....	....	....	....	....	....	....
Other	20,000	32,000	15,000	75,000	1,600,175	1,606,000	250,000
Total	4,857,200	10,012,000	15,817,500	22,629,875	21,107,099	18,792,725	15,500,084

State.	1892	1893	1894	1895	1896	1897	1898
Pennsylvania	$7,376,281	$6,488,000	$6,279,000	$5,852,000	$5,528,610	$6,242,543	$6,806,742
New York	216,000	210,000	249,000	241,530	256,000	200,076	229,078
Ohio	2,136,000	1,510,000	1,276,100	1,255,700	1,172,400	1,171,777	1,488,308
West Virginia	70,500	123,000	395,000	100,000	640,000	912,528	1,334,023
Illinois	12,988	14,000	15,000	7,500	6,375	5,000	2,498
Indiana	4,716,000	5,718,000	5,437,000	5,203,200	5,043,635	5,009,208	5,060,969
Kansas	40,795	50,000	86,600	112,400	124,750	105,700	174,640
Missouri	3,775	2,100	4,500	3,500	1,500	500	145
California	55,000	62,000	60,350	55,000	55,682	50,000	65,337
Kentucky and Tennessee	43,175	68,500	89,200	98,700	99,000	90,000	103,133
Texas and Alabama	100	50	50	20	....	....	765
Arkansas and Wyoming	100	100	100	100	60	40	....
Utah	....	500	500	20,000	20,000	15,050	7,875
Colorado	....	....	12,000	7,000	4,500	4,000	3,300
South Dakota	....	....	....	....	....	....	....
Indian Territory and Oklahoma	....	....	....	....	....	....	....
Louisiana	....	....	....	....	....	....	....
Other	200,000	100,000	50,000	50,000	50,000	20,000	20,000
Total	14,870,714	14,346,250	13,954,400	13,006,650	13,002,512	13,826,422	15,296,813

Approximate value of natural gas produced in the United States, 1885–1913, by States—Continued.

State.	1899	1900	1901	1902	1903
Pennsylvania	$8,337,210	$10,215,412	$12,688,161	$14,352,183	$16,182,834
New York	294,593	335,367	293,232	346,471	493,686
Ohio	1,866,271	2,178,234	2,147,215	2,355,458	4,479,040
West Virginia	2,335,864	2,959,032	3,954,472	5,390,181	6,882,359
Illinois	2,067	1,700	1,825	1,844	3,310
Indiana	6,680,370	7,254,539	6,954,566	7,081,344	6,098,364
Kansas	332,592	356,900	659,173	824,431	1,123,849
Missouri	290	547	1,328	2,154	7,070
California	86,891	79,083	67,602	120,648	104,521
Texas }	8,000	20,000	18,577	14,953	13,851
Alabama }					
Kentucky }	125,745	286,243	270,871	365,656	390,601
Tennessee }					
Arkansas and Wyoming	....	....	....	....	2,460
Utah	1,480	....	....	....	....
Colorado	3,500	1,800	1,800	1,900	14,140
Oklahoma	....	....	....	360	1,000
South Dakota	....	9,817	7,255	10,280	10,775
Total	20,074,873	23,698,674	27,066,077	30,867,863	35,807,860

State.	1904	1905	1906	1907	1908
Pennsylvania	$18,139,914	$19,197,336	$18,558,245	$18,844,156	$19,104,944
New York	522,575	623,251	672,795	766,157	959,280
Ohio	5,315,564	5,721,462	7,145,809	8,718,562	8,244,835
West Virginia	8,114,249	10,075,804	13,735,343	16,670,962	14,837,130
Illinois	4,745	7,223	87,211	143,577	446,077
Indiana	4,342,409	3,094,134	1,750,715	1,572,605	1,312,507
Kansas	1,517,643	2,261,836	4,010,986	6,198,583	7,691,587
Missouri	6,285	7,390	7,210	17,010	22,592
California	114,195	133,696	134,560	168,397	307,652
Texas	14,082	14,409	150,695	178,276	236,837
Alabama					
Louisiana	....	1,500			
Kentucky	322,404	237,290	287,501	380,176	424,271
Tennessee		300	300	300	350
Arkansas and Wyoming	6,515	21,135	34,500	126,582	164,930
Colorado	14,300	20,752	22,800	....	....
Oklahoma	49,665	130,137	259,862	417,221	860,159
South Dakota	12,215	15,200	15,400	19,500	24,400
North Dakota	....	....	....	235	2,480
Oregon	....	....	....	100	250
Iowa	....	....	....	....	93
Total	38,496,760	41,562,855	46,873,932	54,222,399	54,640,374

State.	1909	1910	1911	1912	1913
Pennsylvania	$20,475,207	$21,057,211	$18,520,796	$18,539,672	$21,695,845
New York	1,222,666	1,678,720	1,418,767	2,343,379	2,425,633
Ohio	9,966,938	8,626,954	9,367,347	11,891,299	10,416,699
West Virginia	17,538,565	23,816,553	28,435,907	33,324,475	34,164,850
Illinois	644,401	613,642	687,726	616,467	574,015
Indiana	1,616,903	1,473,403	1,192,418	1,014,295	948,278
Kansas	8,293,846	7,755,367	4,854,534	4,336,635	3,288,394
Missouri	10,025	12,611	10,496	11,576	6,795
California	446,933	476,697	800,714	1,134,456	1,883,450
Texas	453,253	956,683	1,014,945	1,405,077	2,073,823
Alabama			858,145	1,747,379	2,119,948
Louisiana					
Kentucky	485,192	456,293	407,689	522,455	509,846
Tennessee	350	300	300	375	600
Arkansas and Wyoming	226,925	301,151	295,858	309,816	269,421
Oklahoma	1,806,193	3,490,704	6,731,770	7,334,599	7,436,389
South Dakota	16,164	31,999	16,984	30,412	31,166
North Dakota	3,025	7,010	5,738		
Oregon	50	....	....	....	....
Iowa	50	40	70	120	120
Michigan	255	820	1,330	1,470	1,405
Total	63,206,941	70,756,158	74,621,534	84,563,957	87,846,677

The following table shows the production and consumption of natural gas in 1912 and 1913, by States:

Quantity and value of natural gas produced and consumed in the United States in 1912 and 1913, by States.

1912.

State.	Produced.			Consumed.		
	Quantity (M cubic feet).	Cents per M cubic feet.	Value.	Quantity (M cubic feet).	Cents per M cubic feet.	Value.
West Virginia	239,006,682	13.94	$33,324,475	95,402,248	7.34	$7,001,331
Pennsylvania	112,149,855	16.53	18,539,672	173,656,003	15.25	26,486,302
Ohio	56,210,052	21.16	11,891,299	126,854,659	21.44	27,196,162
Oklahoma	73,799,319	10.04	7,406,528	41,549,403	7.58	3,149,376
Kansas	28,068,370	15.19	4,264,706	[a] 60,318,286	14.13	8,521,858
New York	8,625,979	27.17	2,343,379	16,927,598	28.75	4,866,821
Louisiana, Alabama	14,492,696	12.06	1,747,379	[b] 14,492,696	12.06	1,747,379
Texas	7,470,373	18.81	1,405,077	7,470,373	18.81	1,405,077
California	9,354,428	12.13	1,134,456	9,354,428	12.13	1,134,456
Indiana	3,618,077	28.03	1,014,295	3,618,077	28.03	1,014,295
Illinois	5,603,368	11.00	616,467	5,603,368	11.00	616,467
Kentucky	1,950,881	26.26	522,455	5,102,941	20.98	1,070,664
Arkansas, Colorado, Wyoming	1,742,379	17.78	309,816	1,742,379	17.78	309,816
South Dakota, North Dakota	54,320	55.99	30,412	54,320	55.99	30,412
Missouri	53,013	21.83	11,576	53,013	21.83	11,576
Michigan	1,920	76.56	1,470	1,920	76.56	1,470
Tennessee	1,500	25.00	375	1,500	25.00	375
Iowa	240	50.00	120	240	50.00	120
Total	562,203,452	15.04	84,563,957	562,203,452	15.04	84,563,957

1913.

State.	Quantity (M cubic feet).	Cents per M cubic feet.	Value.	Quantity (M cubic feet).	Cents per M cubic feet.	Value.
West Virginia	245,453,985	13.92	$34,164,850	96,645,438	7.59	$7,333,956
Pennsylvania	118,860,269	18.25	21,695,845	177,463,230	16.18	28,709,565
Ohio	50,311,940	20.70	10,416,699	128,204,722	21.10	27,055,824
Oklahoma	75,017,668	9.91	7,436,389	51,249,294	7.30	3,740,981
Kansas	22,884,547	14.37	3,288,394	[a] 46,652,921	14.97	6,983,802
New York	8,515,257	28.50	2,425,633	16,738,545	29.20	4,888,412
Louisiana, Alabama	26,652,626	7.95	2,119,948	[b] 26,652,626	7.95	2,119,948
Texas	12,159,755	17.05	2,073,823	12,159,755	17.05	2,073,823
California	11,034,597	17.07	1,883,450	11,034,597	17.07	1,883,450
Indiana	[c] 3,220,885	29.44	948,278	3,220,885	29.44	948,278
Illinois	4,767,128	12.04	574,015	4,767,128	12.04	574,015
Kentucky	1,821,526	27.99	509,846	5,911,042	20.73	1,225,116
Arkansas, Colorado, Wyoming	1,106,374	24.35	269,421	1,106,374	24.35	269,421
South Dakota, North Dakota	66,492	46.87	31,166	66,492	46.87	31,166
Missouri	20,865	32.57	6,795	20,865	32.57	6,795
Michigan	1,805	77.84	1,405	1,805	77.84	1,405
Tennessee	2,400	25.00	600	2,400	25.00	600
Iowa	120	100.00	120	120	100.00	120
Total	581,898,239	15.10	87,846,677	581,898,239	15.10	87,846,677

[a] Includes gas piped from Kansas and consumed in Missouri; also gas piped from Oklahoma into Kansas and Missouri.
[b] Includes gas piped from Louisiana to Texas and from Louisiana to Arkansas.
[c] Includes gas piped into Indiana from West Virginia.

In the following tables is given the distribution of natural gas consumed in 1912 and 1913, by States:

Distribution of natural gas consumed in the United States in 1912, by States.

State.	Number of producers.	Consumers.		Gas consumed.		
				Domestic.		
		Domestic.	Industrial.	Quantity (M cubic feet).	Cents per M cubic feet.	Value.
Ohio	2,031	641,724	4,414	67,150,744	28.92	$19,420,086
Pennsylvania	1,104	345,765	3,442	49,331,092	24.64	12,153,254
Kansas [a]	253	195,446	1,104	24,821,582	24.25	6,018,363
West Virginia [b]	406	94,273	1,953	16,180,778	18.11	2,930,628
New York	332	129,930	805	15,329,811	29.90	4,583,414
Oklahoma	242	47,017	1,651	6,500,062	19.83	1,288,894
Louisiana [c]	41	31,105	528	2,871,707	28.04	805,265
Alabama	9	152	4			
Texas	41	27,226	329	2,341,628	38.71	906,412
California	43	18,171	232	974,796	53.90	525,428
Kentucky	88	45,603	103	2,762,571	30.38	839,346
Indiana [d]	1,140	27,165	140	2,989,648	30.51	912,252
Illinois [e]	223	10,691	212	1,236,162	23.62	291,987
Arkansas	6	5,601	16			
Colorado	16	1,211	12	871,628	28.62	249,501
Wyoming	8	363	4			
South Dakota	32	403	3	44,420	56.31	25,012
North Dakota	13	162	....			
Missouri	45	500	11	45,413	20.98	9,526
Michigan	21	14	2	1,020	100.00	1,020
Tennessee	7	3	....	1,500	25.00	375
Iowa	5	3	....	240	50.00	120
Total	6,106	1,622,528	14,965	193,454,802	26.34	50,960,883

State.	Gas consumed.					
	Industrial.			Total.		
	Quantity (M cubic feet).	Cents per M cubic feet.	Value.	Quantity (M cubic feet).	Cents per M cubic feet.	Value.
Ohio	59,703,915	13.02	$7,776,076	126,854,659	21.44	$27,196,162
Pennsylvania	124,324,911	11.53	14,333,048	173,656,003	15.25	26,486,302
Kansas [a]	35,496,704	7.05	2,503,495	60,318,286	14.13	8,521,858
West Virginia [b]	79,221,470	5.14	4,070,703	95,402,248	7.34	7,001,331
New York	1,597,787	17.74	283,407	16,927,598	28.75	4,866,821
Oklahoma	35,049,341	5.31	1,860,482	41,549,403	7.58	3,149,376
Louisiana [c]	11,620,989	8.11	942,114	14,492,696	12.06	1,747,379
Alabama						
Texas	5,128,745	9.72	498,665	7,470,373	18.81	1,405,077
California	8,379,632	7.27	609,028	9,354,428	12.13	1,134,456
Kentucky	2,340,370	9.88	231,318	5,102,941	20.98	1,070,664
Indiana [d]	628,429	16.24	102,043	3,618,077	28.03	1,014,295
Illinois [e]	4,367,206	7.43	324,480	5,603,368	11.00	616,467
Arkansas						
Colorado	870,751	6.93	60,315	1,742,379	17.78	309,816
Wyoming						
South Dakata	9,900	54.55	5,400	54,320	55.99	30,412
North Dakota						
Missouri	7,600	26.97	2,050	53,013	21.83	11,576
Michigan	900	50.00	450	1,920	76.56	1,470
Tennessee	....	....	....	1,500	25.00	375
Iowa	....	....	....	240	50.00	120
Total	368,748,650	9.11	33,603,074	562,203,452	15.04	84,563,957

[a] Includes the consumption of gas piped from Kansas to Missouri and from Oklahoma to Kansas and Missouri.
[b] Includes the consumption of gas piped from West Virginia to Maryland.
[c] Includes the consumption of gas piped to Texas from Louisiana and to Arkansas from Louisiana.
[d] Includes the consumption of gas piped from Indiana to Chicago, Ill.
[e] Includes the consumption of gas piped from Illinois to Vincennes, Ind.

Distribution of natural gas consumed in the United States in 1913, by States.

State.	Number of producers.	Consumers.		Gas consumed.		
				Domestic.		
		Domestic.	Industrial.	Quantity (M cubic feet).	Cents per M cubic feet.	Value.
Pennsylvania	1,174	400,823	4,373	46,699,256	26.82	$12,524,478
Ohio	2,056	685,956	5,010	64,732,832	28.82	18,658,295
West Virginia [a]	451	101,234	1,834	15,524,692	19.32	2,999,005
Kansas [b]	305	195,131	950	20,550,852	24.22	4,977,137
New York	366	136,830	639	15,050,594	30.41	4,577,469
Oklahoma	347	49,308	1,793	7,039,196	17.85	1,256,818
Louisiana [c]	57	33,424	604	3,231,608	27.71	895,524
Alabama	7	340	3			
Texas	50	37,350	393	3,359,854	38.30	1,286,667
California	48	164,358	141	1,632,337	67.43	1,100,702
Kentucky	93	54,446	146	2,873,530	32.26	926,950
Indiana [d]	1,100	39,776	239	2,588,120	31.85	824,430
Illinois [e]	231	10,423	279	898,677	25.69	230,851
Arkansas	6	5,836	11			
Colorado	15	1,212	9	650,768	36.39	236,826
Wyoming	11	353	7			
South Dakota	32	397	5	31,922	61.16	19,523
North Dakota	13	62	....			
Missouri	52	342	7	17,899	33.61	6,015
Michigan	19	19	1	1,005	100.00	1,005
Tennessee	7	4	....	2,400	25.00	600
Iowa	5	3	....	120	100.00	120
Total	6,445	1,917,627	16,444	184,885,662	27.33	50,522,415

State.	Gas consumed.					
	Industrial.			Total.		
	Quantity (M cubic feet).	Cents per M cubic feet.	Value.	Quantity (M cubic feet).	Cents per M cubic feet.	Value.
Pennsylvania	130,763,974	12.38	$16,185,087	177,463,230	16.18	$28,709,565
Ohio	63,471,890	13.23	8,397,529	128,204,722	21.10	27,055,824
West Virginia [a]	81,120,746	5.34	4,334,951	96,645,438	7.59	7,333,956
Kansas [b]	26,102,069	7.69	2,006,665	46,652,921	14.97	6,983,802
New York	1,687,951	18.42	310,943	16,738,545	29.20	4,888,412
Oklahoma	44,210,098	5.62	2,484,163	51,249,294	7.30	3,740,981
Louisiana [c]	23,421,018	5.23	1,224,424	26,652,626	7.95	2,119,948
Alabama						
Texas	8,799,901	8.95	787,156	12,159,755	17.05	2,073,823
California	9,402,260	8.33	782,748	11,034,597	17.07	1,883,450
Kentucky	3,037,512	9.82	298,166	5,911,042	20.73	1,225,116
Indiana [d]	632,765	19.57	123,848	3,220,885	29.44	948,278
Illinois [e]	3,868,451	8.87	343,164	4,767,128	12.04	574,015
Arkansas						
Colorado	455,606	7.15	32,595	1,106,374	24.35	269,421
Wyoming						
South Dakota	34,570	33.68	11,643	66,492	46.87	31,166
North Dakota						
Missouri	2,966	26.30	780	20,865	32.57	6,795
Michigan	800	50.00	400	1,805	77.84	1,405
Tennessee	....	....	....	2,400	25 00	600
Iowa	....	....	....	120	100 00	120
Total	397,012,577	9.40	37,324,262	581,898,239	15.10	87,846,677

[a] Includes the consumption of gas piped from West Virginia to Maryland.
[b] Includes the consumption of gas piped from Kansas to Missouri and from Oklahoma to Kansas and Missouri.
[c] Includes the consumption of gas piped to Texas from Louisiana and to Arkansas from Louisiana.
[d] Includes the consumption of gas piped from Indiana to Chicago, Ill., and from West Virginia to Indiana.
[e] Includes the consumption of gas piped from Illinois to Vincennes, Ind.

The following tables give the distribution of gas consumed for industrial purposes in 1912 and 1913, by States:

Distribution of gas consumed for industrial purposes in 1912, by States.

State.	Industrial consumers.			Gas consumed.		
				Manufacturing.		
	Manufacturing.	Other industrial (power).	Total.	Quantity (M cubic feet).	Cents per M cubic feet.	Value.
Pennsylvania	1,987	1,455	3,442	114,617,963	11.45	$13,127,440
Ohio	2,768	1,646	4,414	43,300,321	12.86	5,568,386
West Virginia	888	1,065	1,953	59,189,820	5.07	2,998,754
Kansas	959	145	1,104	32,353,405	6.94	2,246,186
Oklahoma	288	1,363	1,651	20,915,974	4.56	954,498
Louisiana, Alabama	150	382	532	2,992,216	8.38	250,803
California	....	232	232	....	....	....
Texas	(a)	329	329	(a)	....	(a)
Illinois	26	186	212	948,415	10.00	95,088
New York	11	794	805	354,333	16.51	58,518
Kentucky	19	84	103	1,671,287	7.97	133,220
Indiana	20	120	140	223,547	18.19	40,675
Arkansas, Colorado, Wyoming	(a)	32	32	(a)	....	(a)
South Dakota, North Dakota	....	3	3	....	....	....
Missouri	....	11	11	....	....	....
Michigan	....	2	2	....	....	....
Total	7,116	7,849	14,965	276,567,281	9.21	25,473,568

State.	Gas consumed.					
	Other industrial (power).			Total industrial.		
	Quantity (M cubic feet).	Cents per M cubic feet.	Value.	Quantity (M cubic feet).	Cents per M cubic feet.	Value.
Pennsylvania	9,706,948	12.42	$1,205,608	124,324,911	11.53	$14,333,048
Ohio	16,403,594	13.46	2,207,690	59,703,915	13.02	7,776,076
West Virginia	20,031,650	5.35	1,071,949	79,221,470	5.14	4,070,703
Kansas	3,143,299	8.19	257,309	35,496,704	7.05	2,503,495
Oklahoma	14,133,367	6.41	905,984	35,049,341	5.31	1,860,482
Louisiana, Alabama	8,628,773	8.01	691,311	11,620,989	8.11	942,114
California	8,379,632	7.27	609,028	8,379,632	7.27	609,028
Texas	5,128,745	9.72	498,665	5,128,745	9.72	498,665
Illinois	3,418,791	6.71	229,392	4,367,206	7.43	324,480
New York	1,243,454	18.09	224,889	1,597,787	17.74	283,407
Kentucky	669,083	14.66	98,098	2,340,370	9.88	231,318
Indiana	404,882	15.16	61,368	628,429	16.24	102,043
Arkansas, Colorado, Wyoming	870,751	6.93	60,315	870,751	6.95	60,315
South Dakota, North Dakota	9,900	54.55	5,400	9,900	54.55	5,400
Missouri	7,600	26.97	2,050	7,600	26.97	2,050
Michigan	900	50.00	450	900	50.00	450
Total	92,181,369	8.82	8,129,506	368,748,650	9.11	33,603,074

a Included in Other industrial.

Distribution of gas consumed for industrial purposes in 1913, by States.

State.	Industrial consumers.			Gas consumed.		
				Manufacturing.		
	Manufacturing.	Other industrial (power).	Total.	Quantity (M cubic feet).	Cents per M cubic feet.	Value.
Pennsylvania	2,134	2,239	4,373	117,073,829	12.25	$14,338,228
Ohio	3,523	1,487	5,010	49,663,270	13.03	6,472,271
West Virginia	694	1,140	1,834	57,366,691	5.17	2,965,776
Oklahoma	325	1,468	1,793	22,947,560	4.72	1,083,154
Kansas	225	725	950	17,110,874	6.64	1,136,007
Louisiana, Alabama	121	486	607	3,144,472	8.04	252,834
Texas	(a)	393	393	(a)	....	(a)
California	....	141	141	....	....	....
Illinois	22	257	279	643,813	13.83	89,057
New York	100	539	639	364,395	20.14	73,387
Kentucky	20	126	146	2,253,057	8.28	186,520
Indiana	85	154	239	263,079	24.47	64,375
Arkansas, Colorado, Wyoming	(a)	27	27	(a)	....	(a)
South Dakota, North Dakota	....	5	5	....	....	....
Missouri	....	7	7	....	....	....
Michigan	....	1	1	....	....	....
Total	7,249	9,195	16,444	270,831,040	9.84	26,661,609

State.	Gas consumed.					
	Other industrial (power).			Total industrial.		
	Quantity (M cubic feet).	Cents per M cubic feet.	Value.	Quantity (M cubic feet).	Cents per M cubic feet.	Value.
Pennsylvania	13,690,145	13.49	$1,846,859	130,763,974	12.38	$16,185,087
Ohio	13,808,620	13.94	1,925,258	63,471,890	13.23	8,397,529
West Virginia	23,754,055	5.76	1,369,175	81,120,746	5.34	4,334,951
Oklahoma	21,262,538	6.59	1,401,009	44,210,098	5.62	2,484,163
Kansas	8,991,195	9.68	870,658	26,102,069	7.69	2,006,665
Louisiana, Alabama	20,276,546	4.79	971,590	23,421,018	5.23	1,224,424
Texas	8,799,901	8.95	787,156	8,799,901	8.95	787,156
California	9,402,260	8.33	782,748	9,402,260	8.33	782,748
Illinois	3,224,638	7.88	254,107	3,868,451	8.87	343,164
New York	1,323,556	17.95	237,556	1,687,951	18.42	310,943
Kentucky	784,455	14.23	111,646	3,037,512	9.82	298,166
Indiana	369,686	16.09	59,473	632,765	19.57	123,848
Arkansas, Colorado, Wyoming	455,606	7.15	32,595	455,606	7.15	32,595
South Dakota, North Dakota	34,570	33.68	11,643	34,570	33.68	11,643
Missouri	2,966	26.30	780	2,966	26.30	780
Michigan	800	50.00	400	800	50.00	400
Total	126,181,537	8.45	10,662,653	397,012,577	9.40	37,324,262

a Included in Other industrial.

The following table gives the value of natural gas consumed in the United States from 1908 to 1913, inclusive, by States:

Value of natural gas consumed in the United States, 1908–1913, by States.

State.	1908	1909	1910	1911	1912	1913
Pennsylvania	$20,678,161	$21,639,102	$23,934,691	$23,940,001	$26,486,302	$28,709,565
Ohio	15,166,434	18,884,312	21,210,965	22,792,270	27,196,162	27,055,824
West Virginia	[a] 4,020,282	[a] 5,183,054	[a] 5,617,910	[a] 6,240,152	[a] 7,001,331	[a] 7,333,956
Kansas	[b] 7,691,587	[b] 8,356,076	[b] 9,335,027	[b] 9,493,701	[b] 8,521,858	[b] 6,983,802
New York	3,281,312	3,286,523	3,963,872	4,276,324	4,866,821	4,888,412
Oklahoma	860,159	1,743,963	1,911,044	2,092,603	3,149,376	3,740,981
Indiana	[c] 1,312,507	[c] 1,616,903	[c] 1,473,403	[c] 1,192,418	[c] 1,014,295	[c] 948,278
Texas				1,014,945	1,405,077	2,073,823
Louisiana	236,837	453,253	956,683	[d] 858,145	[d] 1,747,379	[d] 2,119,948
Alabama						
Kentucky	424,271	695,577	908,293	901,759	1,070,664	1,225,116
California	307,652	446,933	476,697	800,714	1,134,456	1,883,450
Illinois	[e] 446,077	[e] 644,401	[e] 613,642	[e] 687,726	[e] 616,467	[e] 574,015
Arkansas						
Colorado	164,930	226,925	301,151	295,858	309,816	269,421
Wyoming						
Missouri	22,592	10,025	12,611	10,496	11,576	6,795
South Dakota	24,400	16,164	31,999	16,984	30,412	31,166
North Dakota	2,480	3,025	7,010	5,738		
Michigan	....	255	820	1,330	1,470	1,405
Tennessee	350	350	300	300	375	600
Iowa	93	50	40	70	120	120
Oregon	250	50	....	....	....	....
Total	54,640,374	63,206,941	70,756,158	74,621,534	84,563,957	87,846,677

[a] Includes value of gas piped from West Virginia to Maryland.
[b] Includes value of gas piped from Kansas to Missouri in 1908 and 1909, and from Kansas and Oklahoma to Missouri in 1910, 1911, 1912, and 1913.
[c] A portion of this was consumed in Chicago, Ill.
[d] Includes value of gas piped from Louisiana to Texas and Arkansas.
[e] Includes value of gas produced in Illinois and consumed in Vincennes, Ind.

COMBINED VALUE OF NATURAL GAS AND PETROLEUM.

The following tables give the value of natural gas and of petroleum and their combined value in 1912 and 1913, by States, arranged in the order of the value of the combined production:

Value of the natural gas and petroleum produced in 1912 and 1913, and their combined value, by States.

1912.

State.	Value of natural gas.	Value of crude petroleum.	Value of natural gas and crude petroleum.
West Virginia	$33,324,475	$19,927,721	$53,252,196
Oklahoma	7,406,528	34,672,604	42,079,132
California	1,134,456	39,624,501	40,758,957
Pennsylvania	18,539,672	12,886,752	31,426,424
Illinois	616,467	24,332,605	24,949,072
Ohio	11,891,299	12,085,998	23,978,767
Michigan	1,470		
Texas	1,405,077	8,852,713	10,257,790
Louisiana	1,747,379	7,023,827	8,771,206
Alabama		....	
Kansas	4,264,706	1,095,698	5,360,404
New York	2,343,379	1,401,880	3,745,259
Indiana	1,014,295	885,975	1,900,270
Utah	....	798,470	1,307,947
Wyoming	309,816		
Colorado		199,661	
Arkansas			
Kentucky	522,455	424,842	947,297
South Dakota	30,412	....	30,412
North Dakota			
Missouri	11,576	....	11,576
Tennessee	375	....	375
Iowa	120	....	120
Total	84,563,957	164,213,247	248,777,204

Value of the natural gas and petroleum produced in 1912 and 1913, and their combined value, by States—Continued.

1913.

State.	Value of natural gas.	Value of crude petroleum.	Value of natural gas and crude petroleum.
Oklahoma	$7,436,389	$59,581,948	$67,018,337
West Virginia	34,164,850	28,828,814	62,993,664
California	1,883,450	45,661,400	47,544,850
Pennsylvania	21,695,845	19,805,452	41,501,297
Illinois	574,015	30,971,910	31,545,925
Ohio	10,416,699	17,538,452	27,955,151
Texas	2,073,823	14,675,593	16,749,416
Louisiana }	2,119,948	12,255,931	14,375,879
Alabama }		....	
Kansas	3,288,394	2,248,283	5,536,677
New York	2,425,633	2,169,357	4,594,990
Indiana	948,278	1,279,226	2,227,504
Arkansas }	269,421	....	1,631,432
Colorado }		174,779	
Wyoming }		1,187,232	
Kentucky	509,846	675,748	1,185,594
Missouri	6,795	67,263	75,463
Michigan	1,405		
New Mexico	....		
Alaska	....		
South Dakota }	31,166	....	31,166
North Dakota }			
Tennessee	600	....	600
Iowa	120	....	120
Total	87,846,677	237,121,388	324,968,065

WELL RECORD.

The following table gives the record of natural gas wells in 1913, by States:

Record of natural gas wells in 1913, by States.

State.	Productive Dec. 31, 1912.	Drilled in 1913.			Abandoned in 1913.	Productive Dec. 31, 1913.
		Gas.	Dry.	Total.		
Alabama	19	....	7	7	1	18
Arkansas	97	3	1	4	2	98
California	71	9	4	13	8	[a] 72
Colorado	8	....	....	....	3	5
Illinois	453	60	119	179	58	455
Indiana	2,547	69	24	93	246	2,370
Iowa	6	....	....	....	....	6
Kansas	2,106	506	253	759	315	2,297
Kentucky	267	23	7	30	20	270
Louisiana	155	53	24	77	18	190
Michigan	19	....	....	....	1	[a] 18
Missouri	70	6	....	6	16	60
Montana	....	1	....	1	....	1
New York	1,736	200	54	254	56	1,880
North Dakota	24	....	....	....	7	[a] 17
Ohio	5,163	408	235	643	358	5,213
Oklahoma	936	423	298	721	307	1,052
Pennsylvania	11,543	1,011	259	1,270	299	12,255
South Dakota	35	2	....	2	2	[b] 35
Tennessee	6	2	....	2	....	8
Texas	87	43	29	72	7	123
West Virginia	5,533	1,038	128	1,166	108	6,463
Wyoming	24	4	....	4	....	28
Total	30,905	3,861	1,442	5,303	1,832	32,934

[a] Includes some artesian wells from which gas is used. [b] Artesian wells from which gas is used.

ACREAGE CONTROLLED BY NATURAL-GAS COMPANIES.

The following table shows the number of acres of land held by natural-gas companies in 1912 and 1913, and whether the acreage was owned in fee or leased:

Acreage controlled by natural-gas companies in 1912 and 1913, by States.

State.	1912				1913			
	In fee.	Leased.	Gas rights.	Total.	In fee.	Leased.	Gas rights.	Total.
Alabama	570	216,000	....	216,570	70	170,200	....	170,270
Arkansas	600	20,059	....	20,659	600	8,131	....	8,731
California	2,434	7,690	....	10,124	3,160	1,774	4,960	9,894
Colorado	....	195	....	195	1,080	35	....	1,115
Illinois	3,568	165,337	17,342	186,247	1,687	174,766	2,032	178,485
Indiana	120,020	173,979	8,692	302,691	117,141	177,436	1,758	296,335
Kansas	25,405	366,475	17,870	409,750	32,217	406,046	13,945	452,208
Kentucky	2,970	113,947	....	116,917	3,348	141,840	636	145,824
Louisiana	15,625	301,664	....	317,289	19,896	343,871	4,414	368,181
Missouri	4,077	1,660	....	5,737	1,403	....	....	1,403
New York	10,689	490,506	1,205	502,400	14,220	447,112	74,212	535,544
Ohio	14,834	1,711,552	29,781	1,756,167	20,026	1,393,073	102,463	1,515,562
Oklahoma	7,047	1,058,144	95,857	1,161,048	18,943	1,242,701	149,834	1,411,478
Pennsylvania	115,242	1,675,116	397,030	2,187,388	146,472	1,684,925	380,043	2,211,440
Tennessee	500	....	....	500	500	....	....	500
Texas	7,660	153,919	6,369	167,948	14,857	508,776	16,910	540,543
West Virginia	124,880	2,202,642	691,794	3,019,316	111,712	2,521,253	522,786	3,155,751
Wyoming	2,968	3,970	....	6,938	2,328	16,368	....	18,696
Total	459,089	8,682,855	1,265,940	10,407,884	509,660	9,238,307	1,273,993	11,021,960

NATURAL-GAS INDUSTRY, BY STATES.

PENNSYLVANIA.

The production of natural gas in Pennsylvania in 1913 was the largest ever recorded, amounting to 118,860,269,000 cubic feet, valued at $21,695,845, as compared with 112,149,855,000 cubic feet, valued at $18,539,672, in 1912, an increase of 6,710,414,000 cubic feet in quantity and of $3,156,173 in value.

The reports show unusual activity in the gas fields of the State in 1913, there having been a total of 1,011 productive gas wells and 259 dry holes completed. Some wells equal to those drilled in the early days of the natural-gas industry in this State were completed in 1913. In Allegheny County, where gas was piped and used for manufacturing in the Pittsburgh district as early as 1875, one well was drilled in 1913 which, at a depth of 2,300 feet, had an initial rock pressure of from 800 to 1,000 pounds; another, at a depth of 1,694 feet, had 645 pounds pressure, and two others, at a depth of 2,120 feet, had 400 pounds pressure. Throughout all the gas-producing fields of the State large quantities of gas are purchased at wells from producers by the large gas-distributing companies for distribution to consumers. In Clarion, Forest, Elk, and Jefferson counties are many gas wells ranging from 300 to 700 or 800 pounds in pressure. A new field of some importance was developed in 1913 in Elk County, where, at a depth of from 2,450 to 3,000 feet, about 11 gas wells, with a rock pressure of from 500 to 980 pounds, were drilled. A small gas field was also discovered in Indiana County, where a few wells of 600 pounds pressure were drilled at a depth of 1,646 feet; no gas has been sold from these wells. Throughout the counties of Butler, McKean, Warren, Venango, and Potter large quantities of gas are produced from the oil wells, which is used for both domestic and industrial purposes and add largely to the supply of this State. The gas from these wells is also rich in gasoline, and several plants for the extraction of gasoline from the gas have been installed, an account of which industry appears in another part of this report.

The State of Pennsylvania again takes the lead in both quantity and value of gas consumed in the United States in 1913. In 1912 Ohio led in the value of gas consumed, Pennsylvania taking first place in the quantity of gas consumed. The total gas consumption in Pennsylvania aggregated 177,463,230,000 cubic feet in 1913, valued at $28,709,565, an average of 16.18 cents per thousand cubic feet, as compared with 173,656,003,000 cubic feet in 1912, valued at $26,486,302, an average of 15.25 cents per thousand cubic feet, a gain of 3,807,227,000 cubic feet in quantity and of $2,223,263 in value.

The reports show that of this enormous consumption nearly three-fourths the quantity and more than half the value was for gas supplied for industrial use, which amounted to 130,763,974,000 cubic feet, valued at $16,185,087, an average of 12.38 cents per thousand cubic feet, as compared with 124,324,911,000 cubic feet, valued at $14,333,048, an average of 11.53 cents per thousand cubic feet, in 1912, an increase of 6,439,063,000 cubic feet in quantity and of $1,852,039 in value. Reference to the table showing the distribution of gas consumed in 1913 for industrial purposes, by States, shows that 117,073,829,000 cubic feet, valued at $14,338,228, or nearly 90 per cent, was supplied for manufacturing in this State. The excellence of natural gas as a fuel in all branches of the iron, steel, and glass industries was demonstrated years ago in the Pittsburgh district, the center of the manufacturing industry of western Pennsylvania, and the demand for it continues, notwithstanding the fact that this district has at its very doors fields of excellent coal sufficient for all purposes.

The consumption of natural gas in Pennsylvania in 1913 for domestic purposes was 46,699,256,000 cubic feet, valued at $12,524,478, or 26.82 cents per thousand cubic feet, as compared with 49,331,092,000 cubic feet, valued at $12,153,254, in 1912, an average of 24.64 cents per thousand cubic feet, a decrease in quantity but an increase in value of gas consumed, the average price per thousand cubic feet having advanced 2.18 cents.

As has been stated in previous reports, considerable quantities of the gas consumed in Pennsylvania is piped into the State from West Virginia. On the other hand, large supplies of gas are piped from the Pennsylvania gas fields to New York, Ohio, and West Virginia. The quantity of gas piped to New York alone amounted in 1913 to 8,223,288,000 cubic feet. The difference between the production and the consumption of natural gas (plus exports) in Pennsylvania shows the quantity and value of the gas piped into this State from West Virginia, which, in 1913, approximated 58,602,961,000 cubic feet, valued at

$7,013,720, as compared with 61,506,148,000 cubic feet, valued at $7,946,630, in 1912, a decrease of 2,903,187,000 cubic feet in the quantity of gas imported. The values represent the price received for the gas at the point of consumption. These figures show that the quantity of gas imported into Pennsylvania from West Virginia in 1913 was almost equal to one-half of the gas produced in the State of Pennsylvania in 1913.

The number of productive gas wells in Pennsylvania at the close of 1913 was 12,255, of which 1,011 were drilled in that year. The number of gas wells abandoned in 1913 was 299.

In the following table is given a record of the natural-gas industry in Pennsylvania from 1897 to 1913, inclusive:

Record of the natural-gas industry in Pennsylvania, 1897–1913.

Year.	Gas produced.		Gas consumed.			Wells.		
	Number of producers.	Value.	Number of consumers.		Value.	Drilled.		Productive Dec. 31.
			Domestic.	Industrial.		Gas.	Dry.	
1897	176	$6,242,543	a 201,059	1,124	$5,392,661	314	96	2,467
1898	232	6,806,742	a 213,410	1,021	6,064,477	373	74	2,840
1899	281	8,337,210	a 232,060	1,236	7,926,970	467	104	3,303
1900	266	10,215,412	a 229,730	1,296	9,812,615	513	142	3,776
1901	296	12,688,161	a 326,912	1,743	11,785,996	660	143	4,436
1902	379	14,352,183	185,678	2,448	13,942,783	775	232	5,211
1903	414	16,182,834	214,432	2,834	16,060,196	699	126	5,910
1904	414	18,139,914	238,481	2,929	17,205,804	701	174	6,352
1905	351	19,197,336	257,416	2,845	19,237,218	765	168	6,566
1906	309	18,558,245	273,184	3,307	21,085,077	603	153	7,300
1907	344	18,844,156	295,115	3,812	22,917,547	769	180	8,051
1908	b 572	19,104,944	307,585	4,577	20,678,161	571	147	c 8,831
1909	b 777	20,475,207	294,781	5,377	21,639,102	756	166	c 9,499
1910	b 819	21,057,211	321,430	4,102	23,934,691	857	161	c 10,337
1911	b 1,067	18,520,796	330,537	4,597	23,940,001	832	224	c 10,885
1912	b 1,104	18,539,672	345,765	3,442	26,486,302	993	219	c 11,543
1913	b 1,174	21,695,845	400,823	4,373	28,709,565	1,011	259	c 12,255

a Number of fires supplied.
b Includes 216 producers having shallow wells in Erie County for their own domestic consumption in 1908, 311 producers in 1909, 345 producers in 1910, 399 in 1911, and 401 in 1912 and 1913.
c Includes 350 shallow wells in Erie County in 1908, 429 in 1909, 429 in 1910, 476 in 1911, and 492 in 1912 and 1913.

In the following table are given the depth and gas pressure of wells in Pennsylvania from 1909 to 1913, inclusive, by counties:

Depth and gas pressure of wells in Pennsylvania, 1909–1913, by counties.

County.	Depth, in feet.	Pressure, in pounds.				
		1909	1910	1911	1912	1913
Allegheny	900–3,265	10–600	10–600	10– 800	10– 500	15–*a*1,000
Armstrong	702–3,450	25–900	3–800	3– 435	5– 900	1– 500
Beaver	700–2,000	4–600	4– 75		30– 70	30– 510
Butler	700–3,384	30–600	6–700	4– 800	2– 700	4– 850
Clarion	600–3,000	8–800	25–900	5– 900	1– 900	2– 800
Elk	500–3,200	50–990	50–990	40– 900	60– 840	50– *a* 980
Crawford / Erie	550–1,200 / 300–1,600	1– 85	0– 85	0– 100	2– 100	10– 50
Fayette / Cambria	1,750–2,772 / 2,350–2,500	100–700	100–650	40– 600	35– 700	35– 700
Forest	700–2,900	15–145	10–850	6– 150	5– 800	17– 700
Greene	680–3,600	50–500	40–400	40– 900	60– 575	39– 750
Indiana	1,100–1,646					600
Jefferson	700–3,360	10–635	100–700	60–1,200	90–1,000	100– 960
McKean	750–3,000	30–600	6–600	5– 850	1– 950	3– 800
Mercer / Lawrence	700–1,500	40		160– 250	190	51– 300
Potter	750–2,200	60–500	50–300	35– 500	10– 360	20– 600
Tioga	700–1,400	250	300	13– 350		
Venango	350–2,110	20–250	10– 85	10– 500	15– 200	10– 200
Warren	500–3,290	20– 50	10–190	3– 200	10– 350	5– 280
Washington	606–3,304	12–500	5–800	5– 600	5– 550	5– 400
Westmoreland	1,675–3,300	50–180	10– 25	60– 250	15– 20	6–*a*1,000

a New well.

NEW YORK.

There has been little change in the natural-gas situation in New York since the report for 1912. The quantity of gas produced in 1913 is estimated at 8,515,257,000 cubic feet, as compared with 8,625,979,000 cubic feet in 1912, a decrease of 110,722,000 cubic feet. On the other hand, the value of the gas produced increased from $2,343,379 in 1912 to $2,425,633 in 1913, which exceeded that of any previous year and was $82,254 greater than that of 1912.

Considerable development work was undertaken in New York in 1913 and some very good gas wells were completed. Three wells with a pressure of about 500 pounds were completed in Genesee County. One well, with about 300 pounds pressure, was drilled in Orleans County, but it has been closed in. Erie County continues to furnish considerable gas from wells located in the vicinity of Orchard Park and Hamburg. Wells in Allegany and Cattaraugus counties also added considerable gas to the supply of the State. Conditions in other counties of the State show little change as compared with 1912, except slightly decreasing pressure.

As has already been stated in previous reports, New York imports considerable gas from Pennsylvania. During the year 1913 the total quantity of gas piped into this State was estimated at 8,223,288,000 cubic feet, a quantity almost equal to the total production. The quantity of gas consumed in New York declined from 16,927,598,000 cubic feet in 1912 to 16,738,545,000 cubic feet in 1913, while the total value increased from $4,866,821 in 1912 to $4,888,412 in 1913, a value greater than that of any preceding year. The average price of gas per thousand cubic feet advanced from 28.75 cents in 1912 to 29.20 cents in 1913.

Reference to the table of distribution of gas by States shows that the greater portion of the gas consumed in New York is used for domestic purposes, the quantity so used in 1913 being 15,050,-594,000 cubic feet, valued at $4,577,469, an average of 30.41 cents per thousand cubic feet, while the quantity so used for industrial purposes was 1,687,951,000 cubic feet, valued at $310,943, an average of 18.42 cents per thousand cubic feet. The larger proportion of the gas consumed in this State for industrial purposes is used for the generation of power in gas engines and under boilers, a small quantity only being consumed for manufacturing. It is estimated that the consumption of gas for power in 1913 amounted to 1,323,-556,000 cubic feet, valued at $237,556, and for manufacturing to 364,395,000 cubic feet, valued at $73,387.

The number of domestic consumers supplied in New York increased from 129,930 in 1912 to 136,830 in 1913, whereas the number of industrial consumers decreased from 805 to 639.

The number of productive gas wells in this State at the close of 1913 was 1,880, of which 200 were completed during the year. The number of dry holes drilled in 1913 was 54, and 56 gas wells were abandoned.

The estimated acreage held by gas companies in this State was 535,544 acres at the close of 1913, as compared with 502,400 acres at the close of 1912, an increase of 33,144 acres.

In the following table is given a record of the natural-gas industry in New York from 1897 to 1913, inclusive:

Record of natural-gas industry in New York, 1897–1913.

Year.	Gas produced.		Gas consumed.			Wells.		
	Number of producers.	Value.	Number of consumers.		Value.	Drilled.		Productive Dec. 31.
			Domestic.	Industrial.		Gas.	Dry.	
1897	41	$200,076	[a] 55,086	80	$874,617	33	7	359
1898	62	229,078	[a] 68,662	103	1,006,567	63	9	422
1899	84	294,593	[a] 76,544	121	1,236,007	36	7	447
1900	89	335,367	[a] 89,837	138	1,456,286	57	11	504
1901	114	293,232	[a] 95,161	98	1,694,925	53	14	557
1902	116	346,471	50,536	215	1,723,709	69	8	626
1903	144	493,686	57,935	208	1,944,667	75	11	700
1904	153	522,575	67,203	451	2,222,980	78	12	744
1905	148	623,251	67,848	447	2,434,894	89	17	839
1906	143	672,795	74,538	95	2,654,115	64	14	919
1907	208	766,157	83,805	155	3,098,533	61	13	1,049
1908	215	959,280	91,391	213	3,281,312	68	19	1,211
1909	282	1,222,666	92,958	570	3,286,523	86	18	1,340
1910	273	1,678,720	106,538	717	3,963,872	97	20	1,411
1911	302	1,418,767	116,314	208	4,276,324	167	53	1,531
1912	332	2,343,379	129,930	805	4,866,821	218	54	1,736
1913	366	2,425,633	136,830	639	4,888,412	200	54	1,880

[a] Number of fires supplied.

In the following table are given the depth and gas pressure of wells in New York from 1909 to 1913, inclusive, by counties:

Depth and gas pressure of wells in New York, 1909–1913, by counties.

County.	Depth, in feet.	Pressure, in pounds.				
		1909	1910	1911	1912	1913
Allegany	600–1,900	6–300	10–300	15–150	7–300	7–250
Cattaraugus	400–2,800	8–250	10– 90	1–120	0–700	0–500
Chautauqua	150–2,500	0–800	1–700	0–700	0–[a]900	0–700
Erie	360–3,000	25–500	22–610	10–700	25–[a]950	42–[a]1,000
Niagara	550	150				
Genesee	1,150–1,870	600	500	500	500	400
Livingston	345–2,000	15–450	10–380	100–400	200–525	200–400
Monroe	440–1,300				50–400	160–400
Onondaga	1,000–3,000		300–500	300–600	3–300	400–600
Ontario	114–2,300	60–480	5–400	60–440	55–450	1–450
Seneca	1,250–1,550					
Oswego	700–1,700	3–200	20–200	11–200	8– 75	25–145
Schuyler	1,000–1,600	100–435	100–435	200–435	300–435	150–435
Yates	375–1,900					
Steuben	279–1,150		50–100		75–200	75–400
Wyoming	1,200–2,000	200	50	125	110–140	140–400

[a] New well.

WEST VIRGINIA.

The production of natural gas in West Virginia was greater in 1913 than in any previous year and more than twice the production of Pennsylvania in 1913. West Virginia has led all other States in the quantity of gas produced for the last five years. Her natural-gas resources are unrivaled. The gas production of this State in 1913 is estimated at 245,453,985,000 cubic feet, valued at $34,164,850, an average of 13.92 cents per thousand cubic feet, as compared with 239,006,682,000 cubic feet, valued at $33,324,475, an average of 13.94 cents per thousand cubic feet, in 1912, an increase of 6,447,303,000 cubic feet in quantity and of $840,375 in value.

The quantity of gas consumed in West Virginia in 1913 amounted to 96,645,438,000 cubic feet, valued at $7,333,956, an average price of 7.59 cents per thousand cubic feet, as compared with 95,402,248,000 cubic feet, valued at $7,001,331, an average price of 7.34 cents per thousand cubic feet, in 1912, an increase of 1,243,190,000 cubic feet and of $332,625. Of this total consumption in 1913 there was consumed for domestic purposes 15,524,692,000 cubic feet, valued at $2,999,005, and 81,120,746,000 cubic feet, valued at $4,334,951, was consumed for industrial purposes. Reference to the table of distribution of gas for industrial purposes in 1913, by States, shows that the greater part of the gas consumed in West Virginia was used for manufacturing, the average price received for this gas being 5.17 cents per thousand cubic feet. As much of the gas consumed in this State is not measured, the figures given must be considered approximate.

Many of the gas wells in West Virginia are closed in, some being conserved for future use, others being in lack of a market. There is no market within the State for the great volume of gas produced from the wells, and large quantities of gas are annually purchased at wells from the producers by the large gas-distributing companies and piped out of the State to supply consumers in cities and towns in Pennsylvania, Ohio, Kentucky, Maryland, and, during the last three months of 1913, Indiana. There is a notable difference between the quantity and the value of the gas produced and consumed in West Virginia and the quantity and value of the gas exported from the State to points distant, which in 1913 was 148,808,547,000 cubic feet, valued at $26,830,894, as compared with 143,604,434,000 cubic feet, valued at $26,323,144, in 1912. The indications are that the quantity exported from this State will continue to increase. In addition to the steadily increasing demands of consumers in cities and towns now supplied, other cities, such as Louisville in Kentucky and many towns in Indiana, are being piped to be supplied with gas from West Virginia.

The most prolific gas fields of West Virginia are located in Lewis, Harrison, and Ritchie counties, from which large quantities of gas are exported. These counties have many wells of great volume and high pressure which are holding up well. During 1913 drilling operations were very active in this State and a total of 1,038 gas wells and 128 dry holes were completed. In addition to extending the limits of the older gas fields, a new field was discovered in Taylor County, where one well was drilled with a pressure of 1,000 pounds and two others with a pressure of 480 pounds. The counties in which gas-producing fields are located are as follows: Boone, Braxton, Brooke, Cabell, Calhoun, Clay, Doddridge, Gilmer, Hancock, Harrison, Kanawha, Lewis, Lincoln, Logan, Marion, Marshall, Monongalia, Mingo, Nicholas, Pleasants, Putnam, Ritchie, Roane, Taylor' Tyler, Ohio, Upshur, Wayne, Wirt, Wetzel, and Wood.

Considerable gas is produced from oil wells located in Tyler, Ritchie, Brooke, Wetzel, Pleasants, Hancock, and Wood counties. This gas is rich in gasoline, and many plants have been installed for the purpose of extracting the gasoline from the gas. This industry assumed considerable importance in 1913, the production of gasoline from this source being greater in West Virginia than in any other State. Statistics of this industry will be found in another part of this report.

Another important industry which has developed in this State is the manufacture of carbon black from gas. On account of the abundance of gas and the low price at which it can be purchased, these factories have continued to increase until at the close of 1913 there were 18 carbon-black manufacturers operating in this State, to which this business is almost wholly confined. It is estimated that 22,229,335,000 cubic feet of gas, valued at $485,797, was used in this State in the manufacture of carbon black in 1913, as compared with 25,430,749,000 cubic feet, valued at $559,572, in 1912. The average value in 1913 was about 2.2 cents per thousand cubic feet. The quantity of gas required to make 1 pound of carbon black is estimated at from 1,000 to 1,200 cubic feet. On this basis, the quantity of carbon black produced in this State in 1913 would amount to 19,955,434 pounds.

The total number of productive gas wells in West Virginia at the close of 1913 was 6,463, of which 1,038 were completed during that year. The number of gas wells abandoned in 1913 was 108.

The acreage controlled by gas-producing companies in West Virginia at the close of 1913 was 3,155,751 acres, as compared with 3,019,316 acres at the close of 1912.

In the following table is given a record of the natural-gas industry in West Virginia from 1897 to 1913, inclusive:

Record of natural-gas industry in West Virginia, 1897–1913.

Year.	Gas produced.		Gas consumed.			Wells.		
	Number of producers.	Value.	Number of consumers.		Value.	Drilled.		Productive Dec. 31.
			Domestic.	Industrial.		Gas.	Dry.	
1897	12	$912,528	[a] 30,015	393	$791,192	47	1	196
1898	19	1,334,023	[a] 28,652	125	914,969	32	4	227
1899	30	2,335,864	[a] 38,137	305	1,310,675	78	6	300
1900	34	2,959,032	[a] 45,943	184	1,530,378	129	6	428
1901	44	3,954,472	[a] 55,808	266	2,244,758	177	8	604
1902	79	5,390,181	29,357	877	2,473,174	142	37	745
1903	88	6,882,359	36,179	1,122	3,125,061	242	43	987
1904	90	8,114,249	44,563	1,005	3,383,515	292	33	1,274
1905	76	10,075,804	45,588	1,417	3,586,608	385	28	1,579
1906	67	13,735,343	51,281	913	3,720,440	263	23	1,831
1907	105	16,670,962	53,807	1,000	[b] 3,757,977	377	59	2,169
1908	138	14,837,130	63,228	1,225	[b] 4,020,282	441	80	2,511
1909	183	17,538,565	70,853	1,907	[b] 5,183,054	801	65	3,232
1910	241	23,816,553	86,778	2,659	[b] 5,617,910	1,002	69	4,052
1911	340	28,435,907	87,438	1,566	[b] 6,240,152	905	117	4,790
1912	406	33,324,475	94,273	1,953	[b] 7,001,331	870	149	5,533
1913	451	34,164,850	101,234	1,834	[b] 7,333,956	1,038	128	6,463

[a] Number of fires supplied. [b] Includes gas consumed in Maryland.

In the following table are given the depth and gas pressure of wells in West Virginia from 1909 to 1913, inclusive, by counties:

Depth and gas pressure of wells in West Virginia, 1909–1913, by counties.

County.	Depth, in feet.	Pressure, in pounds.				
		1909	1910	1911	1912	1913
Boone	1,060–1,780	....	....	....	350–520	400–525
Braxton	2,100–3,000			840	....	....
Clay	1,400–2,000	240–525	125–535	200–400	300–600	200–450
Taylor	1,453–2,800			80–800	100–600	400–1,000
Brooke	1,200–1,905	100–600	100–400	0–50	0–270	0–640
Cabell	900–2,325	200–460	250–540	250–500	350–400	350–500
Calhoun	824–4,000	60–1,400	18–1,500	35–655	20–760	60–400
Doddridge	1,400–3,000	100–800	10–760	100–750	5–700	75–900
Gilmer	1,280–3,181	250–875	350–630	640	130–210	100–180
Hancock	700–1,880	10–150	3–100	1–60	20–150	40–100
Harrison	800–3,300	50–900	50–900	50–1,040	40–900	50–900
Kanawha	1,200–2,585	500	480–560	400–500	250–600	50–500
Lewis	1,127–3,000	200–720	125–800	60–950	45–[a]1,100	50–[a]1,100
Lincoln	900–2,720	250–450	400–500	400–650	200–600	400–560
Logan	1,200–2,200	....	....	....	550–560	75–540
Marion	1,500–3,478	125–580	50–600	90–1,200	75–805	40–500
Marshall	1,000–2,900	200–300	10–295	50–300	6–300	125–300
Mingo, Wayne	800–2,100	....	....	300–600	375–550	250–600
Monongalia	1,350–3,500	85–500	70–450	60–700	60–825	60–820
Nicholas	1,200–1,300	....	....			
Ohio	1,500–2,000	....	....	40–125	15–350	25
Pocahontas	2,000–2,500	....	....			
Pleasants	900–2,150	100–250	100–150	150–400	50–300	30–500
Putnam	900–2,400	300–800	300–800	300–800	....	....
Upshur	1,934–2,800			25–740	480–600	460
Ritchie	725–2,925	45–670	20–800	250–275	20–700	30–700
Roane	1,472–2,350	400–500	275–600		320–465	350–750
Tyler	1,650–2,700	65–300	35–440	50–100	50–750	50–650
Wetzel	1,300–3,560	95–250	70–300	0–200	50–113	5–150
Wirt	500–1,875	40–500	35–500	10–450	30–500	18–275
Wood	1,030–1,800	250–540	250–540	160–350	300–520	150–500

[a] New well.

KENTUCKY.

The production of natural gas in Kentucky in 1913 was 1,821,526,-000 cubic feet, valued at $509,846, as compared with 1,950,881,000 cubic feet, valued at $522,455, in 1912, a slight decrease in both quantity and value.

The principal gas-producing field of the State is in Menifee County, from which the Central Kentucky Natural Gas Co. supplies gas to Lexington, Winchester, Mount Sterling, and Paintsville through the Johnson County Gas Co., and to Paris through the Paris Gas & Electric Co. The United Fuel Gas Co., having wells in Martin County, supplies consumers in Ashland, Buchanan, Catlettsburg, Greenup, Inez, Kinner, Kavanaugh, Louisa, Pollard, Russell, and Warfield. The Cumberland Natural Gas Co., operating in Knox County, supplies consumers in Barboursville. Salyersville is supplied with gas from wells in Magoffin County, this field having been developed in 1913. Russellville, Lewisburg, Diamond Springs, and Central City are supplied with gas from wells in Muhlenberg County, where a number of gas wells have been completed. Meade County has been the chief source of the natural gas supplied for so many years to Louisville by the Kentucky Heating Co., now the Louisville Gas & Electric Co., but the wells are now almost exhausted. A new company, known as the Kentucky Pipe Line Co., had in course of construction in 1913 a 12-inch line, to be 200 miles in length, which will probably be completed to supply Louisville with gas before the close of 1914. The gas will come from the fields of West Virginia and will be distributed by the Louisville Gas & Electric Co. During the last two years Morgan County has developed some very good gas wells, a part of the product of which is supplied to consumers in Cannel City, Caney, and West Liberty. Gas from wells in Breckenridge County is furnished to consumers in Cloverport, and consumers in Burning Springs obtain their supplies from Clay County. A number of consumers in West Point are supplied with gas from wells in Hardin County. Hazel Green is supplied with gas from Wolfe County. It will thus be seen that the productive gas territory of Kentucky is widely scattered. The oil wells of Wayne County produce considerable gas, which is used for field purposes, and there are only a few wells in this county which are exclusively gas wells.

The estimated quantity of gas consumed in Kentucky in 1913 was 5,911,042,000 cubic feet, valued at $1,225,116, an average of 20.73 cents per thousand cubic feet, as compared with 5,102,941,000 cubic feet, valued at $1,070,664, or 20.98 cents per thousand cubic feet in 1912, an increase of 808,101,000 cubic feet in quantity and of $154,452 in value. The difference between the quantity and value of the gas produced and the gas consumed in the State in 1913, which amounted to 4,089,516,000 cubic feet, valued at $715,270, represents the quantity and value of the gas piped from West Virginia—a considerable increase over the imports of gas from West Virginia in 1912, which amounted to 3,152,060,000 cubic feet, valued at $548,209. The indications are that the year 1914 will also show an increase.

Some of the cities and towns in Kentucky which are wholly supplied with gas from West Virginia are as follows: Covington, West Covington, Newport, Bellevue, Dayton, Ludlow, Maysville, and Cold Spring.

The table giving the distribution of gas consumed in the United States in 1913, by States, shows that Kentucky consumed nearly as much gas for domestic purposes as for industrial purposes, but that the value of gas for domestic consumption was more than three times greater than that for industrial use. The average price of gas per thousand cubic feet consumed for domestic purposes in 1913 was 32.26 cents and for industrial purposes 9.82 cents. The greater portion of the gas consumed in this State for industrial purposes was used for manufacturing.

The number of productive gas wells in Kentucky was 270 at the close of 1913, of which 23 were drilled in that year. The number of dry holes drilled in 1913 was 7, and the number of wells abandoned was 20.

In the following table is given a record of the natural-gas industry in Kentucky from 1906 to 1913, inclusive:

Record of natural-gas industry in Kentucky, 1906–1913.

Year.	Gas produced.		Gas consumed.			Wells.		
	Number of producers.	Value.	Number of consumers.		Value.	Drilled.		Productive Dec 31.
			Domestic.	Industrial.		Gas.	Dry.	
1906	45	$287,501	17,216	18	$287,501	......	......	166
1907	38	380,176	19,279	239	380,176	31	14	179
1908	38	424,271	21,778	42	424,271	19	23	218
1909	38	485,192	25,639	137	695,577	26	7	212
1910	47	456,293	27,961	112	908,293	23	12	241
1911	74	407,689	41,201	70	901,759	19	8	255
1912	88	522,455	45,603	103	1,070,664	22	27	267
1913	93	509,846	54,446	146	1,225,116	23	7	270

ALABAMA.

Natural gas was produced commercially in Alabama in Fayette, Madison, and Walker counties in 1913, there being a total of 340 domestic and 2 industrial consumers supplied in the towns of Fayette, Jasper, and West Huntsville. Jasper was first supplied with gas in 1913, and this is one of the features that mark the progress of the natural-gas industry in this State. As compared with 1912, the number of consumers supplied in 1913 was more than double, and the income derived from sale of gas was proportionately increased.

Considerable effort has been made and much money spent in trying to find an important oil or gas field in Alabama; the results have not been very encouraging, but the prospectors are hopeful, and the work continues. The gas wells in the Fayette and Walker county fields are holding up very well. The number of productive gas wells in the State at the close of 1913 was 18. One well was flooded and abandoned, but an effort will be made to bring it back, and there is a chance that it may yet be a producer. During 1913 there were 7 dry holes drilled in Alabama, 1 in Fayette County, 1 in Morgan County 4 in Walker County, and 1 in Winston County.

The depth of the productive gas wells in Alabama varies from 300 to 2,400 feet and the pressure from 25 to 800 pounds.

The statistics of the gas production in this State are included with those of Louisiana.

TENNESSEE.

The value of the natural gas consumed in Tennessee in 1913 was nearly double that of 1912, but the production was very small, only four families being supplied. The gas was produced from wells in Franklin County, where there were 5 wells at the close of 1913. Of these wells, 2 were drilled in 1913 by the Franklin Oil & Fuel Co., and have a depth of from 1,500 to 1,900 feet and are said to be the best wells in the State. This company is drilling a third well.

There are also two gas wells in White County and one gas well in Perry County, from which no gas was produced in 1913.

OHIO.

The State of Ohio, which led all other States in the value of gas consumed in 1912, takes second place in 1913, having been displaced by Pennsylvania. However, the difference in values in the two years was slight—$27,055,824 in 1913, as compared with $27,196,162 in 1912, a decrease of but $140,338. On the other hand, the quantity consumed in Ohio in 1913 was greater than in any previous year. The report shows that 128,204,722,000 cubic feet of gas was consumed in 1913, as compared with 126,854,659,000 cubic feet in 1912, an increase of 1,350,063,000 cubic feet. The reduction in the value in 1913 is explained by the table giving the distribution of gas in 1913 by States, which shows an increased consumption of gas for industrial purposes and a decreased consumption of gas for domestic use. The quantity of gas supplied for domestic consumption in 1913 was 64,732,832,000 cubic feet, valued at $18,658,295, or 28.82 cents per thousand cubic feet, as against 67,150,744,000 cubic feet, valued at $19,420,086, or 28.92 cents per thousand cubic feet, in 1912, and the quantity of gas supplied for industrial consumption in 1913 was 63,471,890,000 cubic feet, valued at $8,397,529, or 13.23 cents per thousand cubic feet, as against 59,703,915,000 cubic feet, valued at $7,776,076, or 13.02 cents per thousand cubic feet, in 1912. Of the total quantity of gas consumed in 1913 for industrial purposes, 49,663,270,000 cubic feet, valued at $6,472,271, was used for manufacturing, and $13,808,620,000 cubic feet, valued at $1,925,258, for other industrial or power purposes.

The quantity of gas produced in Ohio declined from 56,210,052,000 cubic feet, valued at $11,891,299, in 1912, to 50,311,940,000 cubic feet, valued at $10,416,699, in 1913. The difference between the quantity of gas consumed and the quantity of gas produced in the State in 1913, which amounted to 77,892,782,000 cubic feet, shows approximately the quantity of gas piped into the State from West Virginia and Pennsylvania. This was an increase of more than 10 per cent over 1912, when the imports of gas from West Virginia and Pennsylvania were 70,644,607,000 cubic feet. It may be said that only a small proportion of this gas is piped from Pennsylvania.

Drilling operations were not so active throughout Ohio in 1913 as in 1912, 643 wells having been completed as against 856 wells in 1912; and no new or important gas fields have been reported. The chief source of gas produced in the State continues to be the central Ohio field, comprising the counties of Ashland, Fairfield, Hocking, Knox, Licking, Medina, Richland, and Wayne, which has produced enormous quantities of gas since its development and is still very productive, although reports received from producers indicate a general depreciation of gas wells in this field. One well completed in Ashland County, in 1913, at 2,518 feet, had a rock pressure of 650 pounds and by the close of the year was stationary at 225 pounds. Another well in the same county completed in July, 1912, at a depth of 2,617 feet and under a pressure of 615 pounds, was down to 207 pounds on December 31, 1913. Knox and Licking counties also report reduced pressure and more trouble with water breaking in. It is stated that there are many wells in the Sugar Grove field with a pressure of from 50 to 60 pounds, whose product can not be used on account of the higher line pressure. A test made on September 1, 1913, of the pressure of certain wells located in the central Ohio field, as compared with a test of the same wells made on December 31, 1912, gave the following results: Ninety-seven wells in the Ashland-Lorain field, including the counties of Ashland, Medina, Lorain, Richland, and Wayne, with an average pressure of 560 pounds, showed a pressure of 491 pounds, a reduction of 69 pounds; 297 wells in the Homer field, including Knox and Licking counties, with an average pressure of 153 pounds, showed a pressure of 135 pounds, a reduction of 18 pounds; 54 wells in the Sugar Grove field, including Fairfield and Hocking counties, with an average pressure of 80 pounds, showed a pressure of 86 pounds, a gain of 6 pounds.

In their search for more gas considerable activity was displayed in 1913 by companies drilling in northern Ohio, particularly in Cuyahoga and Lorain counties, which for a number of years have produced gas from many shallow wells, the gas being used for individual consumption. Deep drilling in these counties and in the city of Cleveland resulted in the completion of several wells of great volume and high pressure, the product of which is being utilized for both domestic and industrial purposes. Productive wells have been reported by the Berea Road Gas Co., which has 2 wells; the City Ice Delivery Co., 2 wells; the Glidden Varnish Co., 1 well; Theodore Kundtz, 2 wells; the Lakewood Engineering Co., 1 well; the Lakewood Gas Co., 2 wells; the National Tool Co., 1 well; the Robert R. Rhodes Co., 1 well; and the Winton Motor Car Co., 2 wells. These wells have a depth of from 2,600 to 2,750 feet and pressure of from 300 to 1,000 pounds. One well, having a pressure of 1,040 pounds when completed in September, 1912, had a pressure of only 450 pounds on December 31, 1913. In Lorain County the Pittsfield Gas Co. has completed 10 good wells, part of the product being supplied to the Oberlin Gas & Electric Co. and by it distributed to domestic consumers in Oberlin, Ohio. In Noble County wells are holding up very well, with pressure of 500 to 600 pounds. Developments in Mahoning County resulted in the completion of a few wells whose product will be used to supply North Lima and New Springfield. On the whole the natural-gas industry in Ohio was in a prosperous condition in 1913, although the production did not reach the high mark of 1912.

The number of productive gas wells in Ohio at the close of 1913 was 5,213, as compared with 5,163 at the close of 1912. A total of 643 wells was drilled in 1913, of which 408 were productive and 235 were dry holes. The number of wells abandoned in 1913 was 358.

The production of gasoline from casing-head gas, the statistics of which are given in another part of this report, is one of the important industries of this State.

In the following table is given a record of the natural-gas industry in Ohio from 1897 to 1913, inclusive:

Record of natural-gas industry in Ohio, 1897–1913.

Year.	Gas produced.		Gas consumed.			Wells.		
	Number of producers.	Value.	Number of consumers.		Value.	Drilled.		Productive Dec. 31.
			Domestic.	Industrial.		Gas.	Dry.	
1897	157	$1,171,777	[a] 85,368	183	$1,506,454	88	51	729
1898	237	1,488,308	[a] 68,211	349	2,250,706	120	12	806
1899	359	1,866,271	[a] 77,787	691	3,207,286	134	17	929
1900	281	2,178,234	[a] 135,743	1,092	3,823,209	97	19	990
1901	305	2,147,215	[a] 149,709	949	4,119,059	113	35	1,099
1902	451	2,355,458	120,127	786	4,785,766	266	40	1,343
1903	515	4,479,040	197,710	1,786	7,200,867	290	62	1,523
1904	453	5,315,564	232,557	1,136	9,393,843	334	49	1,661
1905	425	5,721,462	274,585	2,955	10,396,633	342	58	1,705
1906	409	7,145,809	310,175	3,316	12,652,520	337	51	[b] 1,977
1907	468	8,718,562	380,489	5,476	15,227,780	431	90	2,942
1908	[c] 970	8,244,835	427,276	3,621	15,166,434	398	124	[d] 3,691
1909	[c] 1,534	9,966,938	450,973	5,260	18,884,312	548	149	[d] 4,260
1910	[c] 1,630	8,626,954	475,505	3,187	21,210,965	466	202	[d] 4,717
1911	[c] 1,900	9,367,347	577,263	3,634	22,792,270	450	191	[d] 4,999
1912	[c] 2,031	11,891,299	641,724	4,414	27,196,162	637	289	[d] 5,163
1913	[c] 2,056	10,416,699	685,956	5,010	27,055,824	408	235	[d] 5,213

[a] Number of fires supplied.

[b] Exclusive of complete report of shallow wells.

[c] Includes 735 producers in Ashtabula, Erie, Huron, Lake, Lorain, and Cuyahoga counties having shallow wells for their own domestic purposes in 1908, 1,239 in 1909, 1,289 in 1910, 1,476 in 1911, 1,579 in 1912, and 1,600 in 1913.

[d] Includes 901 shallow wells located in Ashtabula, Erie, Huron, Lake, Lorain, and Cuyahoga counties in 1908, 1,568 in 1909, 1,541 in 1910, 1,757 in 1911, 1,773 in 1912, and 1,778 in 1913.

In the following table are given the depth and gas pressure of wells in Ohio from 1909 to 1913, inclusive, by counties:

Depth and gas pressure of wells in Ohio, 1909–1913, by counties.

County.	Depth, in feet.	Pressure, in pounds.				
		1909	1910	1911	1912	1913
Allen	1,200–1,470	...	...	...	...	...
Ashland	2,500–2,800	...	663	670	250– 650	90– 500
Ashtabula	400–2,200	5– 300	5–300	0– 275	0– 410	...
Athens	440–1,500	160– 280	25–350	25– 350	10– 350	50– 350
Auglaize	1,100–1,300	...	12– 30	2– 90	5– 110	3– 140
Belmont	778–1,970	200– 300	60–600	40– 150	20– 50	60– 140
Carroll	500–1,434	165– 300	185–350	90– 300	100– 150	90– 150
Clinton	715–	...	...	160– 190	160	95
Columbiana	575–1,000	50– 287	55–240	25– 240	25– 350	16– 300
Cuyahoga	337–2,900	2– 100	2– 80	0– 97	0– a800	0– a1,000
Darke	850–1,300	5– 25	15–185	2– 250	2– 300	2– 200
Erie	350– 650	...	...	20– 40	18– 40	...
Fairfield	240–2,800	60– 500	50–280	40– 500	40– 350	16– 320
Guernsey	700–1,500	80– 400	50–300	}350– 400	250	300
Muskingum	800–3,350	1,000–1,100	...			
Hancock	880–1,800	2– 70	2– 50	0– 200	2– 400	2– 150
Hardin	1,200–1,600	25– 40	20–300	25– 300	75– 300	20– 300
Harrison	460–1,650	5– 400	30–345	10– 110	10– 150	5– 225
Hocking	750–3,300	800– 850	...	...	...	...
Huron	400– 800	...	...	10– 25	0– 40	...
Holmes	600–1,160	225	...	135– 220	100– 170	80– 165
Jefferson	600–2,026	40– 230	40–250	0– 400	12– a890	15– 300
Knox	590–3,200	25– 400	80–390	50– 250	15– 250	50– 300
Lake	360–1,700	1– 100	1–135	0– 165	0– 185	...
Lawrence	1,834	...	...	...	...	750
Licking	1,950–3,000	100– 750	80–600	60– 700	80– 400	30– 450
Logan	1,360–1,500	130– 280	...	...	20– 180	160
Lorain	338–2,590	0– 840	0–500	0–a1,150	0– a900	0– 675
Lucas	1,156–1,550	8– 30	4– 11	5– 100	7– 30	9– 30
Mahoning	650– 750	...	...	...	a160	150– 158
Medina	198–3,000	10– 40	3– 30	5– 875	4–a1,100	2– 500
Mercer	1,020–1,400	4– 210	1–150	3– 120	1– 100	1– 105
Monroe	650–2,400	25– 500	60–400	100– 400	8– 200	3– 100
Morgan	240–1,650	10– 400	20–450	20– 450	20– 450	15– 450
Noble	484–2,000	150– 700	100–500	200– 650	100– 620	150– 620
Ottawa	1,250–1,600	100– 350	200–450	85– 450	40– 450	30– 350
Perry	650–3,620	50– 900	40–740	50– 250	150– 800	150– 600
Richland	1,950–2,800	450	250–400	150– 300	200– 250	...
Sandusky	450–1,400	40– 160	5–175	5– 165	5– 160	5– 150
Seneca	370–1,760	50– 175	25–100	25– 140	20– 110	20– 140
Summit	900–3,550	...	...	160	a980– 1,020	...
Trumbull	370– 388	...	...	...	...	10
Tuscarawas	850–1,350	...	325–385	260– 325	180– 350	160– 475
Van Wert	1,200–1,285	35	40	40	40	...
Vinton and Jackson	520– 800	250	...	...	...	...
Warren	275–1,000	...	...	...	...	...
Wayne	3,200–3,235	...	...	...	a800	300–a1,120
Washington	500–2,600	15– 450	15–500	15– 500	15– 600	15– 500
Wood	1,170–1,500	...	20– 40	10– 15	10– 12	10– 15

a New well.

INDIANA.

One of the important features of the natural-gas industry in the United States in 1913, and one of particular interest to the people of Indiana, was the completion of pipe lines and the successful introduction of natural gas into this State from the gas fields of West Virginia. Although this State has long enjoyed the use of this ideal fuel, it has been evident for some time that the gas fields of the State were gradually being exhausted. In the early days of the natural-gas industry, Indiana was one of the most prolific gas-producing States, but no care was taken to conserve the supply and the waste has been enormous.

An examination of the following table shows that with the exception of the year 1909, there has been a constant reduction since 1902, although many efforts have been made to find new gas territory.

The construction of pipe lines to transport gas into Indiana was begun in 1913 by the Logan Natural Gas & Fuel Co. A line from Sugar Grove, Fairfield County, Ohio, has been completed to Muncie, Ind., a distance of approximately 160 miles. This line from Sugar Grove to a point about 3 miles north of Dayton, Ohio, is 18 inches in diameter. From that point to Muncie the line is 16 inches in diameter. From Muncie branch lines of 10 and 12 inches in diameter are laid to Anderson and Fairmount to connect with smaller lines supplying Hartford City, Marion, Kokomo, Elwood, Alexandria, Gas City, Tipton, Shelbyville, Greenfield, and other points in central Indiana. A 10-inch line from the 16-inch trunk line has also been constructed to Richmond, Ind., and at a point farther west on the 16-inch line, an 8-inch line has been laid to supply Newcastle. The supply of gas for this service is obtained from Harrison and Lewis counties, W. Va., the lines from those fields being laid and in operation to Sugar Grove, at which point the Indiana lines have been connected.

Before the close of 1913 four companies were purchasing West Virginia gas from the Logan Natural Gas & Fuel Co., and distributing it to consumers in Indiana. The first gas transported from West Virginia to Indiana was turned on by the Central Indiana Gas Co. on the first day of October, the cities of Muncie, Marion, Anderson, Alexandria, Hartford City, and Elwood being supplied. At a later date the Indiana Gas Light Co. turned natural gas, brought from West Virginia, into its mains and began to supply Noblesville and Tipton. The Interstate Public Service Co. began the distribution of West Virginia gas to consumers in Newcastle about December, and the town of Richmond was supplied about the same time with West Virginia gas by the Richmond Light, Heat & Power Co. The rate charged for West Virginia gas by the above-named companies is from 30 to 40 cents per thousand cubic feet, according to quantity used. The gas is supplied for both domestic and manufacturing purposes, the number of consumers connected to these lines on December 31, 1913, being 19,832 domestic consumers and 67 manufacturing or industrial consumers.

During the year 1913 several gas-producing companies discontinued business in this State on account of shortage of gas and reduced pressure, there not being sufficient gas for commercial purposes, and their wells have either been abandoned or sold to the farmers upon whose lands they are located, and by whom they will be used for domestic purposes. The table giving the distribution of gas consumed in 1913, by States, shows that Indiana consumed for domestic purposes 2,588,120,000 cubic feet of gas, valued at $824,430, and that the quantity consumed for industrial purposes was only 632,765,000 cubic feet, valued at $123,848, this gas being principally utilized for power in the operation of gas engines and under boilers.

The total quantity of gas consumed in Indiana in 1913 was 3,220,-885,000 cubic feet, valued at $948,278, an average price of 29.44 cents per thousand cubic feet, as compared with 3,618,077,000 cubic feet, valued at $1,014,295, an average of 28.03 cents per thousand cubic feet in 1912. These figures of gas consumption can only be said to be approximate as much of the gas consumed in this State is used without measurement and only an estimate of the quantity consumed can be made. The failure to use meters in this State was one of the causes for the great waste of gas.

It will not be possible to give separately the figures of gas production in this State in 1913, since there is but one company piping gas into the State. Therefore, the figures given as the production of gas in Indiana include the quantity and value of the gas piped into the State from West Virginia.

The report shows that the number of productive wells in this State was 2,370 at the close of 1913, as compared with 2,547 at the close of 1912. During the year 93 wells were drilled, of which 69 were productive and 24 were dry holes. The number of gas wells abandoned was 246.

In the following table is given a record of the natural-gas industry in Indiana from 1897 to 1913, inclusive:

Record of natural-gas industry in Indiana, 1897–1913.

Year.	Gas produced.		Gas consumed.			Wells.		
	Number of producers.	Value.	Number of consumers.		Value.	Drilled.		Productive Dec. 31.
			Domestic.	Industrial.		Gas.	Dry.	
1897	452	$5,009,208	a 214,750	935	$3,945,307	419	66	2,881
1898	533	5,060,969	a 173,454	1,867	4,682,401	706	111	3,325
1899	571	6,680,370	a 181,440	1,741	b 5,833,370	838	109	3,909
1900	670	7,254,539	a 181,751	2,751	b 6,412,307	861	156	4,546
1901	656	6,954,566	a 153,869	2,570	b 6,276,119	985	208	4,572
1902	929	7,081,344	101,481	3,282	b 6,710,080	1,331	205	5,820
1903	924	6,098,364	90,118	1,020	b 5,915,367	895	242	5,514
1904	846	4,342,409	84,862	390	b 4,282,409	706	153	4,684
1905	740	3,094,134	63,194	231	b 3,056,634	252	74	3,650
1906	578	1,750,715	47,368	156	b 1,750,755	159	46	3,523
1907	687	1,572,605	46,210	218	b 1,570,605	185	56	3,386
1908	823	1,312,507	42,054	216	b 1,312,507	187	41	3,223
1909	1,010	1,616,903	40,565	369	b 1,616,903	190	70	2,938
1910	1,027	1,473,403	36,054	282	b 1,473,403	69	33	2,955
1911	1,094	1,192,418	31,576	143	b 1,192,418	110	32	2,744
1912	1,140	1,014,295	27,165	140	b 1,014,295	96	39	2,547
1913	1,100	c 948,278	39,776	239	b 948,278	69	24	2,370

a Number of fires supplied.
b Includes value of gas consumed in Chicago, Ill.
c Includes value of gas piped from West Virginia and consumed in Indiana.

In the following table are given the depth and gas pressure of wells in Indiana from 1909 to 1913, inclusive, by counties:

Depth and gas pressure of wells in Indiana, 1909–1913, by counties.

County.	Depth, in feet.	Pressure, in pounds.				
		1909	1910	1911	1912	1913
Adams	1,000–1,050	250	....	....	100	40– 50
Bartholomew	864– 990	50–175	50–250	150–175	75–125	85–165
Blackford	850–1,100	1– 25	1– 10	0– 30	0– 12	0– 8
Clark	128– 244	....	....	....	27	....
Daviess, Martin	300– 600	0– 20	0– 60	9–160	7–150	5–165
Decatur	700–1,200	0–325	0–315	0–325	5–330	5–350
Delaware	728–1,500	1– 55	0– 70	0– 75	0– 60	0– 50
Franklin	728– 730	....	....	....	....	60
Grant	830–1,200	2– 45	2– 50	0–180	2–180	5–200
Hamilton	800–1,280	5–185	15–180	15–225	8–235	8–225
Hancock	700–1,100	0–100	0–100	3–280	5– 80	8–125
Harrison	320– 764	....	....	60–110	112	50
Henry	800–1,200	5–100	0– 90	0– 80	0–100	5–150
Howard	800–1,100	0–200	0–220	20–250	10–180	35–200
Jay	900–1,600	0– 50	0– 40	0–110	0–220	0– 50
Jefferson	1,360	....	....	10	....	20
Madison	800–1,200	0–200	0–190	0–180	1–175	0–175
Miami	900–1,000	0– 10	0– 40	....	....	....
Marion, Ripley	880–1,050	35	40	180–285	150–250	100–160
Pike	1,000–1,400	300–550	125–500	100–480	60–300	25–450
Randolph	900–1,300	0–175	0–180	2–300	4–140	2–190
Rush	700–1,400	9–375	20–325	0–300	12–300	10–300
Shelby	650–1,020	10–310	1–375	1–300	10–366	15–300
Spencer	1,025	....	....	....	410	....
Sullivan	698– 780	250	200	50–100	40–110	30– 50
Tipton	750–1,100	18–180	10–230	15–190	3–180	5–125
Wayne	800–1,150	20–300	50–240	25–150	25– 70	45– 75

ILLINOIS.

It is estimated that the quantity of gas produced in Illinois in 1913 was 4,767,128,000 cubic feet, valued at $574,015, as compared with 5,603,368,000 cubic feet, valued at $616,467, in 1912, a decrease of 836,240,000 cubic feet in quantity and of $42,452 in value. The table giving the distribution of gas in the United States in 1913, by States, shows that the decline in Illinois has been greatest in gas supplied for domestic consumption. The value of the gas utilized for domestic purposes in 1913 was 898,677,000 cubic feet, valued at $230,850, as compared with 1,236,162,000 cubic feet, valued at $291,987, in 1912, the number of domestic consumers also decreasing from 10,691 in 1912 to 10,423 in 1913. The quantity of gas consumed for industrial purposes in 1913 was 3,868,451,000 cubic feet, valued at $343,164, as compared with 4,367,206,000 cubic feet, valued at $324,480, in 1912. It will be seen that more than four times as much gas was used for industrial purposes in Illinois in 1913 as for domestic purposes, but that the value of the gas used industrially was greater by less than half. Of the gas consumed industrially five times as much was used for power as for manufacturing. The greater part of the gas consumed for power was used for gas engines and boilers for operating and drilling in the oil fields and by refineries. Much of the gas used for power was not metered, so that the figures of industrial consumption are largely estimated. Many of the oil wells in Illinois produce gas in considerable quantity, the surplus gas in some cases being sold to the gas-distributing companies for distribution to domestic consumers. Gas from some of the oil wells is also rich in gasoline and a few plants have been installed for the extraction of gasoline from the gas, statistics of which industry will be found in another part of this report.

The commercial gas wells of Illinois are located in Bond, Clark, Crawford, McLean, and Lawrence counties, the towns supplied in 1913 being practically the same as in 1912. The gas from wells in Bond County is supplied to Greenville. One gas well in McLean County is supplying consumers in Heyworth. Carlinville was supplied with gas from wells in Macoupin County in 1913, but the wells in this county were abandoned before the close of 1913.

A portion of the gas produced in Illinois is piped out of the State and supplied to consumers in Vincennes, Ind. However, the figures of this gas consumption are included with those of Illinois.

The average price received per thousand cubic feet for gas supplied for domestic consumption in Illinois in 1913 was 25.69 cents as compared with 23.62 cents in 1912, the rate charged varying from 20 to 30 cents. The average price per thousand cubic feet for gas supplied for industrial consumption in Illinois in 1913 was 8.87 cents, as compared with 7.43 cents in 1912, the rate charged varying from 5 to 20 cents.

The report shows little change in the number of productive gas wells since the last report. During the year 1913 a total of 179 wells were completed by gas-producing companies, of which 60 were productive and 119 dry holes, the number of productive gas wells being 455 at the close of the year. The number of gas wells abandoned in 1913 was 58. None of the gas wells in Illinois, as reported, exceeds a depth of 1,900 feet, the Lawrence County wells being the deepest. The pressure of wells reported is not great, the highest pressure of any well at the close of 1913 being 350 pounds, and this of a well completed in 1913.

Included in the 455 wells reported are 218 shallow gas wells in the following-named counties: Bureau, 105; Champaign, 9; Dewitt, 10; Edgar, 15; Lee, 12; Logan, 2; Montgomery, 2; Morgan, 4; Pike, 59; each producing scarcely more than enough gas for one family. The value of the gas produced from these wells and consumed in 1913 is estimated to have been $15,176.

In the following table is given a record of the natural-gas industry in Illinois from 1906 to 1913, inclusive:

Record of natural-gas industry in Illinois, 1906–1913.

Year.	Gas produced.		Gas consumed.			Wells.		
	Number of producers.	Value.	Number of consumers.		Value.	Drilled.		Productive Dec. 31.
			Domestic.	Industrial.		Gas.	Dry.	
1906	66	$87,211	1,429	2	$87,211	......	......	200
1907	128	143,577	2,126	61	143,577	94	41	283
1908	185	446,077	[a] 7,377	[a] 204	[a] 446,077	121	42	400
1909	194	644,401	[a] 8,458	[a] 518	[a] 644,401	56	11	423
1910	207	613,642	[a] 10,109	[a] 261	[a] 613,642	64	31	458
1911	225	687,726	[a] 10,078	[a] 293	[a] 687,726	69	78	458
1912	223	616,467	[a] 10,691	[a] 212	[a] 616,467	56	147	453
1913	231	574,015	[a] 10,423	[a] 279	[a] 574,015	60	119	455

[a] Includes number of consumers and value of gas consumed in Vincennes, Ind.

In the following table are given the depth and gas pressure of wells in Illinois from 1909 to 1913, inclusive, by counties:

Depth and gas pressure of wells in Illinois, 1909–1913, by counties.

County.	Depth, in feet.	Pressure, in pounds.				
		1909	1910	1911	1912	1913
Bond	1,050–1,100	200–580	200–750	100–350	40–410	35–355
Lawrence	700–1,900					
Bureau	98– 357	0– 23	0– 23	0– 42	0– 80	0– 42
Champaign	80– 140	....	15– 32	15– 30	0– 20	0– 30
Clark	250– 610	38–100	35– 45	10– 60	15–105	0– 30
Crawford	400–1,550	45–275	20–225	10–150	20–200	20–350
Cumberland	500– 575	40	....	....	....	....
Dewitt	85– 127	....	25– 50	20– 50	0– 50	0– 25
Edgar	230– 600	....	75–127	50– 90	75–130	50–135
Lee	126– 280	....	18– 28	19– 28	12– 28	12– 28
Logan	84– 90	....	....	....	....	....
McHenry						
McLean	160– 372	....	....	10– 22	....	....
Macoupin						
Montgomery	55– 60	....	....	....	....	1– 2
Morgan	260– 400	....	....	0–100	0–100	0– 96
Pike	89– 350	3– 7	4– 10	1– 20	0– 10	0– 9

KANSAS.

The following table shows that in point of the value of its gas production the State of Kansas takes fifth place in 1913, as in 1912, although the production decreased from 28,068,370,000 cubic feet, valued at $4,264,706, in 1912, to 22,884,547,000 cubic feet, valued at $3,288,394, in 1913, a decrease of 5,183,823,000 cubic feet in quantity and of $976,312 in value. This reduction was anticipated, as the gas fields of this State have been declining and no large gas fields have been discovered to augment the failing supply. This State, as well as Missouri, depends largely upon the gas fields of Oklahoma for its gas. During the year 1913 more gas was piped into these States from Oklahoma than was produced in Kansas, although the quantity imported was very much less than that of previous years. The quantity of gas piped from Oklahoma to Kansas and Missouri in 1911 was 39,061,737,000 cubic feet, valued at $4,639,167; in 1912, 32,249,-916,000 cubic feet, valued at $4,257,152; and in 1913, 23,768,374,000 cubic feet, valued at $3,695,408—these figures representing the values at the point of consumption.

The total quantity of gas consumed in Kansas and Missouri in 1913 was 46,652,921,000 cubic feet, valued at $6,983,802, an average price of 14.97 cents per thousand cubic feet, as compared with 60,318,286,-000 cubic feet, valued at $8,521,858, an average price of 14.13 cents per thousand cubic feet, in 1912. Of this total consumption there was supplied to 195,131 domestic consumers in 1913 some 20,550,852,000 cubic feet of gas, valued at $4,977,137, an average price of 24.22 cents per thousand cubic feet, while 26,102,069,000 cubic feet, valued at $2,006,665, an average price of 7.69 cents per thousand cubic feet, was supplied to 950 manufacturing and other industrial consumers.

The table of the distribution of gas for industrial purposes in 1913 shows that Kansas and Missouri utilized for manufacturing purposes 17,110,874,000 cubic feet of gas, valued at $1,136,007, and that 8,991,-195,000 cubic feet, valued at $870,658, was utilized for power. The gas consumed in Kansas for manufacturing purposes was principally used at zinc, cement, brick, and glass works.

It is estimated that 8,481,882,000 cubic feet of gas, valued at $453,349, was consumed by zinc smelters in Kansas in 1913, as compared with 12,474,938,000 cubic feet, valued at $666,892, in 1912, and with 13,186,505,000 cubic feet, valued at $543,301, in 1911. The zinc operators in Kansas and the consumers of this gas in 1913 were as follows: American Zinc, Lead & Smelting Co., Chanute Zinc Co., Edgar Zinc Co., Granby Mining & Smelting Co., Kansas Zinc Co., Altoona Zinc Smelting Co., Laharpe Spelter Co., Prime Western Spelter Co., United Zinc & Chemical Co.

The consumption of gas at cement plants in Kansas in 1913 is estimated at 3,018,975,000 cubic feet, valued at $186,858, as compared with 7,140,009,000 cubic feet, valued at $437,042, in 1912, and with 13,272,417,000 cubic feet, valued at $728,911, in 1911. Plants formerly using gas are now burning coal or oil. Operators of cement plants at which gas was used in 1913 were the Ash Grove Lime & Portland Cement Co., the Altoona Portland Cement Co., the Iola Portland Cement Co., and the Western States Portland Cement Co.

The quantity of gas consumed for brick manufacture (including stoneware) in Kansas in 1913 is estimated at 3,492,336,000 cubic feet, valued at $269,618. This was a considerable increase over the consumption of 1912, which was estimated at 2,768,874,000 cubic feet, valued at $171,644. The glass plants of this State consumed 559,983,000 cubic feet of gas, valued at $46,005, in 1913, as compared with 922,142,000 cubic feet, valued at $57,047, in 1912.

Drilling was much more active in Kansas in 1913 than in 1912, resulting in the completion of 506 productive gas wells, but the number of wells abandoned in 1913 was greater than in 1912. About 1½ miles east and south of Liberty, Montgomery County, considerable drilling was undertaken in 1913, and more than 30 gas wells have been completed in this district with an estimated total daily production of over 100,000,000 cubic feet. These wells are shallow, averaging 500 feet, with from 60 to 90 feet of good gas sand, and the big wells are in this shallow sand. The pressure of the wells in this field is about 100 pounds. Some gas from the Bolton field, Montgomery County, was added to the supply of this State in 1913, the product being piped to consumers in Independence. In Chautauqua County a new field was discovered, and 18 gas wells were completed at a depth of from 650 to 850 feet and with a pressure of from 240 to 300 pounds. A few wells drilled in Butler County in 1913 will produce nitrogen gas (80 per cent N.) at 500 to 520 feet, and fuel gas at 1,320 to 1,460 feet. The daily capacity of these wells is from 1,500,000 to 2,500,000 cubic feet of fuel gas and 4,000,000 cubic feet of nitrogen gas. There is no market for nitrogen gas.

There was in this State at the close of 1913 a total of 2,297 productive gas wells, of which 506 were completed in 1913. The number of dry holes drilled in 1913 was 253, and 315 gas wells were abandoned.

In the following table is given a record of the natural-gas industry in Kansas from 1897 to 1913, inclusive:

Record of natural-gas industry in Kansas, 1897–1913.

Year.	Gas produced.		Gas consumed.			Wells.		
	Number of producers.	Value.	Number of consumers.		Value.	Drilled.		Productive Dec. 31.
			Domestic.	Industrial.		Gas.	Dry.	
1897	10	$105,700	[a] 3,956	20	$105,700	16	8	90
1898	29	174,640	[a] 6,186	44	174,640	34	18	121
1899	31	332,592	[a] 10,071	71	332,592	44	22	160
1900	32	356,900	[a] 9,703	65	356,900	54	15	209
1901	48	659,173	[a] 10,227	72	659,173	71	35	276
1902	80	824,431	13,488	91	824,431	144	63	404
1903	120	1,123,849	15,918	143	1,123,849	295	66	666
1904	190	1,517,643	27,204	298	1,517,643	378	135	1,029
1905	171	2,261,836	46,852	601	2,265,945	340	157	1,142
1906	130	4,010,986	79,270	990	[b] 4,023,566	331	99	1,495
1907	196	6,198,583	149,327	1,605	[b] 6,208,862	361	163	1,760
1908	212	7,691,587	168,855	1,162	[b] 7,691,587	403	208	1,917
1909	199	8,293,846	182,657	1,160	[b] 8,356,076	452	214	2,138
1910	204	7,755,367	186,333	1,412	[c] 9,335,027	392	195	2,149
1911	232	4,854,534	199,523	907	[c] 9,493,701	301	152	2,033
1912	253	4,264,706	195,446	1,104	[c] 8,521,858	435	200	2,106
1913	305	3,288,394	195,131	950	[c] 6,983,802	506	253	2,297

[a] Number of fires supplied.
[b] Includes gas taken from Kansas and consumed in Missouri.
[c] Includes gas taken from Kansas to Missouri; also gas piped from Oklahoma to Kansas and Missouri.

In the following table are given the depth and gas pressure of wells in Kansas from 1909 to 1913, inclusive, by counties:

Depth and gas pressure of wells in Kansas, 1909–1913, by counties.

County.	Depth, in feet.	Pressure, in pounds.				
		1909	1910	1911	1912	1913
Allen	600–1,300	5–300	15–350	5–351	10– 300	5– 260
Anderson	230– 770	65–200	40–150	60–225	30– 240	65– 250
Bourbon	200– 710	75	35– 45	40	40	75
Chase	64–1,100	17–300	10–350	1–400	7– 80	3– 95
Crawford	135– 625	55– 80	4– 65	20– 40	15– 50	40– 50
Cowley	1,400–1,500					
Chautauqua	290–1,300	60–500	40–500	25–250	50– 300	35– 410
Douglas	350– 380	40–180	10–100	30–120	10– 280	20– 60
Johnson	130– 870					
Ellsworth	950–1,250	....	....	....	125– 270	240– 270
Elk	500–1,400	40–200	100–225	100–225	100	90– 100
Butler	1,330–1,500	40–500	40–550	65–450	60–[a] 525	550–[a] 560
Woodson	1,015–1,150					....
Greenwood	350	....	....	....	....	
Labette	350–1,000	60–125	50–160	25–235	23– 185	20– 240
Linn	85– 750	10–150	12–130	22–110	6– 70	20– 100
Franklin, Miami	160– 865	20–200	75–210	50–220	3– 260	1– 500
Montgomery	160–1,600	10–350	3–295	5–350	2–[a] 515	5– 700
Neosho	490–1,200	25–350	35–300	20–287	28– 250	15– 325
Wilson	250–1,300	25–400	12–400	20–380	15– 380	15– 285
Wyandotte	271– 800	150–250	50–200	40–250	40– 125	30– 125

[a] New wells.

MISSOURI.

Returns received from gas producers in Missouri show that the total value of the gas produced from wells and consumed in that State in 1913 was $6,795, as compared with $11,576 in 1912, a reduction of $4,761.

The gas wells in Missouri are located in Bates, Cass, and Jackson counties. The wells are shallow, ranging in depth from 100 to 565 feet, and have a pressure of from 20 to 168 pounds. With few exceptions the wells are used by the persons who had them drilled and are supplying but one family each. A small quantity of gas was supplied commercially in this State in 1913. For a portion of the year 1913 domestic consumers in Rich Hill were supplied with gas from wells in Bates County, but these wells were exhausted and abandoned in August of that year. Consumers in Belton were supplied with gas from wells located in Cass County, and consumers in Martin City were supplied with gas from wells located in Jackson County.

During 1913 the number of domestic consumers supplied with gas in Missouri was 342, and the number of industrial consumers supplied was 7. The gas consumed for industrial purposes was used for the operation of gas engines.

The number of gas wells in this State at the close of the year 1913 was 60, as compared with 70 at the beginning of the year. Six gas wells were drilled, but 16 wells were abandoned. All of the wells abandoned are located in Bates County but two, one of which is in Cass County, the other in Jackson County.

OKLAHOMA.

The report shows that Oklahoma reached its maximum output of natural gas in 1913, showing gains in quantity and value of product as compared with 1912, the declining wells of the State being more than offset by the discovery of new gas fields and the extension of gas territory to the west and south. One of the most important developments of this State is that of the Cushing gas field in Creek County, where the volume and pressure are very great. This is conceded to be one of the best gas fields of the State, the wells varying from 715 to 2,200 feet in depth and reported to have as many as six producing gas sands. Although considerable gas was taken from the wells of this field in 1913 and marketed by the Creek County Gas Co., the town of Cushing being supplied from this source, additional pipe lines were under construction to this field at the close of 1913, through which the gas is to be supplied to the large gas-distributing companies of the State. The gas of this field is also rich in gasoline and two plants have been installed at Drumright, the Consumers Refining Co., and the Cushing Gasoline Co., for the extraction of gasoline from casing-head gas. Two gas wells completed in Creek County in 1913 at depths of 2,014 and 2,134 feet had a rock pressure of 820 and 900 pounds, respectively.

A very large acreage and gas property was opened in McIntosh County in 1913, and the indications are that it is one of the best gas fields of the State; but there is no market yet for all of the product. The town of Eufaula and the Henryetta gas plant are using gas from this field.

Information furnished by the Commissioner of Indian Affairs concerning gas operations on the Osage Reservation in 1913 show that the gas wells have decreased greatly in volume. Of a total of 31 gas wells in service on January 1, 1913, with a total volume of 113,402,930 cubic feet, only 26 wells were productive of gas on January 1, 1914, with a total volume of 42,044,831 cubic feet. During the year 3 gas wells were exhausted and 2 gas wells were abandoned on account of water. Of a total of 11 gas wells completed in 1913 with a total initial volume of 28,538,943 cubic feet, 7 were productive on January 1, 1914, with a total volume of 12,119,400 cubic feet, 4 of the wells having been exhausted. While there was this great loss in volume, there was also a corresponding loss in static pressure, which further reduces the efficiency of the remaining volume in the wells.

The gas produced on the Osage Reservation by the Indian Territory Illuminating Oil Co. is supplied through the Osage Producers Co. to domestic consumers in Avant, Bigheart, and Ochelata; to zinc smelters through the Smelter Gas Co.; to the Quapaw-Wichita Co. for distribution to consumers; and large quantities are consumed by operators for field purposes.

The gas-producing counties of Oklahoma remained about the same in 1913 as in 1912. Gas produced from Kay County wells is supplied to domestic consumers in Ponca City, Tonkawa, Newkirk, and Kildare, and to the glass works at Ponca City. In Okfuskee County a small quantity of gas is supplied to domestic consumers in Okemah. A considerable quantity of gas produced from wells in Okmulgee, Tulsa, Rogers, and Washington counties is piped to consumers in Kansas and Missouri by the large gas-distributing companies. A new gas field was developed in Stephens County, where 10 gas wells have been completed of 702 to 907 feet in depth and with a pressure of 250 to 330 pounds, and they show no evidence of exhaustion. Duncan, Marlow, and Lawton were supplied with gas from this field in 1913 and some of these wells were shut in. Some developments in progress in Tulsa County in 1913 discovered gas in several wells at a depth of 1,600 feet with a pressure of 300 pounds. No gas has yet been marketed from these wells. Several gas wells in Washington County were exhausted in 1913. The staying qualities of the Bartlesville sand are not reported good. Some of these wells have been drilled deeper and are now oil wells. In the Healdton field, Carter County, gas has been discovered at a depth of 710 to 725 feet under 300 pounds pressure, one well completed in December having a volume of 33,000,000 cubic feet daily.

Gas pools are constantly being exhausted by waste through oil wells, and to eliminate this waste and conserve the gas in Oklahoma the Federal Government sent two experts from the Bureau of Mines to this State in 1913 to show the operators how to prevent waste by a certain system of drilling and to prove that gas sands may without waste be drilled through to lower oil strata. At first they were met with indifference by the operators, some believing their method was not applicable in Oklahoma, while others feared an increased cost of drilling. Work was begun in the Cushing field and the demonstrations have been successful. The experts directed the drilling of two wells in which there would have been a combined waste of more than 20,000,000 cubic feet of natural gas daily under the old methods.

They succeeded in shutting off the gas in those wells and drilled the wells below the gas stratum and into the oil. They also directed the drilling of other wells past the stratum and without waste of the gas. The system consists in brief in pumping a mud-laden fluid into the well in such a way that it stops the gas from penetrating the well. In the past, it is asserted, in a great many wells drilled in the Cushing field in the gas zone, it was found impossible to drill entirely through the gas formation, owing to the pressure and volume of the gas. In several places it was necessary to shut down the well, and the money spent in drilling was lost. It is asserted that the method urged by the Government will cost the oil men less and that there will be less risk than with the method which has been in vogue. The adoption of this new method, it is said, will under certain conditions prevent the entrance of water, which was threatening the future production of oil in this State.

Oklahoma was the third State in point of gas production in 1913, having produced 75,017,668,000 cubic feet of gas, valued at $7,436,389, an average price of 9.91 cents per thousand cubic feet, as compared with 73,799,319,000 cubic feet in 1912, valued at $7,406,528, an average price of 10.04 cents per thousand cubic feet. It will also be noted that nearly one-third of this gas, or 23,768,374,000 cubic feet, was piped out of the State to Kansas and Missouri. The exportation of gas in 1913 was very much less than in 1912, when 32,249,916,000 cubic feet were piped from the State, showing conclusively the increasing markets and uses for the gas within the State.

The quantity of gas consumed in Oklahoma in 1913 was 51,249,-294,000 cubic feet, valued at $3,740,981, an average price of 7.3 cents per thousand cubic feet, as compared with a consumption of 41,549,-403,000 cubic feet in 1912, valued at $3,149,376, an average price of 7.58 cents per thousand cubic feet. Of the total quantity of gas consumed in the State in 1913, the supply for domestic consumption was 7,039,-196,000 cubic feet, valued at $1,256,818, an average price of 17.85 cents per thousand cubic feet, and for industrial consumption was 44,210,098,000 cubic feet, valued at $2,484,163, or 5.62 cents per thousand cubic feet; in 1912 the quantity of gas supplied for domestic consumption was 6,500,062,000 cubic feet, valued at $1,288,894, an average price of 19.83 cents per thousand cubic feet, and for industrial consumption 35,049,341,000 cubic feet, valued at $1,860,482, or 5.31 cents per thousand cubic feet.

The table of distribution of gas for industrial purposes in 1913 shows that 22,947,560,000 cubic feet, valued at $1,083,154, was supplied for manufacturing and 21,262,538,000 cubic feet, valued at $1,401,009, for other industrial or power purposes, the quantity and value of gas supplied for both classes of industrial consumption being greater in 1913 than in 1912, when 20,915,974,000 cubic feet, valued at $954,498, was supplied for manufacturing and 14,133,367,000 cubic feet, valued at $905,984, was supplied for other industrial or power purposes.

It is estimated that 14,596,005,000 cubic feet of gas, valued at $575,086, was consumed by zinc smelters and brick, glass, and cement plants in Oklahoma in 1913. Another use for natural gas in this State was the manufacture of carbon black, there being one plant in operation in 1913. Large quantities of gas were consumed in 1913 in operating gas engines and boilers in the oil fields and elsewhere, for drilling, pumping, and pipe-line stations, and for cotton gins and refineries. The production of gasoline from casing-head gas has become quite an industry in this State, statistics of which will be found in another portion of this report.

The number of productive gas wells in Oklahoma at the close of 1913 was 1,052, as compared with 936 at the close of 1912. In all 423 productive gas wells and 298 dry wells were drilled and 307 wells were abandoned in 1913.

In the following table is given a record of the natural-gas industry in Oklahoma from 1906 to 1913, inclusive:

Record of natural-gas industry in Oklahoma, 1906–1913.

Year.	Gas produced.		Gas consumed.			Wells.		
	Number of producers.	Value.	Number of consumers.		Value.	Drilled.		Productive Dec. 31.
			Domestic.	Industrial.		Gas.	Dry.	
1906	50	$259,862	8,391	202	$247,282	81	33	239
1907	107	417,221	11,038	277	406,942	99	41	344
1908	115	860,159	17,567	356	860,159	73	40	374
1909	131	1,806,193	32,907	1,527	1,743,963	97	35	454
1910	168	3,490,704	38,617	1,557	1,911,044	93	58	509
1911	204	6,731,770	44,854	1,507	2,092,603	303	143	732
1912	242	7,406,528	47,017	1,651	3,149,376	329	197	936
1913	347	7,436,389	49,308	1,793	3,740,981	423	298	1,052

In the following table are given the depth and pressure of gas wells in Oklahoma from 1909 to 1913, inclusive, by counties:

Depth and gas pressure of wells in Oklahoma, 1909–1913, by counties.

County.	Depth, in feet.	Pressure, in pounds.				
		1909	1910	1911	1912	1913
Hughes	1,000–2,000	...	...	...	200	10–350
Carter	590–1,840					
Cherokee	600–650	50–350	60–100	48–150	...	...
Comanche	380–400					
Craig	500					
Latimer	1,575	...	...	40–470	...	...
Sequoyah	1,200					
Creek	400–2,500	50–900	40–450	20–700	40–850	20–900
Kay	436–1,600	60–385	60–375	40–390	165–365	40–650
Kiowa	350–825	...	35	10–50	...	...
Le Flore	1,300–2,200	...	350	300–355	350–355	300–375
McIntosh	962–2,700				150–600	150–400
Marshall	480–525	...	...	...		
Muskogee	800–1,910	130–160	50–500	18–225	15–350	10–350
Nowata	450–1,700	120–500	70–100	60–450	25–150	25–300
Okfuskee	1,450	...	...	...	...	...
Okmulgee	760–2,600	150–700	150–800	100–700	300	80–[a]800
Osage	900–2,200	300–850	200–650	150–650	200–780	100–700
Pawnee	1,200–2,560	160–260	150–200	200–450	40–800	...
Rogers	380–1,250	50–550	125–530	90–480	40–525	25–500
Stephens	702–907	...	...	...	300–325	250–330
Tulsa	580–2,000	50–700	50–650	80–400	50–625	100–650
Wagoner	750–1,700	210–600	90–120	100–300	...	...
Washington	425–2,260	60–800	80–740	15–620	10–250	10–350

[a] New well.

LOUISIANA.

One of the most important gas fields ever discovered is the Caddo field in Louisiana, and probably more gas has been wasted in this field than in any other. However, these conditions have now been changed and the waste of gas in this State very much lessened by the closing of the three wild wells, which had become famous in this field. After the wild well in the Caddo field was "killed" in 1911 the State Conservation Commission headed a movement to cap the wild gasser at Oil City, which for more than five years has wasted an inestimable quantity of gas. An agreement was reached whereby the commission was to undertake the task and to have the cooperative support of the producers in the field. The crater of the well was first explored, but it was soon found impracticable to close the well from the top. The commission then let a contract for the drilling of a relief well to tap the wild well in the gas-sand stratum from which it was fed. After cutting into the stratum the plan was to pump in mud-laden water and choke the well, the process then to be reversed and the relief well used to reduce the pressure of the wild well, in the hope of being able to get to the original casing of the wild well and cap it. The commission was successful and the wild well succumbed to the water pressure from the neighboring relief well. The closing of this well was accomplished about October 1, 1913, and establishes an important means of conserving the gas of this State. The Dixie well, after flowing gas since September 1, 1907, was choked by salt water and ceased to flow September 18, 1913. The gas pressure had been gradually diminishing and the flow of salt water increasing. The closing of these wild wells has put a stop to any appreciable waste of gas in the Caddo field.

The Caddo gas field is the chief source of gas production in Louisiana, and the most important gas producers in this field are the Arkansas Natural Gas Co. and the South Western Gas & Electric Co., the former company supplying gas to consumers in many cities and towns in Arkansas as far north as Little Rock, a distance of some 200 miles. The South Western Gas & Electric Co., through its branches, the Caddo division, the Shreveport division, and the Texarkana division, is supplying gas to many towns in Louisiana, including Shreveport, Texarkana, Blanchard, Mooringsport, Lewis, Oil City, Vivian, Mystic, and Rodessa, also Ravenna, Ark., besides supplying gas to the Atlanta Gas Co., which is supplying consumers in Atlanta and Queen City, Tex., and the Texarkana Gas Co., which is supplying consumers in Texarkana, Bloomburg, and Cass, Tex. Other gas producers are the Red River Gas Co., supplying consumers in Dixie and Belcher; the Commercial Gas & Oil Co. and the Shreveport Natural Gas Co., both in Shreveport; and the Louisiana-Texas Natural Gas Co., supplying gas through the Marshall Gas Co. to consumers in Marshall and Leigh, Tex. Many of the oil operators of this field have gas wells, the product of which is used and sold for field purposes, in addition to supplying a considerable quantity to the large gas-distributing companies for distribution to consumers. Much of the gas used and sold in the field is supplied at a flat rate and only approximate figures can be given of its production; therefore, the quantity of gas used for power purposes must be considered an estimate.

In De Soto Parish an important gas field has been developed by the Mansfield Gas Co., from whose wells gas is supplied to domestic and industrial consumers in Mansfield.

Other parishes in Louisiana in which gas was produced and used in 1913 were Lafourche and Ouachita, both of which had a small gas production utilized for power purposes. Two wells drilled in Lincoln Parish were abandoned. Two wells drilled in Rapides Parish were also without results and were abandoned. Mr. I. N. Knapp says:

In Terrebonne Parish there are many surface gas escapements and in all some 12 wells have been drilled, 4 being within a mile of the Lirette (discovery) well. There is abundance of gas in the thin sand layers or lenses between clay or shales all the way from 1,500 to 1,900 feet. The closed pressure (original) is 650 pounds. Some of the sands are loose and some are true gas sands; that is, sands more or less cemented. The layers of clay will squeeze into the screen as soon as the pressure is reduced and shut off the gas. Also in the productive horizon it is uncertain which is gas sand or which salt-water sands. It is impossible to distinguish in drilling with the rotary, and it is impossible to drill in any other way. There is a world of gas here, but not available.

The field has been practically abandoned for the present.

The total value of the gas produced in Louisiana and Alabama in 1913, and consumed for domestic and other purposes, was $2,119,948, as compared with $1,747,379 in 1912, a gain of 21.3 per cent. Of this total value, $895,524 was received for gas supplied for domestic consumption, and the value of the gas consumed for industrial purposes is estimated at $1,224,424.

The table of the distribution of gas in 1913 by States shows that the larger portion of the gas consumed in Louisiana and Alabama was utilized for industrial purposes, and that of the gas consumed for industrial purposes the larger part was consumed for power. In Shreveport gas was consumed in 1913 for manufacturing purposes by two glass factories, and also by a stave company, a handle company, and a silo company. For power gas is consumed in Louisiana by cotton gins, cottonseed mills, ice companies, by engines and boilers in the oil and gas fields of the State in the operation of wells, by drilling contractors, and by oil refineries.

The total number of productive gas wells in Louisiana at the close of 1913 was 190, of which 53 were completed during that year. The number of dry holes drilled in 1913 was 24 and the number of wells abandoned was 18.

In the following table is given the record of the natural-gas industry in Louisiana from 1909 to 1913, inclusive:

Record of natural-gas industry in Louisiana, 1909–1913.

Year.	Number of producers.	Number of consumers.		Total value of gas produced.[a]	Wells.		
		Domestic.	Industrial.		Drilled.		Productive Dec. 31.
					Gas.	Dry.	
1909	11	4,034	164	$326,245	26	10	70
1910	21	8,547	320	509,408	23	4	91
1911	27	[b] 17,964	442	858,145	36	18	116
1912	41	[b] 31,105	528	1,747,379	50	20	155
1913	57	[b] 33,424	604	2,119,948	53	24	190

[a] Includes the production of Alabama.
[b] Includes consumers supplied with gas piped from Louisiana to Arkansas and Texas.

TEXAS.

The year 1913 was one of unusual activity in the natural-gas interests of Texas. The completion of new wells and the extension of pipe lines to supply the product to consumers combined to increase the value of the gas consumed in the State from $1,405,077 in 1912 to $2,073,823 in 1913, a gain of $668,746, or nearly 50 per cent, making this the most prosperous year in the history of the natural-gas industry in this State. The consumption of gas increased from 7,470,373,000 cubic feet in 1912 to 12,159,755,000 cubic feet in 1913. The average price of gas per thousand cubic feet in 1913 was 17.05 cents, as compared with 18.81 cents in 1912. This reduction in average price was largely due to the greater gain in quantity of gas supplied for industrial use over that of the year 1912, as compared with the increase in domestic consumption in 1913. The average price received for gas per thousand cubic feet supplied for domestic purposes in 1913 was 38.3 cents; it was 38.7 cents in 1912. The average price received for gas supplied for industrial purposes in 1913 was 8.95 cents per thousand cubic feet; in 1912 it was 9.72 cents.

The chief gas-producing district of Texas is located in Clay County, where there were 33 gas wells at the close of 1913. The gas companies operating in this field are the Henrietta Oil & Gas Co., the Developers Oil & Gas Co., the Wichita Falls Gas Co., and the Lone Star Gas Co. The last-named company supplies gas to consumers through the following-named companies: County Gas Co., Dallas Gas Co., Fort Worth Gas Co., Gainesville Gas & Electric Co., and North Texas Gas Co. The following cities and towns in Texas are supplied with gas from Clay County wells: Henrietta, Dallas, Fort Worth, Gainesville, Eagle Ford, Grand Prairie, Dalworth Park, Arlington, Byers, Petrolia, Wichita Falls, Bellevue, Bowie, Sunset, Alvord, Decatur, Rhome, Bridgeport, Irving, Denison, Denton, Sherman, and Whitesboro.

The next gas field in importance seems to be the Mexia field of Limestone County, which was opened in 1912 and is rapidly coming to the front as a gas producer. At the close of 1913 three companies were operating in this field—the Little Giant Oil & Gas Co., the Mexia Oil & Gas Co., and the Southern Oil & Gas Co.—with a total of 17 gas wells, of which all but 1 were drilled in 1913. The wells vary in depth from 550 to 800 feet and have an average pressure of 275 pounds and a large volume. The towns of Mexia and Teague were supplied with gas from this field in 1913 for both domestic and industrial purposes, the gas consumed for industrial purposes being utilized by cotton gins, cottonseed mills, broom factory, laundries, electric-light plants, etc., besides a large consumption in the field. It is reported that the surplus gas from wells in this field will be supplied to consumers in Waco.

Gas from wells in Webb County is supplied to consumers in Laredo by the Border Gas Co. Moran and Albany are supplied with gas from wells in Shackelford County. Navarro County wells are still supplying gas to consumers in Corsicana.

Some important developments were in progress in Brown County in 1913. At the close of that year there were four good gas wells in this field; but very little of the product was consumed in 1913 except for field purposes. The town of Bangs was piped for gas in 1913 and consumers were being supplied with gas from this field early in 1914.

It is reported that Brownwood will also be supplied with gas from this field.

It is reported that gas produced from wells in Coleman County will be supplied to consumers in Santa Anna, which town was being piped early in 1914.

Gas was also produced and used from wells located in Atascosa, Bexar, Eastland, Goliad, Gonzales, Hardin, Harris, McMullen, Liberty, Throckmorton, and Wichita counties in 1913.

It may be of interest in this connection to refer to a "gushing" well (gas geyser) in Texas. This well is located on the ranch of Mr. C. R. Byrne, 8½ miles east of Tilden, in McMullen County. The well was completed June 24, 1908, and has been open ever since, yet the gas seems to increase. No measurements of yield or pressure have been made, but when ignited no wind has ever extinguished it. For the first year or so the gushes were 8 days apart; then as the sand was thrown out the time between gushes gradually diminished, and now it gushes every 22 to 24 hours. The only attempt to cap this well was made by an experienced oil and gas driller and three minutes was the longest time he would risk keeping it closed. This was between gushes during the regular flow. In three minutes' time enough gas accumulated to force all water down in the casing and it was believed this would force the casing out if kept closed longer. The gas pressure during gushes is much greater than during the regular flow. As the gushes are uncontrolled, the gas from this well can not be used.

The following is the log of this well:

Log of gushing gas well (gas geyser) near Tilden, McMullen County, Tex.

	Feet.
Top, black surface soil	25
Sand rock	25 to 110
Water sand with layers of sand rock—fresh sulphur water	110 to 175
Hard sand rock	175 to 185
Soapstone	185 to 327
Hard sand rock	327 to 330
Water sand, 50 gallons per minute flow, very salt water	330 to 360
Soapstone	360 to 409
Hard shell rock	409 to 410
Green sand showing some oil, but could not test, on account of caving	410 to 445
Soapstone, shale, and mixture of lignite	445 to 680
Sand rock	680 to 694
Water sand, 150 gallons per minute flow; warm mineral and salt water	694 to 734
Very hard rock. As the drill apparently went through into a cavity the gas came with such force that hose could not stand the pressure. The force of this gas threw water and an immense quantity of sand 150 feet high. The casing from surface to the 680-foot rock is 4¼ inches. The hole through the 14-foot rock was reduced to 3½ inches and about 2 feet of the hole in the 734-foot rock (two days' drilling) was done with 3½-inch bit; but this rock was so hard the remaining 5 feet through that bottom rock was bored with a 2-inch bit	734 to 741

A considerable quantity of gas is produced from wells in Louisiana and piped to Texas for consumption, the number of consumers and the value of the gas consumed being included in the statistics for the State of Louisiana, which will be found in another part of this report.

The cities and towns supplied in Texas with gas from this source in 1913 were as follows: Atlanta, Bloomburg, Cass, Leigh, Marshall, Queen City, and Texarkana.

In the following table is given a record of the natural-gas industry in Texas from 1909 to 1913, inclusive:

Record of natural-gas industry in Texas, 1909–1913.

Year.	Number of producers.	Number of consumers.		Total value of gas produced.	Wells.		
		Domestic.	Industrial.		Drilled.		Productive Dec. 31.
					Gas.	Dry.	
1909	17	5,035	130	$127,008	7	6	38
1910	19	14,719	133	447,275	22	5	52
1911	29	22,972	303	1,014,945	19	14	69
1912	41	27,226	329	1,405,077	24	23	87
1913	50	37,350	393	2,073,823	43	29	123

CALIFORNIA.

The year 1913 may be considered a memorable one in the history of the natural-gas industry of California.

Since the discovery of gas in the Buena Vista Hills, near Taft, in Kern County, the natural-gas industry of California has continued to improve, and the year 1913 added an important chapter to its history by the completion of the pipe line from the Midway field to southern California and the introduction of natural gas into Los Angeles and towns and cities in the adjacent territory. The construction of this line by the Midway Gas Co., which was described in the report of this series for 1912, was successfully accomplished after many difficulties and at great expense. The Midway Gas Co. is the pipe-line company and the Southern California Gas Co. the distributing company, which purchases the gas from the producers in the field. The gas piped through this line in 1913 was produced from wells located in the Buena Vista Hills and operated by the Honolulu Consolidated Oil Co. and the Kern Trading & Oil Co. The gas is delivered at West Glendale terminus outside the city of Los Angeles by the Southern California Gas Co., which supplies gas directly to consumers in the city of Los Angeles and to consumers outside of the city limits of Los Angeles, in the cities of Glendale, Vernon, Torrance, Compton, Athens, Gardena, Cudahy, Lynwood, Moneta, Eagle Rock, Tropico, Burbank, San Fernando, and Redondo Beach. The Southern California Gas Co. also sells gas to the Southern California Edison Co., which is supplying Long Beach, and to the Western Fuel & Power Co., which is supplying Venice, Santa Monica, and Sawtelle. Gas is also sold by the Southern California Gas Co. to the Los Angeles Gas & Electric Corporation, which serves consumers in the city of Los Angeles and consumers outside of Los Angeles in the cities of Pasadena, South Pasadena, Vernon, Eagle Rock, Huntington Park, Alhambra, and San Gabriel. Approximately 116,000 consumers were being supplied with natural gas in the city of Los Angeles at the close of the year 1913, and probably

30,000 consumers were being served outside of the city limits. Doubtless artificial gas in southern California will eventually be displaced by natural gas. The rate as fixed by the city council for gas in the city of Los Angeles from July 1, 1913, to July 1, 1914, was 70 cents per thousand cubic feet. The first gas supplied by the Southern California Gas Co. for consumption was in April, 1913.

It is estimated that 11,034,597,000 cubic feet of gas, valued at $1,883,450, or 17.07 cents per thousand cubic feet, was produced in this State and consumed in 1913, as compared with 9,354,428,000 cubic feet, valued at $1,134,456, or 12.13 cents per thousand cubic feet, in 1912. This increase was brought about both by the introduction of gas into southern California and also by an increased production and more general use of gas in other fields of the State.

The wells with greatest capacity and highest pressure are located in Kern County, where at the close of 1913 there were 27 gas wells, 7 of which were completed in 1913. These wells range in depth from 1,600 to 2,782 feet and have a pressure of from 250 to 960 pounds. The towns of Bakersfield, Fellows, Taft, South Taft, and Maricopa are supplied with gas from this field in addition to large quantities of gas consumed for drilling and pumping throughout the oil fields.

Considerable gas is produced from the oil wells of Orange and Santa Barbara counties, where it is largely used for field purposes, and as this gas is very rich in gasoline, several plants have been installed in these counties for the production of gasoline, which has become an important industry of this State. Some gas produced in the Santa Maria field of Santa Barbara County is supplied for domestic purposes to the towns of Santa Maria, Arroyo Grande, Nipomo, Guadalupe, Los Berros, and Betteravia.

The table of the distribution of natural gas in 1913 by States shows that 164,358 domestic consumers were supplied with gas in California at the close of 1913, the quantity of gas consumed for domestic purposes in 1913 being estimated at 1,632,337,000 cubic feet, valued at $1,100,702, or 67.43 cents per thousand cubic feet, as compared with 18,171 domestic consumers supplied at the close of 1912, and a domestic consumption of 974,796,000 cubic feet of gas, valued at $525,428, or 53.9 cents per thousand cubic feet, in 1912. It also appears that large quantities of gas are consumed in this State for power, the estimate for 1913 being 9,402,260,000 cubic feet, valued at $782,748, or 8.33 cents per thousand cubic feet. As has already been stated in previous reports large quantities of gas, for which there is no use, are wasted in the oil fields of California. The establishment of gasoline plants in the fields where the gas is rich in gasoline, is one of the means of utilizing this waste or excess gas. A report of the statistics of gasoline production in 1913 will be found in another part of this report.

The names of the counties in California in which gas was produced and used for either domestic or power purposes in 1913 are as follows: Humboldt, Kern, Orange, Los Angeles, Sacramento, San Joaquin, Santa Barbara, Santa Clara, Solano, Tehama, Ventura, and Fresno.

The number of productive gas wells in this State at the close of 1913 was 72, of which 13 were drilled in 1913, 9 of which were productive and 4 were dry holes. The number of wells abandoned in 1913 was 8.

In the following table is given a record of the natural-gas industry in California from 1909 to 1913, inclusive:

Record of natural-gas industry in California, 1909–1913.

Year.	Number of producers.	Number of consumers.		Total value of gas produced.	Wells.		
					Drilled.		Productive Dec. 31.
		Domestic.	Industrial.		Gas.	Dry.	
1909	35	7,612	104	$446,933	7	......	[a] 64
1910	30	8,292	217	476,697	3	2	[a] 65
1911	32	10,598	307	800,714	8	6	[a] 66
1912	43	18,171	232	1,134,456	6	1	[a] 71
1913	48	[b] 164,358	141	1,883,450	9	4	[a] 72

[a] Includes some artesian wells from which gas was used.
[b] Includes some consumers who are using mixed gas.

ARKANSAS.

The natural-gas situation in Arkansas was practically the same in 1913 as in 1912. The productive gas fields of this State are located in Sebastian and Scott counties, where there was at the close of 1913 a total of 98 productive gas wells, 3 of which were drilled in 1913. The completion of new wells in 1913 in Sebastian County extended the field 1 mile west of former limits. The gas sand is found 200 feet deeper in the new wells. The gas in this field is produced from close, hard, gray sand.

The depth of wells in Arkansas varies from 900 to 2,350 feet. The gas-bearing sands of Sebastian County are found between 1,200 and 1,400 feet and between 2,000 and 2,400 feet. Pressure varies from 21 to 200 pounds in old wells, and reaches 315 pounds in new wells. Wells in Sebastian County with an initial average rock pressure in 1907 of 210 pounds have now an average rock pressure of 42 pounds. One well in steady service for 10 years still shows a rock pressure of over 200 pounds. The wells of the field may be said to be holding up well.

The number of domestic consumers supplied with gas in 1913 was 5,836, as compared with 5,601 in 1912, while the number of industrial consumers decreased from 16 in 1912 to 11 in 1913. The gas used in this State for manufacturing purposes is consumed by brick works.

In an effort to find gas in Bradley County, Ark., in 1913, the Vick Oil & Gas Co. drilled near Vick to a depth of 2,638 feet, but was unsuccessful, the well being a dry hole.

Reference to the natural-gas statistics of Louisiana will show that gas is piped from the Caddo field of that State and supplied to consumers in many cities and towns in Arkansas, the figures of this gas consumption being included with those of Louisiana.

The statistics of the natural-gas industry of Arkansas are included with those of Colorado and Wyoming.

COLORADO.

Reports received from gas producers in Colorado indicate that the quantity and value of gas consumed in 1913 was less than in 1912. This State had at the close of 1912 a total of 8 productive gas wells and only 5 at the close of 1913.

The gas consumed in Colorado in domestic use is chiefly produced from one well located near Boulder, Boulder County, the product of which is supplied to consumers in Boulder. Considerable gas is produced from the oil wells in the Boulder oil field of this State. It is used for operating purposes in the field. The gas produced from the oil wells in this field is rich in gasoline, and two plants have been erected and are in operation for the extraction of gasoline from the surplus gas. The Florence oil field of this State also produces gas which is used under boilers in the field. The gas derived from the oil wells of this State and consumed for field purposes—under boilers, for gas engines, and for the extraction of gasoline—is not metered; and, therefore, the quantity and value of it can only be estimated.

Las Animas County has two gas wells, the product of which is consumed by the owners of the ranches upon which they are located. One of these wells is 16 years old, and the flow of gas has remained about the same for years.

Two gas wells have been drilled in Mesa County, one of which has been furnishing gas for the domestic use of the owner for eight years. The gas is not metered, and an abundance is going to waste. Another well in this county, called the "spouting" well, an account of which was given in the report for 1912, shows no diminution, but rather seems to be increasing its production of gas and water. The Grand River Oil & Gas Co. was drilling a well in 1913 1¼ miles west of De Beque, and had a good showing of oil and gas, but not yet in commercial quantities.

The statistics of the natural-gas industry in Colorado are included with those of Arkansas and Wyoming.

IOWA.

There has been no change in the natural-gas situation in Iowa since the last report. There are six shallow wells located in Louisa County from which sufficient gas is obtained to supply three families with lights and partly for cooking. The wells have a depth of from 100 to 120 feet and a gas pressure of about 5 to 7 pounds.

In Guthrie County attempts have been made in past years to find gas in three wells, which remain undeveloped; the wells were drilled to a depth of 55 to 125 feet. Two of them located 1½ miles from the town of Bayard had a heavy flow of gas, with a flame from 12 to 14 feet high. This gas was allowed to escape for six months, and then the wells were plugged. The other well is located west of Herndon and is said to have had very high pressure.

MICHIGAN.

There is no change in the natural-gas situation in Michigan since the last report. At the close of 1913 there were 18 shallow wells in this State producing both gas and water, from which gas was being used for domestic consumption; and each of these wells was supplying one family, except two wells which supplied two families each. A small quantity of gas produced from oil wells was consumed for operating purposes.

No gas wells were drilled in 1913, and one well was abandoned. The small quantity of gas which was consumed was produced in the following-named counties: Benzie, Macomb, Oakland, St. Clair, Washtenaw, and Wayne. The total value of the gas produced from wells and consumed in this State in 1913 is estimated at $1,405.

MONTANA.

Although there are no statistics of gas production in Montana, it may be of interest to report a gas well completed in this State in 1913 jointly by the Consolidated Oil & Gas Co. and the Mid-West Oil Co. The well is located in Dawson County and has a depth of 2,345 feet. The first gas was encountered at a depth of 840 feet, and two more light flows have been found lower down. The gas has no odor. It is estimated by the drillers that the flow would exceed 1,000,000 cubic feet a day. The gas is used under boilers.

NORTH DAKOTA.

The natural-gas production of North Dakota is of little importance. Although gas has been found and used from shallow wells in Bottineau and Renville counties and from artesian wells in Lamoure County, the only gas used commercially in 1913 was in the town of Lansford, the gas being utilized entirely for domestic purposes.

The wells in Bottineau and Renville counties range in depth from 170 to 325 feet and have a gas pressure of from 25 to 105 pounds. At the close of 1913 there were 17 wells in this State from which gas was being used, 7 having been abandoned during the year.

The statistics of the production of natural gas in this State are included with those of South Dakota.

SOUTH DAKOTA.

No new developments have been reported in the natural-gas districts of South Dakota for 1913. The gas in this State is produced from artesian wells located in the following-named counties: Hughes, Potter, Stanley, Sully, and Walworth. With the exception of the cities of Pierre and Fort Pierre, where gas is used commercially, the gas is produced and used from individual wells by the owners. Some of these producers state that their wells are producing far more gas than they can use; others report that their gas is growing weaker and that windmills are now coming into use in place of the gas for pumping water. In the cities of Pierre and Fort Pierre the gas is consumed for both domestic and power purposes. Over 350 domestic consumers are supplied with gas in these towns, besides gas used at the electric-light and water plants.

At the close of 1913 there were 35 artesian wells from which gas was used, there being no change in number since the last report.

The statistics of the natural-gas industry in this State are included with those of North Dakota.

WYOMING.

Although there was considerable activity in the oil and gas fields of Wyoming in 1913 as compared with 1912, the returns received from gas producers show a reduction in quantity and value of gas consumed. The principal gas production is from wells located in Bighorn County, which supply domestic consumers in the towns of Basin, Greybull, and Byron. The number of gas wells in Bighorn County at the close of 1913 was 15, of which 3 were drilled in 1913, 2 by the Greybull Oil Co. and 1 by the Utah-Wyoming Consolidated Oil Co. It is reported that since January 1, 1914, a well was completed by the Montana & Wyoming Oil Co., with an estimated daily capacity of 4,000,000 cubic feet of gas. This well is located three-fourths of a mile north of the oil wells at Byron and will be used by the company for fuel for drilling other wells and for supplying power to pump their own oil wells. The gas wells of this county vary from 450 to 2,250 feet in depth. Some of the older wells used in this field are almost exhausted; but new wells have a pressure of from 145 to 650 pounds.

Very little gas was produced and consumed from the wells of Converse County in 1913. Considerable gas, which is used for field purposes, is produced from the oil wells in Natrona County. It is reported that some of the flowing oil wells in this field are estimated to produce as much as 1,500,000 cubic feet of gas each 24 hours. In Park County 4 gas wells have been completed, one of which was drilled in 1913 by the Enalpac Oil & Gas Co. Two wells in this county have an estimated capacity of 6,500,000 and 9,000,000 cubic feet of gas each 24 hours. As there is no market for the gas, the wells are shut in. The wells of this county have a depth of from 600 to 1,500 feet and a pressure of from 430 to 455 pounds. Gas produced from oil wells in the Uinta County oil field is used to some extent for operation of gas engines in the oil field.

The statistics of the natural-gas industry in Wyoming are included with those of Arkansas and Colorado.

IMPORTS.

The imports of natural gas for consumption during the last six years have been as follows:

Value of natural gas imported for consumption, 1908–1913.

1908	$22,003	1911	None reported.
1909	6,060	1912	Do.
1910	None reported.	1913	Do.

No exports of natural gas from 1908 to 1913, inclusive, were reported.

NATURAL GAS IN FOREIGN COUNTRIES.

CANADA.

The preliminary report on the mineral production of Canada for 1913, published by the department of mines, states:

There was comparatively little change in the production of natural gas in Ontario, but a large increase in the production in New Brunswick and in Alberta. The total production in 1913 was approximately 20,345,000,000 feet, valued at $3,338,314, of which 828,000,000 feet, valued at $174,006, was from New Brunswick; 12,487,000,000 feet, valued at $2,092,400, from Ontario, and 7,030,000,000, valued at $1,071,908, from Alberta.

The production in 1912 was reported as 15,287,000,000 feet, valued at $2,362,700, and included 174,000,000 feet from New Brunswick, valued at $36,549; 12,529,000,000 feet from Ontario, valued at $2,036,245; and 2,584,000,000 feet from Alberta, valued at $289,906.

These values represent as closely as can be ascertained the value received by the owners or operators of the wells for gas produced and sold or used. The values do not represent what consumers have to pay, since in cases where transmission is by separately operated pipe-line companies such cost is not included.

The following table gives the value of natural gas produced in Canada each year since 1909, by Provinces:

Value of natural gas produced in Canada, by Provinces, 1909–1913.

Year.	New Brunswick.	Alberta.	Ontario.	Total Canada.
1909	....	$61,722	$1,145,307	$1,207,029
1910	....	75,168	1,271,303	1,346,471
1911	....	110,165	1,807,513	1,917,678
1912	$36,549	289,906	2,036,245	2,362,700
1913	174,006	1,071,908	2,092,400	3,338,314

The following table gives the statistics of natural-gas production in the Province of Ontario, Canada, since 1909:

Statistics of natural-gas production in the Province of Ontario, Canada, 1909–1913.

Year.	Wells bored in the year.		Producing wells.	Miles of gas pipe.	Workmen employed.	Gas production.		Wages for labor.
	Productive.	Nonproductive.				Quantity (cubic feet).	Value.	
1909	....	....	744	987	171	5,388,000,000	$1,145,307	$103,672
1910	....	....	828	982	186	7,263,427,000	1,271,303	118,785
1911	268	38	1,179	1,296	287	10,863,871,000	1,807,513	183,663
1912	178	41	1,247	1,448	277	12,529,463,000	2,036,245	184,351
1913	166	48	1,522	1,720	402	12,416,264,000	2,337,000	289,480

Consul General Frank Dillingham, of Winnipeg, Canada, under date of May 5, 1914, says:

According to newspaper reports, natural gas has been found on a farm a few miles west of the town of Dauphin, Manitoba, which is situated about 178 miles northwest of Winnipeg. It is reported that the gas has been burning with the flame 6 feet above the ground for several days.

HUNGARY.

Consul General William Coffin, of Budapest, under date of April 4, 1914, says:

The first actual progress in the utilization of the natural gas of Kissarmas, Hungary, has been registered by the completion and ceremonial delivery to the county authorities of a pipe line from Kissarmas to Marosujvar, a distance of about 30 miles. This pipe line was laid down entirely by Hungarian engineers and workmen and cost a little over a half million dollars. The materials used were entirely of Hungarian manufacture and the time consumed in construction was just one year. This is said to be the only pipe line of importance at present in Europe for conveying natural gas. Since its construction was begun, gas has been discovered in other parts of Hungary, and there is every indication that before many years natural gas will come into general use in Hungary.

This large store of natural gas, which until a few years ago was not known to exist, will be the means of stimulating every branch of industry in Transylvania and even in more distant parts of Hungary. It is said that several companies have already begun to erect manufacturing plants in the neighborhood of the gas fields. A full account of the Transylvania natural-gas fields of Hungary was given in the report for the year 1912.

Another communication from Mr. Coffin, under date of July 24, 1914, says:

A deposit of natural gas has been discovered in the township of Temerin, in the southern part of Bacska County, Hungary. This is the third district in Hungary in which natural gas has been discovered, and there are evidences that it exists in other parts of the country, and that the deposits are enormous. A law enacted in 1911 makes all natural gas deposits discovered in Hungary the property of the Government, and any exploitation of them must be made with the permission and under the authority of the minister of finance. Landowners, on whose lands gas has been discovered, or may be discovered in the future, are entitled to a certain compensation from the Hungarian Government.

An article by Mr. E. Czako, of Karlsruhe, Germany, on the Transylvania and Kissarmas natural-gas fields of Hungary, states that from January 30, 1909, when the first natural-gas (methane) well was discovered in Kissarmas, Kolozs County, little was known of the incident until November, 1911, when another gas well was drilled, which had the proportions of a catastrophe. The subject of natural gas was a new one for all of Europe, and the circle of experts of the Hungarian Government had to exercise much patience and industry to cope with this difficult problem, which involved the drilling of an extraordinarily powerful natural-gas well in 1911 and its utilization for the benefit of industry and of the country—all within a period of three years. With the successful closing of the gas wells, after much trouble, at the end of July, 1912, the work came to an end. The results of these three years' work appeared in a report on the investigations up to date of the occurrence of natural gas in the Transylvania basin.[1] This report states that aside from the gas wells that have become known in drilling artesian wells in the great Hungarian plain and those which were partly used for illumination or power, only locally, to be sure, on account of the small yield of the wells, smaller seepages of natural gas have also been known in Transylvania, but for many years have remained practically uninvestigated. However, since the discovery of natural gas at Kissarmas they have been subject to a thorough geological investigation. These two gas regions have no connection with each other. The gases in the great Hungarian basin are derived from great bogs of earlier periods and are connected with the decomposition (in the absence of air) of the fossil plants, but the natural gas of Transylvania, according to all appearances, is connected with petroleum, which latter, having marine origin, is also closely connected with the occurrence of salt. The natural gas of Neuengamer, in all probability, has a similar origin.

The Kissarmas natural-gas field owes its discovery to the fact that the Hungarian Government had been looking for potassium salts since the year 1907 in the Transylvania Tertiary basin below the salt deposits underlying the former lower Hungarian sea bottom, and had

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[1] Published by Royal Hungarian Minister of Finance, Budapest, 1911.

made systematic borings for them. These borings had not produced the results desired, but the great gas wells of Kissarmas were discovered.

The first well was begun in February, 1908, at Nagysarmas. Many difficulties were encountered. At a depth of about 2,000 feet the work had to cease on account of the caving of the well after one drill had been broken and the boring rod damaged three times. This well yielded salt at various depths in considerable quantity, but only the very smallest quantity of gas.

The second well was begun on November 26, 1908, in the neighborhood of Kissarmas, and at 70 feet combustible gases blew out with the salt water. At 350 feet the gas blew out and set the derrick on fire. After 10 hours' work the gas flame was extinguished by throwing on earth. The deeper the drilling the stronger became the gas, causing great difficulties in the drilling operations, particularly in lengthening the drilling rod. On January 30, 1909, at a depth of 1,300 feet, the gas blew out with such force that the mud pipes were torn away and salt water of 7° B. was blown out to a height of 50 feet. Drilling was stopped in order to make necessary changes in the method of drilling and to take care of the gas pressure. Drilling was continued on March 25. During the intermission Prof. J. Pfeifer investigated the gas well. Between February 16 and February 18, 1909, he determined the composition of the gas, which came from a depth of 650 feet, to be 99.25 per cent methane and 0.75 per cent nitrogen, the gas being almost pure methane. The heating value of the gas in a Junkers calorimeter showed 8,600 calories. The yield per hour by anemometer measurements was determined to be 3,793 cubic meters, and the gas pressure at that time was estimated to be 30 atmospheres. A later analysis made by Professor Doctor Schelle gave the following results:

	Per cent.
Methane	99.0
Hydrogen	0.4
Oxygen	0.4
Nitrogen	0.2

Carbon dioxide, ethylene, and carbon monoxide not present.

The gas from Kissarmas is, therefore, the purest natural gas thus far known in the world.

Drilling was continued and the quantity of gas and the pressure steadily increased, but on account of the great difficultues and danger the drilling contractors did not wish to continue the work further. On April 22, 1909, at a depth of 302 meters, drilling was stopped without having reached the potassium salts, which were supposed to be found at a greater depth. The gas was escaping with a deafening roar, audible for several kilometers, and was so strong that the heaviest tools held over the mouth of the well were blown away with ease. In contrast to the first drilling, this well only yielded salt water at first. Since the middle of February, 1909, the gas has come out dry from the well.

After the completion of the second well the Government became interested in this new question. First of all, the gas well must be closed in order to make economic use of it; second, a geologic investigation was necessary to get some reliable data as to the possible duration and yield of gas. It also became necessary to establish new mining laws to govern present conditions, as the laws in force had received little attention because petroleum and its products were of little importance when the laws were made. An addition was made to the mining laws January 17, 1911, in which petroleum, naphtha, asphalt, paraffin wax, etc., were declared to belong to the Government. The Government has also established a monopoly of the natural gas in the land.

ITALY.

The Rivista del Servizio Minerario gives the production and value of natural gas in Italy from 1909 to 1913, as follows:

Production and value of natural gas in Italy, 1909–1913.

Year.	Quantity (cubic meters).	Value.
1909	8,268,000	$42,287
1910	8,840,000	73,301
1911	9,021,000	74,174
1912	6,800,000	57,128
1913	(a)	(a)

a Not available.

UNITED KINGDOM.

The annual report of the British home office gives the statistics of the production and value of natural gas in the United Kingdom for the years 1909 to 1913 as follows:

Production and value of natural gas at Heathfield,[a] England, 1909–1913.

Year.	Quantity.	Value.
	Cubic feet.	
1909	236,800	(b)
1910	262,000	(b)
1911	221,400	(b)
1912	161,200	(b)
1913	87,450	(b)

a Heathfield in Sussex County. b Not stated.

COMPOSITION OF NATURAL GAS FROM VARIOUS SOURCES.

The following tables give analyses of natural gas from different localities in the United States and foreign countries:

Composition of natural gas in the principal producing regions.

State and district.	Collected from—	Constituents. Methane, marsh gas (CH_4).	Ethane (C_2H_6).	Carbon dioxide (CO_2).	Nitrogen (N).	Oxygen (O).	Other constituents.	Specific gravity (air=1).	Heating value, calculated, per cubic foot.	Analyst.	Where published.	Remarks.
		Per cent.	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*Per cent.*		*B. t. u.*			
ALABAMA.												
Fayette County: Fayette	Well	98.30	......	0.30	1.30	0.10	......	......	......	G. A. Burrell	U. S. Geol. Survey Mineral Resources, 1911.	Collected by D. T. Day, July, 1910.
ARKANSAS.												
Sebastian County: Fort Smith	Wells of Southwestern General Gas Co.	96.12	......	.93	2.71	.13	H 0.01; CO .08; C_2H_4 .02	......	a 966.0	......	Unpublished	
Do	Wells of Mansfield Gas Co.	92.40	......	.42	3.38	.30	H 2.70; CO .50; C_2H_4 .30	......	a 923.0	H. E. Manning	do	Analysis made Oct. 31, 1905.
CALIFORNIA.												
Contra Costa County	Wells on Miner ranch, California Gas & Electric Co.	93.00	......	.40	3.30	......	H 3.30	0.558	......	A. Auchie Cunningham.	U. S. Geol. Survey Bull. 340, p. 342, 1908.	Collected 1904.
Do	do	92.30	......	......	......	......	H 7.50	......	......	do	do	Loss in sampling, etc., 2 per cent; collected 1907.
Fresno County: Coalinga field	Several wells, Kern Trading & Oil Co.	88.00	......	11.10	.90	......	......	......	937.0	G. A. Burrell	Bur. Mines Bull. 19, p. 56.	Collected by G. H Salisbury, June 10, 1910.
Kern County: Buena Vista Hills	Well	79.95	11.27	4.88	3.69	.21	......	.651	1,050.9	W. P. Thompson, analyst; H. H. Craver, chemist.	Unpublished	Received from Hope Engineering & Supply Co.; tested at Pittsburgh Testing Laboratory.
Kern River field	Reed 1A well, Associated Oil Co.	84.30	8.00	6.50	1.20	......	......	......	1,047.0	G. A. Burrell	Bur. Mines Bull. 19, p. 56.	Collected by C. Ballah, Nov. 24, 1909.

King County:													
Sunset field	Well No. 1, Crandall.	87.70		10.50	1.80					934.0	do	do	Collected by Irving C. Allen, July 14, 1909.
McKittrick field	Several wells, Dabney.	66.20	1.00	30.40	2.40					724.0	do	do	Collected by Irvng C. Allen, Sept. 6, 1909.
Los Angeles County:													
West Los Angeles	Well No. 1, Pacific Petroleum Co.	91.00	2.70	1.00	5.20	.10				1,019.0	do	do	Collected by Irving C. Allen, July 23, 1909.
Los Angeles	Gas-producing oil well.	83.70		6.68	6.31	2.86	CO C_2H_4	.25 .20			Hamilton P. Cady and David F. McFarland.	Am. Chem. Soc. Jour., vol. 29, p. 1530.	Collected by Charles R. Fletcher.
Napa County:													
Mount Helena	Cracks in rocks, Phoenix mine.	61.49		.74	31.44	6.33					Dr. Melville	U. S. Geol. Survey Mon. 13, p. 373, 1888.	Depth 150 to 300 feet.
Orange County:													
Fullerton field	Several wells, C. V. Hall.	86.70	9.50	1.70	2.10					1,100.0	G. A. Burrell	Bur. Mines Bull. 19, p. 56.	Collected by Irving C. Allen, July 22, 1909.
Do	Well No. 52, Petroleum Development Co.	85.80	10.90	1.40	1.90					1,117.0	do	do	Collected by J. Collins, Nov. 17, 1909.
San Joaquin County:													
Stockton	Well No. 2	60.47		Tr.	26.66	1.00	CO H	Trace. 11.87	.612		Price & Son, San Francisco.	California State Min. Bur. Bull. 3, p. 75.	
Do	Well No. 5	62.93		.50	24.36	.70	CO H	Trace. 11.51	.607		do	do	
Do	Stockton Natural Gas Co.	83.00		.05		.06	CO H	Trace. .06				U. S. Geol. Survey Mineral Resources, 1888.	Air introduced in sampling, etc., 16.83 per cent.
Do	Western States Gas & Electric Co.	50.60		.30	18.30	1.00	CO H Illu.	1.00 26.70 2.10		680.2	Superintendent of company.	Unpublished	
Santa Barbara County:													
Santa Maria field	Several wells	62.70	20.20	15.50	1.40	.20				1,044.0	G. A. Burrell	Bur. Mines Bull. 19, p. 56.	Collected by Irving C. Allen, Aug. 5, 1909.
Do	Well No. 5, Santa Maria Oil & Gas Co.	64.60	19.00	14.10	2.10	.20				1,042.0	do	do	Collected by W. W. Bradbury, Nov. 11, 1909.
Ventura County:													
Torrey field	Several wells, Torrey.	54.20	35.60	6.80	3.40					1,240.0	do	do	Collected by B. B. Grinnell, Feb. 18, 1910.
ILLINOIS.													
Bureau County:													
Princeton	Well	13.97		.10	85.83	.05	CO	0.05			Dr. Rollin Chamberlin.	Kansas Univ. Geol. Survey, vol. 9, 1908.	Analyzed, 1907.
Pike County:													
Pittsfield	do	73.81		.81	21.92	3.46						Illinois Geol. Survey Bull. 2, p. 82.	

[a] Whether gross or net unknown.

Composition of natural gas in the principal producing regions—Continued.

State and district.	Collected from—	Constituents.						Specific gravity (air=1).	Heating value, calculated, per cubic foot.	Analyst.	Where published.	Remarks.
		Methane, marsh gas (CH_4).	Ethane (C_2H_6).	Carbon dioxide (CO_2).	Nitrogen (N).	Oxygen (O).	Other constituents.					
INDIANA.												
Delaware County:		*Per cent.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*Per cent.*		*B. t. u.*			
Muncie	Wells Nos. 1, 2, 3, 4, and 6.	92.67	0.25	0.25	3.53	0.35	H 2.35 H_2S .15 CO .45	......	......	Prof. H. C. Howard.	U. S. Geol. Survey Eighth Ann. Report, p. 592, 1889.	
Grant County:												
Marion	Well No. 3	93.58	.15	.90	3.42	.55	H 1.20 HS .20 CO .60	......	......	....do	....do	
Do	Well	77.40	14.18	.73	6.66	......	He .17 C_2H_4 .86	......	......	Hamilton P. Cady and David F. McFarland.	Am. Chem. Soc. Jour., vol. 29, p. 1530.	Collected by B. A. Kinney, Aug. 25, 1906.
Howard County:												
Kokomo	Wells Nos. 1 and 2	94.16	.30	.29	2.80	.30	H .18 HS .18 CO .55	......	......	Prof. H. C. Howard.	U. S. Geol. Survey Eighth Ann. Rept., p. 592, 1889.	
Do	Well	93.60	......	.40	6.00	......	......	......	......	F. C. Phillips	Am. Chem. Jour., vol. 16, p. 416, 1894.	Collected by E. C. Somers.
Madison County:												
Anderson	McCullough well	93.07	.49	.26	3.02	.42	H 1.86 HS .15 CO .73	......	......	Prof. H. C. Howard.	U. S. Geol. Survey Eighth Ann. Rept., p. 592, 1889.	
IOWA.												
Dallas County	Wells in drift at Dawson.	......	......	1.60	......	.55	CO 2.50 Hydrocarbon and N. 95.35	......	......	......	Iowa Geol. Survey Eighth Ann. Rept., 1898.	
KANSAS.												
Allen County: Iola	Well	89.66	......	.90	7.76	.45	CO 1.23	......	......	E. H. S. Bailey	U. S. Geol. Survey Mineral Resources, 1896.	

Moran	do	92.00	......	.30	6.35	.20	C_2H_4 He H CO	.35 .21 .39 .20	......	......	Hamilton P. Cady and David F. McFarland.	Am. Chem Soc. Jour., vol. 29, p. 1530.	Collected July 13, 1906.
Iola	Main at office of Iola Gas Co.	94.50	......	......	5.08	.23	H He Other	trace. .18 .01	......	......	do	Am. Chem. Soc. Jour., vol. 29, p. 1529.	Collected June 10, 1906.
Do	Several wells; main at Iola city gas office.	91.50	......	.70	6.97	.40	CO He	.30 .13	......	......	do	Am. Chem. Soc. Jour., vol. 29, p. 1530.	Collected July 13, 1906.
Humbolt	City main	94.00	1.97	......	2.98	.10	He C_2H_4	.14 .81	......	......	do	do	Do.
Allen and Neosho counties.	Several wells; mains of Kansas Natural Gas Co. at Lawrence.	94.30	.75	1.94	2.60	.24	He	.17	......	......	do	do	Collected Dec. 12, 1906.
Anderson County:													
Garnett	City mains	94.30	.36	.20	4.61	......	He C_2H_4	.37 .16	......	......	do	do	Depth 610 feet; pressure, 200 pounds; collected Aug. 1, 1906.
Butler County:													
Augusta	City supply	79.10	7.44	......	12.44	......	He C_2H_4	.25 .77	......	......	do	do	Depth, 1,440 feet; pressure, 650 pounds, collected Aug. 4, 1906.
Chase County:													
Elmdale	Wells	78.60	7.71	.15	12.13	.30	He C_2H_4	.56 .55	......	......	do	do	Depth, 152 feet; pressure, 45 pounds; collected Oct. 6, 1906.
Chautauqua County:													
Peru	Well	81.70	7.60	.51	9.39	.10	He C_2H_4	.19 .51	......	......	do	do	Collected July 20, 1906.
Coffey County:													
Burlington	City supply; high-pressure supply pipe wells south of Burlington.	85.50	3.20	......	10.60	......	He C_2H_4	.50 .20	......	......	do	do	Collected Aug. 4, 1906.
Cowley County:													
Dexter	Well	14.85	.41	......	82.70	.20	H He	Tr. 1.84	......	......	do	Am. Chem. Soc. Jour., vol. 29, p. 1529.	Depth, 310 feet; pressure, 110 pounds; collected 1905.
Do	Greenwell well	14.33	1.06	......	82.87	.10	H He	Tr. 1.64	......	......	do	do	Collected June 12, 1906.
Arkansas City	City supply	81.10	11.95	.10	6.39	.20	He C_2H_4	.16 .10	......	......	do	Am. Chem. Soc. Jour., vol. 29, p. 1530.	Depth, 750 feet; pressure, 355 pounds.
Douglas County:													
Eudora	Town mains	88.60	......	.62	10.20	.31	He	.27	......	......	do	Am. Chem. Soc. Jour., vol. 29, p. 1529.	Depth, 350 feet; pressure, 200 pounds.
Lawrence	Old well	81.40	......	.92	17.22	Tr.	He	.46	......	......	do	do	Depth, 1,200 feet; collected July 4, 1906.

Composition of natural gas in the principal producing regions—Continued.

State and district.	Collected from—	Constituents. Methane, marsh gas (CH_4).	Ethane (C_2H_6).	Carbon dioxide (CO_2).	Nitrogen (N).	Oxygen (O).	Other constituents.	Specific gravity (air=1).	Heating value, calculated, per cubic foot.	Analyst.	Where published.	Remarks.
KANSAS—continued.		*Per cent.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*Per cent.*		*B. t. u.*			
Elk County:												
Moline	Wells west and south of town.	74.10	......	0.54	24.85	......	H Tr. He 0.51	.....	....	Hamilton P. Cady and David F. McFarland.	Am. Chem. Soc. Jour., vol. 29, p. 1529.	Depth, 1,150 feet; pressure, 380 pounds; collected June 24, 1906.
Greenwood County: Eureka	Town supply	51.40	......	.20	46.40	0.50	He 1.50	.....	....	do	Am. Chem. Soc. Jour., vol. 29, p. 1530.	Collected Oct. 5, 1906.
Do	New field	51.80	......	.20	46.40	.10	He 1.50	.....	....	do	do	Do.
Johnson County:												
Spring Hill	City supply of Olathe	84.40	......	......	15.10	Tr.	He .40 C_2H_4 .10	.....	....	do	do	Depth, 530 feet; pressure, 184 pounds; collected Aug. 2, 1906.
Miami County: Paola	Well	95.20	.11	.33	2.34	.45	CO 1.57	.....	....	E. H. S. Bailey	Kansas Univ. Quart., vol. 4, no. 1, p. 10, 1895.	
Osawatomie	do	97.63	.22	.22	.60	......	CO 1.33	.....	....	do	do	
Do	City supply	98.00	......	.70	.88	.40	He .01 Other .01	.....	....	Hamilton P. Cady and David F. McFarland.	Am. Chem. Soc. Jour., vol. 29, p. 1530.	Collected Aug. 3, 1906.
Montgomery County: Coffeyville	Well	96.41	.35	......	2.21	.12	CO .91	.....	....	E. H. S. Bailey	Kansas Univ. Quart., vol. 4, no. 1, p. 10, 1895.	
Cherryvale		92.46	......	.22	5.94	.22	CO 1.16	.....	....	do	do	
Independence		95.28	.67	.44	3.28	Tr.	CO .33	.....	....	do	do	
Caney	Well east of Caney; Caney Gas & Mining Co.	92.40	......	.81	6.46	.15	He .08 C_2H_4 .10	.....	....	Hamilton P. Cady and David F. McFarland.	Am. Chem. Soc. Jour., vol. 29, p. 1530.	Depth, 1,550 feet; pressure, 620 pounds; collected July 14, 1906.
Liberty and Coffeyville.	Supply of Joplin district; Kansas Natural Gas Co.	95.70	......	.92	2.69	......	He .08 C_2H_4 .61	.....	....	do	do	Depth, 950 feet; pressure, 450 pounds.

Havana	Whistler well; Kansas Natural Gas Co.	72.13	13.80	......	13.46	.18	Olefines	.43	......	957.0	H. C. Allen	Unpublished	Analysis made by University of Kansas.
Liberty	Roszell well; Kansas Natural Gas Co.	83.04	8.54	.24	7.93	.25	......		......	970.0	do	do	Do.
Neosho County: Chanute	City supply; wells east of city.	94.70	......	......	4.96	.10	He	.24	......	......	Hamilton P. Cady and David F. McFarland.	Am. Chem. Soc. Jour., vol. 29, p. 1530.	Depth, 850 feet; pressure, 200 pounds; collected July 24, 1906.
Do	Pipe line of Kansas Natural Gas Co. at Lawrence: Sample 1	98.00	......	......	1.88	.12	......		......	......	do	Am. Chem. Soc. Jour., vol. 29, p. 1529.	Collected Oct. 23, 1905.
	Sample 2	98.06	......	.20	1.57	Tr.	He	.17	......	......	do	do	Collected May 16, 1906.
Erie	City supply; wells east of town.	90.30	4.26	.33	4.45	.22	He C_2H_4 Other	.13 .30 .01	......	......	do	do	Depth, 510 feet; pressure, 150 pounds; collected July 3, 1906.
Wilson County: Eson district	Pipe line supplying Parsons; Prairie Oil & Gas Co.	91.90	3.37	.72	3.74	Tr.	He	.27	......	......	do	do	
Neodesha	Well	90.56	.22	1.00	7.07	.65	CO	.50	......	......	E. H. S. Bailey	Kansas Univ. Quart., vol. 4, no. 1, p. 10, 1895.	
Fredonia	Town supply	82.25	......	.61	16.40	......	He C_2H_4	.62 .12	......	......	Hamilton P. Cady and David F. McFarland.	Am. Chem. Soc. Jour., vol. 29, p. 1529.	Depth, 1,080 feet; pressure, 300-480 pounds.
New Albany	Well	89.10	......	.20	9.84	......	H He C_2H_4	.12 .49 .25	......	......	do	Am. Chem. Soc. Jour., vol. 29, p. 1530.	Collected July 25, 1906.
Buffalo	Well inside town	96.20	.78	......	2.46	......	H CO He	.18 .11 .27	......	......	do	do	Collected July 8, 1906.
Altoona	......	92.00	2.85	.92	3.97	......	He	.26	......	......	do	do	Collected July 25, 1906.
Wyandotte County: Bonner Springs	Well of Bonner Portland Cement Co.	97.18	......	......	2.36	.10	H He	.25 .11	......	......	do	Am. Chem. Soc. Jour., vol. 29, p. 1529.	Depth, 600 feet; pressure, 190 pounds; collected July 8, 1906.
	Pipe line of Kansas Natural Gas Co. at Topeka.	94.56	......	1.53	3.71	.20	......		......	......	do	Kansas Univ. Geol. Survey, vol. 9, 1908.	Collected from stove tap in room of Glenwood Hotel, Dec. 22, 1907.
	Pipe line of Kansas Natural Gas Co. supplying Lawrence.	94.47	......	1.85	3.68	Tr.	......		......	......	do	do	Collected Dec. 23, 1907.

Composition of natural gas in the principal producing regions—Continued.

State and district.	Collected from—	Constituents.						Specific gravity (air=1).	Heating value, calculated, per cubic foot.	Analyst.	Where published.	Remarks.
		Methane, marsh gas (CH_4).	Ethane (C_2H_6).	Carbon dioxide (CO_2).	Nitrogen (N).	Oxygen (O).	Other constituents.					
KENTUCKY.		*Per cent.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*Per cent.*		*B. t. u.*			
Martin County, Ky., and Mingo County, W. Va.	Wells of United Fuel Gas Co.; gas taken from measuring station at Inez, Ky.	75.14	23.16	Tr.	1.59	0.11	....	0.677	1,231.2	H. H. Craver, chemist.	Unpublished......	Analyzed Jan. 8, 1914, Pittsburgh Testing Laboratory.
LOUISIANA.												
Caddo Parish: Caddo field........	Well...............	95.00	......	2.43	2.56	......	Sulphide(?) .01	......	980.0	F. C. Phillips.....	U. S. Geol. Survey Bull. 429, p. 138, 1910.	Collected by G. W. Barnes.
Calcasieu Parish:												
Jennings..........	Gas-producing oil well.	88.40	1.03	1.80	5.76	1.81	CO .40 He Tr. C_2H_4 .80	......	....	Hamilton P. Cady and David F. McFarland.	Am. Chem. Soc. Jour., vol. 29, p. 1530.	Small amount of air in sample; collected by A. Reineke, July, 1907.
Iberville Parish: Grosse Tete........	S. R. Ely well......	58.80	......	1.40	39.80	......	....	......	....	G. A. Burrell.....	Unpublished......	35.4 per cent of air extracted before analyzing; depth, 120 feet; collected July 17, 1910, by D. T. Day.
Whitecastle.......	....	90.70	......	4.20	5.10	......	....	......	....	.....do........	.....do........	Collected July, 1910, by D. T. Day.
Ouachita Parish: Monroe...........	....	94.20	......	1.40	4.40	......	....	......	....	.....do........	.....do........	16.8 per cent of air extracted before analyzing; collected July, 1910, by D. T. Day.
Terrebonne Parish:												
Montegut..........	Phyllis well, Lower Terrebonne Refining Co.	89.10	4.45	1.00	3.50	.10	H 1.75 H_2S Tr. CO .10	......	....	Prof. Thile.......	U. S. Geol. Survey Bull. 429, 1910.	

Washington Parish: Bogalusa	.....	62.20	.....	3.00	34.80	Tr.	.....		.....	.....	G. A. Burrell	Unpublished	Collected 1910 by D. T. Day.
MISSOURI.													
Jackson County:													
Kansas City	Well at 2416 Tracy Avenue.	87.20	7.03	.60	3.65	.10	CO He C_2H_4 Other	.20 .01 1.20 .01	.....	.....	Hamilton P. Cady and David F. McFarland.	Am. Chem. Soc. Jour., vol. 29, p. 1530.	Depth, 300 feet; pressure very low.
Sheffield	Wells at Sheffield Nut & Bolt Works.	92.90	.....	.83	5.43	.20	CO He C_2H_4	.10 .04 .50	.....	.....	do	do	Shallow wells; pressure 40 pounds.
NEVADA.													
Churchill County: Stillwater	Artesian well	72.36	.....	4.22	22.86	.56	.....		.....	.....	G. A. Burrell	Unpublished	Burns blue and white flame; depth, 345 feet; collected March, 1911, by C. V. Lindner.
Do	An old slough 15 inches in diameter.	95.60	.....	1.26	3.14	.....	.....		.....	.....	do	do	Burns blue and white flame; collected March, 1911, by C. V. Lindner.
Do	Artesian well	70.91	.....	5.01	23.66	.42	.....		.....	.....	do	do	Burns blue and white flame; depth, 345 feet; collected March, 1911, by C. V. Lindner.
NEW YORK.													
Cattaraugus County: Olean	.....	96.50	1.00	.....	.....	2.00	CO	.50	.692	.....	Robert Young	U. S. Geol. Survey Mineral Resources 1885, p. 235.	
Chautauqua County: Fredonia	Mains of Fredonia Natural Gas Light Co.	90.05	.....	.41	9.54	.....	.....		.....	.....	F. C. Phillips	Pennsylvania Second Geol. Survey Ann. Rept., 1886, pt. 2, p. 800.	Collected, May 12, 1887.
Onondaga County: Baldwinsville	Well	98.40	.25	.....	.40	Tr.	H CO	Tr. .95	.558	1,013.5	Dr. Durand Woodman.	New York Mus. Bull. 30, p. 468.	
Ontario County: West Bloomfield	do	82.41	2.94	10.11	4.31	.23	.....		.693	.....	Prof. Wurtz	Am. Inst. Min. Eng., vol. 13, p. 542.	Analyzed 1870.

Composition of natural gas in the principal producing regions—Continued.

State and district.	Collected from—	Constituents.					Specific gravity (air=1).	Heating value, calculated, per cubic foot.	Analyst.	Where published.	Remarks.
		Methane, marsh gas (CH_4).	Ethane (C_2H_6).	Carbon dioxide (CO_2).	Nitrogen (N).	Oxygen (O).	Other constituents.					
		Per cent.	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*Per cent.*		*B. t. u.*			
NORTH DAKOTA.												
Bottineau County:												
Westhope	Wells of North Dakota Gas Co.	82.70	0.20	......	12.40	3.00	H 0.50; CO 1.20	......	......	E. J. Babcock	U. S. Geol. Survey Bull. 431, p. 7, 1911.	Pressure, 55 to 60 pounds.
Lansford	......	71.15	.10	......	16.61	7.10	H 4.74; CO .30	......	......	do	do	Pressure, 18 to 20 pounds.
OHIO.												
Auglaize County:												
St. Marys	Wilkens well	93.85	.20	0.23	2.98	.35	H 1.74; H_2S .21; CO .44	......	......	Prof. C. C. Howard	U. S. Geol. Survey Mineral Resources, 1890, p. 491.	Trenton limestone.
Cuyahoga County:												
Cleveland	Well	93.50	......	.20	6.30	......	......	......	......	F. C. Phillips	Am. Chem. Jour., vol. 16, p. 416, 1894.	Test made at well.
Fairfield County:												
Thurston field	do	90.48	.30	.25	8.12	.15	H .55; CO .15	......	......	Prof. C. C. Howard	Ohio Geol. Survey Bull. 4, p. 125.	
Hancock County:												
Findlay	Wells of Findlay Gas Light Co.	93.35	.35	.25	3.41	.39	H 1.64; H_2S .20; CO .41	......	......	do	U. S. Geol. Survey Mineral Resources 1890, p. 491.	
Do	......	92.61	.30	.26	3.61	.34	H 2.18; H_2S .20; CO .50	0.570	......	do	U. S. Geol. Survey Eighth Ann. Rept., p. 590 1889.	
Jefferson County:												
Near Toronto	High-pressure line of Manufacturers' Light & Heat Co.	34.08	62.08	.20	2.94	.70	......	.912	1,515.0	W. P. Thompson, H. H. Craver.	Unpublished	
Near Horner	(same as above)	68.80	26.48	.10	4.22	.40	......	.767	1,225.5	do	do	

Knox County:													
Gambier	Neff well	81.40	12.20	.30	4.80	.80	CO	.50	640		Profs. Newberry and Morley.	Pennsylvania Second Geol. Survey, Rept. L, p. 147, 1875.	
Noble County:													
Dexter City	Well No. 1, Mitchell farm, Bull Run, near city.	97.00	.70	.11	1.00	.30	CO	.80			Chas. F. Mabery and Orton C. Dunn.	Am. Chem. Jour., vol. 18, p. 224.	
Do	Well No. 8, Dunn farm, near city.	91.20	2.60	.30	1.20	4.00	CO	.40			do	Am. Chem. Jour., vol. 18, p. 223.	
Richland County:													
Butler	Well of F. O. Levering.	70.00	16.75		12.38	.05	H He C_2H_4	.27 .15 .40			Hamilton P. Cady and David F. McFarland.	Am. Chem. Soc. Jour., vol. 29, p. 1530.	Collected July 19, 1906.
Seneca County:													
Fostoria	Water-tank wells	92.84	.20	.20	3.82	.35	H_2S H CO	.15 1.89 .55			C. C. Howard	U. S. Geol. Survey Mineral Resources, 1890, p. 491.	
OKLAHOMA.													
Kay County:													
Blackwell	Well No. 2, Union Oil & Gas Co.	83.40	10.31		5.19		H He C_2H_4	.33 .16 .61			Hamilton P. Cady and David F. McFarland.	Am. Chem. Soc. Jour., vol. 29, p. 1530.	Pressure 185 pounds.
Glennpool	Gas from oil wells	49.1	44.1	6.1	.7				.768	1,271	G. A. Burrell	Bur. Mines Bull. 42, 1913.	
Stevens County:													
Duncan	Wells of Western Oklahoma Gas & Fuel Co.	96.20		.20	2.40	.60	CO Ethylene	.40 .20		1,025	Gulick Henderson.	Unpublished	Analysis made Oct. 27, 1913.
OREGON.													
Northwestern	Slough on Brown's dairy farm.	95.50		3.50	1.00						G. A. Burrell	do	Collected by G. N. Macready and R. F. Rogers, September, 1910.
Do	do	95.70		3.30	1.00						do	do	Collected by C. W. Washburne.
Do	Bed of Whalen River at Luhkarela ranch.	86.20		.70	13.10						do	do	Collected by G. A. Macready, September, 1910.
Do	Herrick Mineral Spring, Grand Rapids, Whalen River.	87.00		.50	12.50						do	do	Do.
Do	Slough on Brown's dairy farm.	96.10		3.00	.90						do	do	Collected by G. A. Macready and R. F. Rogers, September, 1910.
Tillamook	Well 5½ miles southwest of town.	2.00		.15	97.85						do	do	Collected by G. A. Macready, September, 1910.

Composition of natural gas in the principal producing regions—Continued.

State and district.	Collected from—	Constituents: Methane, marsh gas (CH_4).	Ethane (C_2H_6).	Carbon dioxide (CO_2).	Nitrogen (N).	Oxygen (O).	Other constituents.	Specific gravity (air=1).	Heating value, calculated, per cubic foot.	Analyst.	Where published.	Remarks.
PENNSYLVANIA.												
Allegheny County:		*Per cent.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*Per cent.*		*B. t. u.*			
Creighton	Well	96.36	Tr.	3.64				0.592		F. C. Phillips	U. S. Geol. Survey Mineral Resources, 1885, p. 235.	Test made at well.
Allegheny and Washington counties.	Walker's Mills line of People's Natural Gas Co.	74.06	24.30		1.64	Tr.		.664	1,240.9	H. H. Craver	Unpublished	Gas taken at pump station.
Do	Candor line of People's Natural Gas Co.	80.67	17.46		1.41	0.46		.642	1,184.0	do	do	Do.
Do	Imperial 10-inch line People's Natural Gas Co.	75.09	23.62		1.07	.22		.662	1,239.2	do	do	Do.
Allegheny County:												
Pittsburgh	Painter & Co.'s well.	98.90		.40	.70					F. C. Phillips	Am. Chem. Jour., vol. 16, p. 416, 1894.	Test made at wells.
Do	Exhibition grounds.	92.18		.52	7.30	Tr.				do	do	Do.
Do	Salt well in Allegheny.	92.60		.30	7.10					do	do	Do.
Beaver County:												
Baden	Bryan No. 1 well, Baden Gas Co.	87.27		.41	12.32	Tr.				do	Pennsylvania Geol. Survey Ann. Rept., 1886, pt. 2, p. 811.	Collected May 18, 1887.
Raccoon Creek	Main Bridgewater Natural Gas Co.	90.09		Tr.	9.91	Tr.	Tr.			do	Pennsylvania Geol. Survey Ann. Rept., 1886, pt. 2, p. 810.	Collected May 2, 1887.

Butler County:													
Burns	Well No. 1	75.75	17.84	.34	......	......	CO, &c. H	.01 6.06	.615	....	S. P. Sadtler	Pennsylvania Second Geol. Survey, Rept. L, p. 149, 1875.	
	Well No. 2	75.12	18.39	.35	......	......	CO, &c. H	.01 6.13					
Harvey	Well	80.11	5.72	.66	......	......	CO, &c. H	.01 13.50	.512	....	do	Pennsylvania Second Geol. Survey, Rept. L, pp. 152–160, 1875.	
Greene County	Wells People's Natural Gas Co.	73.14	23.81	......	2.85	.20	......		.736	1,222	H. H. Craver and W. P. Thompson.	Unpublished	
Indiana County:													
Cherrytree	A spring	60.27	6.80	2.28	7.32	.83	H	22.50	......	....	S. P. Sadtler	Pennsylvania Second Geol. Survey, Rept. L, pp. 152–160, 1875.	
McKean County:													
Kane	Wilcox well No. 7, United Natural Gas Co.	90.38	......	.21	9.41	Tr.	......		......	....	F. C. Phillips	Pennsylvania Geol. Survey Ann. Rept., 1886, pt. 2, p. 803.	Collected Jan. 29, 1887.
Do	Well No. 1, Kane Natural Gas Co.	90.01	......	.20	9.79	Tr.	......		......	....	do	do	Collected Jan. 30, 1887.
Venango County:													
Oil City	Main of Northwestern Natural Gas Co.	95.42	......	.05	4.51	Tr.	H	.02	......	....	do	Pennsylvania Geol. Survey Ann. Rept., 1886, pt. 2, p. 805.	Speechley gas. Collected Apr. 13, 1887.
Warren County:													
Sheffield	Wells 1, 2, and 3 of Sheffield Gas Co.	90.64	......	.30	9.06	Tr.	......		......	....	F. C. Phillips	Pennsylvania Geol. Survey Ann. Rept., 1886, pt. 2, p. 802.	
Washington County:													
Houston	Well	84.26	......	.44	15.30	Tr.	......		......	....	do	Pennsylvania Geol. Survey Ann. Rept., 1886, pt. 2, p. 811.	Collected Mar. 18, 1887. Contains also trace of ammonia.
	Line of Peoples Natural Gas Co.	81.59	17.76	......	.65	Tr.	......		.665	1,199.0	H. H. Craver	Unpublished	
McDonald	Gas from oil wells	1.90	67.30	.10	.60	......	Air	30.10	......	1,204.0	G. A. Burrell	Bur. Mines Bull. 42, 1913.	
Do	do	2.70	96.10	.20	1.00	......	......		1.011	1,719.0	do	do	
Do	do	......	......	2.10	23.00	......	C_4H_{10} C_3H_8	40.6 34.3	1.590	2,185.0	do	do	

Composition of natural gas in the principal producing regions—Continued.

State and district.	Collected from—	Constituents: Methane, marsh gas (CH_4).	Ethane (C_2H_6).	Carbon dioxide (CO_2).	Nitrogen (N).	Oxygen (O).	Other constituents.	Specific gravity (air=1).	Heating value, calculated, per cubic foot.	Analyst.	Where published.	Remarks.
PENNSYLVANIA—contd.												
Washington County—Continued.		*Per cent.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*Per cent.*		*B. t. u.*			
McDonald	Gas from oil wells			1.50	16.50		C_4H_{10} 29.0; C^3H_8 24.5; Air 28.5		1,561.0	G. A. Burwell	Bur. Mines Bull. 42, 1913.	
	R. A. Geary deep well No. 770 of Peoples Natural Gas Co.	88.83		3.6	6.77	0.8			946.0	James O. Handy	Unpublished	Collected June 25, 1912. Sample shows indications of being contaminated with ammonia.
		65.07	24.80	.10	9.13	.9			1,154.5	do	do	Collected Aug. 10, 1912.
		a81.88	14.75	Tr.	3.37				1,146.8	H. H. Craver	do	Collected Apr. 1, 1914. Sample contained air.
		b29.97	5.40	Tr.	51.77	12.86						
Westmoreland County:												
Leechburg	Well	89.65	4.95	.35			CO .26; H 4.79	0.558		S. P. Sadtler	Pennsylvania Second Geol. Survey, Rept. L, p. 152, 1875.	
Murrysville	do	95.40		.20	4.40	Tr.				F. C. Phillips	Am. Chem. Jour., vol. 16, p. 416, 1894.	Test made at well.
Murrysville, Lyons Run district.	Hukill well, Philadelphia Co.	97.70		.28	2.02	Tr.				do	Pennsylvania Second Geol. Survey, pt. 2, p. 800, 1886.	Collected Apr. 8, 1887.
Grapeville		35.08	28.87	.58	27.87	.16	H 7.05; CO .22; Olefiant gas .17			Mr. Morrell	Am. Inst. Min. Eng., vol. 15, p. 531.	Analyses made February, 1886.
		14.93	39.64	Tr.	18.69	1.22	H 24.56; CO Tr.; Olefiant gas .96					
PENNSYLVANIA AND WEST VIRGINIA.	City of Pittsburgh supply.	83.00	16.40		.60			.640	1,189.0	G. A. Burrell	Bur. Mines Tech. Paper 10, 1912.	

SOUTH DAKOTA.													
Hughes County:													
Pierre	Gas from artesian well.	73.2	......	1.14	21.7	3.19	He Olefins Other	Trace. .25 .52	......	....	Cady and McFarland.	Kansas Univ. Geol. Survey, vol. 9, 1908.	Collected by Doane Robinson. Sample contained some air.
TENNESSEE.													
Shelby County: Memphis	Seepage	90.36	......	3.13	3.83	.83	H		1.85	....	G. A. Burrell	Unpublished	Collected December, 1911, by Dutro, Trimble & Munn.
TEXAS.													
Clay County:													
Petrolia	Dallas Gas Co	47.20	12.50	.20	38.60	.40	H Illum.	.80 .30	.720	474.0	C. C. Tutwiler	U. S. Geol. Survey Mineral Resources, 1911.	Sample received by United Gas Improvement Co., Philadelphia, Pa., Sept. 9, 1909.
Do	do	55.90	5.50	......	36.80	.20	H CO Illum.	1.00 .30 .30		561.0	do	Texas Univ. Bull. 246, 1912.	Sample received by United Gas Improvement Co., Philadelphia, Pa., November, 1910.
Do		67.93	......	......	30.57	.70	CO Illum.	Tr. .80	......	715.0	W. M. Russell	do	Analysis made in 1909.
Do	Supply city of Dallas	56.80	......	......	43.20	......			......	649.0	S. H. Worrell	do	Analysis made June 4, 1912.
Gonzales County	Well 9 miles west of Gonzales.	85.40	......	......	14.60	......			......	862.5	do	Texas Univ. Bull. 307, 1913.	
Houston County	Locality 14 miles west of Crockett.	90.40	......	......	9.40	.20			......	913.0	do	do	
McMullen County: Crowther	Wells of Boston & Texas Corporation.	74.00	......	.40	2.60	.20	H	22.80	.458	947.0	do	do	
Maverick County	Fleming & Davidson well (712 feet).	34.80	......	......	62.60	1.40	CO	1.2	.826	300.5	do	do	
Red River County	Gas bubbling up through Red River at mouth of Cash Creek.	48.30	......	5.2	18.10	2.60	H	25.8	......	463.0	do	do	
Shackelford County: Moran	Main line, 16 miles from wells at Moran.	80.80	......	......	19.2	......			......	835.5	do	do	
Trinity County	Spring 1 mile east of Trinity.	92.0	......	......	8.0	......			.588	929.0	do	do	
Webb County	Gas supply of Laredo from wells of Border Gas Co.	85.2	......	......	14.8	......			.614	726.0	do	do	
		66.3	......	......	32.7	.60	CO	4.	......	564.0	do	do	

a Calculated to free-air basis.

b Sample as received.

Composition of natural gas in the principal producing regions—Continued.

State and district.	Collected from—	Constituents. Methane, marsh gas (CH_4).	Ethane (C_2H_6).	Carbon dioxide (CO_2).	Nitrogen (N).	Oxygen (O).	Other constituents.	Specific gravity (air=1).	Heating value, calculated, per cubic foot.	Analyst.	Where published.	Remarks.
UTAH.												
		Per cent.	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*Per cent.*		*B. t. u.*			
Grand County: Moab		90.80		3.60	5.60					G. A. Burrell	Unpublished	Collected by A. H. Rogers, September, 1911.
Do		90.00		3.50	6.50					U. S. Geol. Survey Laboratory.	U. S. Geol. Survey Bull. 471, 1910.	Collected by A. H. Rogers.
Salt Lake County: Salt Lake City	12 miles north of city.	22.30	37.8	.80	19.70	0.90	H 16.6; CO 1.2; Ethylene .7			J. T. Kingsbury	U. S. Geol. Survey Bull. 260, p. 481, 1905.	
WASHINGTON.												
Wahkiakum County: Oneida	John Nelson's ranch (1).	91.20		1.20	7.60					G. A. Burrell	Unpublished	Collected September, 1910, by G. A. Macready.
	John Nelson's ranch (2).	91.00		1.00	8.00							
WEST VIRGINIA.												
Brooke County: Follansbee	Gas from oil wells		21.8		.50		C_3H_8 77.7	1.390	2,468	do	Bur. Mines Tech. Paper 10, 1912.	
			10.8		.90		C_3H_8 88.3	1.462	2,407	do	Bur. Mines Bull. 42, 1913.	
			21.4		.40		C_3H_8 78.2	1.410	2,339	do	do	
			28.5		.40		C_3H_8 71.1	1.380	2,286	do	do	
			24.8		.30		C_3H_8 61.9; Air 13.0		1,990	do	do	
Do	Wells of Hope Natural Gas Co.	72.38	26.55	Tr.	1.07	Tr.		.703	1,261.1	H. H. Craver	Unpublished	Gas from an old field.
Doddridge, Harrison, and Lewis counties.	do	80.50	18.00		1.50	Tr.		.653	1,192.2	do	do	Gas from Bates measuring station.
Doddridge and Tyler counties.	do	75.80	23.54	Tr.	.66	Tr.		.691	1,245.3	do	do	Gas from Smith meas uring station.

Doddridge and Wetzel counties.	....do..............	75.27	24.20	......	.53	Tr.	....	.727	1,252	....do............	....do...........	
Harrison County.......	City supply, Shinnston; J. B. Cunningham well No. 1, Gordon sand.[a]	80.85	15.08	......	3.47	.10	H .10 CO .40	.....	1,143.6	C. D. Howard, June, 1904.	West Virginia Geol. Survey, vol. 1a, p. 556, 1904.	Well 3½ miles northwest of Shinnston. Top of sand 2,199 feet below Pittsburgh coal.
Do................	Harbert well No. 1 (fifth sand gas), near West Fork River.[a]	80.70	14.45	.10	3.95	.30	H .10 CO .40	.....	1,131.4	....do............	....do...........	Well ¾ mile east of Lumberport; 2,380 feet below Pittsburgh coal.
Do................	Lucas Bros. well No. 4 (50-foot sand), near mouth Robinson Run.[a]	86.48	7.85	......	4.87	.30	CO .50	......	1,065.3	....do............	....do...........	Well 1 mile west of Shinnston. Top of sand 1,855 feet below Pittsburgh coal.
Do................	Lucas Bros. well No. 1 (Big Injun sand).[a]	79.95	15.09	......	3.96	.20	CO .40 Heavy hydrocarbons. .40	.....	1,140.9	....do............	....do...........	Well 1¼ miles northwest of Shinnston. Top of sand 1,421 feet below Pittsburgh coal.
Lewis County..........	Wells of Hope Natural Gas Co.	82.58	16.65	.13	.38	.26	....	.646	1,189.2	H. H. Craver and W. P. Thompson.	Unpublished......	Analysis made at Pittsburgh Testing Laboratory.
Do................	....do..............	81.90	16.12	.12	1.26	.60	....	.651	1,172	....do............	....do...........	Do.
Lewis and Harrison counties.	....do..............	87.90	7.30	......	4.40	.40	....	......	1,071	....do............	....do...........	Do.
Marion County:												
Fairmont..........	City supply, Bayard sand.	81.60	14.29	.10	3.21	.20	H .20 CO .40	.....	1,136.9	C. D. Howard.....	West Virginia Geol. Survey, vol. 1a, p. 556, 1904.	Tested June, 1904.
Do................	Wells of Hope Natural Gas Co.	59.69	39.10	......	1.21	Tr.	....	.790	1,363	H. H. Craver......	Unpublished......	
Do................	....do..............	73.50	23.90	......	2.10	.50	....	.723	1,228	....do............	....do...........	
Do................	....do..............	43.20	54.72	......	1.78	.30	....	.843	1,478	....do............	....do...........	
Marion, Harrison, and Monongalia counties.	....do..............	82.13	16.84	Tr.	.83	.20	....	.651	1,186.4	....do............	....do...........	Gas taken from Morgan measuring station.
Marshall County.......	George Hicks well No. 987 of Manufacturers' Light & Heat Co.	76.44	21.32	......	1.89	.35	....	.658	1,210.7	H. H. Craver and W. P. Thompson.	....do...........	
Do................	J. W. Richey well No. 1663 of Manufacturers' Light & Heat Co.	77.92	20.74	......	1.23	.11	....	......	1,215.7	....do............	....do...........	
Monongalia County:												
Morgantown.......	Well No. 1, 10 miles west of town.	88.10	7.37	......	3.60	......	H .25 CO .24 He .09 C_2H_4, &c. .35	.....	....	Hamilton P. Cady and David F. McFarland.	Am. Chem. Soc. Jour., vol. 29, p. 1530.	Depth, 1,800 feet; pressure, 160 pounds; collected by B. H. Hite,. Aug 18, 1906.

[a] Fairmont & Grafton Gas Co.

Composition of natural gas in the principal producing regions—Continued.

State and district.	Collected from—	Constituents.						Specific gravity (air=1).	Heating value, calculated, per cubic foot.	Analyst.	Where published.	Remarks.
		Methane, marsh gas (CH_4).	Ethane (C_2H_6).	Carbon dioxide (CO_2).	Nitrogen (N).	Oxygen (O).	Other constituents.					
WEST VIRGINIA—con.		*Per cent.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*Per cent.*		*B. t. u.*			
Monongalia (W. Va.) and Greene (Pa.) counties.	Morgantown supply (Big Injun sand).	80.94	14.60	*a*0.006	3.46	0.20	H Tr.; CO 0.40; Heavy hydrocarbons .40	.....	1,142.6	C. D. Howard.....	West Virginia Geol. Survey, vol. 1a, p. 556, 1904.	Tested June, 1904.
New Martinsville......	High-pressure line of Manufacturers' Light & Heat Co.	72.11	26.65	......	1.24	Tr.	....	0.676	1,263.8	H. H. Craver and W. P. Thompson.	Unpublished......	Tested at Pittsburgh Testing Laboratory.
Roane County: Spencer and Curtis districts.	Gas taken at Ravenswood; United Fuel Gas Co.	81.81	17.41	......	.78	Tr.	....	.674	1,195.2	.....do...........	.....do...........	Tested at Pittsburgh Testing Laboratory, Feb. 13, 1914.
Wellsburg..............	Wellsburg shop high-pressure line of Manufacturers' Light & Heat Co.	78.20	19.60	......	2.20	......	....	.806	1,197.5	.....do...........	.....do...........	Tested at Pittsburgh Testing Laboratory.
Wheeling..............	High-pressure line of Manufacturers' Light & Heat Co.	74.95	24.51	Tr.	.39	.15	....	.668	1,254	.....do...........	.....do...........	Do.
General...........	Wells of Hope Natural Gas Co.	81.20	17.11	......	1.47	.22	....	.649	1,183.0	H. H. Craver and W. P. Thompson.	Unpublished......	Tested at Pittsburgh Testing Laboratory.
General northern...	.....do..............	82.35	16.00	......	1.40	.25	....	.645	1,174.0	.....do...........	.....do...........	Do.
Do.................	.....do..............	79.72	16.19	Tr.	3.64	.45	....	.656	1,150.0	.....do...........	.....do...........	Do.
General, Hastings Station.	.....do..............	85.37	14.08	......	.55	Tr.	....	.649	1,171.0	.....do...........	.....do...........	Do.
Unknown..........	.....do..............	75.14	23.16	Tr.	1.59	.11	....	.677	1,231.0	.....do...........	.....do...........	Do.
WYOMING.												
Bighorn County: Byron..............	Gas from oil well...	64.05	32.28	.47	3.20	......	....	.680	1,282.0	G. A. Burrell......	Bur. Mines Tech. Paper 57, 1913.	Collected by W. R. Calvert, December, 1912.

Greybull	do	51.55	47.20		1.25			.770	1,427.0	do	do	Do.
Do	Island No. 1 gas well.	81.70	17.35	.20	.75			.640	1,192.0	do	do	Do.
Converse County:												
Douglas	Well	87.75	b7.23	.21	Tr.	Tr.	H 3.89; CO Tr.; Illum., etc. .92	.589		Frederick Salathe.	U. S. Geol. Survey Bull. 541C, 1914.	Analysis made in 1904.
Natrona County:												
Salt Creek	Gas from oil wells of Mid-West Oil Co.		60.40		28.97		C_3H_8 10.63	.960	1,437.0	G. A. Burrell	Bur. Mines Tech. Paper 57, 1913.	Collected by W. R. Calvert.
FOREIGN.												
Austria:												
Wels		97.10		1.30	1.00	.60		.567		J. Frank	Jour. Gasbel., vol. 55, pp. 154–155.	
Canada:												
Calgary, Alberta		90.00			8.50	.10	H 1.4			E. Stansfield	Unpublished	Tested, July, 1913.
Do		92.06			1.44	Tr.	H 4.70; Heavy hydrocarbon vapors 1.80			M. F. Connor	do	Tested, May, 1910.
Vancouver, British Columbia.		93.56		.14	6.30					F. C. Phillips	Am. Chem. Jour., vol. 16, p. 416, 1894.	Collected by C. F. Hutchings.
Welland, Ontario	Point Albino well	96.57		Tr.	2.69		H_2S .74			do	Am. Chem. Soc. Jour., vol. 20, p. 700, 1898.	
Moosomin, Saskatchewan.		83.40			14.4	.3	H 1.8; Ethylene .1			E. Stansfield	Unpublished	Tested, June, 1913.
Germany:												
Neuengamme, near Hamburg.		91.50	2.10	.30	4.60	1.50				Dr. Schertel	Jour. Gasbel., vol. 54, pp. 193–198.	
Hungary	Unutilized wells	92.05		.65	7.30						Oesterr. Chem. Tech. Zeitung, vol. 28, p. 16.	
New Zealand:												
Gisborne field, Whatatutu district.	Oil spring at Waitangi Hill.	96.5		3.5							Oil fields of New Zealand, J. D. Henry, 1911.	
Taranaki field, Taranaki district.	Oil well of Taranaki Petroleum Co.	24.4	16.3	49.2	8.8	1.3					do	
Do	do	22.7	25.8	43.7	6.5	1.3					do	
Wairarapa (eastern) field, Akitio district.	Gas spring at Spring Hill.	35.3	17.6		35.1	12.0				Dr. MacLaurin	do	Collected by D. Laing, July, 1910.
Russia:												
Samara	Well at Nov-Usensk.	53.35	.40	1.17	40.86	4.22					Jour. Petroleum, vol. 5, p. 517.	

a Determined by barium hydrate.

b Including butane and propane.

In comparison with the composition shown in the foregoing tables for natural gas, the following table gives for comparison the general composition of coal gas, water gas, and producer gas from bituminous coals. The weights in pounds, the specific gravity, and the usual number of heat units per thousand cubic feet of the various gases are given according to the usually accepted values.

Analysis, weight, and heating quality, per 1,000 feet, and specific gravity, of natural and manufactured gases.

Constituent.	Average of coal gas.	Average of water gas.	Average of producer gas from bituminous coal.
	Per cent.	*Per cent.*	*Per cent.*
Marsh gas (CH_4)	40.00	2.00	2.05
Other hydrocarbons	4.00	.00	.04
Nitrogen	2.05	2.00	56.26
Carbonic acid (CO_2)	.45	4.00	2.60
Carbonic oxide (CO)	6.00	45.50	27.00
Hydrogen	46.00	45.00	12.00
Hydrogen sulphide	.00	.00	.00
Oxygen	1.50	1.50	.05
Total	100.00	100.00	100.00

Average gases.	Pounds in 1,000 cubic feet.[a]	Specific gravity, air being 1.	British thermal units per 1,000 cubic feet.[b]
Natural gas:			
Pennsylvania and West Virginia	47.50	0.624	1,145,000
Ohio and Indiana	48.50	.637	1,095,000
Kansas	49.00	.645	1,100,000
Coal gas	33.00	.435	755,000
Water gas	45.60	.600	350.000
Producer gas from bituminous coal	75.00	.985	155,000

[a] 1,000 cubic feet of air at an atmospheric pressure of 14.7 pounds and at a temperature of 62° F. weighs 76.1 pounds and is a mechanical mixture of 23 parts of oxygen and 77 parts of nitrogen by weight.
[b] A British thermal unit is the heat necessary to raise the temperature of 1 pound of pure water at 39° F. 1°.

GASOLINE FROM NATURAL GAS.

PRODUCTION.

The extraction of gasoline from casing-head gas (natural gas from oil wells) has become one of the important adjuncts of the natural-gas industry in the United States. Statistics of the production of this kind of gasoline have been collected for the last three years, the results of which will be found in the tables which follow. It will be seen that the production is increasing rapidly, the quantity produced in 1913 being almost double that of 1912. This increased production was due to the installation of a greater number of plants and to the advance in the price of gasoline.

A description of the processes employed in the extraction of gasoline from natural gas was given in this report for the year 1911 and need not be repeated further than to say there are two methods in use—one the regular compressor plant, the other the "gas-pump" or vacuum process.

The natural-gas gasoline industry was strictly confined to nine States in 1913 named as follows, according to the quantity of gasoline produced: West Virginia, Oklahoma, Pennsylvania, California, Ohio, Illinois, Colorado, New York, and Kansas, the only production in Kentucky coming from natural condensation in the pipes. The total quantity of gasoline produced in 1913 amounted to 24,060,817 gallons, valued at $2,458,443, an average price of 10.22 cents per gallon, as compared with a production of 12,081,179 gallons, valued at $1,157,476, in 1912, and 7,425,839 gallons, valued at $531,704, in 1911. It is interesting to note the changes in the chief producing States, all of which show increase, greater or less, in both quantity and value of product, West Virginia taking the lead in all three years.

The majority of the compressor plants are erected near the oil wells by the owners or operators of the wells from which they are to receive their supply of gas, but in many cases these operators also buy gas from neighboring oil wells. Some gasoline producers purchase all the gas that they use. Gas is usually purchased on a royalty basis, that is, on a certain proportion of the gasoline produced or of the proceeds of the sales from the gasoline, royalties ranging from one-fourth to one-third, to three-eighths, and to one-half. Gas is also purchased at so much per well per month, or at so much per thousand cubic feet, the price ranging from 3 to 10 cents. The residue, or "exhaust" gas, is usually returned to the producer and is used on leased properties; it is also sold to the gas-distributing companies, or to consumers for industrial use, or is allowed to escape into the air and is wasted.

The uses of natural-gas gasoline are many and varied. It is principally used for raising the standard of naphthas or low-grade distillates consumed in motors; it is also used for lighting; and it can be used in all the arts like regular gasoline. There is an ever-increasing demand for it for automobiles.

In the following tables are given statistics of the production of gasoline from natural gas in the United States in the years 1911, 1912, and 1913, by States:

Production of gasoline from natural gas in the United States in 1911, 1912, and 1913, by States.

1911.

State.	Number of operators.	Plants.		Gasoline produced.			Gas used.		Average yield in gasoline.
		Number.	Daily capacity.	Quantity.	Value.	Price per gallon.	Estimated quantity.	Value.	
			Gallons.	*Gallons.*		*Cents.*	*Cubic feet.*		*Gallons.*
West Virginia	47	72	16,819	3,660,165	$2[illegible]2,661	7.18	1,252,900,600	$76,074	2.92
Ohio	26	39	6,454	1,678,985	118,161	7.04	469,672,000	37,574	3.57
Pennsylvania	43	50	5,669	1,467,043	109,649	7.47	526,152,663	52,615	2.79
Oklahoma	8	8	4,800	388,058	20,975	5.40	144,629,000	4,378	2.68
California, Colorado, Illinois, New York, Kentucky [a]	8	7	3,358	231,588	20,258	8.75	82,343,000	6,320	2.81
Total	132	176	37,100	7,425,839	531,704	7.16	2,475,697,263	176,961	3.00

[a] The only gasoline produced in Kentucky came from natural condensation in the pipes.

Production of gasoline from natural gas in the United States in 1911, 1912, and 1913, by States—Continued.

1912.

State.	Number of operators.	Plants.		Gasoline produced.			Gas used.		Average yield in gasoline.
		Number in operation.	Daily capacity.	Quantity.	Value.	Price per gallon.	Estimated quantity.	Value.	
			Gallons.	*Gallons.*		*Cents.*	*Cubic feet.*		*Gallons.*
West Virginia	66	97	22,366	5,318,136	$513,116	9.6	1,972,882,212	$163,749	2.8
Pennsylvania	69	83	10,524	2,041,109	217,016	10.6	722,730,117	62,010	2.8
Ohio	25	43	7,791	1,718,719	173,421	10.1	576,123,700	46,090	2.98
Oklahoma	11	13	11,910	1,575,644	99,626	6.3	701,044,300	24,901	2.25
California	7	7	6,669	1,040,695	112,502	10.8	600,743,000	25,573	1.7
Illinois	4	4							
Colorado	2	2	2,008	386,876	41,795	10.8	114,273,000	9,662	3.4
New York	1	1							
Kentucky	1	(a)							
Total	186	250	61,268	12,081,179	1,157,476	9.6	4,687,796,329	331,985	2.6

1913.

State.	Number of operators.	Number of plants in operation.	Daily capacity.	Quantity.	Value.	Price per gallon.	Estimated quantity.	Value.	Average yield in gasoline.
West Virginia	63	115	31,930	7,662,493	$807,406	10.54	2,981,119,000	$181,337	2.57
Oklahoma	19	40	61,633	6,462,968	577,944	8.94	2,152,503,000	82,742	3.00
Pennsylvania	100	113	22,207	3,680,096	405,186	11.01	1,372,056,000	114,783	2.68
California	12	14	21,135	3,460,747	376,227	10.87	2,436,445,000	106,539	1.42
Ohio	25	41	8,142	2,072,687	212,404	10.25	744,226,000	63,233	2.79
Illinois	6	12							
Colorado	2	2							
New York	3	3	7,368	721,826	79,276	10.98	203,092,500	17,590	3.55
Kansas	1	1							
Kentucky	1	(a)							
Total	232	341	152,415	24,060,817	2,458,443	10.22	9,889,441,500	566,224	2.43

a Drips.

WEST VIRGINIA.

The production of natural-gas gasoline in West Virginia has exceeded that of any other State in the years 1911, 1912, and 1913. The production in 1913 amounted to 7,662,493 gallons, valued at $807,406, as compared with 5,318,136 gallons, valued at $513,116, in 1912, and with 3,660,165 gallons, valued at $262,661, in 1911. For the first time the statistics of production by counties are given. They are approximately correct. Many of the plants installed in 1913 were in operation only a portion of the year, and the indications are that the production in the future will be considerably increased.

It will be seen that the greater number of plants in operation in 1913 are located in Tyler County, which took the lead in quantity and value of gasoline produced, the production amounting to 3,228,641 gallons. Pleasants County takes second place in number of plants in operation, but not in capacity or production, Ritchie County taking second place in this respect, with a production of 1,440,531 gallons. Brooke County is third in production, followed by Wetzel, Pleasants, Hancock, Wood, and Kanawha.

In the table following is given the production of gasoline from natural gas in West Virginia in 1913, by counties.

Production of gasoline from natural gas in West Virginia in 1913, by counties.

County.	Plants.		Gasoline produced.		Average yield in gasoline per thousand cubic feet of gas.	Average gravity of gasoline as produced and before blending.
	Number in operation.	Daily capacity.	Quantity.	Value.		
		Gallons.	*Gallons.*		*Gallons.*	*° Baumé.*
Tyler	47	13,011	3,228,641	$344,296	1.5–10	70 –97
Ritchie	15	6,710	1,440,531	146,804	1 – 4	82 –96
Brooke	6	1,960	711,867	74,242	2.5– 3	85 –96
Wetzel	4	840	a 683,437	74,412	1.5– 2	60 –86
Pleasants	17	2,070	459,385	41,275	1 – 4	80 –97
Hancock	5	1,825	301,125	37,471	2 – 4.6	86 –92
Wood	9	660	198,232	21,089	1.5– 5.5	80 –105
Kanawha	4	2,564	144,699	15,908	2 – 6	85.2–91.5
Calhoun	2	550	494,576	51,909	1 – 3	80 –91
Clay	1	1,740				
Wirt	1					
Marion	1					
Marshall	1					
Harrison	1					
Doddridge	1					
Total	115	31,930	7,662,493	807,406	2.57	....

a Includes drips.

In the following table is given the yield of natural gas in gasoline in West Virginia in the years 1911 and 1912, by counties:

Yield of natural gas in gasoline in West Virginia in 1911 and 1912.

County.	Number of operators.		Number of plants in operation.		Yield in gasoline per thousand cubic feet of gas.		Average gravity of gasoline as produced and before blending.	
	1911	1912	1911	1912	1911	1912	1911	1912
					Gallons.	*Gallons.*	*° Baumé.*	*° Baumé.*
Brooke	4	5	5	7	1.5–8.0	2.0– 4.0	87 –94	85–95
Calhoun	1	1	1	1	1.0–5.0	0.7– 4.0	83.2–92	82–90
Hancock	1	2	1	3				
Harrison	1	1	2	1				
Marion	1	1	1	1				
Marshall	1	1	1	1				
Pleasants	10	16	13	18	2.0–2.5	1.0– 4.0	75 –91	70–92
Ritchie	5	14	7	14	1.5–4.6	1.0– 4.0	83.2–96	78–96
Tyler	16	14	34	40	1.5–9.0	1.9–11.0	79 –95	80–92
Wetzel	2	2	2	2	1.5–3.0	1.5– 2.75	80 –89	80–88
Wirt	1	1	1	1				
Wood	4	8	4	8	1.0–4.5	2.0– 4.0	87 –89	82–95
Total	47	66	72	97	a 2.92	a 2.8	....	....

a Average.

PENNSYLVANIA.

Pennsylvania, which was second in the quantity of gasoline produced from natural gas in 1912, takes third place in 1913, having been displaced by Oklahoma. It will be noted that there were more gasoline producers in Pennsylvania in 1913 than in any other State, also that the number of plants in operation was 113, as compared with West Virginia, which had 115; but that the production of West Virginia was more than twice as much, the average daily capacity of the plants in Pennsylvania being much smaller. Producers in Pennsylvania not having compressor plants but using the gas-pump or vacuum process are not included in the table under the head of "Plants in operation." Their production, however, is included and amounted to a considerable output in 1913.

The following table shows that Butler County produced more gasoline from natural gas in 1913 than any other county in the State, or a total of 944,009 gallons, followed by Warren County, whose production was 838,006 gallons. Next in order of production are McKean, Allegheny, Venango, and Forest counties.

In the following table is given the production of gasoline from natural gas in Pennsylvania in 1913, by counties:

Production of gasoline from natural gas in Pennsylvania in 1913, by counties.

County.	Plants.		Gasoline produced.		Average yield in gasoline per thousand cubic feet of gas.	Average gravity of gasoline as produced and before blending.
	Number in operation.	Daily capacity.	Quantity.	Value.		
		Gallons.	*Gallons.*		*Gallons.*	*° Baumé.*
Butler	52	4,986	944,009	$99,587	1-6	58-110
Warren	27	3,480	838,006	92,488	1-6	70- 96
McKean	10	7,298	573,466	69,179	2-4.5	86- 95
Allegheny	11	2,367	568,041	62,246	1.8-6	80- 90
Venango	5	1,345	265,982	24,293	1-4	70- 93
Forest	3	1,475	255,773	30,424	1.1-2.5	86- 90
Washington	5	1,256	234,819	26,969	6	87
Potter					1.25	84- 86
Greene					1.5	75
Crawford					1	80
Total	113	22,207	3,680,096	405,186	2.68	....

In the following table is given the yield of natural gas in gasoline in Pennsylvania in the years 1911 and 1912, by counties:

Yield of natural gas in gasoline in Pennsylvania in 1911 and 1912.

County.	Number of operators.		Number of plants in operation.		Yield in gasoline per thousand cubic feet of gas.		Average gravity of gasoline as produced and before blending.	
	1911	1912	1911	1912	1911	1912	1911	1912
					Gallons.	*Gallons.*	*° Baumé.*	*° Baumé.*
Allegheny	2	4	4	9	2.4-6.0	1.5-6.0	86- 87	82- 87
Armstrong	1	1	1	1	2.0	2.0	86- 88	86- 88
Butler	16	29	19	36	1.0-6.0	1.0-7.0	75- 93	74- 95
Forest	1	1	1	1	2.0-2.5	2.0-2.5	86- 88	86- 90
McKean	2	5	2	5	2.0-4.0	2.5-4.0	86- 88	85- 90
Potter	....	1	....	1	....	1.0	....	86
Venango	1	2	1	2	3.0-6.0	3.0	75- 90	[a] 58- 88
Warren	19	25	20	26	1.0-3.0	2.0-7.0	76-100	74-105
Washington	1	1	2	2	6.0	6.0	87	87
Total	43	69	50	83	[b] 2.8	[b] 2.8	....	....

[a] Drips. [b] Average.

OHIO.

Ohio ranks fifth in the production of natural-gas gasoline in 1913, the production amounting to 2,072,687 gallons, valued at $112,404, with 41 plants in operation, as compared with 1,718,719 gallons, valued at $173,421, and 43 plants in operation, in 1912, an increase of 353,968 gallons in quantity and of $38,983 in value. Two plants in this State were idle the entire year 1913 on account of shortage of gas.

The following table shows that the largest production of gasoline in Ohio was from Monroe County, which produced 1,489,490 gallons in 1913, which was more than half the product of the State in that year. The next county in point of production was Washington, with a production of 298,748 gallons. The other gasoline-producing counties of this State in 1913 were Jefferson, Columbiana, Hancock, Fairfield, and Morgan.

The average yield per thousand cubic feet in gasoline of gas in Ohio in 1913 was 2.79 gallons.

In the following table is given the production of gasoline from natural gas in Ohio in 1913, by counties:

Production of gasoline from natural gas in Ohio in 1913, by counties.

County.	Plants.		Gasoline produced.		Average yield in gasoline per thousand cubic feet of gas.	Average gravity of gasoline as produced and before blending.
	Number in operation.	Daily capacity.	Quantity.	Value.		
		Gallons.	*Gallons.*		*Gallons.*	*° Baumé.*
Monroe	24	5,187	1,489,490	$156,184	½–5	84–97
Washington	10	1,330	298,748	29,444	1¼–3	80–92
Jefferson	2	600			4–5.6	....
Columbiana	2	250			3	92–95
Hancock	1		284,449	26,776		
Fairfield	1	775			2–2½	85–88
Morgan	1					
Total	41	8,142	2,072,687	212,404	2.79	....

In the following table is given the yield of natural gas in gasoline in Ohio in the years 1911 and 1912, by counties:

Yield of natural gas in gasoline in Ohio in 1911 and 1912.

County.	Number of operators.		Number of plants in operation.		Yield in gasoline per thousand cubic feet of gas.		Average gravity of gasoline as produced and before blending.	
	1911	1912	1911	1912	1911	1912	1911	1912
					Gallons.	*Gallons.*	*° Baumé.*	*° Baumé.*
Athens	1	(a)	1	(a)	5.0	(a)	....	(a)
Columbiana	2	2	2	2	3.0–5.0	3.0–7.0	88–91	85–94
Fairfield	1	1	1	1	2.0	1.5–2.5	85–88	85–88
Jefferson	1	1	1	1				
Monroe	7	10	17	26	0.5–9.0	0.5–10.0	70–95	78–90
Morgan	2	2	3	3	2.0–2.5	2.0–2.5	80–88	80–88
Washington	12	9	14	10	1.0–9.0	1.5–9.0	80–95	80–92
Total	26	25	39	43	[b] 3.57	[b] 2.98	....	....

[a] Idle. [b] Average.

OKLAHOMA.

Oklahoma ranks second in production of natural-gas gasoline in 1913, and the industry made greater progress than in any other State. The production was four times as much as in 1912, or 6,462,968 gallons, valued at $577,944, as compared with 1,575,644 gallons, valued at $99,626, in 1912; and the production in 1912 was four times greater than in 1911, which was 388,058 gallons, valued at $20,975. The table of production, by States, shows that 40 plants in operation in Oklahoma at the close of 1913 had a total daily capacity of 61,633 gallons, nearly twice the capacity of 115 plants in operation in West Virginia. As some of the plants in Oklahoma were erected during 1913 and were in operation for only a portion of that year and as additional plants have since been in course of erection, the indications are that Oklahoma will have a very much larger production to report for 1914.

It is not possible to give the gasoline production of this State by counties, but it may be said that Creek County leads in production, having produced in 1913 some 4,000,000 gallons, or nearly two-thirds of the production of the entire State, followed by Nowata County with over 1,500,000 gallons. The other producing counties are as follows, being named according to output: Muskogee, Tulsa, Pawnee, Okmulgee, and Washington.

The companies which have plants of largest capacity in Oklahoma are Chestnut & Smith and the Oklahoma Petroleum & Gasoline Co., both operating in Creek and Muskogee counties, and the Henderson Gasoline Co., operating in Nowata County; this company began operations in May, 1913. Other companies which began operations in 1913 are the Consumers Refining Co., Crosbie & Gillespie, the Gypsy Oil Co., and the Quaker Oil & Gas Co., in Creek County; Hull-McCune Co., in Tulsa County; the National Products Co., in Pawnee County; and the Riverside Western Oil Co., in Okmulgee County. Other companies having plants building in 1913 or 1914 are the Atlas Gasoline Co., in Creek County; the Chicago Oil Products Co., in Okmulgee County; the Cushing Gasoline Co., in Creek County; the Golden Gasoline Co., in Washington County; and the Motor Gasoline Co., in Muskogee County.

Gas produced from oil wells in many of the fields of Oklahoma is very rich in gasoline the reported gasoline content ranging from half a gallon to 8 gallons per thousand cubic feet of gas, the average for the State in 1913 being 3 gallons, the highest average yield reported for Oklahoma since the beginning of operations. The highest average yield is reported for Nowata County.

The report shows a gain in the average price per gallon received for gasoline in 1913 as compared with 1912, the average price being 8.94 cents in 1913 and 6.3 cents in 1912. The price ranged in 1913 from 7 to 12½ cents per gallon.

CALIFORNIA.

In progress of the natural-gas gasoline industry, California was second only to Oklahoma in the year 1913, its production having been three and one-half times as great as in 1912. The quantity of gasoline produced in 1913 was 3,460,747 gallons, valued at $376,227, as compared with 1,040,695 gallons, valued at $112,502, in 1912. The number of plants in operation at the close of 1913 was 14, with a total daily capacity of 21,135 gallons, as compared with 7 plants in operation in 1912 with a total daily capacity of 6,669 gallons.

The gasoline plants of this State are located in Orange, Santa Barbara, and Los Angeles counties. The oil wells of these counties produce large quantities of gas, far more than can be used for field operations, and much of this gas has gone to waste in past years. As this gas is very rich in gasoline, the establishment of plants for the extraction of gasoline from this excess gas is both economically and financially beneficial to the producers in this vicinity, as there has been a ready sale for all the gasoline produced. The average price received for gasoline in 1913 was 10.87 cents per gallon, there being no change since 1912.

In 1912 there was but one plant in operation in Orange County, that of the Pacific Gasoline Co. in Brea Canyon district. During 1913 this county made a gain of three plants, as follows: Brea Gasoline Co., 1 plant in Brea Canyon district; Hurley, Smith & Collins Co., 1 plant at Oleo station; and the Olinda Gasoline Co., 1 plant at Olinda. All the plants in this county were in operation in 1913, although one was in operation about three months and another five months, so that the production in 1914 may be largely increased. The production of gasoline in this county in 1913 was a little over one-third of the production of the State. In Santa Barbara County the following plants were in operation in 1912: Pinal-Dome Oil Co., 1 plant; Purity Gasoline Co., 2 plants; Union Oil Co., 1 plant; and Western Gasoline Co., 1 plant; all these companies began operations during the last half of 1912. In 1913 the following plants were added to the number in operation in this county: American Gas Co., 1 plant; Pinal-Dome Oil Co., 1 plant; and the Union Oil Co., 1 plant, a total of 8 plants in operation at the close of 1913. The largest production of gasoline in 1913 came from Santa Barbara County, the output being 1,953,643 gallons. Other gasoline plants in this State are the Columbia Oil Producing Co., 1 plant formerly operated by the Puente Oil Co., and the Standard Oil Co., 1 plant; both of these plants are located in Los Angeles County and were in operation in 1913. An experimental plant was operated near Fillmore, in Ventura County, by the Montebello Oil Co. in 1913. This company is installing a large unit at the present time. It will be seen that the gasoline industry in this State is in a flourishing condition, with greater prospects for the future.

The yield in gasoline per thousand cubic feet of gas used in California in 1913 ranged from 1 to 4 gallons, with an average yield of 1.42 gallons.

ILLINOIS.

The number of plants producing natural-gas gasoline in Illinois increased from 4, with a daily capacity of 1,400 gallons, in 1912, to 12, with a daily capacity of 6,250 gallons, in 1913. The production of this State being 581,171 gallons in 1913, a very substantial gain over 1912. The probabilities are that there will be a further increase in 1914, since some of these plants were in course of erection in 1913 and were in operation only a portion of that year.

The gasoline plants are located in Crawford and Lawrence counties. The yield of gas in gasoline ranged from 1½ to 6 gallons per thousand cubic feet in 1913, the average for the State being 3.6 gallons.

COLORADO.

There has been no change in the condition of the natural-gas gasoline industry in Colorado since the last report. There are only two plants in the State, located in Boulder County, both of which were operating in 1913, the statistics of their production being included with those of other States.

NEW YORK.

Reports received from natural-gas gasoline producers in New York give a small production in 1913. There are three plants in this State—1 near Richburg, Allegany County, and 2 at Carrollton and Four Mile, Cattaraugus County. The oil wells of these counties produce considerable gas said to be rich in gasoline. The probabilities are that this State will continue to increase its gasoline production. One of the companies reporting was in operation but a short time in 1913, but is operating more fully in 1914. The "exhaust" gas is used for drilling and pumping and for domestic consumption.

KANSAS.

For the first time the State of Kansas appears as a producer of natural-gas gasoline. There was one producer in this State in 1913, the Vulcan Oil & Gas Co., which has a plant located in Chautauqua County and uses gas from its own wells. It is reported that another plant is in course of erection in this county.

The production of natural-gas gasoline in Kansas in 1913 is included with that of other States.

GASOLINE EXPORTS AND IMPORTS.

The exports of gasoline from the United States during 1913 amounted to 117,728,286 gallons, valued at $17,418,777; the imports amounted to 12,110 gallons, valued at $1,661.

The quantity of gasoline exported from the United States from July 1, 1912, to December 31, 1912, amounted to 38,070,949 gallons, valued at $4,671,815, and the quantity of gasoline and naphtha imported into the United States during the same period of time was 570 gallons, valued at $118.

ANALYSES OF NATURAL GAS FOR GASOLINE CONTENT.

Through the courtesy of the Bessemer Gas Engine Co., of Grove City, Pa., some analyses are given of natural gas from different localities of the country, with a brief explanation of the method of analysis as carried on in the laboratory of the company to estimate the gasoline content of natural gas. The gas analyses were made by R. A. Bastress and the physical tests by E. W. Jordon, both of the Bessemer Gas Engine Co.

All estimates of the gasoline content are based upon two-stage compression at 250 pounds. Estimates of yield are understood as the marketable product.

Analyses of natural gas for gasoline content.

Analysis No.	Date of analysis.	Location of field.	Absorption heavy hydrocarbons.	Carbon dioxide.	Oxygen.	Nitrogen.	Specific gravity.	Combustion ratios.			R.	R′.	Gallons per thousand cubic feet of gas.
								Contraction.	CO_2.	O_2.			
			Per cent.										
2500	Apr. 2, 1913	Calgary, Alberta, Canada	15	None.	None.	None.	0.67	2.17	1.26	2.37	1.72	0.390	Dry.
2430	Jan. 25, 1913	Electra, Tex.	50	None.	None.	None.	1.12	2.56	2.03	3.59	1.26	.889	3.5
2242	May 20, 1912	Oilfields, Cal.	36	17.0	0.70	3.8	.79	2.21	1.13	2.34	1.96	.403	1.0
2747	Nov. 17, 1913	Casper, Wyo.	45.1	None.	None.	None.	1.04	2.57	1.98	4.54	1.29	.806	3.0
2748	do	do	35.5	None.	None.	None.	.94	2.47	1.72	3.19	1.44	.653	2.0
1477	Feb. 23, 1911	Glenn Pool, Okla.	62.5	4.7	.80	3.0	1.16	2.62	2.15	3.77	1.22	.951	4
2181	Jan. 2, 1912	Childers, Okla.	79.3	None.	None.	None.	1.37	2.89	2.55	4.43	1.13	1.20	5.5
2065	July 17, 1911	Bremen, Ohio	25.0	None.	.30	(a)	.67	2.09	1.10	2.19	1.98	.338	Dry.
D45	Oct. 17, 1911	Cherrydale, Kans.	21.2	.95	None.	None.	.60	2.03	1.01	2.04	2.00	.300	Dry.
2533	Apr. 28, 1913	Titusville, Pa.	49.2	1.50	None.	None.	.90	2.48	1.64	3.13	1.51	.596	2
1632	Mar. 18, 1911	Sistersville, W. Va.	45	.70	6.90	28.3	1.52	2.82	2.89	4.72	.976	1.56	Air-free.
1186	Jan. 26, 1910	do	62.0	None.	2.5	(a)	1.23	2.72	2.24	3.95	1.21	1.02	4.5
1494	Feb. 23, 1911	Kiefer, Okla.	68.6	3.90	None.	None.	1.30	2.66	2.19	3.85	1.21	1.07	.5
2478	Mar. 1, 1913	Charleston, W. Va.	22	None.	None.	None.	.74	2.24	1.29	2.54	1.73	.427	5
A-1-5	Feb. 10, 1910	Grove City, Pa.	15	None.	None.	None.	.63	2.04	1.02	2.06	2.00	.315	Dry.

a Not determined.

Brief explanation of the methods of analysis and estimation.—Absorption is made in Elliott's gas burette, with claroline oil, a heavy, high-flash and burning-point oil as solvent. With 80 cubic centimeters of methane the absorption was found to be 15 per cent, approximately. Gas taken from high-grade natural-gas gasoline was practically soluble.

R and R′ are empirical, arbitrarily chosen constants. R is the result of dividing contraction by CO_2; R′ is the result of dividing specific gravity by R. Thus by comparison of analyses of gases whose gasoline content is known we are able to estimate very closely the yield of an unknown gas.

The following are physical tests made by the Bessemer Gas Engine Co. with Bessemer equipment on some gas which corresponds to that sent in for chemical analysis. These physical tests serve as check on the accuracy of the chemical analysis.

Analysis 2747: Chemical analysis shows 3 gallons. Physical test, suction pressure, 2.1 inches mercury; terminal pressure, 250 pounds; gross quantity of gasoline obtained, 3.83 gallons at 92° Baumé gravity per thousand cubic feet of gas; evaporation, 18.2 per cent; result, 3.13 gallons net of gasoline at 87° Baumé gravity per thousand cubic feet of gas.

Analysis 2748: Chemical analysis shows 2 gallons. Physical test, suction pressure, 4 pounds; terminal pressure, 250 pounds; gross quantity of gasoline, 2.45 gallons at 87° Baumé gravity, per thousand cubic feet of gas; evaporation, 16.6 per cent; result, 2.04 gallons net of gasoline at 84° Baumé gravity per thousand cubic feet of gas.

Analysis 2065 shows dry gas by chemical analysis. Physical test shows less than one-half gallon net of gasoline per thousand cubic feet of gas at 400 pounds compression.

CARBON BLACK.

The use of natural gas for the manufacture of carbon black has been so generally condemned as a waste that possibly the general public has lost sight of the fact that lampblack and carbon black are just as necessary products as any others obtained in the natural-gas industry; and that there is no source from which carbon black can be obtained with less waste than from natural gas, where it is not possible to use the natural gas for any higher purpose. As a matter of fact, in the regions where carbon black is now manufactured this utilization of gas is probably well justified. The carbon black can be manufactured from natural gas wastefully or with great relative efficiency, according to the methods employed. Thus far the Government reports have contained no general description of these methods; therefore, a condensation is given below of a very complete description of the manufacture of lampblack and carbon black, written by Godfrey L. Cabot,[1] of Boston, Mass. The principal features of his description follow:

In the American trade the term "lampblack" is usually understood to be a soot deposited by the smudge process and made from oil, resin, or some other solid or liquid raw material, whereas "carbon black" is the term applied to a black deposited by actual contact of a flame upon a metallic surface.

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[1] Eighth Int. Cong. Appl. Chemistry, vol. 12, pp. 13 et seq.

If the name "lampblack" be taken in its wider sense as meaning any commercial form of soot, it may be prepared in three different ways: First, by the combustion of dead oil of tar, pitch, resin, or some other carbonaceous raw material with an inadequate supply of air and the collection of the floating particles of soot that escape unburned from the flame and slowly deposit themselves on the walls and floors of the collecting chambers; second, it may be formed by the direct impact of a flame upon a collecting surface; and, third, it may be formed by heating carbonaceous vapors to a decomposing point, apart from air or flame.

If lampblack be restricted to the sense in which it is known to the American trade of a commercial soot deposited by the smudge process, the starting point of its manufacture is usually the dead oil of tar, an oil containing a large proportion of naphthalene, a certain proportion of phenol, and various aromatic hydrocarbons particularly suited to the manufacture of lampblack by reason of the large percentage of carbon therein contained. When this dead oil of tar is burnt with an inadequate supply of air, a very considerable proportion—to wit, from 15 to 35 per cent of its weight—can be obtained in the form of lampblack by decomposition in suitably arranged chambers. The quality of the black is determined by the size and shape of the furnaces in which the oil is burned, by the heat to which it is subjected in the process of manufacture, by the position in which the black is deposited, and by the care that is exercised in the process of manufacture and in the selection and preparation of the raw materials.

The oil is usually allowed to flow in a sluggish stream into an earthenware or iron pot or pan, in which it burns and from which the smoke passes through flues into the chambers in which it is deposited.

To absorb and utilize commercially some of the heat, boilers are often placed within reach of the flame and the steam thus generated is used for the industrial processes that may take place in the same factory. Care is necessary to free entirely from water whatever raw material may be employed and also to protect the reservoirs and the pipes from them to the burners from excessive cold, which might cause a stoppage by the coagulation of naphthalene, anthracene, or other solid matter in the pipes. A screen is often used at the final exit from the black-condensing chambers in order to hold back the last traces of the black, both on account of its value and because the smoke that passes from a lampblack factory is very annoying to neighbors.

The best grades of black, in general, are obtained in furnaces of moderate size, so built that the black is practically calcined at the time it is deposited and carries down with it but very little empyreumatic matter. The products of combustion are usually carried through a series of chambers and the black is assorted according to its distance from the point of origin, the lightest being that farthest from the flame and for this reason commanding better prices for certain purposes.

These chambers are periodically emptied, preparatory to which, it is needful to be sure that the black is thoroughly cold and is not afire, for it sometimes happens, if too much oxygen comes into the chambers, that the black gets afire and the fire may lurk undetected, unless great care be exercised. An experienced workman can usually detect fire by the smell, and the workmen are thus put on their guard to hunt out and extinguish the fire. It sometimes happens that the quantity of carbonic-oxide gas is dangerous to the workmen, and this danger should be borne in mind. This gas is very poisonous.

It has been observed that the smokiness of a flame can be increased by artificial cooling; for example, if a coarse wire grating is brought into an ordinary gas flame, the flame immediately begins to smoke, and various attempts have been made to utilize this principle to increase the yield of lampblack.

It is good practice to introduce partition walls in the chambers used for deposition, thereby increasing the distance that the products of combustion must travel before they finally escape into the open air, with a view to increasing the percentage of deposition; but this practice can easily be overdone, for if the chambers are divided up too much more harm is done by increasing the speed with which the products of combustion travel than good by increasing the distance.

Mechanical devices have been used in the form of stirrers, which churn the air and cause the condensation of the smoke in masses sufficiently large for it to deposit itself. The writer cited does not know whether any of these devices are now in use on a commercial scale. The soot thus obtained contains about 80 per cent of carbon, the rest being chiefly oxygen and hydrogen, with traces of grit on the walls and floors of the collecting chambers and a greater or less percentage of oil or other empyreumatic matter.

This oil or other empyreumatic matter can be driven off by heating the lampblack in sheet-iron boxes, care being taken, on the one hand, to heat it sufficiently to drive off the oil, and, on the other, not to make it so hot as to affect the mixing strength. Moreover, it is possible, as already stated, by a proper proportioning of the fireplace, flues, and the supply of raw material and a proper arrangement of the temperature and other conditions, to cause a deposition of a certain proportion of black practically free from empyreumatic matter from the start.

Resin, resinous woods, tar, pitch, and other raw materials have been and still are, to a certain extent, used in the manufacture of lampblack; but in general the quality of the black thus obtained is less good than that obtained from the dead oil of tar and other distillates, and such inferior raw materials are comparatively unimportant as a commercial source of lampblack.

Another method of making lampblack is by the heating of hydrocarbon vapors out of contact with air, a typical instance of which is set forth in patent No. 866883, by Albert D. Purtle and Irving E. Rowland, of Salem, W. Va. For years a similar process was used to extract carbon from natural gas to be used in the manufacture of electric-light pencils, near Red Bank, Pa.; but the carbon thus obtained cost too much to compete in the long run with coke, which is now the chief raw material for these pencils. Lampblack thus obtained is apt to contain particles of adamantine carbon, so hard that they will scratch glass. Another commercial obstacle is the high cost of the apparatus and the large expense from deterioration as compared with the value of the finished product. Therefore, although a much larger proportion of carbon can be obtained from natural gas by this than by any other known process, all such efforts have, up to this time, failed to show a commercial profit; but it is believed that this method of making carbon black will some time be successfully applied.

Attempts have been made, first, to volatilize the raw material and, second, to burn the resulting vapor on the smudge system with an insufficient supply of air and to collect the resulting soot; but it is not known that any such attempts have proved profitable on a commercial scale, and it is hardly believed that they would.

Various devices have been adopted to perfect the separation of the soot from the air, and it may be said that, both in the manufacture of lampblack by the ordinary smudge process and in the manufacture of carbon black by the contact process, one of the most difficult problems is the proper separation of the black from the air in which it floats or which it holds mechanically when it settles. In the case of the smudge process, adjustable blinds made of iron are sometimes used by which the black enters the chimney and which can be worked just like the adjustable slats on an ordinary window blind. Thus the draft is regulated and eddies are formed which help to cause the black to unite into larger pieces and to settle out. High-pressure electric discharges of a static machine have been used experimentally for causing this separation of the black from the air, but this is a too expensive and cumbersome method to prove profitable on a commercial scale, and, of course, on a large scale high-pressure discharges are dangerous. The best material for the chambers in which the black settles is masonry with cement floors and a brick roof put together with cement mortar.

When a new plant is put into operation, the black first made is apt to contain moisture condensed by the coldness of the walls, empyreumatic matter, which has not been calcined out for the same reason, and grit, which at first comes off the walls to an annoying extent, even when great care is exercised in construction. This first black is sold, usually at a cheap price, to those who are willing to use a black containing grit. Only after the operation has been carried on for some time, so that everything is warm and in good running order and the loose grit has fallen, can the best results as to quality be obtained.

The lampblack which is thus precipitated can be freed from empyreumatic matter by calcining, as already stated, or by washing with alkali or acid. So far as known, practically none of it is ever washed with alkali or acid, the expense of drying being very material. The handling of black is, in general, a difficult and expensive process, owing to its great bulk and extreme lightness, which cause a great deal of loss and much dirt and disagreeable work. It is more and more the aim of lampblack manufacturers so to conduct their process that the black is calcined in the process of making, at least, to an extent satisfactory to most buyers.

In the case of carbon black, the black when first scraped from the plates is so light that 30 pounds will fill a sugar barrel. When it is considered that the specific gravity of carbon black is about 1.7 (that is, very much heavier than water), it is perceived that 95 per cent of the bulk of black as it comes from the plates is air, and the problem of packing is to separate this black from the air so far as is commercially feasible. This can be done by screw packers, similar to those used for packing flour, but different in detail and run at a very much lower rate of speed; or it can be done by a plunger, lined with sheepskin, the wool side out, worked up and down vertically by a ratchet or screw. An essential element is time. The process of packing carbon black can not be hurried without much loss by the spurting of the black through the air, and many other evils.

As the black comes on the market, a sugar barrel will hold from 75 to 80 pounds. In fact, it is possible to get 80 pounds into a barrel of less than sugar-barrel size; which means that the black has been compressed to about one-third of its original bulk and that still about 88 per cent of its bulk is air. Under these conditions the black is very hard, and many buyers insist on its being packed under less pressure, owing to the consequent greater difficulty of grinding; but its ultimate quality for most uses is not affected by this pressure.

There is still another source of lampblack, to wit, acetylene gas obtained from the refuse of carbide of calcium factories, namely, those grades containing too little carbide of calcium to be merchantable. This acetylene gas possesses the remarkable quality of exploding by itself without the admixture of air, and Jaenecke & Schneemann manufactured black by exploding this gas under five atmospheres, either by compression or by an electric spark. The difficulty is, first, that the process is very hard on the apparatus, and, second, that the black thus obtained is very inferior in color and strength to carbon blacks from natural gas. It is essentially a by-product; the supply is very uncertain, and the price is irregular, but always averages much higher than that of carbon black. Therefore, it can only be used where its bluish tinge gives it the preference in certain trades.

"Carbon black" is the trade name given in this country, and to a certain extent abroad, to lampblack made upon the surfaces of metal or stone by direct impact of flame.

The first carbon black made and sold in this country in a commercial way seems to have been produced in the year 1864 by J. K. Wright, of Philadelphia, Pa., for use in the manufacture of printing ink. This industry is, therefore, a comparatively new one in this country, and it certainly never attained any great importance abroad, although it is not possible to state when carbon black was first made in other countries. Mr. Wright revolved sheet-iron cylinders over jets of artificial gas, and the black was removed from the cylinders by stationary scrapers. This process was used by other ink makers also; and a very glossy, high-priced ink, of intense color, was obtained.

These pioneers in the carbon-black industry apparently did not consider the process of sufficient importance to patent it, for the first patent granted in this country was issued December 10, 1867, to A. Millochan, of New York, for a process which proved to be of no value; and it was not until the year 1872 that any process was patented that was subsequently used on a regular commercial scale. The attention of many people, among others of Peter Neff, of Gambier, Ohio, and John Howarth, of Salem, Mass., had been attracted to the fact that large quantities of natural gas going to waste in the gas regions offered a cheap and abundant raw material for this manufacture, and on September 17, 1872, John Howarth received a patent for the manufacture of carbon black from natural carburetted hydrogen gas, claiming the production of carbon black from a natural carburetted hydrogen gas issuing from the earth, etc. His plan was to connect the gas well with a gas holder, such as is used in artificial gas works and provided with a blow-off from which might escape the surplus flow of the well not required in the process of manufacture. As the natural pressure of gas in the rock sometimes exceeded 500 pounds on the horizon from which he derived the supply of his factory, and as there was at that time no method of regulating the flow, this waste of gas was a necessary feature of his enterprise. From the gas holder the gas passed through pipe to ordinary gas jets arranged in the same horizontal plane beneath slabs of soapstone. These slabs of soapstone were provided with holes for ventilating, without which the carbonic-acid gas and other inert products of combustion would have formed a layer about the middle of the slabs and have kept the flame away from the surface, thereby diminishing the yield and impairing the color of the resulting product. Above these slabs of soapstone rose in an arch an iron dome or hood with a chimney at the top, and in this chimney a damper that could be set to give the right draft. On the slabs rested pans of water closed in and kept cool by a continuous circulation. The edges of this arch descended below the edges of the soapstone slabs and were grooved horizontally; in the grooves ran a scraper that could be pulled to and fro by hand. This scraper removed from time to time the deposited soot which fell into the sheet-iron aprons or troughs which hung from the burner pipe. From these again the black fell through discharge pipes into receptacles which could be changed by hand when full. This was a very crude, clumsy, and expensive way of making carbon black, decidedly less advantageous than that previously employed in making black from artificial gas, but, nevertheless, owing to the cheapness of the raw material, the price, which had been $3 to $5, immediately dropped to $2.50, then to $1.50, and shortly after to $1.25 a pound. It is, however, a curious fact that the black from natural gas does not possess all the qualities of that made from artificial gas.

On March 23, 1875, John Howarth received a further patent on a traveling car which hung from rails running lengthwise of the bench or row of slabs, and these rails also held between them the slabs themselves. This car carried a scraper, a shallow frame, and, hanging to that frame on each side, two deep receptacles of sheet iron, which could be detached at will and emptied. These receptacles were joined together over the burners by a narrow arch of sheet iron, just wide enough to allow the apparatus to pass over the single row of burners without striking. The car was drawn by an endless rope passing over pulleys and pulled first in one direction and then in the reverse. The scrapers were held against the plates by wire springs, and were only in contact with the plate when passing toward the end at which the receptacles were removed. The dome was a superfluous adjunct. Cast iron was better than soapstone and there was no need of water cooling. Indeed, Mr. Howarth never used water cooling on a commercial scale. Obviously, its effect would hardly be felt through such a nonconductor as soapstone. The first factory was located at New Cumberland, W. Va. The gas came from what is known as the salt sand, was very rich in carbon, and made an excellent black. The factory was made of wood, and before long it burned down and the business was removed to Saxonburg station, Pa.

In two or three years competition sprang up at Gambier, Ohio, where a small factory was erected by Peter Neff, who had made black by a somewhat similar process for 10 or 12 years. He had as many patents for carbon-black apparatus as all the other inventors put together, but most of them were fantastic and useless. His factory reached an output at one time of 125 pounds a day.

The next important competition was by A. V. Nolen, who, in the year 1879, built a factory at New Cumberland, W. Va., and made black on cast-iron pans holding water. By this time the price of black had gone down to about 60 cents a pound, but, nevertheless, whereas the two pioneers had met with little pecuniary success, Mr. Nolen, by superior ability, made a good deal of money, and bought out the original company.

Various other small factories were started from time to time, but it was not until the year 1883 that any considerable advance was made, when the firm of L. Martin & Co., of Philadelphia, Pa., became interested in a small and struggling enterprise at Fosters Mills, Pa., and there erected five plates 24 feet in diameter, cast in segments and suspended on a central mast, which rotated with them upon a bronze bedplate. Beneath this was fixed a stationary burner of parallel, horizontal iron pipe, 1¼ inches in diameter, branching from a central supply 3¾ inches inside diameter, and this, in turn, connected suitably with the well.

Incredible as it may seem, even at this time, after 10 years of experience, no attempt had been made by the three leading manufacturers to control the flow of gas from the wells, although this was then quite possible with available appliances, and a blazing torch at each gas well, wasting daily millions of feet, was a feature at the principal factories, including that at Fosters Mills, Pa.

About the same time a factory was started by Samuel Cabot in the adjacent village of Worthington, Pa., at which some efforts were made to confine and economize the gas, but it remained in large part fruitless for some years, owing to the inefficiency of the foreman.

At the factory at Fosters Mills the idea of a traveling box and scraper was discarded and the plan of a horizontally rotated collecting surface was for the first time successfully adopted on a commercial scale. The same principle was adopted at Worthington at about the same time, but failed of success, owing to purely mechanical imperfections. It would seem at first as if the original idea of moving only the scraper box was the correct principle; and yet it is now entirely abandoned, and about two-thirds of all the black that is made to-day is made on surfaces which are moved over a stationary scraper box and stationary burners.

The first decade of the manufacture of carbon black from natural gas on a commercial scale was the time of factories in which the collecting surfaces were arranged in rectangular shapes, placed end to end to form what the workmen call "benches." The details whereby the black was collected, the dimensions of the different parts, and the arrangements of the size of the burners varied in different factories; but four-fifths of all the black made was made on benches, and the rest was made on the external surfaces of rotating cylinders.

The year 1883 brought with it the introduction of large rotating plates, which replaced at Fosters Mills a factory in which benches had been used. A scraper box and scraper was placed radially so that in revolving the scrapers were at right angles to the direction in which the surfaces passed across them. The black was removed by a screw conveyor in the bottom of the scraper box which carried it outward to a longer conveyor, which in turn ran tangential to five plates in a row and carried the black to a rotating bolt, through which it went into the bin. It was then lifted from the bin by hand in large scoops and packed by hand with a screw press, but the black is very light and the handling of it was very dirty, unhealthy work, which involved also considerable loss in raw material. In the earlier factories it had been the habit to brush the black through a fine horizontal sieve by means of brushes rotating on a vertical axis. A bolt revolving on a horizontal axis which discharged the coarser particles of black at one end and allowed only the finer particles to fall through it was a decided improvement.

In the same year A. R. Blood, of Warren, Pa., devised a method in which a small plate about 3 feet in diameter was used. The advantage of this was that no ventilation holes were needed, as in the case of the larger plates, except, however, that this small plate was cast in the form of a ring with an opening in the center. This plate was moved by means of a ratchet at the center. This ratchet was worked by a lever, and this by another lever revolved on a shaft. Every time the shaft revolved the lever would give the plate a little shove, which would move it 1½ inches. Beneath the plate was a scraper in the mouth of a radial hopper, through which the black fell into a longitudinal conveyor running beneath the row of plates. There were 16 plates in a row and 5 rows in the building. The building was of sheet iron on a framework of pipe and angle iron and was pierced with small holes near the bottom to give the needful supply of air. Along the ridge pole was an opening about 30 inches wide, and about 6 inches above this was a little pent roof to prevent the entrance of rain, and through the space between the products of combustion passed. All of these factories used gas jets either of iron or steatite, such as are ordinarily used in houses. There was one factory which used Argand burners, but it did not last many years. About this same year, 1883, E. R. Blood, the father of A. R. Blood, began to make black on the roller process, using a burner with a small hole in the point of the tip which gave a round flame. This black was at first very unprofitable, owing to the small yield and the comparatively poor color, but the successors of A. R. Blood improved the details of manufacturing, and experience has shown this black to possess some valuable qualities, and in spite of its inferior color it sells for a high price and is very profitable to the owners, the Peerless Carbon Black Co., of Pittsburgh, Pa. This company was for many years the only company making carbon black in this country from natural gas on revolving cylinders, although in earlier days two or three factories used this principle, and there are now three such factories.

In the second decade the process of making carbon black introduced by A. R. Blood became the most important as to output and total value of black produced. The prices of black fell rapidly and reached 7 cents a pound by the year 1887 and 4 cents a pound by 1889. After this there was a considerable improvement in prices, followed by a further rapid increase in output, and by the close of the second decade the total output had reached about 10,000 pounds a day, worth at that time about 6 cents a pound.

Toward the end of the second decade two new processes began to become an appreciable factor in the total output. The first of these was the process of Mr. Cabot, whereby, under 24-foot plates, similar to those previously mentioned though varying somewhat in details, was rotated a burner and black box radially placed. The burner was made up of parallel 1¼-inch pipe inserted in a central supply pipe 3¾ inches in diameter. As first used the radial black box discharged into a hopper placed at the side of the plate by means of a little trapdoor with a lever which was pressed in such a way as to open the trapdoor every time it passed over the hopper; after the discharge the trapdoor closed again by means of a counterpoise. This method of rotating burner was introduced at Worthington about the year 1884, but did not become a commercial success until 1887. The factory changed hands, and the new owner changed the method to that of a central discharge whereby the black was continuously discharged downward by a vertical spout at the inner end of the radial black box into a circular box; thence it went through a hole in the bottom into a long conveyor. By the former method the long conveyor had been tangent to the ring, and by this method it went within 2 feet of the center. A cover was hung above this round box in such a way as to exclude air and rotate with the burners, black-collecting box, etc. The bottom of the vertical spout above alluded to pushed the black in front as it slowly swung around the ring until the black reached the orifice through which it fell. One great advantage of this method was that the black was not exposed to the air. By the former method whenever the box emptied, a cloud of black arose, causing annoyance and much loss of output. As rebuilt, the black was kept under cover and carried to a bolt, also shut in, and raised from beneath this bolt by an elevator into a bin. From this bin, it was packed by machinery in either sacks or barrels, always under cover, so that from the time the black was made until it was used by the consumer, it was never touched by hand and was always under cover and protected from all appreciable drafts of air.

The other process above referred to was introduced about the year 1891 at Gallagher, Pa., and consisted of a system of channel beams turned with flat side downward over horizontal rows of stationary burners and black boxes. By a reciprocating mechanism, these beams slowly moved back and forth and the black was scraped and removed by a screw conveyor in the usual manner. This black was packed direct without bolting. The chief advantage of this system is the perfection of the surfaces, which are smoother than the surfaces of cast-iron plates.

In the beginning of the third decade of this industry, another attempt was made to manufacture carbon black with the use of petroleum and under a somewhat new principle by evaporating petroleum and burning its vapors through gas burners. The cost of making this black was probably less than that of any other black made from petroleum by the contact process; still it was more than could be realized by its sale. One great difficulty was the formation of adamantine carbon in the black. These particles were so hard that they would scratch glass, and the manufacturer was unable to discover a method of removing them. Since that time there has been no carbon black made from oil on a commercial scale in this country, although there is a small quantity of a very expensive grade made in Europe from what are known as gas oils, heavy oils obtained in the distillation of shale and used chiefly by manufacturers of illuminating gas. No important improvement in making carbon black appeared in the third decade. The output steadily increased and reached 20,000 pounds a day.

The price fluctuated a good deal, the average for the decade (1893–1902) being about 6 cents. The output of black produced with rotating burners and with the reciprocating channel beams very considerably increased. There were also modifications made in the process of the small stationary plate, and the output made on this general principle increased. In 1902, about one-quarter of all the carbon black was made with rotating burners, about one-fifth with reciprocating channel beams, not quite one-half on rotating cast-iron plates, mostly with the smaller sizes, and the rest chiefly with rollers. There was only one factory in existence which operated on the bench principle.

In the year 1899 the construction at the Grantsville, W. Va., factory was begun, which used 24-foot plates, with revolving burners and black box, etc., beneath them. By the end of the third decade, namely, about the year 1902, this had become the largest factory in existence and has been still further increased until it is making about 10,000 pounds of carbon black a day. Possibly a brief description of this factory may be of interest. It lies on the right bank of Little Kanawha River and comprises 113 plates, each 24 feet in diameter and surrounded by protecting rings of corrugated iron 26 feet in diameter. Above these plates is a roof made partly of triangular sheets of sheet iron and partly of rectangular sheets of corrugated iron and reaching about two-thirds of the way to the top of the 16-foot mast on which these plates are hung, leaving, therefore, in the center a space having about one-third the diameter of the plate, through which the products of combustion can escape upward.

These plates are arranged in rows parallel to the river and disposed on two sides of a central avenue which runs from the river to the road, at right angles to both.

The black is collected by long conveyors running through the center of the rows of plates toward the central avenue; here it passes into larger conveyors, which bring it to the packing house and elevate it into bins; from them the black is packed partly by sack packers and partly by barrel packers, which work with a plunger.

The black is carried down Little Kanawha River in gasoline boats. Large tanks, containing about a thousand barrels of water, stand on the hillside above the factory, and the factory is adequately piped in every part over an area of about 6 acres, whereby water can be turned on, either for the purpose of putting out fire or for the purpose of knocking black out of the ventilator holes in the rings on which the black is deposited.

These rings are of two patterns: One of them is made with 14 radial arms in the shape of T rails, which support 70 cast-iron plates, 5 between each pair of arms. The other pattern has for each plate 48 segments, 16 in the inner row and 32 in the outer row, which are supported directly by guys. In each case the plate is supported by guys screwed into a cap, which has approximately the shape of a very blunt, truncated cone. This cap rests upon the top of the hollow mast and the joint between the cap and the mast is made good with asbestos board. The mast stands in a bedplate on the upper surface of which is a groove, in which run $1\frac{1}{2}$-inch steel balls. Upon these steel balls rests a casting having 8 horns, which project outward and upward and are fixed in the lower ends of struts made of 2-inch pipe. On the outer end of these struts of 2-inch pipe is an angle casting into which the 2-inch pipe fits and through which a horizontal hole accommodates a horizontal guy rod, attached at the inner end to an octagonal plate, which rotates with the burner around the central mast. On the outer end of these horizontal guy rods are $\frac{3}{4}$-inch nuts, and by screwing these up the struts can be raised to the correct position, thus regulating the height of the burners beneath the plate. On the face of these angle castings supported by the 2-inch struts is bolted an iron bar, which hangs vertically down from these angle castings, and to this iron bar is attached an angle iron, in which runs the chain that rotates the burners, black box, etc. Against these angle castings is also bolted a horizontal ring, made of bars $4\frac{1}{4}$ by $\frac{1}{4}$ inch and forming a circle around the plate, and on this ring is supported the gridiron of burner pipe. This gridiron of burner pipe has as its central supply a piece of $3\frac{3}{4}$-inch casing, 22 feet 6 inches long, and this casing, in its turn, is fed with gas by $21\frac{1}{2}$-inch pipes, connected with the help of 4 ells and a union to an octagonal gas box, at the top and bottom of which sit glands. This gas box is fed through holes in the mast. The glands are stuffed with asbestos so that the gas can not escape as the carbon black box revolves around the mast.

The black is removed from the plates by scrapers placed radially to the mast above the box; in the bottom of the box lies a screw conveyor, which in its turn is actuated by a pinion on its inner end, and this pinion engages a bevel fixed to the central mast. Beneath the octagonal plate, to which the horizontal guys are fastened, is bolted a hanger in which turns the shaft of the conveyor which carries the pinion just mentioned. On the inner end of the box the black descends in a vertical 3-inch pipe through the rotating cover into the circular box from which it discharges downward into the long conveyor, which runs tangent to this circular box and 2 feet from the center of the ring.

In the last decade certain new processes have come into use which are, however, only modifications of those mentioned. In one factory, namely, that of the Bristol Oil & Gas Co., of West Virginia, the black is collected on a hollow channel iron, flat beneath, through which a blast of air is blown, with a view of cooling the plates.

The question is often asked whether the heat of the gas used in the manufacture of carbon black is saved or lost, and why. It is always lost, and for the reason that the expense of utilizing this heat would greatly exceed the value of the power to be obtained. The Grantsville works, producing about 10,000 pounds of black a day, are operated by 5 gas engines, which probably do not consume 50 cents worth of gas a day at the price at which gas is bought at this plant. If these works were in the immediate vicinity of a large city it is probable that it would pay to circulate water underneath them in an immense coil and to heat the neighboring quarter of the city with hot water. Located as they are in a sparsely settled country, 30 miles from the railroad terminus, there is no practical way of saving this heat. Wasteful as this operation seems, it is better than that all of this gas or a great part of it should pass into the atmosphere through the numerous oil wells of the Yellow Creek and other adjoining fields.

Another source of waste in this manufacture is the smoke, which ascends day and night to a very great height in the atmosphere and can sometimes be seen at a distance of 18 miles, but this consists of lampblack rather than carbon black and would probably only sell for 2 or 3 cents a pound if it could be collected, and the task of colecting even one-half of it would probably be much more expensive than the whole maintenance of the factory and its fuel supply.

The total value of carbon black made in a year would somewhat exceed $1,000,000, and the total annual value of the world's output of lampblack would probably be two or three times as much; but the real importance of these two commodities to humanity is inadequately represented by these figures.

They form the basis of the black printing inks, with which all our printing is done, and they are also largely used in black paints, for stove polish, and for coloring rubber, oilcloth, leather, and many other substances too numerous to mention,

It is rather a curious fact that the use of carbon black and of lampblack are separately defined, and quite sharply defined at that; so that the market price of each commodity fluctuates with little reference to the market price of the other.

Carbon black is much better for black ink, stove polish, and vulcanized rubber. Lampblack is much better for coloring oilcloth, leather, and other forms of rubber, and is much more widely used in paint, although carbon black is better for certain kinds of paint and varnish.

If a buyer is using a black made by the smudge process or by the heating or explosion of hydrocarbon vapors, he does not wish to change and to take the black made on the contact process; and if a buyer is using a black made on the contact process, he can not safely switch over to a black made on the smudge or the explosion process.

The gradual diminution of the margin between the cost of making black and the average selling price goes on, and there seems to be no reason why it should not continue through the present decade. There seems no likelihood, either, of any shortage of carbon black, except from some temporary cause, or of any great and permanent enhancement in the price during the life of any one now living.

CITIES AND TOWNS SUPPLIED WITH NATURAL GAS.

The following list contains the names of cities and towns in the United States which were either wholly or in part supplied with natural gas in the year 1913:

ALABAMA.

Fayette.	Jasper.	West Huntsville.

ARKANSAS.

Argenta.	Emmet.	Huntington.	Pulaski Heights.
Arkadelphia.	Fort Smith.	Little Rock.	Ravana.
Bauxite.	Garland.	Mabelvale.	Sheridan.
Benton.	Gifford.	Malvern.	Texarkana.
Bierne.	Gum Springs.	Mansfield.	Van Buren.
Boughton.	Gurdon.	Perla.	
Bryant.	Hope.	Pine Bluff.	
Donaldson.	Hot Springs.	Prescott.	

CALIFORNIA.

Alhambra.	Burbank.	Fairfield.	Huntington Park.
Athens.	Cement.	Fellows.	Longbeach.
Arroyo Grande.	Compton.	Gardena.	Los Angeles.
Bakersfield.	Cudahy.	Glendale.	Los Berros.
Betteravia.	Eagle Rock.	Guadaloupe.	Lynwood.

CALIFORNIA—continued.

Maricopa.
Moneta.
Nipomo.
Orcutt.
Oxnard.
Pasadena.
Redondo Beach.
Sacramento.
San Fernando.
San Gabriel.
Santa Maria.
Santa Monica.
Santa Paula.
Sawtelle.
South Pasadena.
South Taft.
Stockton.
Suisun City.
Taft.
Torrance.
Tropico.
Venice.
Ventura.
Vernon.

COLORADO.

Boulder.

ILLINOIS.

Annapolis.
Birds.
Bridgeport.
Carlinville.
Casey.
Duncanville.
East Chicago.
Eaton.
Flat Rock.
Greenville.
Heyworth.
Hutsonville.
Lawrenceville.
Marshall.
Martinsville.
New Hebron.
Oblong.
Olney.
Palestine.
Pinkstaff.
Porterville.
Robinson.
Stoy.
Sumner.

INDIANA.

Adams.
Albany.
Alexandria.
Anderson.
Arcadia.
Atlanta.
Batesville.
Cambridge.
Carmel.
Carthage.
Charlottesville.
Chesterfield.
Cicero.
Clarksburg.
Connersville.
Converse.
Cowan.
Daleville.
Downeyville.
Dublin.
Dunkirk.
Dunreith.
Eaton.
Elwood.
Falmouth.
Farmland.
Fortville.
Fountaintown.
Frankton.
Freeport.
Geneva.
Gentryville.
Germantown.
Gowdy.
Greenfield.
Greensburg.
Gwynneville.
Hagerstown.
Hartford City.
Herbst.
Homer.
Honey Creek.
Hope.
Hortonville.
Kennard.
Knightstown.
Kokomo.
La Fontaine.
Letts.
Lewisville.
Loogootee.
McCordsville.
Manilla.
Marion.
Markleville.
Maxwell.
Mays.
Middletown.
Mier.
Milford.
Millgrove.
Millhousen.
Milroy.
Milton.
Modoc.
Mohawk.
Montpelier.
Morristown.
Mount Auburn.
Mount Summit.
Muncie.
Newcastle.
New Lisbon.
New Point.
Noblesville.
Oaklandon.
Oakland City.
Oakville.
Ovid.
Pendleton.
Pennville.
Portland.
Powers.
Princeton.
Raleigh.
Raysville.
Redkey.
Richmond.
Ridgeville.
Rushville.
St. Paul.
Sandusky.
Sardinia.
Sharpsville.
Shelbyville.
Sheridan.
Shirley.
Spiceland.
Springport.
Straughn.
Sullivan.
Sweetsers.
Tipton.
Union City.
Vincennes.
Waldron.
Warrington.
West Liberty.
Westport.
Williamstown.
Winchester.
Windfall.
Winslow.

KANSAS.

Altamont.
Altoona.
Arkansas City.
Atchison.
Augusta.
Baldwin City.
Bartlett.
Bassett.
Baxter Springs.
Benedict.
Bonner Springs.
Bronson.
Buffalo.
Burlington.
Caney.
Carlyle.
Chanute.
Chautauqua Springs.
Cherokee.
Cherryvale.
Chetopa.
Coffeyville.
Colony.
Columbus.
Cottonwood Falls.
Coyville.
Deerfield.
Earleton.
Edgerton.
Edna.
Edwardsville.
Eldorado.
Elk City.
Elk Falls.
Elmdale.
Elsmore.
Empire City.
Emporia.
Erie.
Eudora.
Eureka.
Fairhaven.
Fall River.
Fort Scott.
Fredonia.
Galena.
Gardner.

KANSAS—continued.

Garnett.
Gas.
Greeley.
Havana.
Hepler.
Howard.
Humboldt.
Hutchinson.
Independence.
Iola.
Jefferson.
Kansas City.
La Harpe.
Lawrence.
Leavenworth.
Lenexa.
Liberty.
Merriam.
Moline.
Moran.
Mound City.
Mound Valley.
Neodesha.
New Albany.
Newton.
Niotaze.
North Altoona.
Olathe.
Osawatomie.
Oswego.
Ottawa.
Paola.
Parsons.
Peru.
Pittsburg.
Pleasanton.
Princeton.
Rantoul.
Richmond.
Roper.
Rose.
Savonburg.
Scammon.
Scipio.
Sedan.
Shawnee.
Spring Hill.
Stanley.
Strong.
Sycamore.
Tonganoxie.
Topeka.
Turner.
Tyro.
Vilas.
Weir.
Welda.
Wellington.
Wellsville.
Wichita.
Winfield.
Yates Center.

KENTUCKY.

Bshland.
Barbourville.
Bellevue.
Buchanan.
Burning Springs.
Caney.
Cannel City.
Catlettsburg.
Central City.
Clifton.
Cloverport.
Cold Spring.
Covington.
Dayton.
Diamond.
Dunmor.
Greenup.
Hazel Green.
Inez.
Kenner.
Kavanaugh.
Lewisburg.
Lexington.
Louisa.
Louisville.
Ludlow.
Maysville.
Mount Sterling.
Newport.
Paintsville.
Paris.
Pollard.
Rothwell.
Russell.
Russellville.
Salyersville.
Warfield.
West Covington.
West Liberty.
West Point.
Winchester.

LOUISIANA.

Belcher.
Blanchard.
Dixie.
Hosston.
Ida.
Lewis.
Mansfield.
Mooringsport.
Mystic.
Oil City.
Rodessa.
Shreveport.
Vivian.

MARYLAND.

Corinth.
Cumberland.
Deer Park.
Frostburg.
Loch Lynn.
Lonaconing.
Luke.
Mountain Lake Park.
Oakland.
Western Port.

MISSOURI.

Belton.
Carl Junction.
Carterville.
Carthage.
Joplin.
Kansas City.
Martin City.
Nevada.
Oronogo.
Rich Hill.
St. Joseph.
Webb City.
Weston.

NEW YORK.

Addison.
Akron.
Alden.
Alexander.
Alfred.
Alfred Station.
Allentown.
Almond.
Ambush.
Amherst.
Andover.
Angelica.
Angola.
Armor.
Attica.
Baldwinsville.
Batavia.
Belfast.
Belmont.
Blasdell.
Bolivar.
Bowmansville.
Brant.
Bristol.
Bristol Center.
Brocton.
Buffalo.
Caledonia.
Canisteo.
Cattaraugus.
Ceres.
Chipmonk.
Churchville.
Clarence.
Clarence Center.
Collins.
Collins Center.
Corfu.
Corning.
Crittenden.
Cuba.
Deer Creek.
Depew.
Dunkirk.

NEW YORK—continued.

East Aurora.
East Bloomfield.
East Hamburg.
East Pembroke.
Ebenezer.
Eden.
Elma.
Elmira.
Evans.
Farnham.
Forestville.
Fredonia.
Friendship.
Gangloff.
Gardenville.
Genesee.
Getzville.
Gorham.
Gowanda.
Greenwood.
Hamburg.
Hanover.
Holcomb.
Holland.
Honeoye Falls.
Hornell.
Independence.
Irving.
Jamestown.
Jewettville.
Lacona.
Lackawanna.
Lancaster.
Le Roy.
Lima.
Limestone.
Millgrove.
Montour Falls.
Mumford.
Naples.
North Collins.
North Tonawanda.
Obi.
Olean.
Orchard Park.
Pavilion.
Perry.
Petrolia.
Phoenix.
Pomfret.
Portland.
Portville.
Pulaski.
Reserve.
Rexville.
Richburg.
Ripley.
Rushville.
Salamanca.
Sandy Creek.
Scio.
Sheridan.
Silver Creek.
Southport.
Springville.
Stanards.
Tonawanda.
Town Line.
Versailles.
Warsaw.
Watkins.
Webb Mills.
Wellsville.
West Bloomfield.
West Clarksville.
Westfield.
West Phoenix.
West Seneca.
Wheatland.
Williamsville.
Wyoming.
Zoar.

NORTH DAKOTA.

Lansford.

OHIO.

Academia.
Ada.
Adelphi.
Akron.
Alexandria.
Alger.
Alliance.
Amanda.
Amboy.
Amesville.
Amherst.
Amsterdam.
Andover.
Antioch.
Appleton.
Arcanum.
Arlington.
Ashland.
Ashtabula.
Ashville.
Athens.
Austinburg.
Avery.
Bairdstown.
Baltimore.
Bangs.
Barberton.
Barlow.
Barnesville.
Bartlett.
Basil.
Batesville.
Beach City.
Beallsville.
Beem City.
Bellaire.
Belle Valley.
Belleville.
Bellevue.
Belmont.
Beloit.
Belpre.
Berea.
Bergholz.
Berlin Heights.
Bethany.
Bethesda.
Bettsville.
Beverly.
Bexley.
Birmingham.
Bladensburg.
Bloomdale.
Bloomingburg.
Bowerston.
Bowling Green.
Bratenahl.
Bremen.
Bridgeport.
Brilliant.
Brink Haven.
Buckeye City.
Buckeye Lake.
Buchtel.
Buckingham.
Bucyrus.
Buffalo.
Bullett Park.
Burbank.
Burgoon.
Butler.
Byesville.
Cadiz.
Caldwell.
Cambridge.
Canal Dover.
Canal Winchester.
Canfield.
Canton.
Cardington.
Carey.
Carroll.
Carrollton.
Cedarville.
Celina.
Centerburg.
Chatham.
Chauncey.
Chesterhill.
Chicago.
Chillicothe.
Chippewa Lake.
Cincinnati.
Circleville.
Clarington.
Claysville.
Clearport.
Cleveland.
Cleveland Heights.
Clintonville.
Clyde.
Coal Grove.
Coal Run.
Coalton.
Cochransville.
Coldwater.
Columbiana.
Columbus.
Conneaut.
Corning.
Coshocton.
Covington.
Crestline.
Creston.
Cridersville.
Crooksville.
Croton.
Cuyahoga Falls.
Cygnet.
Dakes.
Danville.
Dayton.
Deavertown.
Delaware.
Dennison.
Derwent.
Dexter City.
Doylestown.
Drakes.
Dresden.
Dudley.
East Cleveland.
East Fultonham.
East Liverpool.
East Palestine.
Eaton.
Edison.
Elba.
Elmore.
Elyria.
Empire.
Enterprise.
Euclid.
Euphemia.
Findlay.
Florence.
Flushing.
Fly.
Forest.
Fort Recovery.
Fostoria.
Franklin.

OHIO—continued.

Frazeysburg.
Fredericktown.
Fremont.
French Creek (Avon).
Fulda.
Fultonham.
Gahanna.
Galena.
Galion.
Gallipolis.
Gambier.
Geneva.
Genoa.
Germantown.
Gibsonburg.
Girard.
Glenroy.
Glouster.
Gore.
Grandview.
Granville.
Graysville.
Greenville.
Grogan.
Groveport.
Guysville.
Hallsville.
Hamden.
Hamilton.
Hanging Rock.
Hannibal.
Hanover.
Hanoverton.
Harlem Springs.
Harpster.
Harriettsville.
Hayesville.
Hebron.
Hemlock.
Homer.
Homeworth.
Hooker.
Hopedale.
Horns Mills.
Howard.
Hubbard.
Huntsville.
Ironton.
Jackson.
Jackson Center.
Jacksontown.
Jacksonville.
Jefferson.
Jeromesville.
Jerusalem.
Jewett.
Johnstown.
Jolly.
Junction City.
Kansas.
Kent.
Kenton.
Kilgore.
Kilbuck.
Kingston.
Kingsville.
Kirkersville.
Lakeside.
Lakewood.
Lancaster.
Laurelville.
Leesville.
Leetonia.
Leonard.
Leroy.
Lewisburg.
Lewisville.
Lexington.
Lima.
Linden.
Lisbon.
Litchfield.
Lockville.
Lodi.
Logan.
London.
Lorain.
Loudonville.
Lowell.
Lowellville.
Lower Salem.
McArthur.
McConnellsville.
Macksburg.
Malaga.
Malta.
Mansfield.
Maria Stein.
Marietta.
Marion.
Martinsburg.
Martins Ferry.
Massillon.
Maumee.
Medina.
Mendon.
Miamisburg.
Middleport.
Middletown.
Milan.
Millersburg.
Millersport.
Millers Run.
Millwood.
Milo.
Miltonsburg.
Mineral City.
Mingo.
Minster.
Monroe.
Monroeville.
Montezuma.
Morral.
Morristown.
Mount Gilead.
Mount Liberty.
Mount Sterling.
Mount Vernon.
Mount Victory.
Moxahala.
Murray.
Nashport.
Negley.
Nelsonville.
Neptune.
Nevada.
New Albany.
New Alexandria.
Newark.
New Athens.
New Berlin.
New Boston.
New Bremen.
Newburgh.
New Carlisle.
New Castle.
Newcomerstown.
New Hagerstown.
New Knoxville.
New Lexington.
New Matamoras.
New Middletown.
New Philadelphia.
Newport.
New Riegel.
New Springfield.
New Straitsville.
Niles.
North Amherst.
North Baltimore.
North Georgetown.
North Hampton.
North Kingsville.
North Lima.
Norwalk.
Nottingham.
Oakharbor.
Oberlin.
Orrville.
Osgood.
Outville.
Ozark.
Pataskala.
Pennsville.
Perrysburg.
Perrysville.
Petersburg.
Pickerington.
Piqua.
Pleasant City.
Pleasantville.
Plymouth.
Point Pleasant.
Poland.
Polk.
Pomeroy.
Portage.
Portsmouth.
Quaker City.
Ravenna.
Rendville.
Reno.
Rex Mills.
Reynoldsburg.
Richmond.
Rockbridge.
Rock Creek.
Rockyridge.
Roseville.
Roxbury.
Rural.
Rushville.
St. Clairsville.
St. Henry.
St. Louisville.
St. Marys.
Salem.
Salineville.
Sandusky.
Sarahsville.
Sardis.
Scio.
Sciotoville.
Sebring.
Senecaville.
Seville.
Shadyside.
Sharon.
Shawnee.
Shelby.
Shepard.
Sherodsville.
Shreve.
Sidney.
Simons.
Somerset.
Somerton.
South Charleston.
South Olive.
South Zanesville.
Spencer.
Spencerville.
Springfield.
Stafford.
Sterling.
Steubenville.
Stewart.
Stockport.
Stoutsville.
Strasburg.
Struthers.
Sugar Creek.
Sugar Grove.
Summerfield.
Sunbury.
Sycamore.
Tarlton.
Texas.
Thornville.
Thurston.
Tiffin.
Tippecanoe City.
Tiro.
Toledo.
Toronto.
Tremont City.
Trimble.
Trinway.
Troy.

OHIO—continued.

Uhrichsville.
Upper Sandusky.
Urbana.
Utica.
Vanburen.
Vincent.
Wadsworth.
Wapakoneta.
Warner.
Warren.
Warsaw.
Washington Court House.
Washingtonville.
Waterford.
Watertown.
Waterville.
Wellington.
Wellston.
Wellsville.
West Alexander.
West Bedford.
West Carrollton.
Westerville.
West Jefferson.
West Lafayette.
West Manchester.
West Millgrove.
West Rushville.
West Salem.
Wheelersburg.
Whipple.
Wilberforce.
Williamsport.
Woodsfield.
Wooster.
Worthington.
Youngstown.
Xenia.
Zanesville.
Zenz City.

OKLAHOMA.

Arcadia.
Ardmore.
Avant.
Bartlesville.
Beggs.
Bigheart.
Bixby.
Blackwell.
Bluejacket.
Boynton.
Braman.
Bristow.
Broken Arrow.
Cameron.
Chandler.
Chelsea.
Choteau.
Claremore.
Cleveland.
Coalton.
Collinsville.
Copan.
Coweta.
Cross.
Cushing.
Davenport.
Dawson.
Delaware.
Depew.
Dewar.
Dewey.
Drumright.
Duncan.
Dustin.
Edmond.
Eufaula.
Gotebo.
Guthrie.
Hallett.
Haskell.
Hattonville.
Henryetta.
Inola.
Jenks.
Jennings.
Kellyville.
Kiefer.
Kildare.
Lawton.
Lenapah.
Luther.
Marlow.
Meeker.
Miami.
Midlothian.
Morris.
Mounds.
Muskogee.
Newkirk.
Nowata.
Ochelata.
Oglesby.
Okewah.
Oklahoma.
Okmulgee.
Oologah.
Osage.
Owasso.
Pawhuska.
Ponca.
Porter.
Poteau.
Pryor.
Ramona.
Red Fork.
Sand Springs.
Sapulpa.
Shawnee.
Skiatook.
South Coffeyville.
Stroud.
Terlton.
Tonkawa.
Tulsa.
Turley.
Vinita.
Wagoner.
Wainwright.
Wann.
Welch.
Wellston.

PENNSYLVANIA.

Aliquippa.
Altoona.
Alverton.
Ambridge.
Apollo.
Argentine.
Arnold.
Austin.
Avalon.
Avonmore.
Baden.
Barnes.
Beallsville.
Beaver.
Beaver Falls.
Belle Vernon.
Bellevue.
Bingham.
Blackstown.
Blairs Corners.
Blairsville.
Bloomster.
Bluff.
Bolivar.
Bowerton.
Boyers.
Bradford.
Bradys Bend.
Branchton.
Brockport.
Brockwayville.
Brookville.
Brownsville.
Bruceton.
Bruin.
Bryant.
Buena Vista.
Buffalo.
Bullion.
Bully Hill.
Burgettstown.
Butler.
Cabot.
California.
Callensburg.
Callery.
Campbelltown.
Candor.
Canonsburg.
Carnegie.
Carnot.
Carrick.
Carrolltown.
Castle Shannon.
Cecil.
Centerville.
Ceres.
Charleroi.
Chicora.
Clairton.
Clarendon.
Clarendon Boro.
Clarington.
Clarion.
Claysville.
Clermont.
Clintonville.
Cochranton.
Colegrove.
Coleville.
Colona.
Connellsville.
Conoquenessing.
Conway.
Cooksbur.
Cooperstown.
Coraopolis.
Corry.
Corsica.
Coryville.
Coudersport.
Courtney.
Craigsville.
Cresson.
Crosby.
Curllsville.
Darlington.
Davistown.
Dawson.
Dayton.
Derrick City.
Derry.
Donora.
Dubois.
Duke Center.
Dunbar.
Dunkard.
East Brady.
East Hickory.
Easton.

PENNSYLVANIA—continued.

East Sharon.
East Springfield.
Edgeworth.
Edinburg.
Eidenau.
Elbon.
Eldersville.
Eldred.
Elizabeth.
Elkland.
Ellwood City.
Emlenton.
Emporium.
Emsworth.
Endeavor.
Enon Valley.
Enterprise.
Erie.
Evans City.
Fairmount City
Fairview.
Falls Creek.
Farrell.
Fayette City.
Finleyville.
Florence.
Ford City.
Fosters Mills.
Foxburg.
Franklin.
Fredonia.
Freedom.
Freeport.
Frogtown.
Fryburg.
Galeton.
Garland.
Gastonville.
Genesee.
Geneva Hill.
Gibsonton.
Gill Hall.
Gilmore.
Ginger Hill.
Girard.
Glade Run.
Glassport.
Glendale.
Glenfield.
Glenhazel.
Glen Osborne.
Glenwillard.
Grand Valley.
Grapeville.
Great Belt.
Greenfield.
Greensburg.
Greenville.
Grove City.
Guitonville.
Hackett.
Hadley.
Halsey.
Harmony.
Harpers Corners.
Harrisville.
Hawthorn.
Haysville.
Hazel Hurst.
Heidelburg.
Herman.
Hickory.
Highland.
Hilliards.
Hillsville.
Holbrook.
Homer.
Homer City.
Hooker.
Hopwood.
Houston.
Hydetown.
Imperial.
Indiana.
Industry.
Ingomar.
Instanter.
Irvineton.
Irwin.
James City.
Jamestown.
Jeannette.
Jefferson.
Johnetta.
Johnsonburg.
Johnstown.
Jollytown.
Kane.
Kane Boro.
Kane City.
Karns City.
Kaylor.
Keisters.
Kellettsville.
Khedive.
Kinzua.
Kittanning.
Knoxville.
Kushequa.
Lamont.
Langloth.
Larabee.
Latrobe.
Leechburg.
Leeper.
Leesburg.
Leetsdale.
Lickingville.
Ligonier.
Limestone.
Lucinda.
McClellandtown.
McDonald.
McKees Rocks.
McKinley.
Manor.
Manorville.
Marble.
Marianna.
Marienville.
Mars.
Marvindale.
Marwood.
Masontown.
Mayburg.
Meadow Lands.
Meadville.
Mercer.
Middle Fork.
Midland.
Millers Eddy.
Millport.
Monaca.
Monessen.
Monongahela.
Monterey.
Mount Alton.
Mount Jewett.
Mount Morris.
Mount Oliver.
Mount Pleasant.
Myonia.
Natrona.
Nedskey.
New Bethlehem.
New Brighton.
New Castle.
New Florence.
New Galilee.
New Kensington.
New Mayville.
New Salem.
New Sheffield.
New Stanton.
Newton.
Newtown Mills.
New Wilmington.
Noblestown.
North Blackville.
North East.
North Girard.
Norwich.
Oakdale.
Oakland.
Oak Ridge.
Oil City.
Ormsby.
Osgood.
Oswayo.
Otto.
Parkers Landing.
Petersville.
Petroleum Center.
Petrolia.
Philipston.
Pittsburgh.
Pittsfield.
Pleasantville.
Plummer.
Point Marion.
Polk.
Pollock.
Port Allegany.
Porter.
Portersville.
Poseytown.
Primrose.
Prospect.
Punxsutawney.
Queen.
Queenstown.
Ratigan.
Redman.
Red Rock.
Reidsburg.
Renfrew.
Reno.
Reynoldsville.
Ridgway.
Rimer.
Rimersburg.
Rixford.
Rochester.
Rockland.
Rogersville.
Rolfe.
Roscoe.
Roseville.
Roulette.
Rouseville.
Rural Valley.
Rynd Farm.
St. Marys.
St. Petersburg.
Salina.
Salem.
Saltsburg.
Sandy Lake.
Saxonburg.
Scottdale.
Semples.
Seneca.
Sewickley.
Sharon.
Sharon Center.
Sharpsville.
Shawmut.
Sheffield.
Shinglehouse.
Shinglehouse Boro.
Sligo.
Slippery Rock.
Smethport.
Smiths Ferry.
Snowden.
South Brownsville.
South Heights.
South Sharon.
Spring Church.
Stoneboro.
Straight.
Strattonville.
Sturgeon.
Sugar Creek.
Summerville.
Tarentum.
Tarrs.
Taylorstown.
Tidal.
Tidioute.

PENNSYLVANIA—continued.

Tiona.
Tionesta.
Titusville.
Townville.
Troutman.
Turtle Creek.
Tylersburg.
Uniontown.
Upper Middletown.
Utica.
Vanderbilt.
Vandergrift.
Vanport.
Venetia
Venus.
Vides.
Volant.
Walkers Mills.
Waltersburg.
Warren.
Warren Boro.
Washington.
Waters.
Waynesburg.
West Alexander.
West Elizabeth.
Westfield.
West Freedom.
West Hickory.
Westline.
West Middlesex.
West Middletown.
West Monongahela.
West Monterey.
West Newton.
West Sunbury.
West Winfield.
Wetmore.
Wheatland.
Whiskerville.
Whitetown.
Wick.
Widnoon.
Wilcox.
Wilkinsburg.
Wilson.
Wireton.
Woodlawn.
Worthington.
Youngsville.
Youngwood.
Zelienople.

SOUTH DAKOTA.

Fort Pierre.
Pierre.

TEXAS.

Albany.
Alvord.
Arlington.
Atlanta.
Bangs.
Bellevue.
Bloomburg.
Bowie.
Bridgeport.
Byers.
Cass.
Corsicana.
Crowther.
Dallas.
Dalworth.
Decatur.
Denison.
Denton.
Eagle Ford.
Fort Worth.
Gainesville.
Grand Prairie.
Henrietta.
Irving.
Laredo.
Leigh.
Marshall.
Mexia.
Moran.
Petrolia.
Queen City.
Rhome.
Sherman.
Sunset.
Teague.
Texarkana.
Whitesboro.
Wichita Falls.

WEST VIRGINIA.

Adamston.
Alma.
Arvilla.
Barboursville.
Barrackville.
Belington.
Belmont.
Bens Run.
Benwood.
Benson.
Beraman.
Big Isaac.
Big Springs.
Blacksville.
Blue Creek.
Blueville.
Boothsville.
Branchland.
Bridgeport.
Briscoe.
Bristol.
Broad Oaks.
Brookville.
Buckhannon.
Buffalo.
Burdett.
Burning Springs.
Burnsville.
Burton.
Cairo.
Cameron.
Cannelton.
Cedargrove.
Center Point.
Centerville.
Ceredo.
Charleston.
Chelyan.
Chester.
Clarington.
Clarksburg.
Clendenin.
Coalburg.
Colfax.
Colliers.
Corinth.
Crawford.
Creston.
Crown Hill.
Culloden.
Danville.
Davis.
Daybrook.
Deanville.
Dunbar.
Eastbank.
Edgewood.
Elizabeth.
Elkins.
Ellenboro.
Elm Grove.
Elm Run.
Enterprise.
Erie.
Eureka.
Fairmont.
Fairview.
Farmington.
Farnum.
Finch.
Flat Woods.
Flemington.
Follansbee.
Fort Gay.
Friendly.
Fulton.
Gandeeville.
Gassaway.
Gay.
Glen Dale.
Glen Easton.
Glenova.
Glenville.
Glovergap.
Goose Greek.
Grafton.
Grantsville.
Griffithsville.
Hamlin.
Handley.
Hannahdale.
Hansford.
Harrisville.
Haymond Heights.
Haywood.
Heaters.
Hepzibah.
Hundred.
Huntington.
Hurricane.
Hutchinson.
Jacksonburg.
Jacksonville.
Janelew.
Jarvisville.
Kenova.
Kermit.
Keyser.
Kygar.
Lima.
Littleton.
Logan.
Longacre.
Lost Creek.
Loudenville.
Loveland.
Lumberport.
McMechen.
Madison.
Mahone.
Mannington.
Meadowbrook.
Metz.
Middlebourne.
Miletus.
Milton.
Monongah.
Montgomery.
Monticello Add.
Morgantown.
Moundsville.
Mount Clare.

WEST VIRGINIA—continued.

Mount Zion.
Murphytown.
Myra.
New Cumberland.
New Martinsville.
Ogdin.
Ona.
Paden City.
Palestine.
Parkersburg.
Parsons.
Patterson.
Pennsboro.
Peoria.
Petroleum.
Philippi.
Piedmont.
Pine Grove.
Pleasant Valley.
Poca.
Point Pleasant.
Pratt.
Proctor.
Pruntytown.
Pullman.
Ravenswood.
Reedy.
Ripley.
Rockford.
Rowlesburg.
St. Albans.
St. Marys.
Salem.
Sandyville.
Schultz.
Sedalia.
Seth.
Sherrard.
Shiloh.
Shinnston.
Shirley.
Shrewsbury.
Silverton.
Simpson.
Sistersville.
Smithburg.
Smithers.
Smithfield.
Smithville.
South Buckhannon.
Spencer.
Spring Hill.
Star City.
Sutton.
Tanner.
Terra Alta.
Thornton.
Tyler City.
Wallace.
Walton.
Ward.
Warwood.
Waverly.
Wayne.
Wellsburg.
West Fork.
Weston.
West Union.
Wheeling.
Wileyville.
Williamson.
Williamstown.
Wilsonburg.
Woodlawn.
Woodsdale.
Woodville.
Worthington.
Wyatt.

WYOMING.

Basin.
Byron.
Greybull.

THE SOURCE, MANUFACTURE, AND USE OF LIME.

By Ernest F. Burchard and Warren E. Emley.

INTRODUCTION.

In June, 1909, the United States Geological Survey, in cooperation with the National Lime Manufacturers' Association, began a study of lime. Both field and laboratory work were undertaken. In the field the conditions prevailing as to quarrying, handling, crushing, burning, and hydrating were studied, and samples of limestone, burned lime, and hydrated lime were collected from a wide territory embracing nearly all the States east of Missouri River and from quarries in various types of rock, grading from high-calcium to high-magnesium limestone. In collecting the samples the geologic formations in which the quarry was situated were noted, as well as the dip and strike of beds and the lithologic and structural features that might have a bearing on the quarrying and utilization of the stone. In the laboratory, which was situated at Pittsburgh, Pa., the work included chemical analyses and physical tests of the limestone and chemical and physical tests of quicklime and hydrated lime. The principal aim of the investigation is to show the effect of impurities contained in various limes, the effect of low and high temperatures on the quality of the lime burned, the different degrees of plasticity displayed by different limes, the strength of the lime mortars, and to determine, if possible, the best conditions for hydration. The work was carried on for about one year under the United States Geological Survey, but on July 1, 1910, the structural-materials laboratories at Pittsburgh were transferred to the United States Bureau of Standards, under which organization the work has been continued. During the early stages of the investigation the authors were associated in the field work; the laboratory work has been performed by W. E. Emley, of the Bureau of Standards. Some results have already been published by the Bureau of Standards and by the National Lime Manufacturers' Association, as indicated in the following list:

Ashley, H. E., The spreading and setting qualities of lime mortars: Nat. Lime Mfrs. Assoc. Trans., pp. 43–47, 1910.

Bleininger, A. V., and Emley, W. E., The burning temperature of limestones: Am. Ceramic Soc. Trans., vol. 13, pp. 618–638, 1911. Also in Nat. Lime Mfrs. Assoc. Trans., pp. 68–78, 1911.

Bleininger, A. V., The physical properties of lime: Nat. Lime Mfrs. Assoc. Trans., pp. 365–369, 1909.

Emley, W. E., Kiln design: Nat. Lime Mfrs. Assoc. Trans., pp. 90–107, 1910.

——— Some investigations on lime: Nat. Lime Mfrs. Assoc. Trans., pp. 48–50, 1910.

——— Tests of lime: Nat. Lime Mfrs. Assoc. Trans., pp. 192–199, 1911.

——— Lime: Its properties and uses: Bur. of Standards Circ. 30, 22 pp., 1911.

——— Manufacture of lime: Bur. of Standards Tech. Paper 16, 130 pp., 1913.

Wig, R. J., The use of hydrated lime in Portland cement mixtures: Nat. Lime Mfrs. Assoc. Trans., pp. 213–220, 1911.

The publication of the present joint paper by the United States Geological Survey is in response to a continuous demand from correspondents for correlated information concerning limestone and lime. It has been the endeavor of the authors to furnish briefly the essential data needed by the prospective lime manufacturer as well as by the active manufacturer who desires a combined summary of the raw materials and of the recent developments in the lime industry. The data have been presented in as simple and nontechnical a manner as is consistent with clearness, and many definitions have been introduced in order to facilitate comprehension by the busy reader. In the chapters on the manufacture and use of lime the conclusions resulting from recent investigations have been stated without discussing to any considerable extent the experimental evidence on which they are based.

The introduction to Circular No. 30 of the Bureau of Standards, on Lime: its properties and uses, is as follows:

> Lime has been used as a building material for centuries, but until recently very little exact information about its properties has been obtainable. It has always been such a cheap commodity that the transportation cost was of more importance to the consumer than the quality of the lime. Recently the chemical industries have opened a new market for lime in which quality is of paramount importance, and contractors and builders have learned that low cost and cheapness are by no means synonymous. Therefore it has now become necessary to study the properties of lime with a view to drawing up standard specifications so that manufacturer and consumer will be enabled to reach an exact understanding. Such a study must include the distribution of economically available deposits of limestone, the methods of manufacture, the methods of testing lime, and the properties which the lime must have in order to satisfy the various consumers. The first two of these subjects will be treated more in detail in articles by Mr. Burchard and Mr. Emley shortly to be published by the United States Geological Survey and the United States Bureau of Standards respectively.

The present paper endeavors to fulfill the proposed work mentioned in the last part of the quotation.

In the chapter on the source of lime the author has borne in mind the desirability of presenting the elements of geology as related to the lime industry, and has endeavored to outline this field briefly and in an elementary manner through a discussion of such topics as follow: classification, origin, varieties, gradations, and impurities of limestone; rock structure; ages of rocks; formations; value of fossils; table of rock systems; thickness of sedimentary rocks, and overburden. A few diagrams are inserted which illustrate points discussed. The general distribution of limestones and marbles in the United States westward as far as the Rocky Mountain States is outlined by States or groups of States, and is illustrated by a general map which shows the areas in which high-calcium limestones predominate and those in which magnesian limestones predominate. This map (Pl. VIII) is drawn to such a relatively small scale that it can not show very definite boundaries, and of course the areas which are indicated as underlain predominantly by limestone contain other rocks in places. Likewise there are many small areas of limestone that it has not been practicable to show on the map.

MAP SHOWING PRINCIPAL LIMESTONE AREAS IN THE UNITED STATES EAST OF THE ROCKY MOUNTAINS

Prepared under the direction of Ernest F. Burchard

1914

SOURCE OF LIME.

By Ernest F. Burchard.

For the sake of clearness and at the risk of repeating certain statements that may be made in the chapter on the manufacture of lime it is thought best at the outset to define lime and to indicate its chemical composition in order that its derivation may readily be understood.

Chemically pure lime is the oxide of calcium (CaO), and contains by weight 5 parts of calcium and 2 parts of oxygen. It is chemically rather active. Therefore it is not found native, but always in combination with other substances. The most common substance that combines with lime is the gas, carbon dioxide (CO_2), forming calcium carbonate, according to the following reaction: Lime (CaO) + carbon dioxide (CO_2) → calcium carbonate ($CaCO_3$). Conversely, if calcium carbonate in any of its forms is broken up by heat, there is obtained as a result lime and carbon dioxide, according to the following reaction: Calcium carbonate ($CaCO_3$) + heat → lime (CaO) + carbon dioxide (CO_2).

Substances containing calcium carbonate, or, as it is more commonly termed, lime carbonate, such as limestone, calcite, marble, and oyster shells, are therefore the most common commercial sources of lime.

The chemical activity of lime is of interest as illustrating the cycle of changes that the material undergoes. When exposed to the air lime absorbs water or moisture and forms calcium hydroxide. Calcium hydroxide in turn absorbs carbon dioxide from the air and forms calcium carbonate and water. Thus, lime if exposed to the air will in time revert to a substance having the same chemical composition as the one from which it was derived. The reactions are as follows:

Lime (CaO) + water (H_2O) →calcium hydroxide ($Ca(OH)_2$).

Calcium hydroxide ($Ca(OH)_2$) + carbon dioxide (CO_2) → calcium carbonate ($CaCO_3$) + water (H_2O).

These reactions take no account of impurities nor of other substances associated with calcium carbonate in limestone. Limestone masses rarely are wholly composed of calcium carbonate, therefore the lime derived from these rocks is rarely pure. Certain of the more common impurities are silica, alumina, and iron oxides, and one other substance, magnesium carbonate, which behaves similarly to calcium carbonate and is nearly everywhere present in widely varying proportions. (See "Varieties of limestone," p. 1515.)

The chemical activity of lime forms the basis for the manufacture of lime products and for the many uses of lime and its products in the industries. The more important of these processes and uses, as well as the methods of manufacture of lime, will be indicated by Mr. Emley in succeeding sections of this paper.

LIMESTONE.[1]

CLASSIFICATION.

Limestone belongs to the class known as sedimentary rock as distinguished from igneous and metamorphic rocks. The lime manu-

[1] For data on limestone see various modern textbooks on geology, and the following special works:
Clarke, F. W., The data of geochemistry: U. S. Geol. Survey Bull. 491, 1911.
Crosby, W. O., Common minerals and rocks, D. C. Heath & Co., 1906.
Dale, T. N., Commercial marbles of western Vermont: U. S. Geol. Survey Bull. 521, 1912.
Kemp, J. F., Handbook of rocks, D Van Nostrand Co., 5th ed., 1911.
Merrill, G. P., Stones for building and decoration, John Wiley & Sons, 1903.
Pirsson, L. V., Rocks and rock minerals, John Wiley & Sons, 1909.
Van Hise, C. R., A treatise on metamorphism: U. S. Geol. Survey Mon. 47, 1904.

facturer does not have to deal with igneous rocks at all; therefore they will not be considered here. True marble belongs to the class known as metamorphic rock. Sedimentary rocks are generally composed of the fragments or materials of older rocks of any class that have undergone disintegration on the surface of the land.

Metamorphic rocks are those sedimentary or igneous rocks which have, in the course of time, become greatly changed in composition and texture. The chief agents that bring about these changes are pressure, heat, and chemical reactions, generally at considerable depth below the surface of the earth. By metamorphic agencies limestone is transformed into marble. During the transformation the original bedding of the limestone may become nearly or completely obscured, and the crystalline texture and folded structure characteristic of marble are induced.

ORIGIN.

Sedimentary rocks have been deposited under water in seas and lakes, also on land surfaces, and in cavities and crevices in other rocks. The chief agent in the transportation of rock débris is water in motion, including rain water, streams, and the waves of the seas and lakes. Ice in motion in the form of glaciers and icebergs transports an important quantity of material, and the wind carries small quantities of very fine, light material. Where material is carried as solid particles, the deposits are said to be mechanical. Where the deposits are formed through the agency of organisms, they are called organic; such deposits include those formed by deposition from solution; if they are precipitated without the aid of organisms, they are called chemical deposits.

Calcium carbonate ($CaCO_3$), the principal compound in limestone, is slightly soluble in pure water, 1 liter of pure water solution at 8.7° C. containing 0.01 gram of the compound.[1] In water charged with carbon dioxide (CO_2), forming a solution of carbonic acid, calcium carbonate is more soluble, and forms calcium bicarbonate. These reactions are as follows:

$$\underset{\text{Water.}}{H_2O} + \underset{\text{Carbon dioxide.}}{CO_2} \rightarrow \underset{\text{Carbonic acid.}}{H_2CO_3}$$

$$\underset{\text{Carbonic acid.}}{H_2CO_3} + \underset{\text{Calcium carbonate.}}{CaCO_3} \rightarrow \underset{\text{Calcium bicarbonate.}}{CaH_2(CO_3)_2}$$

One liter of water saturated with carbon dioxide contains at 15° C. and zero partial pressure of carbon dioxide, 0.385 gram of calcium bicarbonate.[2] Under natural conditions, a less quantity is dissolved, but under pressure that exists at depths below the surface of the earth, water is believed to dissolve still greater quantities. Water sinking through the soil meets and dissolves carbon dioxide, which is constantly being given off from decaying vegetable matter. This acidulated water then takes up calcium carbonate from the soil and from the rocks through which it percolates. The water of streams is therefore constantly bringing a supply of dissolved calcium carbonate to

[1] Seidell, Atherton, Solubilities of inorganic and organic substances, p. 86. D. Van Nostrand Co., New York, 1907.
[2] Idem, p. 87.

the ocean. Evaporation tends to concentrate this material in sea water, and were it not for the fact that large quantities of calcium carbonate are constantly being removed by the agency of organic life, as stated below, the sea water would become overcharged with this salt. One thousand parts of sea water contain about 34.40 parts, by weight, of mineral matter in solution. The proportions of the principal solids are shown in the following table:

Percentages of mineral salts in 100 parts of total solids contained in sea water.[1]

Sodium chloride (NaCl)	77.758
Magnesium chloride (MgCl)	10.878
Magnesium sulphate ($MgSO_4$)	4.737
Calcium sulphate ($CaSO_4$)	3.600
Potassium sulphate (K_2SO_4)	2.465
Magnesium bromide (MgBr)	.217
Calcium carbonate ($CaCO_3$)	.345
	100.000

Gases are also present in sea water, including a relatively large quantity of carbon dioxide, and these tend to increase the solvent power of the water toward calcium carbonate. There is no sharp line of distinction between chemical and organic deposits. The latter are really chemical in the broader sense of the term, but as their precipitation is immediately dependent upon living organisms, they are termed organic. Subaqueous inorganic chemical deposits are probably mostly formed in shallow water, and include (1) those due to evaporation of the water, and (2) those due to chemical reactions between solutions resulting in the precipitation of new and insoluble compounds.

Chemical deposits formed in shallow water are chiefly simple precipitates resulting from evaporation. All substances in solution are necessarily precipitated upon complete evaporation of the solvent, but since sea water rarely is saturated with its important salts, only a few are precipitated in quantities sufficient to be of geological importance. Where evaporation is incomplete, the principal deposits that are of interest in this connection are calcium carbonate ($CaCO_3$) (limestone) and calcium sulphate ($CaSO_4.2H_2O$) (gypsum); sodium chloride (NaCl) (rock salt); and chlorides and sulphates of potassium and magnesium.

The deposits of calcium carbonate, including shells and coral, have been very much greater than those of gypsum, because marine plants and animals extract calcium carbonate and not calcium sulphate from the water for their skeletons and shells, although there is more than ten times as much calcium sulphate as calcium carbonate in sea water. Calcium sulphate is more soluble in natural water than calcium carbonate, but rivers carry much more carbonate than sulphate to the sea since calcium carbonate is much more abundant on the land.

The secretion of lime carbonate by organisms does not depend on the quantity contained in the water, but may be carried on when the quantity in solution is very small. The principal deposits of calcium carbonate which have ultimately formed limestone have been made through the agency of plants and animals in the form of shells,

[1] From Dittmar, William, Narrative of the cruise of H. M. S. *Challenger*, vol. 1, pt. 2, p. 954, 1885.

coral, bones, and teeth. Some of these deposits show more or less distinctly the fossil remains of the organisms which played so important a part in their formation, but others show no trace of their organic origin on account of the fineness to which the fragments were broken by the waves prior to their consolidation into rock masses. Although it is probable that the larger part of the calcium-carbonate deposits in the open sea are of organic origin, it is equally probable that in closed seas in which the conditions are favorable for concentration, precipitation may take place.

The purely chemical deposits of limestone are subject to solution, redeposition, and other changes, just as all other limestone deposits are. As a result, they often lose many of their original characteristics.

According to F. W. Clarke[1]—

It is evident that important limestones may be formed in various ways, which, however, are chemically the same. Calcium carbonate, withdrawn from fresh or salt water, is laid down under diverse conditions, yielding masses which resemble one another only in chemical composition. An oceanic ooze may produce a soft, flourlike substance, such as chalk, or a mixture of carbonate and sand, or one of carbonate and mud or clay. Calcium carbonate, transported as a silt, may solidify to a very smooth fine-grained rock, while shells and coral yield a coarse structure, full of angular fragments and visible organic remains. Buried under other sediments, any of these rocks may be still further modified, the fossils becoming more or less obliterated, until in the extreme case of metamorphism a crystalline limestone is formed. All trace of organic origin has then vanished, a change which both heat and pressure have combined to bring about, aided perhaps by the traces of moisture from which ew rocks are free.

Sedimentary rocks are usually made up of layers or beds, which can be easily separated. These layers are called strata, and rock deposits in such layers are said to be stratified. The surface of the earth over wide regions is in slow motion. It very slightly rises or sinks with reference to the sea, and in this way shore lines are changed. As a result of upward movement of the earth's crust, marine and lacustrine sedimentary rocks may become part of the land, and in fact the greater part of the land area is occupied by rocks such as sandstone, shale, and limestone, which were originally deposited as sediments in the seas and in fresh-water lakes.

CHARACTER.

Limestone includes many and widely varying types of rock, differing in origin, color, texture, hardness, structure, and composition. The character of some of these various types will be taken up in connection with their probable origin. The one property they have in common is that of consisting largely of the mineral calcite (calcium carbonate, $CaCO_3$) or of the mineral dolomite, a combination of calcium and magnesium carbonates ($CaCO_3.MgCO_3$). No natural limestones are chemically pure, however, and few are nearly so. All contain more or less foreign material, either chemically combined or as admixed minerals. The more common of these foreign substances are magnesium carbonate ($MgCO_3$), ferrous carbonate ($FeCO_3$), ferrous oxide (FeO), ferric oxide (Fe_2O_3), silica (SiO_2), alumina (Al_2O_3), clay, carbonaceous matter, mica, talc, and minerals of the pyroxene group. The colors and stains commonly noted in limestones are due to the presence of foreign minerals. The light-blue, buff, yellow, pink, red, and brown shades are largely due to iron com-

[1] Clarke, F. W., The data of geochemistry: U. S. Geol. Survey Bull. 491, p. 531, 1911.

pounds, and the grays and blacks are often due to the presence of carbonaceous matter derived from organic remains. Manganese oxides also act as coloring agents.

VARIETIES OF LIMESTONE.

An outline of the important varieties of limestone, based on texture is given below, but it must be borne in mind that a limestone may represent a mixture of several of the following varieties:

(1) Compact, dense, fine-grained limestone.
(2) Crystalline limestone (nonmetamorphosed).
(3) Crystalline limestone, or marble (metamorphosed).
(4) Oolitic and pisolitic limestone.
(5) Fossiliferous limestone.
(6) Shell limestone (fragmental, including coral limestone).
(7) Chalky limestone.
(8) Conglomeratic limestone.
(9) Cherty limestone.
(10) Fresh-water marl.
(11) Travertine, or calc sinter.
(12) Stalactitic and stalagmitic limestone and onyx marble.

Based on chemical composition, the following varieties may be distinguished:

(1) High-calcium limestone.
(2) Magnesian limestone.
(3) Dolomite.
(4) Argillaceous limestone.
(5) Arenaceous and siliceous limestone.

It should be emphasized that many of these varieties grade into one another, and that many limestones combine the characteristics of two or more varieties.

VARIETIES BASED ON TEXTURE.

Dense, fine-grained limestone.—The more compact, dense, fine-grained limestones are considered to have been deposited in quiet water, some distance from the shore, where only the fine-grained sediments would be carried by currents. However, it is possible that in many places this variety of limestone has been the result of chemical precipitation in shallow water. The lithographic limestone of Bavaria is dense and fine grained, and many of the beds in the so-called "Trenton" of the Mississippi basin are of this texture. Dense, fine-grained limestone where chemically of suitable composition is burned to lime in many places.

Nonmetamorphosed crystalline limestone.—The crystalline nonmetamorphosed limestones are of sedimentary origin. Their crystalline texture is probably due to recrystallization through the agency of water. These rocks are not true marbles, but are often so styled in a commercial sense, particularly if they will take a good polish. Well-known examples of crystalline nonmetamorphosed limestones occur in the vicinity of Knoxville, Tenn., Carthage, Mo., and Batesville, Ark. Lime is made from this variety of limestone at all these places.

Metamorphosed crystalline limestone (marble).—Marble is a term applied commercially, rather loosely, to a granular crystalline limestone or dolomite, and even to other rocks that are susceptible of polish and possess attractive colors. Scientifically, marble is a granular crystalline limestone or dolomite in which recrystallization has resulted from the effects of heat and pressure, usually aided by the action of water. True marbles are therefore found in regions that have been subjected to metamorphic action, and they are associated with other metamorphic rocks, such as gneiss, schist, quartzite, and slate, and are usually situated near areas of igneous rocks, such as granite and diorite. In pure limestone and dolomite little chemical change takes place during metamorphism to marble, but the rock mass becomes more completely crystalline. Deposits of marble occur in the form of lenticular masses, interbedded with other metamorphosed rocks, and also as metamorphosed zones along the contact of a limestone with an igneous rock. If the original limestone contains silica and other impurities, certain silicate minerals may be developed in the marble. The calcite crystals in a thin section of marble are generally irregular in size, shape, and arrangement, and many of these crystals are twinned.

Marble is burned to lime in New England and in many of the Appalachian States.

Oolitic limestone.—Granular limestone, composed of small, rounded, concretionary grains cemented together to form a solid rock, is known as oolitic limestones. The grains resemble the roe of a fish, and are named oolites, from the Greek word for "egg." The oolites are considered to have been formed by the deposition from solution of successive concentric coats of calcium carbonate about preexisting nuclei. These nuclei may be particles of sand composed of silica, or calcium carbonate, or of any other foreign matter, and it has even been suggested that minute gas bubbles may form a center of growth. If the concretionary grains are coarse and approach the size of a pea, the rock is termed pisolitic. Among the best-known examples of oolitic limestones are the stones quarried at Bedford, Ind., at Bowling Green, Ky., and at Darlington, Ala. A white oolitic limestone has recently been quarried near Bromide, Okla. Oolitic limestone sand is now forming on the south shore of Great Salt Lake, Utah, and is reported to be used as a flux by the copper smelters at Garfield.

Oolitic limestone generally makes a high quality of lime, and its use for this purpose is extensive in the localities where it occurs.

Fossiliferous limestone.—Fossiliferous limestones are so termed from the presence of noticeable quantities of remains of organisms. The texture of the fossiliferous rock may correspond with that of any of the water-laid, nonmetamorphosed varieties herein described, although the dense, fine-grained beds are likely to contain fewer recognizable fossils than some of the coarser varieties. The quantity of fossils present depends also on the period in which the beds were deposited. In the earlier sedimentary rocks, such as the Cambrian, fossils are much rarer than in those deposited later. The term "fossil" refers not only to perfect forms that have been embedded in the rock, such as the shells of sea animals, but to any fragment or form that has resulted from living organisms, whether animal or plant. The term "crinoidal" refers to a limestone that contains fragments of the stems of crinoids, or sea animals resembling lilies. Fossil impressions of recent leaves are also found in deposits of travertine.

The mode of formation of the common types of fossiliferous limestone is very simple. When the animals that have extracted calcium carbonate from the water and incorporated it in their hard parts die, their shells and other secretions collect on the bottom of the sea. These materials, either whole or fragmentary, become cemented together principally by calcium carbonate, and the mass eventually forms limestone. Where sufficiently pure, fossiliferous limestone is generally suitable for making lime, particularly if it is slightly porous.

Shell limestone.—Shell limestone is simply a form of fossiliferous limestone, in which the mass of the rock is made up almost wholly of shells, of shell fragments, and of shell sand, more or less compactly massed together. The coquina at St. Augustine, Fla., is an example of this sort of rock, and coral limestone is of a similar nature, except that it is made up of fragments of corals. This type of limestone, where not too siliceous, generally makes good lime.

Chalky limestone.—Chalky limestone, or "chalk," is soft, fine-grained, light colored, white limestone, composed largely of the minute calcareous shells of foraminifera. These shells are mostly of microscopic size. Fine crystals of calcite (pure calcium carbonate, $CaCO_3$) are also present in places. This rock probably originated in quiet seas, little effected by débris from the land. Deposits of chalk occur in the Southern and Great Plains States, such as Alabama, Mississippi, Louisiana, Texas, Kansas, Nebraska, the Dakotas, and Colorado. Some chalky limestones contain too much clayey impurities to make good lime, but the highly calcareous deposits are exploited by lime manufacturers in many places.

Conglomeratic limestone.—Conglomeratic limestone consists of fragments of broken limestone that have been rounded by wave action and cemented together by calcium carbonate into a mass of rock. Such rocks are comparatively rare, but beds of this nature have been observed in the Ozark region of northern Arkansas.

Cherty limestone.—Cherty limestones are those containing nodules and bands of chert or "flint." Chert is composed of silica (SiO_2), and the nodules or concretions have been segregated within the limestone, either from the immediately surrounding rock, or from without by the agency of water. The nodules are probably of secondary growth rather than original deposits. Unless the chert can be separated and removed from the limestone at very little expense, cherty limestone is generally not suitable for lime manufacture.

Marl.—Fresh-water marl is a fine-grained loose, earthy material containing a large proportion of calcium carbonate. It occurs in the basins of small fresh-water lakes and in marshes. The material has been brought to the lakes by spring or stream waters carrying calcium carbonate in solution, and has been extracted by the direct action of vegetable and animal organisms, or precipitated chemically. Bodies of fresh-water marl are common in the southern peninsula of Michigan, in northern Indiana, and in western New York. This type of rock, owing to its occurrence in a loose state and in water, is more suitable for the manufacture of Portland cement than of lime.

Travertine.—Travertine, or calc sinter, often called calcareous tufa, is a massive, porous to compact limestone, deposited by waters of springs or streams along their courses. It is found over the faces of limestone bluffs, also filling crevices in limestone, and around springs. Travertine deposits relatively are not extensive, and the material is little used for lime making, although there are instances of its use in connection with other limestone with which it is associated.

Stalactitic and stalagmitic limestone and onyx marble.—Stalactites are the pendant, icicle-shaped forms of calcium carbonate, deposited from dripping water in caverns in the earth. Stalagmites are the forms that rise from the floors of caves toward the stalactites above, and are formed by lime-bearing waters dripping upon the floors of caverns. The principle already mentioned, that the solvent power of water is increased by the presence of carbon dioxide, is involved in the formation of caves and their deposits. In passing through the fractures or joints of limestone strata, or in slowly percolating through the pores of the beds, water takes up lime carbonate in solution, thereby enlarging the open spaces and forming cavities in the rocks. When these lime-bearing waters reach an open cavity, the pressure sustained by the water becomes less, carbon dioxide is given up, and evaporation takes place to a certain extent. Both of these factors tend to precipitate the calcium carbonate carried by the water. The reaction involving the precipitation of the calcium carbonate is as follows:

$CaH_2(CO_3)_2$	$\rightarrow$	$CaCO_3$	+	CO_2	+	H_2O
Calcium bicarbonate (in solution).		Calcium carbonate.		Carbon dioxide.		Water.

Some of the calcium carbonate is therefore deposited on the roof of the cavern, and the drops that finally fall from the stalactite at the top deposit part of the remaining calcium carbonate and form the stalagmite on the floor below.

Onyx marble is a chemical deposit of calcium carbonate whose deposition depends on the same principle as that of stalactites and other cave deposits of calcium carbonate, but which is considered generally to have resulted from precipitation by deep-seated hot-spring waters. Merrill [1] considers it probable that such deposits took place on the bottom of shallow pools. Onyx marble is very finely crystalline, and is generally banded, in some places delicately, in others, brilliantly. In composition the material generally carries 90 to 96 per cent calcium carbonate, 2 to 7 per cent iron carbonate, and less than 1 per cent of manganese carbonate. The iron and manganese compounds on oxidation produce the bright bands and veins of color that are characteristic of onyx marble. Large deposits of this material are found in warm, arid countries, in the neighborhood of recent volcanic activity, such as in Arizona, southern California, and Lower California. This rock is generally of more value for ornamental purposes than for lime manufacture.

VARIETIES BASED ON COMPOSITION.

High-calcium limestone.—The distinguishing characteristic of this variety of limestone is its freedom from magnesium, as well as from ingredients regarded as impurities, such as silica, alumina, the oxides and sulphides of iron, alkalies, phosphates, and organic matter. High-calcium limestone carries from 93 to more than 99 per cent

[1] Merrill, G. P., Stones for building and decoration, 3d ed., p. 245, 1903.

of calcium carbonate, and may embrace all the physical varieties of limestone except the cherty rock. So far as composition is concerned, high-calcium limestone makes the purest and the most active lime.

Magnesian limestone.—Magnesian limestone is limestone containing magnesium carbonate in any quantity up to 45.65 per cent. The majority of magnesian limestones carry either a small percentage or a high percentage of magnesium carbonate, although there are here and there deposits that are intermediate in composition. Magnesian limestone may embrace several varieties, texturally, and if physically suitable may be burned to lime, which will be a mixture of calcium oxide (CaO) and magnesium oxide (MgO).

Dolomite.—Dolomite is a mineral composed of the double carbonate of calcium and magnesium ($CaCO_3.MgCO_3$). It contains 54.35 per cent $CaCO_3$ and 45.65 per cent $MgCO_3$.[1] In practice, magnesian limestone containing 20 per cent or more of magnesium carbonate has generally been called dolomite, but it would be preferable if magnesian limestone could be distinguished as "low magnesian" and "high magnesian," restricting the term dolomite to rock containing nearly, if not quite, the theoretical quantity of magnesium carbonate necessary to combine with the calcium carbonate in the proportions given above, or in the ratio of 1:1.19. The mineral dolomite in places forms rock masses, in which the crystals of dolomite can be distinguished. In some rocks these crystals make up a large proportion of the beds, and, on weathering, the rock crumbles to a sand composed of dolomite crystals. Rock and sand of this character are common in southwest Wisconsin near the junction of Wisconsin and Mississippi rivers. The texture of magnesian limestone and so-called dolomite is commonly more or less rough on weathered surfaces. The Galena dolomite of the Ordovician system and the Niagara limestone of the Silurian system are well-known representatives of this type of rock in the Mississippi Valley, and the Knox dolomite and the Shenandoah limestone in the Appalachian valleys both contain much dolomite.

In the formation of magnesian limestone and dolomite, magnesium carbonate is believed to have replaced calcium carbonate, either while the beds were being deposited in the sea, or after the beds became part of the land surface. The degree of replacement is variable, and ranges from less than 1 per cent to 45.65 per cent, although most commonly found to be either low or high. Rock containing a higher percentage of magnesium carbonate than true dolomite may be termed "supermagnesian" limestone, and if the theoretical quantity of calcium carbonate should be replaced by magnesium carbonate, the rock would become magnesite. This process of replacement is known as dolomitization, and is accompanied by contraction or shrinkage of about 12.3 per cent of the volume of the original limestone.[2] This contraction is believed to produce porosity in the rock under conditions in which the pressure is not sufficiently great to close the pores of the rock. The properties of magnesian and dolomitic limes are of much interest and are discussed at length on pages 1581–1593.

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[1] Dana, E. S., A text-book of mineralogy, p. 358, John Wiley & Sons, New York, 1900.
[2] Van Hise, C. R., A treatise on metamorphism: U. S. Geol. Survey Mon. 47, p. 806, 1904.

Argillaceous limestone.—Argillaceous limestone contains a considerable proportion of clay material, consisting mainly of silicate of alumina. If this is present in certain proportions, mortar made from the lime burned from this stone has the property of setting under water, and is therefore known as hydraulic lime. Clay material was probably introduced into the limestone during its formation on the sea bottom. Not a great deal of hydraulic lime other than a comparatively small quantity of "natural cement" is made annually in the United States.

Arenaceous and siliceous limestone.—Arenaceous limestone is a rock containing fine silica sand deposited with calcareous sediments in the sea. Other varieties of limestone contain silica in the form of quartz that has been introduced by ground waters into the pores of the rock, and into cavities, forming geodes, vugs, and veins, and limestone may contain a siliceous cement.

In rare instances limestone may contain calcium silicate, in the form of wollastonite, produced by igneous metamorphism. Such material has been noted near Havre, Mont. All such varieties of limestone, as well as the cherty variety mentioned above, are therefore siliceous; and, as silica, where present to the extent of 4 per cent or more, is an undesirable impurity, arenaceous or siliceous limestones are rarely suitable for making lime.

GRADATIONS IN LIMESTONE.

In the foregoing definitions and sketches of the origin and characteristics of the common varieties of limestones, an attempt has been made to show why it can not be expected that all deposits of limestone should conform to a single standard of purity. It should be added here that although the criteria for differentiating the varieties of limestone are very definite, there are all gradations from one variety of rock to another, and also there are many combinations of the varieties mentioned. On account of the method of formation of beds of limestone in nearly horizontal deposits in successive layers on the sea bottom, the character of the rock will be subject to greater variation in a given distance perpendicular to the bedding planes than parallel to them. It is a matter of common experience among quarrymen that in order to secure stone of uniform composition they must follow the beds that are of the desirable composition rather than extend the quarry into beds stratigraphically much higher or lower (across the beds). Broadly, there are also differences in composition of limestones from place to place along the same bed, and these differences are found to be greater in a direction at right angles to the shore line of the ancient body of water in which the rock was deposited than in a direction parallel to that shore line. This is explained by the sorting action of currents and waves.

IMPURITIES IN LIMESTONE.

From the points that have been mentioned in the foregoing descriptions of limestones, this subject need only be summarized here. Among the common impurities in limestone are clay material, silica, alumina, iron oxide or iron rust, iron carbonate, iron pyrites and marcasite or iron disulphide, gypsum, alkalies, and carbonaceous material. Clay is introduced into the beds while they are being deposited on the sea bottom, and is most often found along the bedding planes, but it is also disseminated through the rock. Clay also results from the decomposition of impure limestone in the process of weathering at the surface, in joint cracks that have been enlarged by solution, and in solution channels and caves. Much surface clay is carried down into the cracks, crevices, and irregularities in the rock surface, and when quarries are operated on a large scale, it is difficult to separate this clay cheaply from the adjoining limestone. Silica is both an original and secondary impurity in limestone. In marble it is usually found combined with some other mineral, such as alumina, iron, calcium, and magnesium, and occurs, therefore, in the form of silicate minerals. In ordinary hard limestone, it occurs as nodules or masses of chert (flint), or else combined with alumina as clay matter. In soft limestone, such as marl and chalk, silica usually occurs as grains of sand that were introduced during the deposition of the limestone, but certain beds of Cretaceous chalk carry an abundance of chert nodules, notably the chalk deposits along the English channel, and to a less extent in Texas. Alumina is commonly present in combination with silica as silicate minerals or as clay matter. Iron compounds may have been disseminated with the original sediments, but they have also been brought in by percolating waters. Chemical action between the iron compounds and the calcium carbonate and other minerals has resulted in the replacement of particles of limestone by iron compounds. Sulphur is present in combination with iron as the disulphide, and in gypsum ($CaSO_4.2H_2O$), so that it is not free under ordinary conditions. The alkalies, soda and potash, are present in some limestones in small quantities, probably in the form of carbonates and in the clay impurities as silicates.

On the outcrop and next to a cover of residual clay, débris, and soil, limestones are generally weathered to varying depths, depending on the physical and chemical character of the stone. Impurities are noted in greater proportion in the weathered rock than in the unweathered, because the impurities are less soluble than the limestone. It is difficult in quarrying to avoid the minor impurities that occur within limestones, but where chert occurs, if it can not be picked out advantageously, it is best to select other beds, for it can not reasonably be expected to disappear as the bed is worked farther from the outcrop.

STRUCTURE OF ROCKS.

GENERAL CONSIDERATIONS.

Originally the sediments composing beds of limestone were deposited in a nearly horizontal position, or with a low initial dip corresponding to the slope of an ocean beach or of the floor of a depression in the ocean bottom. Throughout the Central States and the Great Plains the rocks lie for the most part as they were deposited, namely, nearly flat, and quarry operators here usually have very simple conditions with which to deal. In New England, in the Appalachian region, in the Rockies, and in other western mountainous regions, however, beds of rock seldom lie in normal positions, but are in highly inclined or vertical attitudes, and in many instances the strata are bent, curved, twisted, and broken within small areas.

The flat-lying strata have been very little disturbed during the broad oscillations of the earth's crust coupled with the retreat of the oceans, by which they were brought into their present position. Certain structural effects, however, have been introduced in these rocks, such as dislocations, called joints and faults.

DISLOCATIONS.

Joint.—A joint is a crack or crevice cutting beds of rock nearly in a plane. A joint plane generally makes a high angle with the bedding planes. (See Pl. IX, *A*.) Joints usually occur in systems, the planes of each system being roughly parallel to one another. Where there are two systems, the joints of each system are usually nearly at right angles to one another. In many regions, especially where the rocks have been much disturbed, there are several systems of joints, intersecting at various angles. The spacing of joints is rather irregular, some being only a few inches apart and others 50 to 100 feet, or more, apart. Joints are often enlarged by solution, and the spaces may be open, or they may be filled with residual clay, with clay and gravel that have been washed down from the surface, or they may be lined or filled with mineral matter deposited from solution, perhaps in

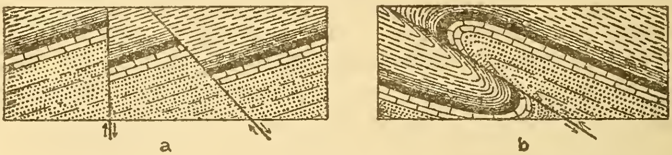


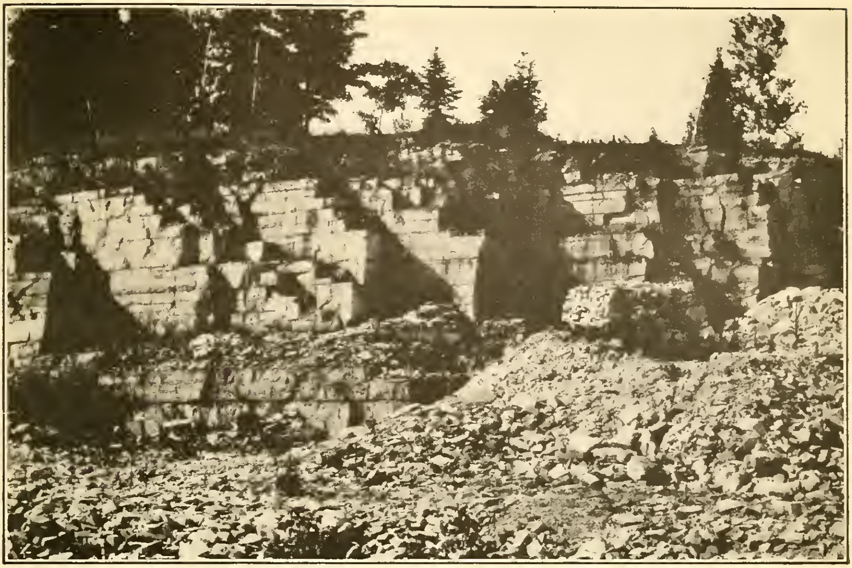
FIGURE 23.—Ideal sections of strata, showing (*a*) normal faults and (*b*) a thrust or reverse fault.

crystalline form. Advantage is often taken of the jointing of rocks in the operations of quarrying and mining.

Fault.—A fault is a fracture along which strata have moved unequally, so that the edges of strata on opposite sides of the fracture or fault plane do not correspond in position. There are many types of faults, but in flat-lying rocks the normal fault is the most common. The normal fault is one in which the fault plane is inclined toward the beds that have relatively slipped downward. The movements of the beds during faulting need not, however, have been mainly vertical. There are many places in which beds have been shoved over each other almost in a horizontal direction, and also in which the movement has been in a lateral direction along the fault plane. Of course, combinations of all these directions of movements are common. (See figs. 23 and 24.)

FOLDS.

The cooling of the earth's interior and the consequent shrinkage of the crust, and other causes, generate tangential forces that tend to produce corrugation or wrinkling of the crust. There are certain very broad types of corrugations of the crust, such as continents, ocean basins, and mountain ranges, but the type of most interest in the present connection is the minor one which includes rock folds or arches. Since stratified rocks were originally nearly horizontal, they were peculiarly subject to the crumpling action from the tangential



A. JOINTED STRUCTURE IN HORIZONTALLY BEDDED NIAGARA LIMESTONE, DRUMMOND ISLAND, MICH.

B. OUTCROP OF CHICKAMAUGA LIMESTONE BEDS NEAR EWING, VA., SHOWING DIP AND STRIKE.

pressure in the earth's crust, and they have very evidently suffered great disturbances in places. All inclined beds are portions of great rock folds or arches. Beds that slope downward into the ground do not continue to slope at the same angle, but at comparatively moderate depths the inclination gradually changes and the bed rises to the surface again. On the other hand, if the bed be projected into the air, it can be considered as bending downward

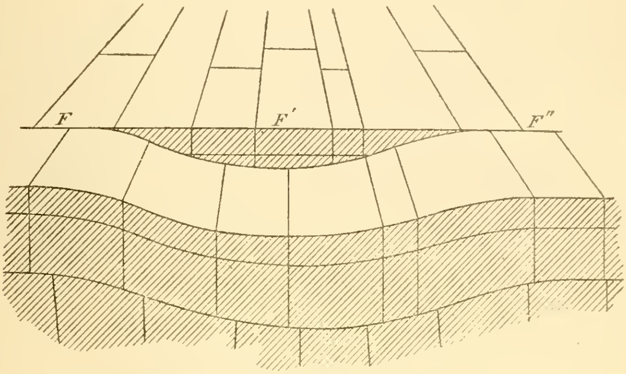


FIGURE 24.—Ideal diagram of a complete normal fault. (Modified from Crosby, W. O., Common minerals and rocks.) *F–F'–F''*, trace of fault plane on a flat surface.

again in an imaginary curve and descending to the level of the present surface at some point not far distant. The portions of beds that form the imaginary arch above the present surface have been removed by erosion, and generally there is little in the topography or surface relief to indicate troughs or arches in the strata. For his information, the geologist has to depend largely on sections afforded by stream cutting, artificial excavations, tunnels, etc., and on the

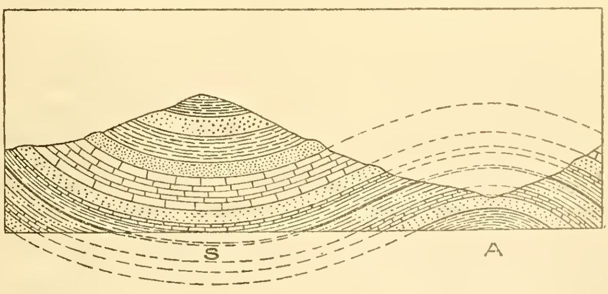


FIGURE 25.—Ideal section across folded strata. A, Anticline; S, syncline.

principles of the mechanics of geologic structure. A section across some folds of the character just outlined is given in figure 25.

Anticline, syncline, dip, and strike.—The troughlike arch or fold is termed a syncline and the upward bending arch an anticline. The median line passing lengthwise through the lowest points of a synclinal fold or through the highest points of an anticlinal fold is called the axis. The inclination of the beds to the horizon is their dip. The horizontal direction of the outcrop is called the strike. The strike is at right angles to the dip and is generally parallel to the axis of the fold. The dip involves two elements: (1) The direction of dip, which is always at right angles to the strike and is the direction of the steepest inclination on the surface of the strata; and (2) the degree of dip, which is the angle between a horizontal plane and the line of the steepest inclination. (See Pl. IX, *B*.)

Monocline.—In addition to the anticline and the syncline, there is a simple type of fold in which the beds bend from one nearly horizontal plane to another, and this type is known as a monocline.

General characteristics.—Rock folds are of all sizes, from minute wrinkles, such as are seen in hand specimens, to enormous arches several miles in length and width and many hundreds of feet in height or depth. The plan of a rock fold is a more or less elongated ellipse—that is, roughly boat shaped—and the axis of the fold may pitch at a low angle in one direction. Where the folding of a region has been intense the axial planes of the folds are generally inclined to the vertical, and the arch may even be pushed over to one side, so that the beds on the two sides, or limbs, of the fold dip in the same direction. Such a fold is said to be overturned. (See fig. 26.)

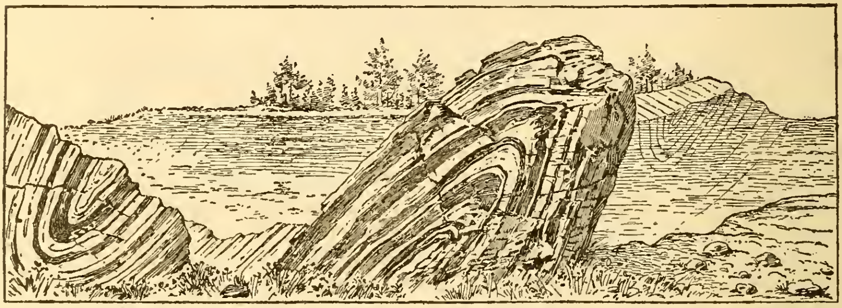


FIGURE 26.—Diagram showing unsymmetrical and overturned folds in marble strata at Lenox, Mass. (By T. N. Dale.)

This close folding in the case of brittle rocks, such as limestone, takes place very slowly at considerable depths below the surface and under great pressure, under conditions that may render the rock plastic. In many instances, however, fracturing and faulting of the beds have occurred as an accompaniment of close folding, and overthrust faults having a section similar to the type shown in figure 23, *b*, are developed in places. The best known examples in the United States of the folds outlined above are perhaps to be found in the southern Appalachian region.

Topographic expression.—On account of the modification of the earth's surface by erosion the various structural features of rocks are not always clearly shown in the topography. In areas of flat-lying rocks at considerable altitude above sea level, subject to stream erosion, the harder rocks stand out in bold cliffs, often protecting softer rocks beneath. Limestones form many stream bluffs and some ridges, but they are so soluble that more generally they form gentle slopes and valleys. Where rocks are thrown into folds the upturned edges of the harder beds on the limbs of the fold generally form the ridges, and the valleys are developed on the softer and more soluble rocks along the axes of the fold. In the majority of places ridges are developed near the axes of synclinal folds, and valleys are formed along the axes of anticlines (see fig. 25), but in some places the reverse relations occur.

AGES OF ROCKS.

TIME AND STRATIGRAPHIC SUBDIVISIONS.

The time during which rocks were formed is divided into major intervals called eras, which are in turn divided into smaller intervals called periods, and these into smaller subdivisions called epochs. The age of a rock is expressed by the name applied to the time interval in which it was formed.

All the sedimentary formations deposited during a period are together termed a system. The principal divisions of a system are called series. Any aggregate of formations less than a series is called a group.

FORMATIONS.

For purposes of geologic mapping rocks are divided into formations. A sedimentary formation contains between its upper and lower limits either rocks of uniform character or rocks more or less uniformly varied in character, as, for example, an alternation of shale and limestone. Where the passage from one kind of rocks to another is gradual, it may be necessary to separate two contiguous formations by an arbitrary line, and in some cases the distinction depends almost entirely on the contained fossils.

When for scientific or economic reasons it is desirable to recognize one or more specially developed parts of a varied formation, such parts are called members, or are designated by some other appropriate terms, such as lentils.

The names of formations or their subdivisions are derived from the localities in which the rock is most typically developed.

Value of fossils.—Sedimentary deposits accumulate successively; therefore the younger rest on those that are older, and their relative ages may generally be determined by observing their positions. In many regions of intense disturbance, however, the beds have been overturned by folding or superposed by faulting, so that it may be difficult to determine their relative ages from their present positions. Under such conditions fossils, if present, may indicate which of two or more formations is the oldest. Only the simpler kinds of marine life existed when the oldest fossiliferous rocks were deposited. From time to time more complex kinds developed, and as the simpler ones lived on in modified forms life became more varied. But during each period there lived peculiar forms which did not exist in earlier times and have not existed since; these are characteristic types, and they define the age of any bed of rock in which they are found. Other types passed on from period to period, and thus linked the systems together, forming a chain of life from the time of the oldest fossiliferous rocks to the present. Where two sedimentary formations are remote from each other and it is impossible to observe their relative positions, the characteristic fossil types found in them may determine which was deposited first. Fossil remains in the strata of different areas, regions, and even continents thus afford the most important means for combining local histories into a general earth history.

It is in many places difficult or impossible to determine the age of an igneous formation, but the relative age of such a formation can in general be ascertained by observing whether an associated sedimentary formation of known age is cut by the igneous mass or is deposited upon it. Similarly, the time at which metamorphic rocks were formed from the original masses may be shown by their relations to adjacent formations of known age; but the age of the original rocks which have become metamorphosed is not always possible of exact determination.

ROCK SYSTEMS.

The systems and series to which distinctive names have been applied are given in order, from youngest to oldest, in the following table:

Rock systems and main subdivisions.

Era of deposition.	Rock system.	Rock series.
Cenozoic	Quaternary	Recent. Pleistocene.
	Tertiary	Pliocene. Miocene. Oligocene. Eocene.
Mesozoic	Cretaceous	Upper Cretaceous. Lower Cretaceous.
	Jurassic	Upper Jurassic. Middle Jurassic. Lower Jurassic.
	Triassic	Upper Triassic. Middle Triassic. Lower Triassic.
Paleozoic	Carboniferous	Permian. Pennsylvanian. Mississippian.
	Devonian	Upper Devonian. Middle Devonian. Lower Devonian.
	Silurian	
	Ordovician	Upper Ordovician. Middle Ordovician. Lower Ordovician.
	Cambrian	Saratogan or Upper Cambrian. Acadian or Middle Cambrian. Waucoban or Lower Cambrian.
Proterozoic	Algonkian Archean	

THICKNESS OF SEDIMENTARY ROCKS.

The thickness of sedimentary rocks is measured in a direction perpendicular to their bedding planes. The thickness of such rocks in the crust of the earth is very great in places. In one of the very early systems the thickness of the sedimentary beds has been estimated at more than 15,000 feet. Probably no single limestone formation is anywhere near this thickness, however. The Shenandoah limestone has been considered as reaching a thickness of about 6,000 feet in Pennsylvania and of about 5,000 feet in southern Virginia, and the Knox dolomite has been found to reach a thickness of about 4,000 feet in the southern Appalachians. The majority of limestone formations, however, rarely exceed a thickness of 500 feet, and many so-called units are less than 50 feet thick.

OVERBURDEN.

The overburden that must be stripped from limestone deposits in connection with quarrying varies with the location, position, and condition of the deposits. It may consist of the following types of material:

(*a*) Beds of limestone not suitable for lime manufacture.

(*b*) Beds of different kinds of rock, such as shale or sandstone.

(*c*) Residual soil, material from the limestone, such as clay and rock débris.

(*d*) Alluvium, loess, and glacial drift.

The materials under (*d*) consist of unconsolidated sand, silt, clay, gravel, and bowlders deposited by the agencies of water, wind, and ice. The western and southern limit of the area formerly covered by the glaciers in the United States in general corresponds with Missouri and Ohio rivers, and a line southeastward from northwestern Pennsylvania to Long Island, N. Y. Within this boundary deposits of glacial drift from a few inches to 75 feet or more thick cover the surface except where the drift has been removed by erosion, and in certain limited driftless areas, the largest of which lies principally in southwest Wisconsin. South and west of the drift boundary for a few miles there are thin and scattered deposits of drift, and in many places beyond are sheets of loam and gravel that have been derived from the drift deposits and transported by heavy floods at the close of the glacial epoch.

AGE AND GENERAL DISTRIBUTION OF LIMESTONES SAMPLED.

The limestones quarried at the several plants visited by Mr. Emley during the field work of 1909 to 1911 range in age from pre-Cambrian to Mississippian or lower Carboniferous, all the main systems except the Devonian being represented. The oldest rock sampled was the pre-Cambrian Franklin limestone near Hamburg, N. J. This is a very coarsely crystalline marble that has been subjected to metamorphism. Its local distribution is shown on the maps of the United States Geological Survey Folio No. 161, of the Franklin Furnace, N. J., quadrangle, and it extends beyond this area a few miles to the southwest and northeastward into Orange County, N. Y.

Representatives of rocks that may be of either late Cambrian or early Ordovician age, or that extend from the late Cambrian into the early Ordovician, are the Rockland formation quarried near Rockland, Maine, the Stockbridge limestone at Cheshire, Mass., and East Canaan, Conn., the Shenandoah limestone at Cedar Hollow, York, and Thomasville, Pa., and the Shenandoah group at Riverton and Indian Rock, Va. The distribution of the most important areas of the Rockland formation is shown on the maps of the United States Geological Survey Folio No. 158, of the Rockland, Maine, quadrangle, although there are a few small areas of this rock a few miles northwest of the Rockland quadrangle. From Canada to southern Connecticut the Stockbridge limestone or its equivalent extends as a belt of marble and highly crystalline limestone. This is quarried at the marble centers near Rutland, Vt., Lee, and Ashley Falls, Mass., and at the lime manufacturing points, Cheshire, Mass., and East Canaan, Conn. The upper part of the series in which the Rutland and Cheshire quarries are working is characterized by high-calcium stone, but at lower horizons, as at Lee and East Canaan, the stone contains a high percentage of magnesia.

Limestones of late Cambrian and early Ordovician age are therefore rather widely distributed in the eastern United States. Their composition, however, varies from high calcium to high magnesium, as is shown by analyses accompanying the discussion of lime manufacture, page 1558. This fact illustrates that the chemical composition of rocks of equivalent age is not necessarily uniform. In Pennsylvania and in Virginia the important formation or group of formations of late Cambrian and early Ordovician age is known as the Shenandoah limestone or Shenandoah group. These limestones find topographic expression in broad valleys, the Valley of Virginia being a notable example. The typical development of these limestones is in the Shenandoah Valley, whence the name. In Virginia the Shenandoah group of limestones includes some shale beds. At Indian Rock, Va., the stone quarried is in the Natural Bridge limestone, one of the formations of the Shenandoah group. Southward, in Tennessee and Alabama, limestones of Shenandoah age are included in the Knox dolomite. In portions of the Mississippi Valley, Minnesota, Wisconsin, Missouri, and Arkansas, late Cambrian and early Ordovician rocks occur and include beds of magnesian limestone and dolomite.

The next later series of rocks that yield great quantities of limestone for the manufacture of lime and cement is also of Ordovician age. From New England southwestward through eastern New York and the Appalachian valleys of Virginia and Tennessee into Georgia and Alabama these later Ordovician rocks outcrop generally parallel to those of late Cambrian and early Ordovician age. They also outcrop in the vicinity of Cincinnati, Ohio, central Kentucky, Nashville, Tenn., and in important areas of the Mississippi Valley in southeastern Minnesota, southwestern Wisconsin, northeastern Iowa, northwestern Illinois, and southeastern Missouri. Ordovician rocks are also well developed in the Ozark region outcropping along White River and its tributaries. The well-known term Trenton limestone has been applied to one of the most characteristic formations of the Ordovician system.

The rock sampled by Mr. Emley at the quarries of the Tennessee Marble Lime Co., at Knoxville, is the Holston marble, a lentil in the Chickamauga limestone, of Ordovician age. Among the other quarries at which limestones of Ordovician age were sampled during the lime investigation are those at Bellefonte, Pa., La Garde, Ala., and Glencoe, Mo.

The Silurian system contains many important areas of limestone and dolomite in central New York and in the Appalachian region of Pennsylvania, Maryland, Virginia, Tennessee, Georgia, and Alabama; also around the Cincinnati and Nashville uplifts; in the vicinity of the Great Lakes in Ohio, Indiana, Illinois, Michigan, and Wisconsin; in the Mississippi Valley in Iowa, Wisconsin, and Illinois; and in the Ozark region of Missouri and Arkansas. Quarries in the Silurian limestone that were sampled by Mr. Emley are those at Woodville, Ohio, Sheboygan and Highcliffe, Wis., and Manistique, Mich.

Limestones belonging to the Devonian system are generally of a high degree of purity. Rocks of this system are represented in

Maine, New York, Ohio, Michigan, Indiana, Iowa, Missouri, Tennessee, and Arkansas, besides in the Appalachian region from Pennsylvania to Tennessee. In the southern Appalachians, however, the Devonian deposits are very thin and do not carry important beds of limestone. No quarry in Devonian rocks was sampled by the Survey during the field work on which this report is based.

The Carboniferous system, especially, in its lowest division, the Mississippian series, contains some thick and extensively distributed limestone formations. This series is typically represented along the inner Mississippi Valley in Illinois and Missouri. Mississippian rocks are well represented in other States of the Mississippi basin, large areas outcropping in western Pennsylvania, West Virginia, Ohio, Kentucky, Tennessee, northern Alabama, Indiana, Michigan, Iowa, Missouri, Arkansas, and Oklahoma.

The quarries both at Marblehead, Ill., and Ash Grove, Mo., are in rocks of the Mississippian series of the Carboniferous system.

GENERAL DISTRIBUTION OF LIMESTONE IN THE UNITED STATES EAST OF THE ROCKY MOUNTAINS.

The general distribution of the limestone formations in the United States east of the Rocky Mountains is shown on the map, Plate VIII. On a map having so small a scale there are necessarily many small areas omitted, and many inaccuracies in the boundaries. The main purposes of the map are merely to show in a broad way the areas in which limestone forms the principal surface rock as contrasted with the nonlimestone areas, and to differentiate the areas of high-calcium limestone from those areas which may contain more or less magnesian stone. One striking fact brought out by this map is that the total area of limestone east of the Rocky Mountains is not so great as has popularly been supposed. The misleading statement that received widespread publication a few years ago to the effect that there is hardly a county in the United States that is not supplied with the raw materials for the manufacture of Portland cement seems clearly to be refuted by this map, particularly when it is considered that only the nonmagnesian limestone (such as is shown by the blue pattern) is suitable for Portland cement. As a result of rough planimeter measurements of the areas of both kinds of limestone and of the nonlimestone country east of the Rocky Mountains it appears that only about 15 per cent of the total area can be considered as bearing limestone, and this percentage includes both the high-calcium and magnesian varieties. The percentage of counties containing high-calcium and magnesian limestone probably would be slightly greater. Of course, in much of the limestone area the rock is not accessible for quarrying.

In the following pages is outlined the general distribution of the limestone areas perhaps a little more fully than is expressed by the map (Pl. VIII). The areas in the smaller Eastern States are discussed by groups of States, but west of the Mississippi the discussion is by States. The reader who desires greater detail in regard to high-calcium limestone suitable for making Portland cement is referred to earlier Survey publications,[1] particularly to Bulletin 522, which

[1] Burchard, E. F., The cement industry in 1910: U. S. Geol. Survey Mineral Resources, 1910, pp. 488-532, 1911. Eckel, E. C., Portland cement materials and industry in the United States, with contributions by E. F. Burchard and others: U. S. Geol. Survey Bull. 522, 1913. (May be purchased from the Superintendent of Documents, Government Printing Office, Washington, D. C., for 65 cents, or consulted in the larger public libraries.)

contains a number of State maps on a scale of about 40 miles to 1 inch, showing the distribution of limestone formations within those States.

The location of every limestone quarry and lime kiln in the United States east of Mississippi River was shown in a series of seven maps in the chapter on the stone industry in Mineral Resources for 1911, Part II, and the location of every such plant in the States between the Mississippi and the western boundary of Montana was shown in a series of six maps in the corresponding chapter and volume of Mineral Resources for 1912. The quarries and lime kilns in the remaining Western States and in the Pacific coast States are shown in three maps accompanying the chapter on the stone industry in Mineral Resources for 1913. The locations of these kilns have been plotted in connection with the preparation of a map showing the quarries of stone of all classes. The location of quarries of limestone operated independently of lime kilns as shown on these maps are also of interest in the present study, since they indicate in a general way the distribution of limestone formations that are available for quarrying, although they in no way indicate the type of stone quarried.

Chemical analyses of a large number of typical limestones and limes produced in various parts of the United States were published in the chapter on the production of lime in Mineral Resources for 1911, Part II. For a summary of the recent literature on lime, see the bibliography at the end of the chapter on the production of lime in 1913, published elsewhere in this volume of Mineral Resources.

NEW ENGLAND STATES.

Limestone, lime, and marble.—Practically all the limestone in the New England States is so highly crystalline as to be considered marble. The principal areas of calcareous rocks are near the coast of Maine, in Knox and Waldo counties, and in western Vermont, Massachusetts, and Connecticut. Lime is the principal product of the Knox County, Me., area, and it is made on a large scale also in Berkshire County, Mass., and in Litchfield and Fairfield counties, Conn. In Vermont also the marble is suitable for the manufacture of lime, although the production of lime in that State falls below that of the other States mentioned.

The marble of New England as reported here includes four types of stone. By far the most extensive deposits are of true marble, the distribution of which is outlined above. The true marbles of Vermont are too well known to need description here. They consist of calcite and dolomite marbles, comprise white rock and rock of such tints as cream, gray, bluish, and greenish, and are used for structural, decorative, ornamental, and statuary purposes.[1] The active quarries are located principally in Addison, Bennington, Orange, and Rutland counties. The three other types of stone commercially termed marble are quarried also in Vermont. One type is a dark-blue, dense, fine-grained fossiliferous limestone quarried on Isle La Motte, in Grand Isle County. This rock takes a high polish, becoming nearly black when polished, and is used much for interior decoration. Floor tiles are made from it, and the slabs are often sawed so that they dis-

[1] Dale, T. Nelson, The commercial marbles of western Vermont: U. S. Geol. Survey Bull. 521, 1912.

play a section of a large coiled gastropod shell (*Maclurea magna*) on the surface of the tile. Another type of marble is a mottled red and white quartzose and argillaceous dolomite. It is quarried at Swanton, Franklin County, and is commercially known as "Champlain marble." Besides various shades of red this rock also displays olive-greenish tints. It is very hard, taking a high polish, and is used chiefly for flooring and interior work. Stairways are built of it in many public buildings. The fourth type of stone, commercially styled marble, is not a marble at all, since it is not a calcareous rock. It is the so-called "verde antique marble" quarried at Roxbury, Washington County, Vt., and is in reality a serpentine, and therefore need not be further considered. The extent of the marbles of Isle La Motte, Swanton, and Roxbury is slight compared to that of the true marbles of Vermont. The belt of the latter rocks extends southward through Massachusetts, where it is quarried at 10 or more places in Berkshire County, into Connecticut, where it is quarried at one place for marble. Southward through Connecticut the stone becomes much fractured and is of value chiefly for the manufacture of lime.

NEW YORK, NEW JERSEY, AND PENNSYLVANIA.

Limestone and lime.—New York and Pennsylvania are both especially rich in limestone beds. A belt of Silurian limestones extends eastward from Buffalo nearly across New York, and adjoining this belt on the south are Devonian formations, which also carry limestones. On account of the proximity of these limestone areas to several east-west railroads and of the exceptional purity of the stone, they are extensively quarried, especially for flux for blast furnaces at Buffalo. East of Lake Ontario, in addition to a lobe of Silurian limestone there is an area of Ordovician rock which contains limestone in the vicinity of Watertown. Along St. Lawrence River and the northern end of Lake Champlain, Cambrian and Lower Ordovician limestones occur, and quarries are operated in the vicinity of Ogdensburg and Plattsburg. Lime is burned in many of these localities in New York, but the lime industry is much more widely distributed in Pennsylvania than in New York. In Pennsylvania limestones of commercial value occur in the western half of the State in the Carboniferous areas, and chiefly in the Pennsylvanian ("Coal Measures") formations. From the middle of the State eastward the limestones are chiefly of late Cambrian, Ordovician, Silurian, and Devonian age, and the limestone areas are distributed in long, narrow strips, analogous to the outcrops of the "valley" limestones in the southern Appalachians. The dips of the beds in eastern Pennsylvania are steep as compared with those in the western half of the State.

Many of the limekilns in Pennsylvania, are small and are operated intermittently by the farmers to furnish lime for local fertilizers.

Much of the limestone of New York, especially in the western half of the State, is high in calcium carbonate; in Pennsylvania both high-calcium and high-magnesian stone occurs in abundance, the magnesian rock being especially well represented in the valleys of southeastern Pennsylvania. The "cement" rock and purer limestone beds of the Lehigh district in eastern Pennsylvania are quarried to some extent for crushed stone. Near Philadelphia the limestone has been subjected to intense folding and pressure, and in many places the beds have been recrystallized to marble, although they are utilized mostly for lime rather than for marble. In northwest New Jersey the beds utilized for crushed stone in the Lehigh district of Pennsylvania extend into Warren, Sussex, and Hunterdon counties, N. J. Much of this rock is highly magnesian.

The New Jersey stone area is limited to the northwestern and northern part of the State. This is explained by the fact that the deposits of the Coastal Plain, which underlie the remainder of the State, are composed mainly of but feebly consolidated materials, such as clay and sand.

Marble.—True marble is not widely distributed in either New York or Pennsylvania. In New York there are deposits in Westchester County of a white and gray, coarsely crystalline dolomite, and it is reported[1] that one of the belts of this stone reaches Manhattan Island, crossing Harlem River at Kings Bridge. There are also deposits in St. Lawrence County of a coarsely crystalline, light-gray magnesian marble; and in Dutchess County, near the Connecticut line, are quarries of coarse white dolomite marble. In Pennsylvania, as mentioned above, true marble occurs in the southeastern part of the State, and the most noteworthy belt of this material extends northeastward from the southern part of Lancaster County across Chester County, well into Montgomery County. There are a few marble quarries in these areas in both New York and Pennsylvania.

The prevailing colors of the stone throughout the larger part of the southeastern Pennsylvania area are yellowish and bluish, clouded shades rendering the stone not especially desirable for building purposes, but not affecting its value for lime. In an area of highly metamorphosed rocks between Brandywine and Wissahicken creeks the stone is granular crystalline and is reported to contain white as well as veined marble.

In New York there are several localities in which the limestones outlined above are of pleasing colors and of such a texture that they will take a fine polish, and the products are commercially styled marbles. This type of marble is found in Clinton County near Plattsburg, in Essex County, and in Warren County at Glens Falls.

MARYLAND, DELAWARE, VIRGINIA, WEST VIRGINIA, NORTH CAROLINA, AND SOUTH CAROLINA.

Limestone, lime, and marble.—The limestones of this area fall physically into three groups: (1) The nonmetamorphosed limestones of the Appalachian valleys; (2) the metamorphosed or crystalline limestones of the Piedmont region, both of which are hard limestones; and (3) the soft limestone of the Coastal Plain. The great limestone deposits of the Valley of Virginia are the most noteworthy in this area. They are easily accessible and consequently are extensively utilized for lime burning. These same limestone belts extend from northern Virginia across the corner of Western Virginia and through Maryland into Pennsylvania. West of the Alleghenies there are hard limestone deposits in eastern West Virginia, but only in the northern part of the State are they extensively utilized for

[1] Merrill, G. P., Stones for building and decoration, p. 97, 1897.

the production of stone and lime. Southwestward they extend into Tennessee. Limestone is not abundant in the Piedmont region, except where it has been altered to marble, but it is quarried in a few places, notably in Henderson, Transylvania, and Yadkin counties, N. C.; Cherokee County, S. C.; Loudoun County, Va.; and Frederick and Carroll counties, Md. The hard limestones may be either high-calcium or magnesian rocks. The soft limestones of the Coastal Plain consist largely of shell marl, and important quarries are situated in Norfolk County, Va.; Craven and Jones counties, N. C.; and Charleston County, S. C. The shell limestones are generally quite pure and contain little magnesia, but they contain considerable silica in places, owing to the admixture of sand.

The marble deposits are mainly east of the middle of the Appalachian area, either in the mountainous country or on the Piedmont Plateau. In some places crystalline limestone occurs among the rocks in the Great Valley which have suffered little or no metamorphism, and although some beds may not be true marbles, according to the strictest definition, they are, nevertheless, commercially to be regarded as marbles. The principal development of marble quarries in this area is in Baltimore, Carroll, Harford, and Washington counties, Md.; and there are also quarries in Albemarle and Botetourt counties, Va.; in Graham and Cherokee counties, N. C.; and in Oconee County. S. C.

Lime is manufactured extensively from these three tpyes of limestone, not only in the urban districts for industrial use but in the more sparsely settled areas for agricultural purposes.

TENNESSEE, MISSISSIPPI, ALABAMA, GEORGIA, AND FLORIDA.

Limestone and lime.—Calareous rocks predominate, at least so far as suitability for quarry purposes is concerned, in Tennessee, northern Alabama, and northern Georgia, and much of the limestone is suitable for the manufacture of lime. In Franklin County, Ala., are extensive quarries in an oolitic limestone that strongly resembles the famous Bedford (Ind.) limestone, and is of about the same geologic age. Much of the limestone quarried in these States is crushed for concrete, railroad ballast, wagon roads, and for fluxing iron ores. Some hard limestone occurs in Tishomingo County, Miss., but owing to the proximity of large quarries in Alabama it has not yet been utilized to an appreciable extent. In the deposits of the Coastal Plain there are soft limestones of Cretaceous and Tertiary age. In Choctaw, Clarke, and Washington counties, Ala., these rocks are utilized. Florida is largely underlain by beds of shell marl and chalky limestone of Tertiary and Recent age; but these limestones are covered, for the most part, by comparatively thick deposits of sand and gravel. The Coastal Plain material that is utilized in this State for limestone and lime is mainly in the vicinity of Ocala.

Marble.—The marble produced by this group of States is of two types. That of the Piedmont region in northwestern Georgia and east central Alabama is a true marble, much of which is beautifully white or white and veined. In Talladega County, Ala., in Cobb, Cherokee, Pickens, and Gilmer counties, Ga., and in other counties in this northeast-southwest belt are situated large deposits of this type of marble. The other type is a very important marble of commerce, the highly crystalline limestone in east and central Tennessee. This marble—the Holston marble lentil of the Chickamauga limestone—is particularly characteristic of the Appalachian Valley and is of Ordovician age. The marble, which may be regarded as a representative, is of several handsome shades, ranging from light-pink to a rich chocolate color. It has been subjected to some alteration through pressure. The beds are highly tilted and have been squeezed so as to distort the bedding planes and produce handsome veining effects called "crows' tracks or suture joints." Lime is produced in important quantities from the waste rock at certain of the marble quarries in the Knoxville district.

This type of marble occurs in Anderson, Blount, Coffee, Cumberland, Franklin, Hawkins, Knox, and Union counties, Tenn.

WISCONSIN AND MICHIGAN.

Limestone.—A considerable portion of the area of Wisconsin and Michigan is thickly covered by glacial deposits of clay, gravel, and sand. Doubtless this cover retards the development of quarries to some extent, first by obscuring outcrops of good limestone, and, second, by the expense which its removal entails in quarry operations. Silurian rocks underlie the greater part of the eastern tier of counties in Wisconsin, and contain a thick formation of magnesian limestone. This rock is quarried in many places for stone to be burned into lime, and also to be crushed for concrete, macadam, and railroad ballast. The proximity of some of the quarries in eastern Wisconsin to water transportation on Lake Michigan has greatly aided their rapid development. Bordering the Silurian rocks on the west and extending across the southern tier of counties is a belt of rocks of Middle and Upper Ordovician age, which also contain magnesian limestone. The limestone quarries west of Green Bay and west and south of Lake Winnebago, as well as in the southern counties, are in these rocks. Between the border of the Middle Ordovician area and the crystalline area of north-central Wisconsin is a wide belt of rocks of late Cambrian and early Ordovician age, consisting chiefly of alternating beds of sandstone and magnesian limestone. There are a few limestone quarries in these rocks, mainly near Mississippi River between Prairie du Chien and Hudson. The greater part of the lime made in Wisconsin is burned from Silurian magnesian limestone in the eastern part of the State, but there are a few small kilns burning lime for local use in the southern and western areas. One thin formation of relatively high calcium Ordovician limestone is burned for lime in Lafayette County.

In Michigan Devonian formations, largely of limestone, border the northern part of the southern peninsula of the State along Lakes Michigan and Huron, and also cross the southeastern part of the State from Lake St. Clair to the Ohio line. A small area of Silurian limestone borders Lake Erie in the extreme southeast corner of the State, and at the extreme northern point of the southern peninsula there is also a narrow strip of Silurian rocks. Bordering the north end of Lake Michigan and the Straits of Mackinac are Silurian formations that constitute the country rock for some distance back from the shore in the northern peninsula. This is an extension of the belt of rocks that borders Lake Michigan in eastern Wisconsin. Adjoining the Silurian area on the west and north are rocks of Middle and Upper Ordovician age that enter the State from west of Green Bay, Wis., and succeeding these rocks toward the west and north are formations of late Cambrian and Ordovician age that form the shore line of Lake Superior east of Marquette and part of the shore line between Marquette and Keweenaw Point, but which contain little limestone of importance. The central area of the southern peninsula of Michigan is underlain by rocks of Carboniferous age, largely sandstone and shale. The limestone quarries in Michigan are therefore distributed mainly around the borders of the southern peninsula and near the shores of Green Bay and Lake Michigan in the northern peninsula, and are mainly in rocks of Ordovician, Silurian, and Devonian age. There are certain exceptions, however, such as the quarries near Saginaw Bay, which are in Mississippian limestone. The limestones of the Carboniferous and of the Devonian are generally high-calcium rocks; the lower limestones are generally high in magnesium.

ILLINOIS, INDIANA, OHIO, AND KENTUCKY.

Limestone.—The central part of Illinois is so heavily drift laden that quarries can not generally be opened economically, and this condition applies also to much of the area of northern and central Indiana and to parts of Ohio.

In this group of States the principal limestone formations are of Ordovician, Silurian, Devonian, and Carboniferous age. Of the Carboniferous rocks the lowest or Mississippian series contains the most important limestone formations in the western part of the area. In Illinois the Ordovician formations in the north-central part, the Silurian in the Chicago area, and the Silurian and Devonian in the northwestern part of the State are all worked for limestone. Some high-calcium limestone is found in the Ordovician, but the beds are mainly magnesian. The Silurian limestones are also magnesian, but the Devonian limestone carries a high percentage of calcium carbonate. Along Mississippi River and the lower Illinois Valley practically all the limestone quarries are in Mississippian rocks, which are generally well exposed in the bluffs, and consequently economical quarrying sites are not difficult to find. Thus far development has taken place principally at points where railroads happen to be built near good limestone outcrops, although, of course, some quarries have been opened at a distance and connected with the main line by spur tracks. On Ohio River in southern Illinois Mississippian rocks are also quarried. In eastern Illinois a few quarries have been opened in Pennsylvanian rock, notably a large quarry producing limestone for blast furnace flux and Portland cement in Vermilion County. The Carboniferous rocks generally are fairly high in calcium and low in magnesium, but the Mississippian rocks particularly are apt to contain a considerable percentage of silica, in some places in the form of chert. Lime is made from all these limestones in Illinois.

Indiana is underlain by formations having the same range in age as those in Illinois. The Pennsylvanian rocks outcrop in western

Indiana; Mississippian rocks are found in a belt a little west of the middle of the State and in an area in the extreme northeast corner; Devonian and Silurian formations underlie the northwestern, central, and northeastern portions, with Ordovician rocks in the southeast corner, which is affected by the Cincinnati anticline. The limestone quarries in Indiana are chiefly in the Mississippian, Devonian, and Silurian formations. Thirty-eight counties are reported as producers of limestone. Lawrence and Monroe counties are the principal producers of building stone in the State. The famous oolitic limestone quarried about Bedford as a center occurs in these counties in a favorable situation for quarrying. This limestone is of Mississippian age and has few counterparts in the United States so far as its physical characteristics are concerned. This Bedford stone is of medium fine-grained even texture, and is composed of small round concretionary grains and of broken fragments of fossils, all compactly cemented together by calcite. The stone occurs in masses 30 to 50 feet and even 70 feet thick. When fresh from the quarry the stone is soft and cuts easily, but after the "quarry water" has left the stone it becomes much harder. The color of the stone is a very attractive light gray, but it is easily affected by sulphurous and carbonic-acid gases and darkens quickly in the presence of soot. The instability of color is due largely to the high absorptive capacity and to the chemical activity of the stone, which is nearly pure calcium carbonate. On account of its evenness of grain and its softness when first quarried, the stone is easily dressed and carved and is very popular among builders for ornamental stone construction. The stone also possesses ample crushing strength for any use to which it may be put. A great industry has been built up in the district in which it is quarried in cutting stone according to specifications, and much special machinery has been designed for this purpose. On account of the purity of the stone, much of the waste from the quarries is used for making lime and for blast-furnace flux, and a Portland cement mill was operated for several years using this stone in the manufacture of a high-grade product. Some of the most easily accessible stone has now been worked out, and in places, in addition to 5 feet of clay, thicknesses of as much as 35 feet of less desirable overlying limestone have to be removed in order to reach the quarry stone.

In addition to the counties mentioned, Owen, Crawford, Harrison, and Washington counties, Ind., are said to be underlain by this oolitic limestone. In Bartholomew, Decatur, Jennings, and Ripley counties there is considerable quarrying in limestone of Devonian and Silurian age, and farther north, in Delaware, Grant, Wabash, and Huntington counties there are many quarries. This latter area is mainly in magnesian limestone of Silurian age. Some lime is burned from the Silurian limestone in Indiana, but the greater part of the output comes from the high-calcium Mississippian oolitic rock.

In Ohio the limestone quarries are chiefly in three areas which correspond to three geologic systems of rocks. In the northwestern and western part of the State the quarries are very largely in Silurian magnesian limestone; in southwestern Ohio near Cincinnati rocks of Ordovician age yield limestone low in magnesia but rather high in silica, or in silica and alumina; in eastern Ohio, in Carroll, Stark, Tuscarawas, and other counties, Pennsylvanian limestones are quarried. These latter rocks are high in calcium carbonate. Lime is burned principally from the magnesian Silurian limestone and from the high-calcium Pennsylvanian beds.

Kentucky is underlain by the same geologic formations that have been mentioned above in Illinois, Indiana, and Ohio. In fact, these four States are more closely associated geologically than any other group of the United States having an equal area. Kentucky has a less area, however, of Silurian rocks, these formations being confined to a narrow strip in central Kentucky around the border of Ordovician rocks that form the Cincinnati anticline. The formations that yield the greater part of the limestone quarried in Kentucky are of Ordovician and Mississippian age. The Ordovician system is represented in the central part of the State southward from Cincinnati, Ohio, and quarries in it are operated in Harrison, Bourbon, Scott, Franklin, Anderson, Fayette, Jessamine, Mercer, Boyle, and other counties. A small quantity of lime is burned in this area. Limestone quarries in Mississippian rocks are scattered pretty well through the southern part of the State, but the most important area is near Bowling Green, Warren County. An oolitic limestone outcrops here, very similar in physical characteristics and of nearly equivalent age to the stone described above occurring in the Bedford (Ind.) district. This oolitic limestone is in a massive, homogeneous stratum 22 feet thick. It is quarried and dressed on a large scale, and its production represents a large and growing industry. Other areas of oolitic stone occur near Somerset, Pulaski County, and in Barren, Simpson, Logan, Meade, Hardin, Grayson, Caldwell, Todd, Christian, Wolfe, Powell, and Rockcastle counties and is quarried in a few of them. This oolitic stone has a high content of calcium carbonate and is burned for lime at Bowling Green and several other places.

Onyx marble.—True marble does not occur anywhere in this group of States. In the mountainous regions of eastern Kentucky there may be thin beds of limestone sufficiently crystalline in places to take a good polish, but none have been noted by the Survey. The so-called marble reported as quarried in Barren County, Ky., is a cave deposit of calcium carbonate known as onyx marble. These deposits occur in caves in limestones and are formed by deposition from solution in waters that have percolated through the surrounding limestones into the cave and through release of pressure, evaporation, etc., have deposited the mineral matter held in solution. The formation of sheets of onyx marble on the ceiling or walls of caves and on the walls of enlarged openings along joint planes is analogous to the deposition of calcium carbonate to form stalactites and stalagmites in caves.

Some very beautiful effects are produced by cutting and polishing pieces of onyx marble so as to bring out the banding or other figures, and the material is in demand for decorative and ornamental purposes. This material is reported to be present in the limestone regions of Indiana, Tennessee, and Alabama as well as in Kentucky and should be suitable so far as composition is concerned for the manufacture of high-calcium lime.

MINNESOTA.

Limestone.—The limestone areas are mainly in the southeastern part of Minnesota along Mississippi River and westward to the middle of the southern part of the State.

A considerable portion of Minnesota is thickly covered by glacial deposits of clay, gravel, and sand. Probably this cover retards the development of quarries to some extent, first, by obscuring outcrops of good rock, and, second, by the expense which its removal entails in quarry operations. The majority of the stone quarries are, therefore, near the streams, where erosion has cut sections through the glacial drift and exposed the hard rock, generally in terraces or bluffs.

Much of the limestone quarried along Mississippi River and its tributaries in Houston, Winona, Wabasha, Goodhue, and Washington counties is of Cambrian and Lower Ordovician age. The beds are generally highly magnesian and received the name "Magnesian" limestones in early geological reports. They are blue when freshly mined, but weather to a buff color. They lie horizontal and in beds from a few inches to a foot or two in thickness. This belt of rock extends up Mississippi River nearly to St. Cloud and up Minnesota River to beyond Mankato; it is quarried extensively near Kasota and Mankato both for building stone and for natural cement and at other places for crushed stone and for the manufacture of lime. Along Mississippi River the limestone is used extensively for riprap.

The quarries at Kasota and Mankato are in a high-grade magnesian limestone that can be tool-faced, carved, polished, etc. Although the stone at both places belongs to the same formation, that at Kasota is more worked for cut stone. The stone at Mankato is of a buff color, and that at Kasota is of a light-pink shade, banded faintly in places. The stone at Mankato is used largely for massive masonry and as crushed stone, whereas that at Kasota is used for flagging and for building purposes, including polished wainscoting and other interior work. The stone is a fine-grained, hard, highly magnesian limestone. At Kasota the beds range from a few inches thick at the top (the thinness is due to weathering) to about 4 feet below. Massive blocks 12 feet long may be quarried if desired. The stone is quarried to a depth of about 12 feet below the stripping, which amounts to 3 to 5 feet of sand and gravel. In winter the quarries are closed and the beds covered with straw so as to prevent the stone from being disintegrated by frost. The quarry companies have cutting shops at Kasota, at which the stone is sawed, tooled, turned and polished. The supply of stone here is ample and the facilities for its production are larger than the demand.

The United States post-office building at Aberdeen, S. Dak., is faced with cut stone from Kasota, and much of the "marble" wainscoting in the Minnesota State capitol building at St. Paul is of polished stone from Kasota.

Tests made by Maj. Q. A. Gillmore before 1875 showed this stone to have a crushing strength of 10,700 pounds per square inch on "bed"; specific gravity, 2.63; weight per cubic foot 164.4 pounds; and ratio of absorption 1.56.

Overlying the Cambrian and Lower Ordovician rocks in southeastern Minnesota, between Mississippi and St. Peter rivers, are rocks of Middle and Upper Ordovician age, including the so-called "Trenton" limestone. Quarries have been opened in these beds near Rochester, Mantorville, Faribault, and Minneapolis. The color and bedding of these rocks are similar to those of the earlier Ordovician rocks. Near Faribault certain of the limestone beds consist of so nearly pure calcium carbonate that the stone has been burned for the manufacture of lime for use in beet sugar refining. Most of the material for structural purposes produced from the so-called "Trenton" limestone is used in the form of rubble and crushed rock.

The local surface rock at Minneapolis is the so-called "Trenton" limestone. This rock consists of beds of high-calcium, fine-grained, dense, light-gray rock, beds of bluish to greenish argillaceous magnesian limestone, and beds that approach shale in texture. The first-mentioned beds are the most desirable for all purposes, but most of the quarries are obliged to move considerable of the inferior stone, and more or less of it is worked into the product.

Lime is burned from local stone in the following Minnesota counties: Blue Earth, Fillmore, Goodhue, Mower, Rice, and Scott. As noted above, the limestone in most of these counties is magnesian, but that in Rice and Mower counties is high in calcium carbonate. Analyses of certain of these limestones and limes are given in Mineral Resources for 1911, Part II, pages 673 and 701. The magnesian stone is of Ordovician age, earlier than the "Trenton," and the high-calcium stone belongs to the so-called "Trenton" and later formations. The quarry at Le Roy, Mower County, is in an area of Devonian rock.

Limestone is quarried in 16 counties in Minnesota, 6 of which produce lime; and in addition lime is burned near Duluth from stone quarried in Ohio and shipped by boat through the Lakes. As at present developed there are more quarries of limestone in Minnesota than of any other rock, and if the value of the output of lime, as well as of limestone is considered, the industry based on limestone quarrying yields more wealth than any other phase of the quarrying industry.

NORTH DAKOTA.

The stone resources of North Dakota have been little developed and there are very few data at hand concerning the undeveloped resources of the State. About two-thirds of the area of the State, viz, the portion north and east of Missouri River, is generally deeply covered by glacial drift, and rock exposures are scarce. Except in the valley of Red River, where there may be granite, the rocks below the drift are sedimentary beds of Cretaceous and Tertiary age which consist mostly of soft sandstone, chalky limestone, shale, and clay, thus affording but little suitable rock for quarrying. No lime production has been reported from North Dakota in recent years.

SOUTH DAKOTA.

The greater part of the area of South Dakota is underlain by sandstone, shale, clay, and chalky limestone of Cretaceous and Tertiary age. Glacial drift overlies much of the area of the State east of Missouri River. Aside from the Cretaceous and Tertiary areas there is one small but important area in South Dakota where hard limestones are available for quarrying, viz, the Black Hills uplift. Marble also occurs, but is not quarried at present.

Limestone and lime.—Except for beds of chalky limestone in the Cretaceous of eastern South Dakota (which are of value for cement making rather than for structural purposes), the limestone beds of importance occur in the Black Hills. The limestone beds in the Black Hills are mostly of Carboniferous age, but there are also Silurian, Triassic, and Cretaceous limestones in this locality. One of the most important limestones is the Pahasapa, of early Carboniferous (Mississippian) age. It is reported to be about 500 feet thick in the northwestern part and about 225 feet in the southeastern part of the Hills. The lower part is massive, and above there are cherty beds. This stone has been used mainly for smelter flux and for making lime. It has been quarried near Doyle, Pringle, and Deadwood. The Minnekahta limestone, of late Carboniferous (Permian) age, has been used for lime burning and for building stone. It averages less than 50 feet thick. It has been quarried at Spearfish. One limestone quarry is located in Cretaceous rocks at Chester, Lake County. Limestone, including that quarried for lime and flux, is obtained in five counties in South Dakota.

Marble.—According to Todd,[1] an extensive deposit of white, crystalline dolomite marble occurs 4 or 5 miles northeast of Custer. It grades from a pure white fine-grained crystalline rock to coarse mottled stone with thinner layers of white, attractively spotted and banded with light and dark green serpentine. The marble is in distinct layers from 1 to 3 feet or more thick, the upper layers being the thinner. The total thickness is 30 to 40 feet. The deposit is embedded in and interstratified with pre-Cambrian schists. The deposit has been prospected by means of strip pits at several points in a distance of 1½ miles.

A deposit of grayish schistose marble, 20 feet thick, occurs on Box Elder Creek, but no development is reported.

IOWA.

Limestone.—Although a considerable part of the surface of Iowa is covered with glacial drift, streams have so dissected the drift mantle as to produce many good exposures of the underlying beds of hard rock. Paleozoic rocks underlie the eastern two-thirds, as well as the southwest corner of the State. Cretaceous rocks underlie the remaining northwestern portion, with the exception of a few square miles in the northwest corner, which are underlain by Huronian (Sioux) quartzite. The Paleozoic rocks, which begin with the Cambrian and Lower Ordovician along Mississippi River in the northeast corner of the State, outcrop in successive northwest-southeast belts and include rocks of Middle and Upper Ordovician, Silurian, Devonian, and Carboniferous age. The Carboniferous rocks include large areas of Mississippian and Pennsylvanian rocks, and a very small area of probably Permian beds in Webster County. The Cambrian and Ordovician systems comprise beds of magnesian limestone, soft, friable sandstone, and some fairly high-calcium limestone; the Silurian and Devonian systems carry magnesian limestone and high-calcium limestone, respectively; the Mississippian series is composed mostly of high-calcium limestone, but some magnesian and some cherty beds and some sandstone; and the Pennsylvanian series contains much sandstone and a smaller pro-

[1] Todd, J. E., Mineral resources of South Dakota; South Dakota Geol. Survey Bull. 3, p. 88, 1902.

portion of shaly limestone. Most of the systems contain shale, but no account is taken of that material in this connection.

The distribution of stone quarries follows closely that of the streams and incidentally that of the railroads, and also falls almost entirely within the area of Paleozoic rocks. With possibly the exception of limestone quarries in Montgomery County, apparently there are no regularly working quarries in the Cretaceous areas, although doubtless there are a few local pits that produce limited quantities of Cretaceous limestone for use on the farms.

The limestone quarries of Iowa are distributed over the eastern two-thirds of the State and have been opened in each of the Paleozoic limestones mentioned above. Probably the greater number of quarries are in limestone of Mississippian age, although there are numerous quarries in the Cambrian and Ordovician areas. There are about 243 limestone quarries in Iowa in 42 counties. Twenty-three of these quarries in 7 counties produce stone for making lime. High-calcium lime is burned from formations of Mississippian and Devonian age and magnesian lime is produced from Mississippian and Ordovician rocks.

NEBRASKA.

Limestone.—With three exceptions—quarries at Sidney, Cheyenne County, and at Scotia, Greeley County, in limestone of late Tertiary age, and quarries at Roca, Lancaster County, in Cretaceous beds—the limestone quarries in Nebraska are in rocks of Carboniferous age, and are confined to the southeastern portion of the State south of Omaha and east of Lincoln. Most of these quarries are in Pennsylvanian areas, but some are in the Permian. A fossiliferous limestone containing a great number of Fusulina, a fossil resembling a grain of wheat, is very common. The greater part of the output of limestone in Nebraska is sold as crushed stone mostly for concrete, and the next largest item, comprising nearly 10 per cent of the total value, is the production of riprap on Missouri River.

Lime production is reported from only one locality, Weeping Water, Cass County. The total number of limestone quarries is 32, distributed among 9 counties in Nebraska.

There is little literature available on the quarrying industry in Nebraska, but fortunately a report has been published on the geology of Cass County,[1] one of the most important stone-producing counties in the State, and also a report on a special phase of the industry, viz, the production of flint ballast.[2]

Woodruff states that the stone-producing area is in three localities, one along the Platte, another on the Weeping Water, and between these two a small triangular section facing Missouri River. The overburden is generally loess, ranging in thickness from a few feet to 20 or more feet. The State capitol at Lincoln is built of native Carboniferous limestone quarried at Louisville, Cass County.

In Gage County cherty limestone, apparently in the area of Permian rocks, is crushed and screened at several quarries and marketed for railroad ballast and concrete. The markets for this material are by no means local but extend well beyond the borders of Nebraska.

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[1] Woodruff, E. G., The geology of Cass County, Nebr.: Nebraska Geol. Survey, vol. 2, pt. 2, 1906.
[2] Barbour, E. H., The flint ballast industry of Gage County, Nebr.: Nebraska Geol. Survey, vol. 3, pt. 5, 1909.

MISSOURI.[1]

The southeastern part of Missouri, comprising over one-fourth of the area of the State, is overlain by rocks of Cambrian and Ordovician age consisting chiefly of interstratified magnesian limestone and sandstone. Bordering the Ordovician rocks on the east, north, and west, is a belt of Mississippian rocks. These rocks form the inner valley and bluffs of Mississippi River except for part of its course north of the mouth of the Missouri in Pike and Lincoln counties, where Silurian rocks outcrop. The Mississippian rocks extend westward from the Mississippi north of the Missouri, crossing the Missouri in Boone County, and in Pettis County they make an abrupt bend to the south and southwest, extending beyond the southwest corner of the State into Arkansas and Oklahoma. They consist largely of limestone, some of which is cherty. A narrow belt of Devonian rocks lies between the Ordovician and the Mississippian areas north of Missouri River in Callaway, Montgomery, Warren, and St. Charles counties. The Devonian and Silurian rocks consist largely of limestone. North and west of the Mississippian area Pennsylvanian rocks occupy the remainder, or nearly one-half the area of the State. The Pennsylvanian rocks consist of sandstone, shale, and limestone.

Limestone.—The wide distribution of limestone in Missouri, which has already been outlined, insures a large production of this valuable material. Most of the limestone is suitable for crushed stone, and much of it is also suitable for building stone, for the manufacture of lime and for flux, so that each of these branches of the industry contributes largely to the output of limestone. Limestone of Cambrian and Lower Ordovician age is quarried in Missouri in the following counties: Bollinger, Cape Girardeau, Cole, Dallas, Franklin, Madison, Miller, Moniteau, Osage, Perry, St. Francois, and Wright; Middle and Upper Ordovician limestone in Cape Girardeau and Jefferson counties; Silurian limestone in Lincoln and Pike counties; Devonian (probably) limestone in Jefferson County; Mississippian limestone in Barry, Boone, Callaway, Clark, Cooper, Greene, Jasper, Jefferson, Knox, Lawernce, Lewis, McDonald, Marion, Monroe, Montgomery, Pettis, Pike, Platte, Ralls, St. Charles, St. Clair, St. Louis, Saline, and Shelby counties; and limestone of Pennsylvanian age in Andrew, Atchison, Audrain, Bates, Buchanan, Caldwell, Carroll, Cass, Clark, Clay, Clinton, Daviess, Dekalb, Grundy, Harrison, Holt, Jackson, Knox, Lafayette, Linn, Livingston, Mercer, Montgomery, Platte, Ray, St. Clair, Saline, and Sullivan counties.

A total of 283 quarries have produced limestone in the last two or three years, of which 80 quarries furnished stone for making lime. Out of the total of 283 quarries, 41 were in Cambrian and Lower Ordovician limestone, 8 in Middle or Upper Ordovician, 5 in Silurian, 4 in Devonian, 105 in Mississippian, and 120 in Pennsylvanian limestone. Of the quarries producing stone for lime 12 were in Cambrian and Lower Ordovician limestone, 5 in Middle or Upper Ordovician, 1 in Devonian, 59 in Mississippian, and 3 in Pennsylvanian limestone. It is thus evident that the Mississippian and

[1] A detailed report entitled "Lime and cement" was published by the Missouri Bureau of Geology and Mines as vol. 2, 2d ser., 1904.

Pennsylvanian series contain the most extensively worked limestone formations, and that for the manufacture of lime the rock of Mississippian age has proved most suitable. The Mississippian limestone is mostly high-calcium stone; the beds of Cambrian and Lower Ordovician age are highly magnesian, and certain of the limestone beds of the Middle and Upper Ordovician are high in calcium carbonate. Analyses of many limestones from Missouri are given in Mineral Resources for 1911, Part II, pages 673–674.

A well-known representative of the Mississippian rocks is the limestone quarried at Carthage, Jasper County, at Phenix, Springfield, and Ash Grove, Green County, and near Hannibal, Marion County. The largest limestone-quarrying center in the State is at Carthage. Here the stone is of a remarkably uniform color, a faint bluish-gray in the quarry, and bluish white when cut and dressed. The rock is composed of medium-sized, irregular grains of calcite, closely interlocked, cemented by a calcite matrix. Analyses show more than 98.5 per cent of calcium carbonate and less than 0.25 per cent of iron oxide and alumina. The rock occurs in thick beds. Some chert is present near the base, but can easily be separated in quarrying This limestone shows stylolitic or suture jointing along the stratification planes, but these joints are generally so tight that the rock does not break readily along them. To avoid showing these stylolites on a sawed face the stone is generally sawed parallel to the bedding and laid on edge in the wall. Few limestones will admit of this practice, but in the case of the stone at Carthage the results appear to be satisfactory. The stone is considerably harder and consequently more difficult to saw and dress than limestones of the type quarried near Bedford, Ind., and it is also considerably stronger and denser and is less affected by the weather and by soot, gases, etc., than most other limestones.

The limestone quarried at Carthage is used principally for building purposes, either rock-faced, tooled, or hammered; some is polished for interior decoration; and a considerable quantity is burned for lime. Some producers term the rock a marble.

The limestone quarried at Phenix is more coarsely crystalline than that at Carthage. It has a bluish-gray color and uniform texture and occurs in thick beds. It is used for both building material and for lime manufacturing.

KANSAS.

Limestone.—Limestone beds belonging to four geologic divisions are abundant in Kansas. From the lowest up, these divisions are as follows: Mississippian series, Pennsylvanian series ("Coal Measures"), Permian series, and Cretaceous system.

Mississippian rocks occur only in one small area in the extreme southeast corner of Kansas, about 30 square miles in Cherokee County being covered by rocks of this age. This series is composed of limestone with interbedded chert and a few beds of shale. The limestone is usually heavy bedded and low in magnesia. It is said to be the rock that is extensively quarried at Carthage and other points in Missouri. Pennsylvanian rocks outcrop in the three eastern tiers of counties and in part of the counties in the fourth tier. Although made up mostly of shale and sandstone, the series includes many thin beds of limestone. Permian rocks occur west of the Pennsylvanian rocks and include a few beds of limestone. The chalk and chalky limestones of the Cretaceous occur in western Kansas. The principal outcrops are in Jewell, Smith, Phillips, Rooks, Osborne, Graham, Ellis, Trego, Grove, Logan, Ness, Lane, and Finney counties, and the same rocks are exposed in southern Nebraska and along Republican River.

A brief outline of the stone resources and industry of Kansas has been published by the University Geological Survey of Kansas,[1] from which the following quotation concerning limestone is taken:

> Years ago * * * Mississippian stone was quarried at Galena, at Lowell, and elsewhere for the production of lime. It is so abundant in quantity and so easily accessible along the hillsides that it is a great wonder more limekilns are not in operation. The same rock is quarried at different places in Missouri and burnt into lime, producing lime of a good quality, but no better than might be obtained from Kansas quarries.
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> To the northwest of Cherokee County many local quarries in heavy limestone formations have been operated, some of which are still operated in an irregular manner. The most extensive of these is the quarry at Iola, which has produced large quantities of dimension stone and sawed flagstone for local trade and for shipment to other points. The limestone at Iola exists in a layer nearly 40 feet thick, from which dimension blocks of any size or proportion desirable can be obtained.
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> Still farther to the northwest the next quarries are those along the banks of the Kansas River west of Kansas City, from which large quantities of stone are taken for ballast and for macadamizing streets. Near Kansas City a deposit of fragmentary material exists from which large quantities have been shipped for making sidewalks and for macadamizing streets and for similar puposes.
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> Other places furnish quantities of stone, the output of which would be greatly increased if the demand were sufficient to justify the extensive operation of quarries. Generally, however, it is principally a local demand, for which no statistics can be gathered, but which in the aggregate amounts to many thousands of dollars.
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> Still farther west a limestone exists which is remarkable in many of its properties, permitting it to be successfully quarried for all kinds of dimension stone wherever it comes to the surface. It is known commercially as the Cottonwood Falls limestone, because such large quantities have been shipped from Cottonwood Falls and Strong City to so many points within and without the State. The same rock has been quarried at a dozen or more places to the north of Cottonwood Falls, such as Eskridge, Alma, Manhattan, Beattie, and a number of other places. This limestone is not very thick, averaging from 5 to 8 feet, and generally consists of two individual layers, known in the markets as the "upper" and the "lower." The rock from the two layers differs slightly in quality, the lower one generally producing the best stone. Its most valuable properties are two—almost perfect uniformity of texture throughout and the absence of vertical fissures. It is white or light cream in color, fine and noncrystalline in texture, and well filled with the little rice-grain-like invertebrate fossils *Fusulina cylindrica*. The color is so uniform that when the stone is placed in a building the general color effect is very pleasing and satisfactory. The absence of vertical fissures and the uniformity of texture throughout make it possible to obtain dimension blocks of any size desired, which can be worked with perfect uniformity. * * *
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> A few hundred feet above the Cottonwood Falls limestone are heavy beds of the Permian limestone, which are unusually filled with flint nodules. These soft Permian limestones, carrying so much flint, are very serviceable for railroad ballast and are extensively quarried and crushed for this purpose at different places. The quarry near Strong City has probably yielded more ballast of this kind than any other one in the State, but extensive quarries are operated farther west along the Santa Fe at Florence and near Marion, and along the Rock Island at different points, all of which produce practically the same kind of stone.
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> In the central and west-central part of the State the Cretaceous limestones have been quarried to a great extent. On account of their soft, chalky character they are generally spoken of locally as a magnesian limestone, although such a term is entirely misapplied. A belt of country stretches across the State, by way of Beloit and Russell, throughout which a fine layer of limestone is quarried and broken into pieces suitable for fence posts. The Cretaceous limestones also serve many structural purposes in

[1] Haworth, Erasmus, Mineral resources of Kansas for 1897: Kansas Univ. Geol. Survey, pp. 74-76, 1898.

all of the cities and villages within the Cretaceous area. The rock is so soft it can easily be sawed into blocks and worked with chisel and hammer much more rapidly than ordinary limestone. This, added to its property of materially hardening after being quarried, greatly increases its value. None of it is what would be called a first-class building material, yet it is capable of being used in many ways to a great extent, and furnishes a convenient and durable structural material for that part of the State, which tolerably effectually prevents other stone from being shipped in.

More than 200 quarries report recent production of limestone in Kansas, including 22 quarries which supply stone for lime burning. All but 6 of the localities, which are in the Cretaceous, are in the Paleozoic limestone. The total number of limestone-producing counties in Kansas at present is 41, in 7 of which lime is burned. The largest item among the limestone products is crushed stone, although building stone and stone for paving are produced also in large quantities.

ARKANSAS.

Limestone and marble.[1]—The Ozark region of northern Arkansas is underlain by several formations containing limestone, some of which are of great beauty and value. Certain of the limestone beds are composed of crystalline calcite and take a fine polish, and they are therefore commercially classed as marble beds, although they do not fulfill all the requirements of the scientific definition of marble. In this description the term "marble" will be used in its broad and popular sense. In the Ozark region hundreds of miles of outcrop of limestone and marble are afforded by the dendritic drainage of White River and its tributaries. The rocks lie nearly horizontal and are generally finely exposed in the stream bluffs. The principal limestone and marble formations are the following: Magnesian limestone of Cambrian and Lower Ordovician age, several beds including "cotton rock"; Izard limestone, a blue, dense, amorphous stone, about 280 feet thick, of Ordovician age; the St. Clair marble (Silurian), a fine-grained fossiliferous crystalline rock, about 150 feet thick, varying in color from light gray to dark chocolate brown, the St. Joe limestone member of the Boone limestone (Mississippian), a fine to medium grained crystalline fossiliferous limestone, showing in some places an abundance of crinoid stems and varying in color from light pink to dark chocolate brown, also mottled with gray and green, having generally a thickness of 25 to 40 feet, but in places reaching 100 feet; gray crystalline limestone of the Boone limestone (Mississippian) in places oolitic, as near Batesville; the Pitkin ("Archimedes") limestone, of Mississippian age; and the Brentwood ("Pentremital") limestone member of the Bloyd shale, of Pennsylvanian age. These limestones and marbles, with the exception of those of Cambrian and Lower Ordovician age, which are highly magnesian, are all high in calcium carbonate. Relatively the great limestone and marble resources of northern Arkansas have been little developed, partly because of the lack of transportation lines and partly on account of the lack of large markets. Two railroads have been recently built in a northwest-southeast direction across the Ozarks, connecting the Frisco and Kansas City Southern lines on the west with the Iron Mountain route on the east, and this has led to the opening of a

[1] See the exceptionally full and detailed report of T. C. Hopkins, entitled "Marbles and other limestone": Arkansas Geol. Survey Ann. Rept. 1890, vol. 4, 443 pp. and atlas, 1893.

number of quarries near the new railroads. The limestone near Batesville is a grayish-white, hard, crystalline rock, and will take a good polish. It occurs in layers 3 to 5 feet thick, is comparatively free from seams or flaws, and it is reported that it can be quarried in as large pieces as can be handled. It makes an excellent building stone, and the new State capitol at Little Rock is being constructed from this material. The high degree of purity of many of the limestones of northern Arkansas renders them suitable for the manufacture of lime, and a thriving lime industry has been built up in this part of the State.

Twelve quarries in Arkansas have recently reported the production of limestone, besides 13 quarries which produced stone for lime, and 7 quarries have reported the production of marble. Thirteen counties comprise the area from which these three products are obtained. The principal uses for the limestone appear to be as crushed stone for concrete and as stone for building purposes.

LOUISIANA.

Limestone.—Practically the whole of Louisiana is within the Coastal Plain and is underlain by formations of Tertiary and Quaternary age, consisting principally of clay, sand, and soft limestone. Locally there are hard beds of limestone and sandstone in the Tertiary deposits, and if situated conveniently to transportation lines they may be quarried.

The only limestone reported as quarried in Louisiana is near Winnfield, Winn Parish. Hand specimens of this limestone sent to the Survey are of a dense, subcrystalline, bluish limestone, gashed and seamed with white calcite veins from the thickness of a knife blade up to three-fourths of an inch. The material makes a good crushed stone for ballast, macadam, and concrete. An analysis published in Mineral Resources for 1911 shows nearly 92 per cent calcium carbonate, and the material is probably suitable for the manufacture of lime.

OKLAHOMA.

Limestone.—Limestones of several different ages occur in Oklahoma. The earliest rocks are those of the Cambrian, Ordovician, and Silurian systems, which have a total thickness of nearly 8,000 feet, and make up a large part of the Arbuckle Mountains and the northern foothills of the Wichita Mountains. The lowest of these, the Arbuckle limestone, consists of limestone and dolomite of Cambrian and Ordovician age. It is 4,000 to 6,000 feet thick, and samples from the lower part and from the upper 600 or 700 feet which have been tested for magnesia and lime show a very small percentage of magnesia. Probably 2,000 feet of massive beds in the middle part of the formation are highly magnesian. The Viola limestone, of Ordovician age, 500 to 700 feet thick, outcrops in a belt about the border of the Arbuckle Mountains and in small areas in the central part. It also occurs in three small hills near Rainy Mountain Mission, in the Wichita Mountains. This formation contains local deposits of chert, but samples taken from the Arbuckle Mountain area show it to contain very little magnesia. It is fine textured and generally hard. Still higher lies the series of Silurian and Devonian limestones, which have been called "Hunton limestone," but which are now differentiated into several formations. They have an average thickness of about 200 feet, and vary in physical character and composition. A massive bed at the base is in places almost pure white limestone; in other places it is in large part siliceous. Toward the middle, beds of clay and "marl" are interstratified with the limestone. Near the middle the beds contain a small amount cf magnesia, and toward the top local segregations of chert are found. Like the Viola limestone these limestones outcrop around the borders of the Arbuckle Mountains in a narrow belt, besides occurring in many small areas in the central part of the uplift. In northern Oklahoma are a few belts of Carboniferous limestone, continuations of the areas which are so important in Kansas. These limestones thin out and disappear to the south and are of workable thickness only in the northern part of the State. Other thin-bedded limestones of Carboniferous age occur in eastern Oklahoma and extend into Arkansas north of the Boston Mountains. Along the southern edge of the coal field outcrops a long lentil of Mississippian limestone, the Wapanucka, which attains in places a thickness of nearly 300 feet. The eastern end of this belt extends nearly to the Arkansas line on the north flank of the Wichita Mountains and the western end reaches the Arbuckle Mountains. Gould [1] considers that the Wapanucka limestone is the most valuable limestone in the State for general utility. Near Bromide the stone is white and oolitic and makes an excellent building stone, the ledge being 50 to 70 feet thick. At Wapanucka and Hartshorne this stone is burned into lime; at Limestone Gap it is crushed for ballast and concrete; and at Hartshorne it is planned to use it as Portland cement material.

Cretaceous limestones occur in the southern part of the State, and several distinct formations are associated with limy clays. These limestones are mostly soft, thin bedded, and of various shades from light-blue to white. The lowest bed is massive, white, and generally homogeneous.

Gould [2] discusses the limestones of Oklahoma according to six separate areas: Northern Oklahoma, the Ozark uplift, the Wapanucka limestone area (in southeastern Oklahoma), the Cretaceous area (south of Wapanucka area), the Arbuckle Mountains area, and the Wichita Mountains area. In his discussions and in his maps Gould appears not to have included limestones that, according to reports to the United States Geological Survey from producers of stone and lime, outcrop in Major, Dewey, Blaine, northern Kiowa, Greer, and Jackson counties, and which are apparently in the area of Permian rocks.

Limestone has been quarried recently in 27 counties of Oklahoma from a total of 67 quarries, 10 of which quarries produced stone for lime.

Marble.—One deposit of true marble has been discovered in Oklahoma. It is exposed at several localities along Sallisaw Creek, in Sequoyah County. Its color ranges from pure white to pink and in places it is mottled. This deposit is near the Mississippian-Pennsylvanian geologic boundary, but is probably within the Mississippian area.

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[1] Gould, C. N., and others, Preliminary report on the structural materials of Oklahoma: Oklahoma Geol. Survey Bull. 5, pp. 77–78, 1911.
[2] Idem, pp. 72–83.

This marble has been quarried near Marble City, and most of the product used for building stone, some of it in the construction of buildings in Oklahoma City.

TEXAS.

Limestone.—The sedimentary rocks of Texas include representatives of most of the systems from the Cambrian to the Tertiary. Hard rocks of Paleozoic age extend well into north-central Texas. Tertiary rocks of the Great Plains underlie the western part of Texas as far south as Pecos River. On the Gulf Coast of Texas are sand and clay of Quaternary age, with three parallel belts of Tertiary rocks of different stages of deposition lying farther inland, while still farther in the interior, or extending in a northeast-southwest direction across central Texas and beyond Red River into southeastern Oklahoma, are two belts of Cretaceous rocks.

Limestone occurs in rocks of the Cambrian, Ordovician, Carboniferous, Cretaceous, and Tertiary systems. In particular, the Cretaceous of central Texas consists very largely of limestone. The principal area of Cretaceous rocks occurs as a wide belt extending southward across the central part of the State from Red River to the Rio Grande. The cities of Sherman, Dallas, Fort Worth, Waco, Austin,[1] and San Antonio are located on this belt. A railroad either follows or parallels this belt of Cretaceous rocks, and many railroads cross it. Two divisions of the Cretaceous system contain limestone deposits of remarkable purity. These are the Austin chalk and the limestones of the Fredericksburg group (Goodland limestone to the north and Edwards limestone and Comanche Peak limestone to the south). The Austin chalk is massive white, friable, chalky limestone. It is several hundred feet thick and carries from 70 to 90 per cent of carbonate of lime and generally less than three-fourths of 1 per cent of magnesium carbonate. The silica is variable, and in places increases in quantity as the lime carbonate decreases. The limestones of the Fredericksburg group are situated west of and generally parallel to the outcrop of the Austin chalk. They occur in large areas in Wise, Parker, Hood, Erath, Bosque, Hamilton, Coryell, Lampasas, Burnet, Blanco, Kendall, Comal, and Bexar counties. Large areas are exposed in the Edwards Plateau west of San Antonio. North of the Brazos River valley they are represented by the Goodland limestone, a massive, semicrystalline, white limestone 30 to 50 feet thick. From the Brazos River valley southward they gradually increase in thickness, reaching 300 feet on Colorado River. In central Texas the lower part is a massive white chalky limestone nearly 100 feet thick (Comanche Peak limestone), and the upper part is composed of thick beds of nearly pure chalky and siliceous limestone alternately stratified (Edwards limestone). These siliceous beds contain quantities of nodular and almost pure flints.

Limestone has been produced from 64 quarries in Texas within the last three years, 29 of which produce stone for lime. These quarries are distributed among 31 counties. By far the greater part of the output of limestone not used for making lime is sold as crushed stone for macadam, ballast, and concrete.

[1] Burchard, E. F., Structural materials available in the vicinity of Austin, Tex.; U. S. Geol. Survey Bull. 430, pp. 299-303, 1910.

Marble.—True marble is found in Mason County, central Texas, and in several counties of trans-Pecos Texas, and beds of crystalline limestone susceptible of a good polish are found in many other parts of the State. Dumble [1] states that among the true marbles of Mason County are beds that are snowy white and of even grain. From the Carrizos to the Quitman Mountains outcrops of fine-grained marble occur in the vicinity of the railroad, and include white as well as banded and clouded varieties. Bluish limestone probably of Lower Ordovician age outcropping at Marble Falls, Burnet County, is of a dense subcrystalline character, and will doubtless take a good polish. Other varieties of nonmetamorphosed marble are reported to occur elsewhere in Burnet County, and in Llano, San Saba, Gillespie, and other counties, and many of them are well adapted for interior decorative purposes. Certain quarries in areas of Cretaceous and Tertiary rocks, remote from any intrusive rocks, report the production of marble which is in reality limestone susceptible of receiving a good polish. The fossiliferous Cretaceous limestone at Austin, known locally as the "Austin marble," is to be classed as such.

MONTANA

Limestone.—Limestone is found chiefly in the mountainous western part of Montana, where it occurs in great abundance along the flanks of the mountain ranges. In the Plains region, which comprises the eastern two-thirds of the State, the formations are mostly of Cretaceous age, except in the local uplifts of the Little Rock, Judith, and Snowy Mountains. The Cretaceous formations contain lenses and concretions of limestone which are available for burning to quicklime. In the mountainous regions the limestones are mainly of Paleozoic age, and the principal limestone-bearing series is the Mississippian, whose massive beds flank the great ranges of the State. Devonian and Silurian limestones are impure and the Cambrian limestones are thin bedded and generally irregular in composition. Limestone beds outcrop along the northern slope of the mountain front from Red Lodge, in Carbon County, westward to Livingston, northward about the flanks of the Bridger, Little Belt, and Belt ranges to the Main Range west of Great Falls. Practically all the southern ranges of the western part of the State are uplifts with cores of gneiss or granite mantled by limestones of various ages. Such rocks occur westward almost to the Bitterroot Valley. Deposits of interesting limestones occur about 5 miles south of Havre. These limestones are notable because the action of igneous intrusions has produced in them considerable wollastonite, a natural lime silicate.

Limestone is quarried in 12 counties in Montana, a total of 23 quarries having been enrolled as producers in recent years. At 12 of these quarries in 8 counties, the stone produced was used for the manufacture of lime. Over two-thirds of the value of the limestone output came from sales of stone for smelter flux, although much of the limestone that is now produced in Montana is burned into lime that is used in the refining of beet sugar. Analyses of limestones quarried in Carbon, Cascade, Gallatin, Jefferson, Lewis and Clark, and Park counties were published in Mineral Resources for 1911, Part II, page 675. Nearly

[1] Dumble, E. T., Building stones of Texas: Stone, vol. 5, p. 567, 1892.

all these rocks, especially those that are high in calcium carbonate, are used in beet-sugar factories.

Marble.—The production of marble has recently been reported from quarries in Gallatin and Lincoln counties. No data are at hand as to the character of the Lincoln County rock. According to Rowe[1] the marble near Manhattan, Gallatin County, is similar to Mexican onyx and takes a splendid polish. He states that marble has also been quarried in Nelson Gulch, 6 miles southwest of Helena, and at Dempsey Creek, Powell County. The deposits in Nelson Gulch are reported to show seven distinct varieties of marble, including white statuary marble, marble for monumental work, and blue marble suitable for building.

WYOMING.

Limestone.—There are thick and extensive deposits of limestone in the Paleozoic and Cretaceous formations in Wyoming. The Paleozoics lie on the flanks of the crystalline rock masses of the mountains and the Black Hills. The Cretaceous beds border the Paleozoics around the mountain uplifts. Quarries have been opened from which stone for the manufacture of lime and for use in beet-sugar refining is obtained, as well as crushed stone for ballast and concrete. Many of these limestones, especially those found in Albany, Carbon, Laramie, and Weston counties are nearly pure calcium carbonate. Analyses of several of these limestones were published in Mineral Resources for 1911, Part II, pages 697–698. Ten quarries in six counties produce limestone in Wyoming. The bulk of the output goes to beet-sugar factories, some of which are in other States.

Marble.—Marble has been reported from several places in Wyoming. In Muskrat Canyon fine-grained reddish marble, variegated with white and drab colors, as well as pink marble of uniform color are reported to occur. White and greenish marbles of good quality are reported to occur in Cedar Creek in the eastern part of the Platte River valley. White crystalline limestone or marble with mossy veining is reported to occur about a mile west of the railway near Iron Mountain station. It has been suggested by Darton[2] that possibly limestone in the upper part of the Madison limestone (Mississippian), in the Bighorn Mountains might be worked for marble. A deposit near Hartville is reported as a possible future marble producer.

COLORADO.

Limestone.—The limestones of Colorado may conveniently be divided geographically and geologically into two groups. The first of these groups includes limestone mostly of Cretaceous age, which occurs in the Plains region of the eastern half of the State and in a narrow belt immediately east of the Front Range. The second group includes the limestones mostly of Carboniferous age, which lie west of the Front Range. The two limestone formations of greatest importance in the Cretaceous system are the Niobrara and the Greenhorn. The Niobrara outcrops as a narrow but fairly continuous belt

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[1] Rowe, J. P., Some economic geology of Montana: Montana Univ. Bull. 50, Geol. ser. No. 3, pp. 48–49, 1908.
[2] Darton, N. H., Geology of the Bighorn Mountains: U. S. Geol. Survey Prof. Paper No. 51, p. 115, 1906.

from the Wyoming line southward to Colorado Springs, passing just west of Fort Collins and Denver. South of Colorado Springs are two areas of limestone of Niobrara age, which occupy much of Pueblo, Otero, Huerfano, Las Animas, Bent, Prowers, Kiowa, and Cheyenne counties, the upper area of outcrop lying along Arkansas River, from near Florence to the Kansas line. The thickness of the Niobrara is about 400 feet, but calcareous shale makes up a considerable part of this thickness.

In central and western Colorado limestones of Mississippian age cover large areas. Analyses of limestones from a number of points in Garfield, Grand, Gunnison, Jefferson, Park, Pitkin, and Summit counties indicate that they are low in magnesia.

The abundance of easily worked sandstone, as well as the suitability of much of the granite for building purposes in Colorado, has retarded the development of any of the limestone beds in this State for building purposes. Such limestones as are used as building stone are of the crystalline variety and are classed as marble. For chemical uses and the manufacture of lime the limestones of Colorado are much in demand. Limestone is quarried in 13 counties in Colorado, 8 of which produce lime, and a large output is recorded.

Marble.—Marble deposits have been known in several counties in Colorado for more than 30 years, but only within the last six or seven years has any important development taken place. Merrill[1] states that a specimen of handsome black, white-veined breccia marble has been sent to the National Museum from Pitkin; that a chocolate-colored marble is reported to occur near Fort Collins, and a breccia marble near Boulder. According to records of the Colorado State School of Mines, Denver, 1884, a white dolomitic marble is reported from Calumet, Chaffee County. A yellow marble stated to resemble the famous Siena marble of Italy has been reported to the Survey from near Canon City.

The most extensively developed deposits of marble in Colorado are on Yule Creek, in northern Gunnison County. The deposits that are quarried here are high on the left bank of the creek and dip westward at an angle of about 52°. The marble bed is reported to be about 240 feet thick and to contain four bands of chert each 2 to 4 feet thick. The underlying rock is cherty blue dolomite, and overlying the marble is a sill of igneous rock which is, in turn, overlain by 500 to 800 feet of blue cherty limestone. The marble itself is for the most part white and of medium fine grain, but there are bands of handsome green-stained material within the mass. This quarry has a complete equipment and has maintained a large output of marble for several years. The rock is carried to the mill at Marble, about 3½ miles distant by an electric tramway. At the marble mill, which is electrically driven and is one of the most completely equipped in the United States, the product is sawed, planed, turned, polished, carved, and otherwise prepared for all kinds of interior and exterior construction work. This white marble has been used for interior decoration in the Cuyahoga County courthouse at Cleveland, Ohio, in the Chessman Park shelter house, Denver, Colo., in office buildings at Salt Lake City, and elsewhere, and is being used in the Lincoln Memorial Temple at Washington, D. C.

[1] Merrill, G. P., Stones for building and decoration, p. 208, 1903.

NEW MEXICO.

Limestone.—Limestone of the Cambrian, Ordovician, Carboniferous, and Cretaceous systems occur in New Mexico, although little is known concerning their chemical and physical properties, except where they have been studied in connection with metalliferous and coal deposits. In the vicinity of Carthage, Socorro County, the Pennsylvanian San Andreas limestone has a thickness of about 200 feet and outcrops within half a mile of a railroad. Limestone quarries are situated in 8 counties, of which 6 have produced stone for the manufacture of lime. The output of limestone other than for lime is used for railroad ballast and concrete.

Marble.—Marble, which is also widely distributed in New Mexico, has been reported as quarried in the following counties: Grant, Guadalupe, Lincoln, Luna, and Otero. Only a small production is maintained at present, since most of the quarries are idle.

WESTERN AND PACIFIC COAST STATES.

The literature and unpublished data available on the limestone and marble deposits of the United States west of the Rocky Mountains is so fragmentary that it is not practicable to construct at this time even a reconnaissance map of these rocks. There is presented, however, elsewhere in the current volume of Mineral Resources (in the chapter on the stone industry in 1913), a discussion of these resources by States, and the stone quarry maps accompanying that chapter show the location of all limestone and marble quarries and limekilns.

CHARACTER OF LIME PRODUCED IN VARIOUS STATES.

The following tabular outline indicates, by States and counties, whether high-calcium or magnesian lime, or both, is being burned in a given locality:

Character of lime proaucea in the United States in 1913, by States and counties.

State or Territory.	County.	
	High-calcium lime.	Magnesian lime.
Alabama	Blount	Colbert.
	Calhoun	Shelby.
	Dekalb	
	Etowah	
	Jefferson	
	Madison	
	Shelby	
Arizona	Coconino	
	Yavapai	
Arkansas	Benton	
	Izard	
	Washington	
California	Amador	Siskiyou.
	Contra Costa	
	Eldorado	
	Kern	
	Mono	
	Placer	
	San Benito	
	San Bernardino	
	Santa Cruz	
	Shasta	
	Siskiyou	
	Tuolumne	
	Ventura	

Character of lime produced in the United States in 1913, by States and counties—Contd.

State or Territory.	County.	
	High-calcium lime.	Magnesian lime.
Colorado	Chaffee	Boulder.
	Douglass	Fremont.
	Fremont	La Plata.
	La Plata	
Connecticut	Fairfield	Fairfield.
		Litchfield.
Florida	Marion	Marion.
Georgia	Walker	Bartow.
Hawaii	Hawaii	
Idaho	Bannock	Cassia.
	Bear Lake	Lemhi.
	Cassia	
	Kootenai	
	Lemhi	
	Nez Perce	
	Oneida	
Illinois	Adams	Cook.
	Carroll	Kankakee.
	Madison	Rock Island.
	Will	Whiteside.
		Winnebago.
Indiana	Bartholomew	Bartholomew.
	Carroll	Huntington.
	Crawford	Jay.
	Harrison	Jefferson.
	Lawrence	
	Ripley	
	Washington	
Iowa	Cerro Gordo	Dubuque.
	Clayton	Jackson.
Kansas	Elk	Shawnee.
	Leavenworth	
Kentucky	Breckenridge	Meade.
	Meade	Warren.
	Rockcastle	
	Scott	
	Warren	
Maine	Knox	Knox.
Maryland	Allegany	Allegany.
	Baltimore	Baltimore.
	Carroll	Carroll.
	Frederick	Frederick.
	Garrett	Garrett.
	Howard	Washington.
	Washington	
Massachusetts	Berkshire	Berkshire.
Michigan	Alpena	Bay.
	Arenac	Emmet.
	Bay	Menominee.
	Charlevoix	Schoolcraft.
	Cheboygan	
	Emmet	
	Mackinac	
	Schoolcraft	
	Wayne	
Minnesota	Mower	Blue Earth.
	Scott	Goodhue.
Missouri	Callaway	Cole.
	Cape Girardeau	
	Cooper	
	Dade	
	Franklin	
	Greene	
	Jasper	
	Jefferson	
	Lawrence	
	Marion	
	Miller	
	Osage	
	Pettis	
	Pike	
	Ralls	
	St. Clair	
	St. Genevieve	
	St. Louis	
Montana	Deerlodge	Madison.
	Powell	Park.
Nevada	Lyon	

Character of lime produced in the United States in 1913, by States and counties—Contd.

State or Territory.	County.	
	High-calcium lime.	Magnesian lime.
New Jersey	Hunterdon	Hunterdon.
	Sussex	Somerset.
	Warren	Sussex.
		Warren.
New Mexico	San Miguel	Grant.
		San Juan.
		Santa Fe.
New York	Clinton	Albany.
	Fulton	Dutchess.
	Genesee	Jefferson.
	Herkimer	Orange.
	Jefferson	Ulster.
	Lewis	Westchester.
	Livingston	
	Monroe	
	Niagara	
	Onondaga	
	St. Lawrence	
	Ulster	
	Warren	
	Washington	
North Carolina	Columbus	Swain.
	Craven	
	Henderson	
	Yadkin	
Ohio	Delaware	Belmont.
	Erie	Clark.
	Holmes	Greene.
	Marion	Hardin.
	Ottawa	Montgomery.
	Preble	Ottawa.
	Stark	Sandusky.
	Tuscarawas	Seneca.
		Wood.
		Wyandot.
Oklahoma	Coal	
	Delaware	
Oregon	Baker	
	Jackson	
	Josephine	
	Wallowa	
Pennsylvania	Adams	Armstrong.
	Armstrong	Bedford.
	Bedford	Berks.
	Berks	Chester.
	Blair	Cumberland.
	Bucks	Dauphin.
	Butler	Franklin.
	Center	Huntingdon.
	Chester	Jefferson.
	Clarion	Juniata.
	Clinton	Lancaster.
	Columbia	Lawrence.
	Cumberland	Lebanon.
	Dauphin	Lehigh.
	Fayette	Lycoming.
	Franklin	Monroe.
	Huntingdon	Montgomery.
	Jefferson	Montour.
	Juniata	Northampton.
	Lancaster	Northumberland.
	Lawrence	Perry.
	Lebanon	Union.
	Lycoming	Westmoreland.
	Montgomery	York.
	Montour	
	Northampton	
	Northumberland	
	Perry	
	Snyder	
	Somerset	
	Union	
	Westmoreland	
	York	
Rhode Island		Providence.
South Dakota	Custer	Meade.
	Lawrence	
	Meade	
	Pennington	

Character of lime produced in the United States in 1913, by States and counties—Contd.

State or Territory.	County.	
	High-calcium lime.	Magnesian lime.
Tennessee	Carter	Rhea.
	Coffee	
	Cumberland	
	Davidson	
	Dickson	
	Franklin	
	Houston	
	Knox	
	Lawrence	
	Montgomery	
	Rhea	
	Union	
	Washington	
Texas	Comal	Coryell.
	Coryell	El Paso.
	Dallas	Tarrant.
	El Paso	
	Nolan	
	San Saba	
	Travis	
	Williamson	
Utah	Cache	Cache.
	Salt Lake	Salt Lake.
	Sanpete	Wasatch.
	Sevier	Weber.
	Utah	
	Wasatch	
Vermont	Addison	Windsor.
	Chittenden	
	Franklin	
	Rutland	
	Windham	
Virginia	Augusta	Augusta.
	Botetourt	Frederick.
	Frederick	Loudoun.
	Giles	Montgomery.
	Montgomery	Rockbridge.
	Rockbridge	
	Rockingham	
	Russell	
	Shenandoah	
	Tazewell	
	Warren	
	Washington	
Washington	Chelan	San Juan.
	Ferry	Stevens.
	Okanogan	
	San Juan	
	Stevens	
	Whatcom	
West Virginia	Berkeley	Berkeley.
	Greenbrier	Jefferson.
	Jefferson	Preston.
	Preston	Wayne.
Wisconsin	Door	Buffalo.
	Lafayette	Calumet.
	Oconto	Dodge.
	Waukesha	Door.
		Fond du Lac.
		Kewaunee.
		Manitowoc.
		Outagamie.
		Ozaukee.
		Shawano.
		Sheboygan.
		Trempealeau.
		Vernon.
		Washington.
		Waukesha.
Wyoming	Carbon	

THE MANUFACTURE AND USE OF LIME.

By Warren E. Emley.

GENERAL DISCUSSION.

DEFINITION AND CLASSIFICATION OF LIME.

Strictly speaking, lime is the oxide of calcium. It can be prepared by heating calcium carbonate under such conditions that the compound is decomposed, the carbonic acid is driven off as a gas, and the calcium oxide remains as lime. Calcium carbonate occurs in nature as calcite, which is the main constituent of limestone. It is almost always associated with impurities, such as silica, the oxides of iron and aluminum, and magnesium carbonate. With the exception of magnesia, these impurities may be found in almost any proportions, so that there is no sharp line of distinction between limestone on the one hand and sandstone, cement rock, or clay on the other. Any of these substances can be heated in such a manner that whatever calcium carbonate they contain will be decomposed. This makes it necessary to set an arbitrary limit by stating that the resultant product must contain at least a certain proportion of calcium oxide in order that it may be called lime. The chief physical characteristic of lime is that it will slake when treated with water. The slaking is accompanied by an evolution of heat and an increase in volume, and results in the formation of a plastic putty. It has been found that if the impurities are present in too large proportions this power of slaking is impaired or destroyed. If the ability to slake is considered as a condition which a substance must fulfill in order that it may be called lime, then experience tells us that the product of calcination of a limestone is lime only when the sum of the silica, ferric oxide, and alumina is less than 5 per cent.[1] It has been found that magnesia does not impair the slaking power of the lime seriously and that the presence of this substance improves the quality of the lime for many purposes. From a commercial standpoint, magnesia is not considered as an impurity, and limes are classified according to their composition as follows:

Classification of lime.

High-calcium lime contains 0 to 5 per cent magnesia.
Magnesian lime contains 5 per cent to 25 per cent magnesia.
Dolomitic lime contains 25 per cent to 45 per cent magnesia.
Superdolomitic lime contains over 45 per cent magnesia.

This classification is the one officially adopted by the National Lime Manufacturers' Association. The definitions given by Mr. Burchard conform more nearly to the proper and generally accepted uses of the terms, viz: High-calcium lime is made from stone containing more than 93 per cent calcium carbonate; magnesian lime is made from stone containing 7 per cent or more of magnesium carbonate; dolomitic lime is a special grade of magnesian lime in which the ratio of calcium oxide to magnesium oxide is very nearly 8 to 5.

[1] Glossary of terms: Nat. Lime Mfrs. Assoc. Trans., 1910, pp. 14–24.

MANUFACTURE.

PROCESS OF MANUFACTURE.

QUARRIES.

QUALITY OF STONE.

The quality of limestone suitable for burning may vary, both chemically and physically, within rather wide limits. Chemical analyses of some samples of stone used for manufacture of lime are given in the accompanying table. They were made under the direction of Mr. P. H. Bates, chemist, by Mr. A. J. Phillips, assistant chemist, of the Bureau of Standards of the Department of Commerce.

The chemical composition of a lime depends on that of the stone from which it was made. Consequently only those limestones may be used from which a marketable lime can be produced. It must be remembered that on account of the loss of about half the weight of the stone as carbon dioxide during the burning the proportion of every other constituent of the stone will be nearly doubled in the lime. The composition which a lime should have for any given purpose is a much-mooted question and will be fully discussed in the following chapter on the uses of lime.

For the present it may be stated that the presence of a rather large proportion of impurities in the stone is permissible, except where a finishing lime or a particular grade of chemical lime is to be made. The ratio of calcium to magnesium desired depends largely on the market in the particular locality. When the lime is sold for chemical purposes, this ratio will generally be specified.

Chemical composition.—The chemical composition of the stone influences the cost of burning. Experience has shown that it generally requires less heat and a lower temperature to burn a magnesian than a high-calcium stone. The greater the proportion of impurities, the more easily is the lime overburned, and therefore too large a proportion of these constituents will cause a diminution of the capacity of the kiln. It is possible that the proportion of silica may be high enough to form the dicalcium silicate ($2CaO.SiO_2$). This substance when cooled slowly assumes allotropic forms. Thus, at 675° C. (1,247° F.) it charges from β to the γ modification, with a marked increase in volume.[1] This causes the lime to fall to pieces, a phenomenon commonly known as "fire slaking."

From the chemical analyses of the samples of stone collected it will be seen that the quantity of lime varies from 29.77 per cent to 55.56 per cent, and of magnesia from 0.31 per cent to 21.23 per cent, but that the total quantity of both carbonates combined in any stone is never much less than 97 per cent. The silica is occasionally somewhat over 2 per cent without injury to the stone for lime burning, but the alumina and oxide of iron are generally under 0.5 per cent. It must be remembered, however, that this investigation did not cover the entire field, and that limes are produced in which the proportion of impurities is so high that they are practically natural cements.

[1] Day, A. L., and Shepherd, E. S., The lime-silica series of minerals: Am. Chem. Soc. Jour., p. 1089, 1906.

Analyses of limestones.[a]

Company and location.	No.	Designation of stone.	Silica (SiO_2).	Alumina (Al_2O_3).	Iron (Fe_2O_3).	Calcium carbonate ($CaCO_3$).	Magnesium carbonate ($MgCO_3$).	Total.
Rockland-Rockport Lime Co., Rockland, Me.	1	Soft	1.29	0.15	0.35	95.91	2.27	99.97
	2	Rockport	2.41	.22	.40	85.18	11.72	99.93
Farnam-Cheshire Lime Co., Cheshire, Mass.	3	(b)	.44	.08	.20	98.05	1.30	100.07
Connecticut Lime Co., Canaan, Conn.	4	(b)	.34	.19	.28	58.20	41.16	100.17
New Jersey Lime Co., Hamburg, N. J.	5	McAfee	.85	.06	.20	96.70	2.04	99.85
	6	Hamburg	1.21	.41	.45	95.70	2.25	100.02
Chas. Warner Co., Cedar Hollow, Pa.	7	West end south quarry.	.81	.56	.47	54.68	43.66	100.17
	8	East end south quarry.	.91	.09	.30	63.02	35.78	100.10
	9	North quarry [c]	2.27	.51	.40	53.16	43.89	100.23
	10	Whiteland	.94	.15	.45	54.09	44.58	100.21
Lowell M. Palmer Co., York, Pa.	11	White	.53	.04	.05	99.21	.74	100.57
	12	Blue	.14	.02	.10	98.73	1.01	100.00
American Lime & Stone Co., Bellefonte, Pa.	13	Calico	.27	.07	.30	86.43	12.98	100.05
	14	Quarry No. 13	1.41	.25	.40	96.36	1.55	99.97
Thomasville Stone & Lime Co., Thomasville, Pa.	15	(b)	.15	.10	.15	99.02	.57	99.99
Riverton Lime Co., Riverton, Va.	16	Slaty	.42	.07	.32	97.20	2.02	100.03
	17	Oily	.36	.07	.22	96.07	3.26	99.98
	18	(b)	.46	.06	.20	89.20	10.14	100.06
E. Dillon's Sons, Indian Rock, Va.	19	Lower quarry	.28	.16	.20	98.50	.78	99.92
	20	Upper quarry	.80	.10	.35	97.05	1.72	100.02
	21	Fertilizer [d]	1.05	.40	.55	96.21	1.76	99.97
Tennessee Marble Lime Co., Knoxville, Tenn.	22	Main quarry	.16	.13	.06	98.93	.76	100.04
	23	Other quarries	.23	.08	.20	98.25	1.26	100.02
	24	Luttrell	.65	.05	.30	84.50	14.53	100.03
Lagarde Lime & Stone Co., Lagarde, Ala.	25	(b)	1.64	.33	.31	94.39	3.42	100.09
Ash Grove White Lime & Portland Cement Co., Ash Grove, Mo.	26	(b)	.10	....	.05	99.05	.88	100.08
Glencoe Lime & Cement Co., Glencoe, Mo.	27	Gray	.32	.13	.30	98.29	1.05	100.09
	28	Blue	.21	.06	.15	98.89	.67	99.98
	29	Brown	.26	.02	.20	98.84	.65	99.97
	30	White [c]	1.35	.53	.40	94.89	3.05	100.22
Marblehead Lime Co., Marblehead, Ill.	31	(b)	.21	.04	.10	98.45	1.28	100.08
Sheboygan Lime Works, Sheboygan, Wis.	32	(b)	.55	.24	.40	55.09	43.91	100.19
Union Lime Co., High Cliff, Wis.	33	(b)	1.12	.06	.40	54.82	43.79	100.19
White Marble Lime Co., Manistique, Mich.	34	Manistique [c]	1.92	.03	.30	54.04	43.81	100.10
	35	Blaney	1.23	.19	.50	94.38	3.74	100.04
	36	Marblehead	.56	.05	.20	55.00	44.31	100.12
	37	Indian Dam	1.04	.05	.25	54.25	44.52	100.51
Woodville White Lime Co., Woodville, Ohio.	38	(b)	.34	.02	.15	56.79	42.92	100.22

[a] For a more extended tabulation of analyses of limestones and limes, see Burchard, E. F., The production of lime in 1911: U. S. Geol. Survey Mineral Resources, 1911, pt. 2, pp. 658-707, 1912.
[b] Average of stone burned for lime.
[c] Not burned for lime.
[d] Burned for fertilizer only.

Physical properties.—So far as its physical properties are concerned, any kind of limestone is suitable for burning. These properties do, however, influence the cost of production to a noticeable extent. Experience has shown that fine-grained, dense stone can be burned at a lower temperature and with less heat than one which is coarsely crystalline and porous. Coarsely crystalline stones, especially if very pure, are apt to fall to pieces in the kiln, thus reducing the production of lump lime. The same occurrence is sometimes noticed when a porous stone is used, although in this case it is probably due to the rapid expulsion of water from the pores. On the other hand, laboratory work done by the Bureau of Standards indicates that "all naturally porous stones lost their carbon dioxide at a lower temperature, 900° C. (1,652° F.), than the denser materials."[1] Why these laboratory results are contradicted in practice is a subject for future investigation, and is probably dependent upon the size of the pieces of stone, the quantity of material used, and similar factors.

Whether a limestone is porous or not, its water content is of importance, for this water must be evaporated, with the consequent loss of heat and lowering of kiln efficiency. Moreover, some of the water, in chemical composition with the clayey impurities of the stone, will probably not be given off until the stone has reached a red heat. This will require the stone to remain in the burning zone for a longer time and may therefore reduce the kiln capacity to some extent.

Evidently the first point to be considered in the manufacture of lime is the selection and opening of a suitable deposit of stone. The quality of stone required is noted above. It should be ascertained that the quality is reasonably uniform throughout the deposit and that a sufficient quantity of stone is above drainage level, so that the quarry floor will not be continually under water. Transportation facilities and other details of similar importance should be carefully considered.

QUARRYING.

On account of the extreme variations of limestone deposits it is impossible to formulate any definite rules for quarrying which will apply to all of them. However, a few generalities may be stated.

Thus it is usually true that the quality of the stone throughout the same bed (within a small area) will be more nearly uniform than that from different beds. It is therefore advisable in opening a quarry to follow either the dip or the strike of the beds rather than to cut across them.

If a quarry can be so located that its floor is above the tops of the kilns, the cost of hoisting stone can be eliminated. Where this is not possible, it would seem best to maintain the floor at above the drainage level. From a given area this will render available the maximum quantity of stone which can be obtained without pumping. In some cases the value of real estate is sufficiently high to warrant quarrying stone below drainage level, even though a considerable quantity of water must be pumped. An economical method of handling the water is to drain it into a "water hole" or "sump" and to raise it to the surface by means of a bucket elevator.

Experience seems to indicate that the cost of labor and explosives will be less if the quarry can be worked with a vertical rather than a horizontal face and that a vertical face can be worked to best advantage when about 20 feet high. If it is much higher than this, especially designed methods of quarrying must be employed, or the cost of explosives will be increased. Faces higher than 20 feet can be worked in "benches" or sections, each of which is about the height required.

Stripping.—"Stripping" is the name technically applied by quarrymen to the overburden material which covers a deposit of stone. It

[1] Bleininger and Emley, Burning temperature of limestone: Nat. Lime Mfrs. Assoc. Trans., 1911, p. 77.

may consist of almost any material, but the substances generally met with in the lime industry are clay, gravel, and impure or weathered limestone. The clay or gravel may be of commercial value, and the impure or weathered limestone is generally marketable as ballast or for road material. However, stone to be used for lime manufacture should be quarried where the stripping is as little as possible. The impure limestone, and more especially the clay, is apt to become mixed with the stone for burning and may thus impair the quality of the lime.

If the beds of stone are nearly horizontal and are covered by clay or gravel of uniform thickness, the stripping may be done by hand digging and hauling in carts, by the use of the plow and scraper, or by means of the steam shovel, according to the thickness of the overburden. If the beds are horizontal, but the country is hilly, it is evident that the thickness of the stripping will vary with the height of the hill. Clay from such a formation can be washed away by hydraulic pressure where a sufficient volume of water is available and drainage is possible. Sometimes, however, this method ceases to be economical, and underground mining of the limestone must be practiced.

One method of mining consists of driving horizontal entrances 18 feet high by 50 feet wide into the face of a quarry, leaving enough stone intact to form a roof and the necessary supporting pillars. In a mine of this type, and in an open pit quarry which is driven downward only, the stone is inclosed on five sides. Consequently, the cost of labor and explosives is much higher in a mine than in a hillside open quarry.

In some localities the beds of stone are steeply tilted and the outcropping edges have been eroded. The stripping in such a place is apt to occur in pockets or cavities which may extend down some distance between the beds. Wherever there are many pockets of considerable size a steam shovel may be employed to advantage.

Drilling.—After the stripping, or overburden, has been removed holes are drilled in the stone preparatory to blasting. This is generally accomplished by means of a common bar drill, operated by steam, compressed air, or electricity. The holes are from 1½ to 2 inches in diameter by from 10 to 26 feet deep, depending upon the available depth of stone. Vertical holes are drilled in a row from 4 to 8 feet back of the working face of the quarry and from 5 to 15 feet apart. The distance between holes is governed by the hardness and bedding of the stone and by the fineness to which it is desired to shatter it.

Compressed air is very well suited for this purpose. The air compressor may be installed in the central power plant, since there is very little loss during the transmission to the quarry. The air may be carried by a 4-inch or 6-inch pipe, from which it can be distributed to the drills by 1-inch leads. It is generally compressed to 90 pounds pressure.

Electricity has many economical advantages over compressed air. The loss of power during transmission is less. The current may be used for other purposes besides drilling. Time will be saved, because in moving a drill from place to place, it is necessary merely to connect another length of wire instead of being obliged to cut and fit pipe. When a blast is made, pipes are apt to be covered up or damaged, but wires can easily be moved out of the way. A common type of electric drill consists merely of an ordinary bar drill operated by a small electric motor which is supported on the tripod of the drill.

On the other hand, steam would seem in most instances to be the least economical power for drills. If the quarry is at a distance from the kilns, steam can not be generated economically in a central power plant on account of the high cost of transmission; therefore a boiler for this especial purpose must be maintained at the quarry. This entails extra labor and handling of fuel, and even then the loss of power in the pipes leading to the drills is apt to be very large on account of loss by radiation, condensation, and freezing when not in use.

Recently the well drill has replaced the bar drill in many large operations. The holes made are 4 to 6 inches in diameter by as much as 80 feet deep. These can be placed much farther apart than the smaller holes; the quantity of rock thrown down at one blast is generally much larger, and it is not necessary to blast so frequently.[1]

Blasting.—It is the general practice in quarrying stone for the manufacture of lime to blast it loose. Blasting also serves the purpose of breaking the stone to pieces small enough to be put into the kiln. Based on these two purposes, two methods of blasting are in common use—by one method, the stone is merely loosened and thrown down into the quarry in blocks; by the other, it is shattered to pieces small enough for immediate use. The difference in operating by these methods is in the number and position of the holes and the kind of explosive used. The more finely the stone is to be shattered the closer must the holes be to one another and to the working face and the more powerful must be the explosive.

The first method requires less explosive for the first blast, but the large stones thrown down must be drilled and blasted separately, so that this method probably requires in the end more labor and explosive than the second. On the other hand, the second method produces a great deal more fine stuff than the first. However, this is no great objection if a crusher is provided to take care of it. These considerations seem to favor the second method of blasting.

The selection of the explosive to be used depends on the nature of the stone and the method of blasting desired. For a very soft stone, or if the stone is to be taken out in large pieces, a large amount of a weak explosive, such as black powder, would answer the purpose. If the stone is hard or if it is desired to shatter it, 40 per cent dynamite is the explosive in general use.

It is often the practice to "spring" the holes before blasting. This is done by charging them with black powder, not in sufficient quantity to loosen the rock. When this is set off, it springs or enlarges the ends of the holes into chambers, thus giving room for a large charge of explosive for the regular blast. Since more explosive may be used in each enlarged hole, it follows that a smaller number of holes are required to blast out a given mass of rock. That is, the method of springing the holes saves drilling, but costs more for explosives. It is therefore probably more economical for hard rock, but less for soft rock than the ordinary method of blasting.

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[1] Russell, S. R., Well drill hole blasting: Nat. Lime Mfrs. Assoc. Trans., 1912.

Sorting and loading.—After the stone has been blasted loose and thrown down into the quarry, the larger blocks are broken up with dynamite. This is generally placed in holes drilled in the blocks, but may simply be laid on top of the stone and covered with mud. The former method is called "pop shooting" and the latter "mud capping." Pop shooting requires more labor and power than mud capping, but saves so much in the cost of dynamite that the latter method has been abandoned except in quarries where steam drills are used.

The stone is then broken still smaller by sledging, until it is reduced to the size necessary for charging into the kilns. It is then loaded into the car, cart, or wheelbarrow which takes it out of the quarry. This loading is generally done by hand, so as to give an opportunity for sorting the stone:

Limestone must be sorted in order that only the proper quality and size of stone may be put into the kiln. The quality of stone required for burning has already been described. A quarry should be so located and operated as to give as little unsuitable stone as possible. If some "bad" stone must be quarried with the good, its appearance should form a clear indication of its character; otherwise it can not be sorted out, and a poor quality of lime may result. If the lime is to be used for finishing purposes, particular attention must be paid to sorting the stone, since any considerable quantity of clay adhering to the surface of an otherwise good stone is apt to produce an inferior lime.

The size of the stone to be used depends on two considerations—(1) the tendency of stone to fall to pieces; (2) the amount of draft available. A hard, dense stone may be used in smaller sizes than one which is soft and has a tendency to fall to pieces in the kiln. If the draft is normally rather low, large stone should be used, or the draft may be choked below its economical limit. It is the general custom to use everything from a "one-man" stone (a stone as large as one man can readily handle) down to pieces about 4 inches in diameter. On account of more nearly uniform draft it would probably give greater kiln efficiency if the stone were sorted more nearly to the size required by the kiln, but this is hardly economical unless a market for crushed stone is at hand, so that good use may be made of the smaller sizes.

METHODS OF TRANSPORTATION.

The methods in use for taking the stone from the quarry to the kilns are numerous. This is to be expected, since the method must be varied to suit the particular conditions of each plant, such as the distance between the quarry and the kilns, the shape of the quarry, the elevation from the quarry floor to the top of the kilns, and the quantity of stone to be handled. An enumeration of the methods used includes wheelbarrows, carts drawn by horse, cars drawn by horse, cable, or locomotive, cars or buckets transported by aerial cables, and skips hoisted by derricks. It is frequently the custom to use two or more of these methods in combination.

The transportation of stone may be considered as being carried out in three stages: (1) Taking the stone out of the quarry, (2) taking it from the quarry to the kilns, (3) elevating it to the top of the kilns.

The wheelbarrow has the advantage over all other vehicles, except the cart, in that its direction of action is unlimited, that is, it can follow the constantly shifting working face of the quarry. However, taking stone out in a wheelbarrow is a very slow and laborious process and is certainly not to be recommended, even where the quantity of stone to be moved is very small. Wheelbarrows are sometimes used for elevating stone to the top of the kilns, but only if the charging doors are too small to admit a whole carload.

The horse and cart has the same unlimited action in the quarry as the wheelbarrow. If the distance to the kiln is not too great, this vehicle may be used for the transportation; and there are quarries where the grade is sufficiently low for the horse to haul the stone to the top of the kilns. The method is very slow, however, and is not to be recommended where any considerable quantity of stone must be moved.

Tramcars labor under the disadvantage of requiring tracks. These tracks must be extended and shifted to keep up with the working face, and they must be moved every time a blast is made. If the kilns are very near the quarry, it is the custom to slope the quarry floor, so that the cars can be taken to one point by gravity. Here a cable is hooked on, and they are drawn up an incline to the top of the kilns. If the kilns are more than half a mile from the quarry, it is generally considered economical to use a locomotive for the transportation. If the distance is too short to warrant this but too long for a cable, animal power may be used. Generally it will be found impossible, on account of the grade, for either locomotive or horse to take the stone to the top of the kilns. They deliver it at the foot of an incline, where a cable is attached to pull it up to the top.

The consensus of opinion seems to be that the construction and repair costs of aerial cables are higher than for other methods of transportation. Moreover, they are not adaptable to the changing face of the quarry, so that some other means must be relied on to take the stone to them. They may be necessary in some places, however, as when the stone must be carried over a hill too steep for locomotive or horse, or over a railroad track or some similar right of way.

If the quarry is very deep, sometimes the only possible way to get stone out is by hoisting it. It may be loaded on skips and pulled up by derricks, which load it on cars for transportation to the kilns.

KILNS.

METHOD AND TIME OF CHARGING.

When stone is brought to a kiln by horse and cart the method of dumping it in needs no explanation.

There are two types of cars in general use, bottom-dump and side-dump cars. They are usually built of iron and hold 2 or 3 tons of stone. In bottom-dump cars the bottom consists of two plates so hinged that when released they will swing downward and allow the stone to fall into the kiln. Side-dump cars are built V shaped in cross section, so that they are top-heavy when full of stone and must be fastened to the trucks on both sides. When dumping, the fastening on one side is released and the car is permitted to roll over toward the other side. It must be righted again by hand. An interesting device in this connection is the automatic car. The fastening of this is tripped by an upright piece bolted to the track, the car rolls over and discharges its load, and is righted again by springs attached to the trucks.

Some of the kilns visited are charged either by wheelbarrows or by hand. These methods are very slow and laborious, but are used apparently because the design of the kiln makes it impossible to use any other.

It is a well-known fact that when a carload of stone is dumped into a kiln the larger pieces will stay where they strike while the smaller ones will roll away. Thus, when side-dump cars are used much difficulty is experienced because the stone in one side of the kiln is larger than that in the other. This difficulty can be overcome by using bottom-dump cars, which discharge in the center of the kiln; the fine stones roll to the outer edges and tend to check the draft, which is normally greatest there.

The buckets or cars brought to a kiln by an aerial cable are dumped by being lowered till they catch on a horizontal tripping device over the kiln and are upset.

Kilns which are built without hoppers should of course, be filled after each draw. Kilns with hoppers are generally filled once a day, or twice if the quarry and hoisting apparatus have sufficient capacity.

Lime burning is a continuous process. It is generally impracticable to store more than two days' supply of stone in the hopper of a kiln, and it is most economical to run the kiln at full capacity. Thus a steady and reliable stone supply is necessary. Arrangements should be made whereby the kilns will be filled at least once every day.

KILN DESIGN.

Practically all of the lime produced in this country to-day is burned in some form of kiln. What is known as the shaft kiln is used almost universally, although a few attempts have been made to adapt the rotary kiln, so well known in the cement industry. The rotary kiln, although it has many advantages over the shaft type, has the one great disadvantage at present, that the stone must be crushed to a fine size. Therefore the product is not salable as lump lime and can be used only for hydration. The manufacture of hydrated lime is a comparatively new industry, but is growing very rapidly, so that the use of the rotary kiln is fast gaining in favor.

This paper deals only with the shaft kilns, of which there are a great many varieties. In general, a shaft kiln resembles a short, wide stack, of either square, round, or elliptical cross section. It consists of a casing of steel or stone which is lined with refractory material. The long, vertical chamber formed by this lining may be divided into three compartments by imaginary horizontal planes. The top compartment, called the hopper, is used for storing and preheating the stone. Its sides slope in so that the stone may slide down into the middle compartment, the shaft. This shaft is the place where the lime is burned. It may be of either square, round, or elliptical cross section, independently of the outside of the kiln. Generally the sides of the shaft are vertical, although in some cases they slope outward. In this latter method of construction it is customary to omit the hopper. At the bottom of the shaft the third compartment (the cooler) is used for storing the lime after it is burned. The top of the cooler must, of course, have the same cross section as the shaft. The sides are drawn in to form a slide leading to the drawing door. A hole in the side or bottom of the cooler is closed by a door or by sheets of iron which swing on a pivot and are known as shears. The lime is removed through this opening. The fuel used in burning the lime is consumed in the fire boxes usually arranged on two sides of the kiln. They are very similar to the common fire boxes in use under boilers. Each kiln has two or more, which are set in openings through the casing and lining into the lower part of the shaft. In this paper the level of the grates in the fire box will be considered the bottom of the shaft, it being assumed that lime is not burned below this point. When gas is used as the fuel, the fire box is a mere port through which the gas pipe is led into the kiln. In either case the draft caused by the combustion of the fuel draws the flame up through this shaft in direct contact with the lime and stone and the gases formed pass out the top of the hopper. To increase this natural draft a stack is sometimes placed on top of the kiln. Forced or induced draft, or a combination of both, is also in common use. The forced draft is generally created by blowing steam through the grates into the fire box; the induced draft by drawing the gas out through the top with a fan. These two methods may be combined, or the gas which is drawn from the top may be forced back through the grates, according to the Eldred process. These methods of increasing the draft have in some cases necessitated closing the top of the kiln. Hence, a charging door must be supplied through which the stone can be dumped.

There are many considerations which limit the practical size of a kiln. Chief of these is probably the market which the kiln has to supply. Lime is a perishable article, hence any cessation in the demand necessitates a curtailment of the supply. If the market demands a definite supply of lime for a continuous period, a kiln can be built large enough to supply that demand. Generally, however, it is safer to build a number of small kilns, so that if the demand falls off, it will not be necessary to close the entire plant. Recently the custom has been introduced at a few plants to run the kilns at full capacity and to hydrate what lime can not be used immediately; for hydrate may be stored. The cross section of the shaft is limited by the distance the heat can be made to penetrate toward the center. The total height of the kiln above the grates is limited by the conditions of the draft. If natural draft is used, the gases must leave the top of the kilns hot enough to produce the draft. That is, the kiln must not be too high, or the stone will absorb too much heat from the gases. With any form of induced draft the kiln should be just high enough for the gases to leave it approximately at the temperature of the external air. If the kiln is lower than this, the heat carried off by the gases is simply wasted; if higher, the added quantity of stone causes unnecessary work for the fan.

What is perhaps the simplest type of kiln recognized by modern practice might be constructed as follows: An outer casing or shell is built up of sections of steel rolled to shape and bolted together, so as to form a stack, say, 10 feet in diameter by 30 feet in height. Inside of the casing, and concentric with it, is erected another stack of fire brick. This may be cylindrical in shape, 6 feet inside diameter by 30 feet high, with walls 18 inches thick. The annular space between the fire brick and the steel is filled with ashes, brickbats, or other similar material, which acts as an insulator to prevent loss of heat by radiation, and which also serves to take up the expansion of the fire brick. Two openings in the fire brick stack, opposite each other and about 3 to 5 feet from the bottom, form the inner ends of the fire boxes. These fire boxes extend out horizontally through the steel casing. They are of the ordinary type used for boilers and may be, for example, 4 feet long (from the outer door to the interior of the kiln) by 3 feet wide by 2 feet high (from the grate bars to the top of the arch). The kiln as described is supported on what is known as the firing floor. The bottom of the kiln is closed by a conical steel chamber, known as the cooler, which is hung under the firing floor. This cooler may be 6 feet in diameter at the top by 18 inches diameter at the bottom by 4 feet high. The bottom is closed by the shears previously mentioned and is generally 4 or 5 feet above the cooling floor, so that a wheelbarrow can be placed under the cooler to receive the lime as it is drawn out of the kiln. A kiln of this type, when used to burn a dense high-calcium stone, with a good grade of gas coal, will have a capacity of 8 to 10 tons of burned lime per 24 hours.

The design as given is subject to a great variety of modifications. The form, the dimensions, and even the materials may be changed to meet the peculiar requirements of each plant. Thus, if it is desired to increase the natural draft, a stack may be mounted on top of the kiln. This stack should be connected to the shaft by a conical chamber, so that the gas is not compelled to turn sharp corners which would tend to set up eddy currents and reduce the draft. The size of stack must be so selected that there will be no tendency to throttle the gas. Its dimensions can be calculated by the ordinary formulas for chimney design. For the kiln as described, under ordinary conditions, a stack 20 inches in diameter will have sufficient capacity and will add one-eighth inch of water to the draft for every 35 feet of height. If induced draft, or the Eldred process, is to be used, the top of the kiln should be closed by a flat plate bolted to the casing, in order that the fan will not have a large amount of unnecessary air to handle.

The casing of the kiln is sometimes built of stone or concrete instead of steel. These materials probably diminish the amount of heat lost through the kiln wall, but the casing should be designed primarily for strength. Most of the strain is found to be lateral, which tends to push the stone out. It is resisted much better by steel. Reinforced concrete, when properly designed, should combine the strength of the steel with the heat insulating properties of the stone, and is therefore finding favor in modern construction.

The shaft of the kiln may be built of material other than fire brick. In the burning zone, or that part of the shaft extending 8 or 10 feet above the grates, the brick are subjected to a high temperature (2,200° F. to 2,600° F.) and also to the fluxing action of the caustic lime. In the upper part of the shaft the temperature is low, and the wear is caused mainly by abrasion. A good grade of fire brick will stand the former condition pretty well, but is too soft to resist the abrasion. For this reason the upper part of the shaft is frequently built of cut granite, sandstone, paving brick, concrete, or some equally hard and cheap material. Even a good fire brick in the burning zone will wear out in time, owing to the fluxing action of the lime. It has recently been found that silica brick give longer service under some circumstances.[1]

[1] Seaver, Kenneth, Limekiln linings: Nat. Lime Mfrs. Assoc. Trans., 1914.

The upper part of the shaft is frequently enlarged to form a hopper. This practice is to be commended, because it gives an opportunity to store a supply of stone, so that the kiln can be operated for a day or two independently of the quarry. Moreover, this stone is stored in such a way that it is preheated, and it requires no further handling. If the kiln has a capacity of 10 tons of lime per day, the hopper should hold 27½ cubic yards of stone, or two days' supply. Care should be taken in designing a hopper that the slope of the sides shall be steep enough to prevent the stone from arching over instead of sliding freely into the kiln.

The shape of the cross section of the shaft need not be circular, but may be square, rectangular, or elliptical. When the products of combustion enter the kiln from the fire boxes they tend to pass upward immediately, along the walls of the shaft. The shaft must be designed so as to force them to penetrate as far as possible toward the center of the kiln. If the shaft is square or rectangular, the corners will form chimneys through which the gases can escape. Obviously, an elliptical shaft gives a larger area with the same distance between the fires than a circular shaft, and this larger area is the cause of increased capacity. The elliptical shaft is therefore the most economical of the four when the capacity of the kiln and the uniformity of the product are considered. The other shapes are frequently used, because they are much cheaper to build and repair. The objections to the circular shape can be overcome by the use of three or four fire boxes instead of two.

The cooler is sometimes lined with fire brick. This retains sufficient heat to complete the calcination of any stone which may have passed through the kiln unburned. The advantage of this process is doubtful, because it necessitates drawing the lime out of the kiln while it is still hot, with the attendant difficulties of handling it.

METHODS OF OPERATING KILNS.

There are two methods in common use for operating lime kilns, which are known as the "following" and the "sticking" processes. By either process only a part of the lime is taken out at a time, since enough must remain to fill the cooler and so keep the unburned stone above the grate level. The "following" method is very simple. When the lime is drawn from the bottom of the kiln the remaining lime and stone slide down and fill up the space, as would naturally be expected. The difficulty with the process lies in the fact that the stone will not burn evenly. Owing to the tendency of the flame and hot gases to pass up the side of the shaft, rather than to go into the center, the mass of unburned stone always extends down farther in th center than at the sides. It is obvious that if the stone falls down evenly, the unburned portion in the center must be brought below the grate level before the burned lime at the sides can be removed from the burning zone. It is the custom to draw out enough lime so that the lowest part of the stone will reach to about the grate level and then take a chance on overburning the lime in front of the fires.

The difficulty just explained may be obviated by the use of the "sticking" process. In this the kiln is generally chilled by omitting to fire and leaving the fire doors open for from 20 minutes to 1 hour before drawing. This chilling causes a contraction of the lining and also a solidification of the fused compounds resulting from the action of the lime on the lining. When the lime is drawn from the cooler these two processes acting together prevent the stone from following and cause it to "stick" or "hang." After drawing the lime is knocked down by bars inserted through the fire boxes, and finally the whole mass is caused to fall by knocking the supporting pillar of lime away. By this method the lime can all be removed from the burning zone and an even layer of fresh stone is presented to the fire. It has great disadvantages, however. It requires altogether from half an hour to an hour and a half to complete the drawing, during which time no lime is burned, labor is expended, and the kiln is cooling down. Consequently it is extravagant in time, labor, and fuel.

It must not be supposed that there is a hard and fast distinction between "following" and "sticking" kilns. In general, it may be said that if the sides of the shaft slope outward; that is, if the diameter is larger at the fire than at the top of the shaft, the kiln will "follow;" if straight, it will "stick." A skilled fireman can usually operate any kiln by either process, but sometimes kilns designed to "follow" will "stick," and vice versa. "Following" kilns also have a troublesome habit of "turning over" at times. That is, something will cause a quantity of lime to stick in one part of a kiln while the stone falls down past it, with the result that a layer of lime remains above some unburned stone.

To summarize, the "following" process is probably more economical of fuel, labor, and time than the "sticking" process. But, owing to the less danger of obtaining overburned or recarbonated lime, the "sticking" process probably yields a larger output of more nearly uniform quality. The relative values of the two processes have not been definitely determined.

BURNING.

GENERAL DISCUSSION.

A short theoretical discussion is necessary in order that the conditions required for the economical burning of lime may be comprehended.

There are three factors essential to the process of lime burning: (1) The stone must be heated to the temperature of dissociation of the carbonates; (2) this temperature must be maintained for a certain length of time; (3) the carbon dioxide evolved must be removed.

The physical properties of the stone undoubtedly have some influence on the heat required and on the time in which this heat can be transferred at any given temperature. Thus it will take longer to burn a large piece of stone than a smaller one. A fine-grained dense stone will conduct the heat more readily than one which is coarsely crystalline and porous. The time required to transfer a given amount of heat, roughly speaking, varies inversely with the temperature difference. Therefore it has been found economical to use as high a temperature as possible in order to reduce the time required for burning. The upper limit of the temperature is determined by the phenomenon of "overburning." Overburned lime can be recognized by its yellow color and the extreme length of time it takes to slake. These properties are probably caused by a chemical combination of the lime with the impurities contained in it. That this is the case is indicated by the fact that it has been found practically impossible to overburn some limes which are exceptionally pure. Lime may be overburned by being heated for too long a time as well as at too high a temperature. In general it is better to underburn than to overburn the lime, for the unburned stone may be put back into the kiln, but the overburned lime is useless. Moreover, the properties of overburning seem to assert themselves gradually, so that the best lime is obtained by using the minimum amount of heat.

To summarize: A certain quantity of heat must be supplied to dissociate the carbonates in the stone. The quantity varies with the chemical and physical properties of the stone. In supplying this heat it is optional to use either a high temperature for a short time or a lower temperature for a longer time. The temperature used must be higher than 898° C. (1,648° F.) if the decomposition is to take place at atmospheric pressure. The more nearly the amount of heat used approaches the minimum required the better will be the quality of the lime.

It is well known that the chemical reaction involved in burning lime is reversible. That is, calcium carbonate may be decomposed into calcium oxide and carbon dioxide, or these substances may recombine to form calcium carbonate. The factor which determines the way the reaction shall go is the pressure of the carbon dioxide.[1] If this gas is removed as formed so that its partial pressure is kept below that given for the temperature by Johnston's equation, the reaction will continue in the direction to form lime. But if the gas is allowed to accumulate until its pressure becomes higher than this, the reaction will be reversed and will give rise to the phenomenon known technically as "recarbonating." Therefore the prompt removal of the gas is an essential operation in lime burning.

Wood has long been recognized as the best fuel with which to burn lime and is used wherever it can be obtained with any degree of economy. The number of such localities is rapidly growing smaller, so that the problem of using some other fuel is of increasing importance. Experience has shown that wood gives a larger capacity and a better quality of lime, and requires less care in the operation of the kiln than coal. Therefore the tendency of experiments with the latter fuel has been to modify the normal coal fire so that it will to some extent resemble the combustion of wood. A wood fire has three characteristics which distinguish it from a coal fire in its adaptability to lime burning: (1) Its flame is longer. This enables the heat to penetrate farther toward the center of the shaft and creates a larger burning zone. Therefore the capacity of the kiln is greater and the lime tends to burn more evenly, causing less difficulty in the operation. (2) The amount of water generated by burning wood is much greater than that from coal. The pressure of this steam in the products of combustion lowers the temperature required for calcination [2] and thus lengthens the burning zone and increases the capacity of the kiln. (3) The flame from a wood fire is cooler than the flame from coal. This, in connection with the effect of the presence of

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[1] Bleininger, A. V., Am. Ceramic Soc. Trans., vol. 9, p. 454, 1907.
[2] Peppel, S. V., Ohio Geol. Survey Bull. 4, p. 294, 1906.

steam, results in less danger of overburning and a better quality of product.

In all kilns where wood is burned, natural draft has been found satisfactory.

The easiest way of modifying a coal fire so as to cause it to resemble the combustion of wood is to use a mixture of wood and coal. This works successfully wherever tried, but even the small amount of wood needed is not economically obtainable in many localities.

Many lime manufacturers are, therefore, forced, much against their will, to use coal for their fuel supply. The reasons cited above show why the coal fire should be modified to resemble the wood fire, and it may also be added that in many kilns the normal combustion of coal has proved distinctly unsatisfactory for the burning of lime. Experiments on modifying the fire have been mostly confined to different methods of producing the draft.

METHODS OF PRODUCING THE DRAFT.

The following methods for producing draft are in general use: Natural draft; forced draft, caused by blowing steam under the grates; induced draft, created by a fan which draws the gas from the top of the kiln; and the Eldred process, according to which a fan takes the gas from the top of the kiln and forces as much of it as is required back under the grates. In order to determine the relative efficiencies of these processes a number of heat balances were made.

From the results so obtained, the following general conclusions can be drawn: If the lime is drawn hot, or if it is left in the cooler until cold, the heat which it contains will be lost. This heat can be saved and used to preheat the air required for combustion, if this air is taken in through the shears in direct contact with the lime, or through ducts built in the walls of the cooler.

The heat contained in the escaping stack gases can be recovered in part by introducing some of the gas under the grates, as in the Eldred process. The recovery may be more nearly complete if the gases are passed through a boiler or feed-water heater, and their heat used to generate power. If natural draft is relied upon the heat of the gas must be considered as being used to create the draft. It was found, however, that natural draft requires a great deal more heat than any kind of artificial draft. The use of the heat of the gas for this purpose is not to be recommended, therefore, and it would probably be found more economical to build the kiln sufficiently high, so that the heat of the gas would all be taken up by the stone, and to rely upon a fan to furnish the draft.

With good capacity and careful firing the loss of heat due to combustible material in the ash should be very small; by the use of a good gas producer, it should be reduced to a minimum.

The heat lost by radiation and conduction may be considered as emanating from three parts of the kiln—the gas main or fire box, the bottom of the kiln, where the lime is permitted to cool after being burned, and the shaft of the kiln. A study of the designs of the various kilns show that the following methods should tend to reduce the amount of heat lost in this manner. The gas main leading from the producer to the kiln should be short or should be insulated. The comparatively poor gas which it is necessary to use for burning lime carries a large part of its energy as sensible heat, and the loss of this heat can be prevented only by introducing the gas into the kiln at the same temperature at which it leaves the producer. Fire boxes will show less loss by radiation when built within the shell of the kiln, rather than externally. A large part of the heat contained in the lime after it is burned will be lost by radiation before the lime is drawn out of the kiln unless means are supplied by which this heat can be recovered and used. Unless the kiln wall is extraordinarily thin or the temperature used extraordinarily high, the loss by radiation from the shaft of the kiln seems to be very small. This can be still further reduced by increasing the diameter of the kiln.

In conclusion, it must be emphasized that the heat efficiency is only one item of the total plant economy. The cost of labor, the ratio of capacity to investment, and the quality of the product must also be considered. Therefore, merely because the figures show a plant to have a high heat efficiency would be no reason for stating that it is the most economical plant.

In the light of the facts brought out by investigation a theoretical discussion of the different methods of producing the draft may not be out of place.

Natural draft, by the use of stacks, can be made sufficient to give good capacity. However, there is grave danger of overburning most stone, for with strong draft the flame may be short and hot. Conditions may easily arise which will force the products of combustion down into the cooler, thus causing recarbonation. Since there is no means of controlling the pressure of gas over the fire, every time the fire door is opened cold air rushes in, which may cause a loss of heat and increase the cost of repairs.

The practice of blowing steam under the grates is obviously one method of introducing the moisture obtained by burning wood. But water content does more than lower the calcination temperature. Part of it is undoubtedly dissociated into its elements while passing through the hot fire. This dissociation takes up heat, which is later given out in the kiln where the elements recombine. Consequently the use of steam tends to cool the fire and produce a longer flame, both highly desirable objects to lime burners. On account of the cooler fire and lower calcination temperature, the capacity of the kiln may be increased with less danger of overburning than when natural draft is used. The forced draft under the grates permits of regulating the pressure above the fire, and therefore the fire door may be opened without admitting enough air to influence the efficiency or repair cost of the kiln. Forced draft does not, however, prevent the products of combustion from going down into the cooler.

This danger of recarbonating the lime can be eliminated by the use of induced draft. When used alone, however, the characteristics of the fire produced by this type of draft have all the disadvantages of a normal coal fire. Since induced draft is created by a fan, any heat carried off by the waste gases is a total loss.

In many kilns a combination of forced and induced draft is used with very good results. The induced draft prevents recarbonation of the lime by removing the carbon dioxide as fast as formed. The forced draft by means of the steam jet gives a cooler fire and a longer flame and also permits control of the gas pressure over the fire. Owing to the lower calcination temperature and the greater rapidity of combustion attainable, this method should give the maximum kiln capacity.

Another method of combining the forced and induced draft is according to the Eldred process. For maximum economy the top of the kiln should be closed air tight, and all the gas should be removed by the fan, as in creating induced draft. This fan should deliver as much gas as needed under the grates and should blow the remainder out through a stack. Separate and fairly accurate means of controlling the supply of both air and gas should be provided, and the induced draft created by the fan should be entirely independent of the amount of gas used for the forced draft. As thus installed, many advantages of the combined forced and induced draft may be obtained by using the Eldred process. The induced draft tends to prevent recarbonation and the forced draft permits regulation of the gas pressure over the fire. The fire is kept cool by diluting the air with carbon dioxide taken from the kiln, thus causing a slower rate of combustion. The introduction of an excess of carbon dioxide might be expected to cause recarbonation of the lime, but experience has shown that it does not—probably because the temperature is sufficiently high to prevent the combination. This carbon dioxide also aids by mechanically carrying heat from the fire into the kiln. Moreover, it may act chemically to some extent, since some of it may be reduced to carbon monoxide while passing through the hot fire. This reduction absorbs heat from the fire and liberates it again when the carbon monoxide burns in the kiln in a manner similar to the action of steam. Carbon dioxide does not serve the same purpose as steam, however, for it does not lower the temperature of calcination.

In comparing the two methods—steam and induced draft versus the Eldred process—it must be noted that they both produce a cool fire by mechanically and chemically transferring the heat from the fire box into the kiln. The former method gives a high rate of combustion and a lower calcination temperature, both of which tend to increase the capacity. Owing to lack of oxygen, the Eldred process causes the coal to burn more slowly. This would tend to give a lower output.

In general it may be said that the best method to be used for creating the draft depends on local conditions, chiefly the kind of stone. Thus, if the stone is difficult to overburn, a high output and good quality of lime may be obtained with natural draft. If there is danger of overburning, the forced and induced draft will probably give good results. If there is great danger of overburning or if the lime is apt to act as a flux on the lining, the Eldred process may be used to obtain a good quality of product and keep the repair cost within reasonable limits.

COMPARISON OF COMBUSTION ECONOMY.

Direct combustion.—No mechanical stoker has been perfected which can be adapted to lime-kiln practice; hand firing must be relied upon exclusively. What is known as the coking system of firing has given very good results wherever tried. By this method the green coal is put on a dead plate just inside the fire door, left there until coked, and then pushed back and replaced by a fresh charge. The gases distilled from the coal must pass between the fire and the arch and meet with a large amount of air coming through the burned coal at the rear of the fire box. Hence, complete combustion is practically assured. Whether this method is used or not, the economical combustion of gas coal requires that the coal be fired frequently and in small quantities. However, this requires more labor than firing larger quantities at longer intervals, and it is a question of local conditions whether or not the saving of coal would pay for the increased labor.

The heat lost in the waste gases may be increased by two means—the admission of excess air, or the incomplete combustion of the fuel. Of course, it is impossible to regulate the air to exactly the theoretical quantity, and it is always better to have too much than not enough. Incomplete combustion may be caused by not having enough air or by chilling the gases distilled from the coal below their ignition point. To prevent this latter occurrence, the arch of the fire box must be kept hot, and no more air than necessary should be admitted over the fire. In order to overcome these losses of heat the stack gases should be watched closely. If possible the firing should be adjusted according to gas analyses. If this is not practicable, their appearance is a fair indication of their composition. If they are perfectly colorless, it is safe to assume that too much air is being admitted; if black and smoky, the combustion will generally be found to be incomplete. The greatest economy seems to be obtained when the gases have a rather dark-gray appearance.

When a fire is cleaned it is bad practice to draw it completely, since this admits a large quantity of cold air into the kiln and causes a considerable loss of heat. There is a method in use in boiler practice by which one side of a fire is cleaned at a time. This process could be used to advantage by lime burners.

In the preceding discussion of draft, stress is laid on the fact that with forced draft the pressure of the gas over the fire may be regulated. The idea in this is to use forced draft of just sufficient strength to force the air through the fire, and induced or natural draft of a strength very little more than sufficient to pull it into the kiln. By this means the pressure of the gas over the fire may be made very nearly equal to atmospheric pressure. Therefore when the fire door is opened the quantity of air admitted is very small. However, this method causes a slower rate of combustion and lowers the output of the kiln, unless the draft can be increased directly after firing and again checked during firing.

Gas producers.—Instead of modifying the draft to make a coal fire resemble the combustion of wood the coal itself may be modified by converting it into producer gas. The claim for the greater economy of gas producers is based on the lower labor cost and the greater convenience and adaptability of the gas. By adaptability is meant that the fire can be placed where it is wanted. This is especially important in lime kilns, in which coal must be burned in external fire boxes, whereas the gas can be introduced directly into the kiln itself.

All of the producers installed in lime plants generate mixed gas, consisting of the products of distillation, carbon monoxide, and hydrogen. Air is blown through the bed of coal by a steam jet. In such producers, the heat of the coal is used up in four ways, namely, in the reduction of the carbon dioxide formed to carbon monoxide, the decomposition of the steam, the distillation of the hydrocarbons from the coal, and the raising of the termperature of the gas. When the gas is burned the hydrogen and carbon monoxide liberate the exact amount of heat taken up by their formation. This, together with the heat generated by combustion of the hydrocarbons, may be called the "potential" heat of the gas. It is evident from the definition that a gas should have practically the same potential heat at the kiln that it had when leaving the producer, but the amount of sensible heat retained depends entirely on the chances for loss by radiation. Therefore, it is imperative to have the producer as near the kiln as possible and to have all gas mains well insulated. Of course, the higher the proportion of noncombustibles in the gas the greater will be the sensible heat in proportion to the potential heat and the more carefully must loss be guarded against. In lime-kiln practice it has been found that a rich gas (one high in combustibles) gives too hot a fire with too great danger of overburning the lime. Therefore, a gas with a large proportion of noncombustibles should be used, and care should be taken to prevent the loss of sensible heat. Another reason for keeping the gas hot is to prevent condensation of the hydrocarbons. These have a high heating value, and the loss of even a small amount of them should not be permitted. It is evident that if the gas is kept hot enough to prevent condensation of the hydrocarbons the potential heat is independent of the temperature; also that if the gas enters the kiln at the temperature at which it leaves the producer the loss of sensible heat will be zero. It should be possible therefore to design a plant so that the use of a poor gas instead of a rich one should make practically no difference in the efficiency of transmission of heat from producer to kiln.

It is customary to mix the gas with air just as it enters the kiln, thus producing combustion in direct contact with the stone. The gas is blown in by forced draft, and steam is one of the chief products of combustion. These considerations indicate that in a gas-fired kiln it should be possible to force the flame farther toward the center, the burning zone should be longer, and the calcination temperature should be lower. Consequently the kiln should have a larger output and should produce a better quality of lime. For a large plant the labor cost should be less. There is, however, the danger of recarbonation, which occurs wherever forced draft alone is used. Care must be taken not to blow in the gas and air so fast that the products of combustion will have any tendency to go down into the cooler.

Gas producers have one decided advantage over methods of direct firing in that a much cheaper fuel may be used; and, although the coal must be low in sulphur to prevent corrosion of the iron, it may be higher in ash and have a lower heating value than the grade of coal economical for direct firing.

Producers may be obtained which are supplied with a device for automatically and continuously feeding the coal and removing the ashes. The fuel bed revolves, so that its depth is kept uniform. Such a producer would cost more to install than the types generally used and would require but little power for its operation. These economic difficulties may be more than counterbalanced by the saving in labor and the production of a uniform quality of gas. This last point is of especial importance to lime manufacturers.

If the plant is properly designed, with especial regard to preventing any loss of heat by radiation, and is run by a competent fireman so that the gas is not too rich, is not blown in too fast, and is mixed with very nearly the theoretical quantity of air, the use of a gas producer should prove at least as economical as any method of direct firing of coal.

HYDRATED LIME.

Hydrated lime is a product recently put on the market to take the place of lump lime. As its name indicates, it is lime which has already been hydrated—that is, the chemical combination with the water has already taken place. It is a fine, dry, white powder which is shipped in paper or burlap bags, and which may be used for any purpose instead of lump lime.

The keeping qualities of hydrated lime have been the subject of a great deal of discussion. The original statement which was generally accepted was that hydrated lime would keep indefinitely. On this assumption, samples were tested in their ordinary commercial packages. The average of 11 samples so received showed a content of 3.77 per cent carbon dioxide, and 1 of them contained 10.09 per cent. These figures correspond, respectively, to 8.57 per cent and 22.93 per cent of calcium carbonate or inert material which had presumably been introduced by air slaking in transit. In order to investigate this matter a sample of lime was ground and screened through a 60-mesh sieve, and part of this was hydrated. A sample of the quicklime and one of the hydrated lime prepared from the quicklime and having the same fineness were exposed to the action of the air under the same conditions and were analyzed for carbon dioxide at frequent intervals. The results are as follows:

Analyses of quicklime and hydrated lime.

Age of sample (days).	Percentage of carbon dioxide.	
	Quicklime.	Hydrated lime.
1	0.93	3.14
4	1.68	6.38
6	3.23	7.45
7	3.87	10.34
8	4.02	10.73
10	8.73	11.25

These figures seem to prove that hydrated lime will not keep any better than quicklime of the same fineness. The fineness is important, however, for an impervious coating of air-slaked lime will form on the top of a pile of hydrated lime and prevent access of the air to the interior of the pile.

The chief advantages to the consumer of hydrated lime are as follows: It can be handled more easily on account of its being in powder form. It will keep better than lump lime on account of its fineness. It does not require slaking, but must merely be soaked in water to prepare it for use. This saves time and labor and eliminates any danger of loss of lime due to unskilled slaking. Any unburned or overburned lime which has passed the sorter will not hydrate, and can be screened out of the finished product. Hence, hydrated lime should contain less refuse than lump lime. On the other hand, hydrated lime contains 15 to 25 per cent of water, on which the consumer must pay the freight.

Manufacturers reap several advantages from the operation of a hydrate mill. It gives them a product which can be stored, so that in case the orders for lump lime decrease unexpectedly the lime can be hydrated and stored and the kilns need not be shut down. There are several grades of stone in use which burn either to a dark-colored lime or one which falls to pieces in the kiln. Such lime can not be marketed in the lump, but will give a good quality of hydrate.

A very convenient method for testing hydrated lime is to determine its content of carbon dioxide. If properly made and stored, the proportion of carbon dioxide should be less than 1 per cent. Another method which might prove of value as a practical comparative test depends on the density of the the material. Pure calcium hydroxide has a lower specific gravity than any other material which may be present in hydrated lime except water. Of 19 samples of commercial hydrated lime tested by the Bureau of Standards, 8 samples of good high-calcium hydrate showed densities between 2.15 and 2.24; 7 samples of magnesian hydrates showed densities greater than 2.38; the other 4 samples showed densities between 2.34 and 2.38. Two of these four were high-calcium hydrates containing unusually large proportions of silica; one was a high-calcium hydrate with a large proportion of unhydrated (quick) lime; and the fourth was a magnesian hydrate in which the magnesia was hydrated (because of an unusually low temperature used in burning the lime).

MANUFACTURE OF HYDRATED LIME.

Hydrated lime is manufactured on a commercial scale by a process essentially as follows:

Crushing.—Lump lime, as it comes from the kiln, is crushed to pieces 1 inch and smaller in diameter. This is done so that the lime can be handled mechanically, and it also serves to hasten the reaction between the lime and the water.

Hydrating.—The lime is then fed into the hydrator. Theoretically, the only function which this machine has to perform is to mix the lime and the water quickly and thoroughly, in order to prevent the production of a burned hydrate. If there is not enough water present or if the lime and water are not mixed thoroughly, the heat generated by the slaking may be localized and may become so intense that it will change the physical qualities of the hydrate—notably, the plasticity will be diminished.

The hydrators commonly used are of two different types, intermittent or continuous.

The intermittent hydrator consists of a circular iron pan large enough to hold about 1½ tons of hydrated lime and capable of revolving horizontally. Suspended in the center of this pan is a fixed shaft with arms radiating from its lower end. These arms carry plows, which scrape the bottom of the pan, and are arranged in a horizontal spiral, so that every part of the pan is touched at least once each revolution. The whole machine is surmounted by a hood and stack to carry the dust out of the building.

In operating the pan it is first started revolving. A definite quantity of crushed lime is then fed in, generally from an automatic weighing bin. Then the water is turned on. The quantity of water used is sometimes regulated automatically by an overflow tank or some such arrangement, but more often it is left to the discretion of the man in charge. If the man is a good operator, the latter method is probably to be preferred. A large proportion of the water added is given off as steam, and the steam generated depends on whether the room is warm or cool, and to what extent the machine has been heated by previous charges. Therefore the quantity of water necessary is not constant and requires supervision. After the water has been added the pan is kept rotating until hydration is complete. This requires from 6 to 20 minutes, according to the quality of lime used. The end of the reaction can be readily discerned with practice. The powder becomes very light and appears drÿ, and the evolution of steam ceases. A central section of the bottom of the pan is then raised and the plows force the product through this opening into the bin below.

The continuous hydrator consists of a series of long iron tubes, one above the other, to save space. Within the pipes a screw conveyor is arranged which carries the lime through them. The lime is admitted at one end of the top section of the pipe. As close as possible to the end through which the lime enters a large vertical stack is erected. The water is admitted about two-thirds of the way up this stack, and falls down it, over a series of baffle plates, into the pipe. Here it meets the lime. The two sbstances are mixed very thoroughly by the screw conveyor, and at the same time are carried by it through the tube. The conveyor is run at such speed that when the mixture has reached the end of the pipe, hydration is complete. In this machine it is impossible to regulate the quantity of water automatically, on account of the constantly increasing temperature (and consequent evaporation).

A comparison of the two hydrators seems to result in favor of the continuous. First, since the lime and water are admitted in small constantly flowing streams, a quicker and more thorough mixture is obtained. It is much easier to insure the presence of sufficient water for complete hydration; hence the danger of burning is diminished. The stream of water flowing down the stack absorbs the dust. This dust is a serious nuisance around a hydrating plant and makes the labor problem a difficult one. Besides absorbing the dust, the water also condenses the steam generated, and therefore enters the hydrator hot. It is a matter of common experience that a better quality of slaked lime can be obtained with hot water than with cold.

Water.—The quantity of water to be used in making hydrated lime is a very important factor. As already indicated, it must be varied to suit constantly changing conditions, and considerable experience is required to be able to tell by the appearance of the finished product just when the correct quantity has been added. Too much water will cause the product to become pasty and clog the screens. If too little is used more will be later absorbed from the air, with the consequent bursting of the bags in which it is stored. No practical means has yet been devised for determining the quantity of water present in the finished product, so that it must be judged merely by its appearance.

Volume.—The hydration of lime is accompanied by an increase in volume which causes the lumps to disintegrate. Evidently, anything which does not hydrate will retain its original lump form and can be separated from hydrated lime by screening.

Screening.—The next step, therefore, is to screen the material which comes from the hydrator. This may be done either by means of a screen or of an air separator. The screen ordinarily used consists of a wooden or metal frame covered with wire gauze of 36 diagonal mesh (36 wires per linear inch, with the diagonals of the square holes running lengthwise of the screen). An air separator is essentially a fan into which the hydrate is fed. The hydrate is picked up by the current of air and carried away, while any impurities settle to the bottom of the fan casing and may be drawn off. The air current passes into a large chamber, which so reduces its velocity that the hydrate settles and the air is taken back and used over again. The air separator has two great advantages over the screen: First, it can be built more nearly dust proof; and, second, it will distribute a hydrate so wet that a screen would be clogged. This permits the use of a little more water in the hydrator, with consequently less danger of burning.

Storage.—The hydrate is now taken to the storage bin, to be kept until ready for packing and shipping. Attention must be called to the extremely disagreeable character of hydrated lime dust. All elevators, conveyers, and bins must be designed to prevent the escape of this dust. Screw conveyers are generally used for horizontal transportation, and bucket elevators, inclosed in boxes built of two thicknesses of matched lumber with a layer of canvas between, are used for vertical transportation.

Packing.—The machine in general use for packing the hydrate in bags consists of a long, narrow, horizontal wooden box, in which is revolved a shaft with pins projecting from it. The hydrated lime flows from the bin into the box. The pins convey it along the box and keep it stirred up to prevent its sticking. Along the bottom of the box are several openings, which may be closed by means of a lever and which when open connect with a long muffle-shaped chute. The bag to be filled is connected to the chute and the lever is raised so that the hydrated lime flows in. The bag rests upon a scale pan, counterbalanced by a weight. When this weight of hydrate has been admitted, the scale pan drops and in so doing pulls down the lever, thus closing the opening in the box and stopping the flow of hydrated lime. The bag is so made that both of its ends appear to be closed, and resemble the bottom of an ordinary bag. In forming the ends the smaller sides are folded over first and are overlapped by the larger sides. One of the smaller sides is left unfastened and through this opening the small muffle-shaped chute is inserted. When the bag has been filled, the pressure of its contents forces the smaller side against the overlapping portions of the larger sides and thus closes the bag. When made of paper such a bag can not be opened without tearing. If cloth is used, the top is made open in the usual manner and is tied before filling. The bag is then filled through a valve in the bottom. This bag gives much less opportunity for the dust to get out than a bag which is filled while still open and which must be handled and tied after filling.

CHEMICAL AND PHYSICAL PROPERTIES OF LIME.

Lime, chemically, is the oxide of calcium (CaO), but the commercial article may differ very widely from this composition. It may contain anywhere from 0 per cent to 44 per cent of magnesium oxide, and it generally contains more or less impurities, such as silica and oxides of iron and aluminum. When properly burned and fresh from the kiln, it should contain no water and less than 0.5 per cent of carbon dioxide. If the impurities added by the combination between the lime and the brick lining of the kiln be neglected, the composition of any lime will be essentially the same as that of the stone from which it was burned, minus the carbon dioxide.

The lime will generally retain the same form as the stone, but the porosity is increased very greatly. Lime is nearly white, but it may have a gray, pink, or yellow tinge, depending on the impurities present. Stones in which crystals are apparent frequently retain the same structure after calcination.

When lime is slaked the calcium oxide combines with water to form calcium hydroxide. The impurities may be present in chemical combination with the calcium oxide, in which event they also may take up some water. The manufacturers of hydrated lime judge from the gain in weight of their product that magnesium oxide when burned at the temperature of an ordinary limekiln hydrates very slowly, if at all. Nine samples of magnesian hydrates analyzed by the Bureau of Standards showed an average content of 30.92 per cent magnesium oxide and 2.29 per cent magnesium hydroxide. This peculiarity has been made the subject of scientific research,[1] the conclusions from which are that magnesium oxide will combine with water with reasonable rapidity only when it has been burned at some temperature below 1,100° C. (This is somewhat lower than the temperature of an ordinary limekiln.)

The hydration of calcium oxide generates heat. Since a large part of the magnesium oxide does not hydrate, it acts merely as an inert substance which must be heated by the calcium oxide. Therefore, other things being equal, the less magnesium oxide present in a lime, the more quickly will it slake and the greater will be the heat generated.

The porosity of the lime plays a very important part here, however. Thus, the more porous the lime, the more quickly can the water penetrate it, and hence the chemical combination will take place more readily. Indeed, in some cases the porosity seems to be of more importance than the chemical composition, that is, a very porous magnesian lime may slake more quickly than a dense lime with a much higher content of calcium oxide.

If lime is underburned the calcium carbonate left in it acts as inert matter. Overburned lime exhibits the same phenomenon, although in this case it is probably due to a diminution of the quantity of active calcium oxide present. At the higher temperatures this

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[1] Campbell, E. D., On the influence of the temperature of burning on the rate of hydration of magnesium oxide: Jour. Ind. and Eng. Chemistry, vol. 1, p. 665.

material combines with the impurities, and hence is not free to take part in the reaction of slaking.

The appearance of underburned lime varies with that of the stone, and can be distinguished only by one who has had practice with the particular lime in question. Overburned lime is generally yellow or black in color and can be readily separated from good lime.

When lime is exposed to the air it absorbs water and carbon dioxide, and "air slakes." This reaction takes place in two more or less distinct stages, first, the absorption of water, and second, the displacement of the water by carbon dioxide. Since these reactions are slow, it is possible to obtain lime which has air slaked to almost any degree, and this has led to a great confusion in the literature in regard to the properties of air-slaked lime. For instance at one stage of the process (when the water has been absorbed and has not been displaced to any extent), the product is similar in composition to "water-slaked" or hydrated lime. In order to avoid such confusion, the Bureau of Standards has designated as "air-slaked" lime only that product in which the process has been completed, that is, air-slaked lime must be composed chiefly of calcium carbonate or of a mixture of calcium and magnesium carbonates, and therefore it is chemically similar to natural limestone. Any intermediate product will be designated as partially air-slaked.

The absorption of water during the process of air slaking involves a large increase in volume, and therefore the lumps fall to pieces. This fact gave rise to the demand for "lump lime," the consumer being of the opinion that all fine lime is air slaked. There are several grades of limestone which fall to pieces in the kiln. The stone may be so soft that it is broken up by the abrasion; it may have its pores filled with water, which when heated shatters the stone; or its component crystals may be bound together by organic matter which is consumed in the kiln. Stones like these are burned, and in some cases over 50 per cent of the output of the kiln is fine stuff. Such fine lime is as good for all purposes as lump lime, and it is easier to handle and will keep better. This is obvious from the consideration that the top layer of fine lime will air slake and the crust of inert material so formed will prevent access of the air to the quicklime underneath. The old prejudice against fine lime is rapidly losing ground, as is shown by the fact that some manufacturers are putting crushed lime on the market. The better-keeping qualities of this product are being taken advantage of by some firms, who ship the fine lime in open gondola cars.

The weight of a lump of lime is about 55 per cent of the weight of the stone from which it was burned. Owing to the fact that the lime is in lumps the weight of it which any given volume will contain varies very widely. Thus, a barrel of lime contains from 150 to 350 pounds net in different localities, and a bushel from 32 to 88 pounds.

COMMERCIAL PACKAGES.

Quicklime is put on the market as lump lime (just as it comes from the kiln), or as pulverized lime, which has been ground to any desired fineness. It may be shipped in bulk, in wooden barrels of about 200 pounds capacity, or in iron casks holding 400 pounds.

Hydrate is packed in either 100 pound burlap sacks or 40 pound paper sacks.

USE OF LIME.

When lime is mixed with water, it will form a plastic putty, which will set or harden on exposure to the air. Also, lime is the cheapest of the alkalies. Those two facts have led to the use of lime for a great number of different purposes. These uses may be grouped, so that limes may be classified by means of them into the following four classes:

(1) Building lime, used either alone or with cement in making mortar for masonry work, or for the scratch or brown coat of plaster, or for stucco.

(2) Finishing lime, used either alone or with plaster of Paris for the white coat of plaster.

(3) Agricultural lime, used as a fertilizer.

(4) Chemical lime, used in the various chemical industries.

BUILDING LIME.

MORTAR.

In deciding what lime is the best for making a mortar, we must consider not only the local conditions, such as cost and experience of the laborer, but also three factors inherent in the lime itself: The volume of mortar which it will produce, the ease with which the mortar can be worked, and the strength developed by the mortar when it sets.

The quantity of mortar which a lime will produce varies very widely with the properties of the lime. Thus a pure, properly burned high-calcium lime will produce about 10 cubic feet of putty per barrel (200 pounds) of lime.[1] The presence of any impurities (including magnesia) will decrease the yield of paste. If the lime is either over-burned or underburned, the yield will also be decreased. Moreover, the greater the volume of paste, the greater the volume of sand which can be added to it to make a mortar. This is not a direct relation, because the characteristic stickiness of a paste made from a pure high-calcium lime enables it to carry more sand in proportion to its volume than a leaner lime. At any rate, a high-calcium lime will yield the greatest volume of mortar, provided the mortar is properly prepared. If the lime is permitted to burn during hydration, the yield will be materially decreased; and the better the lime, the greater the danger of its burning. The elimination of this danger of burning is one reason why hydrated lime is growing in favor so rapidly. The yield of mortar is obviously a very important factor, because it determines how many pounds of lime will be required to lay a thousand brick.

If we accept the definition of lime as given—that it shall contain not more than 5 per cent of impurities (not including magnesia)—there will be some difference in the working qualities of the putty produced. But when a large quantity of sand is added to make a mortar, any such differences will be hidden. The working quality of the mortar, therefore, need not be considered, provided the lime comes within the definition.

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[1] Emley, W. E., Crushing strength of lime mortar: Nat. Lime Mfrs. Assoc. Trans., 1913.

Mortar made from high-magnesian or "dolomitic" lime will eventually become about three times as strong as that made from a high-calcium lime.[1] If a cubic foot of brickwork weighs 150 pounds, the load imposed on the mortar at the bottom of a wall, due only to the weight of the masonry, will be about 1 pound per square inch for every foot of height of the wall. Evidently, therefore, it is unnecessary to consider the strength of the mortar in most ordinary buildings. If, for any reason, a particularly strong mortar is desired, it is common practice to use Portland cement instead of lime, so that, in any event, the strength of a lime mortar should not be used as a criterion for judging the quality of lime.

In conclusion, therefore, we find that if all other conditions are equal, pure, well-burned, high-calcium lime should be the best for making mortar, because it produces the greatest volume of mortar from a given weight of lime. The deciding factor in choosing a lime for mortar is the experience of the labor in the particular locality, for this will determine the yield of mortar obtained from any given lime.

Obviously, the same conclusions apply to lime used for the scratch or brown coat of plaster.

LIME AND PORTLAND CEMENT.

Although Portland cement gives a strong mortar, it is not very satisfactory for such purposes, because its lack of plasticity makes it rather difficult to work. It has been found that the addition of small quantities of hydrated lime will increase the plasticity without material injury to the other properties of the mortar.

If a cement mortar is sufficiently rich in cement, and the surface is well troweled, it can be made practically waterproof.[2] Unfortunately, the working qualities of the material are such that it is difficult to get a laborer to trowel it sufficiently. The addition of hydrated lime increases the plasticity of the mortar, so that the troweling does not entail so much work. Moreover, the particles of hydrated lime are fine in comparison with the cement and sand, and therefore tend to fill up the voids and produce a denser mortar. For these reasons hydrated lime is looked upon as a waterproofing material.[3]

The use of hydrated lime for this purpose brought about a demand for information toward which a number of investigators have been working. Their conclusions may be summarized as follows: (1) The magnesia in a magnesian hydrate does not act the same as magnesia in the cement itself, but a mixture of cement and magnesian hydrate is stronger at the end of a year than a similar mixture containing high-calcium hydrate.[4] (2) A series of tests made by the Bureau of Standards indicates that cement can be replaced by hydrated lime without material diminution of strength if the ratio of hydrate to cement is less than 1 to 3 by weight. Of course, this conclusion can be applied only to the particular cement used, and it must be noted that the mortars tested were of unusually thin consistency.[5] (3)

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[1] Emley, W. E., Crushing strength of lime mortar: Nat. Lime Mfrs. Assoc. Trans., 1913.
[2] Wig, R. J., and Bates, P. H., Tests of the absorptive and permeable properties of Portland cement mortars and concretes: Bur. Standards Tech. Paper No. 3, 1912.
[3] Lazell, E. W., Concrete-Cement Age, March, 1914, p. 130.
[4] Lazell, E. W., Tests of cement-lime mortars: Nat. Lime Mfrs. Assoc. Trans., 1911.
[5] Emley, W. E., Hydrated lime in a Portland cement mortar: Nat. Lime Mfrs. Assoc. Trans., 1914.

Mortars containing hydrated lime in the proportions of 1 to 3 or less harden better under water than when exposed to air, and some investigators therefore believe it safe to recommend the addition of hydrated lime to cement used for road material or for foundation work.[1]

FINISHING LIME.

A lime to be used as a white coat in plastering must work easily under the trowel, must not pop or pit in the wall, and must be very nearly white. A large yield of putty from a given weight of lime is, of course, advantageous, but can hardly be considered the controlling factor.

In general, it may be stated that magnesian limes work better under the trowel and most of them have a better color than high-calcium limes.[2] The former are therefore to be preferred, even though the latter give the greater volume of putty.

Occasionally the failure of a finishing lime occurs when small particles expand and fall out, leaving pinholes in the wall. This is known technically as "popping" or "pitting." It has been found to be due largely to the presence of lime which has been burned during hydration, that is, to improper slaking of the lime.[3] For this reason hydrated lime is to be preferred to quicklime for finishing purposes. The manufacturer of hydrate should have a better understanding of the problem and is better equipped to prevent the burning during hydration than is the unskilled laborer employed to slake quicklime.

AGRICULTURAL LIME.

The use of lime as a fertilizer dates from the inception of modern scientific farming. Agricultural chemists have shown that there are five or six different functions which lime may perform to benefit a soil, which may be summarized briefly as follows:[4] 1. It is an essential element of plant food. 2. It aids in the conversion of decaying organic matter into humus. 3. It forms compounds with the humic acids which tend to prevent their being leached out of the soil and lost. 4. By producing proper sanitary conditions the growth of injurious bacteria is largely prevented, while the growth of nitrifying bacteria is encouraged. These nitrifying bacteria convert the nitrogen of the humus into a form such that it is available as a plant food. 5. Lime aids in the liberation of potash and phosphorus from inert compounds. 6. It tends to flocculate clay soils, rendering them granular and more porous.

Obviously, permanent results can not be expected unless care is taken to insure the presence of some organic fertilizer at all times. Lime used alone may be temporarily beneficial, but will eventually be harmful; when used with cowpea vines it becomes more efficient for general purposes than almost any other fertilizer.[5] Of course, lime is not beneficial to all crops to the same extent, and not all soils

[1] Spackman, H. S., Effect of hydrated lime on change in volume and strength of mortars and concretes: Nat. Lime Mfrs. Assoc. Trans., 1914; Concrete-Cement Age, March, 1914. p. 112.
[2] Emley, W. E., Tests of commercial limes: Nat. Lime Mfrs. Assoc. Trans., 1913.
[3] Young, S. E., On the popping of lime: Amer. Ceramic Soc. Trans., 1913.
[4] Fippin, E. O., Relation of lime to soil improvement: Nat. Lime Mfrs. Assoc. Trans., vol. 8, p. 78, 1910.
[5] Gardner, F. D., Fertility of soils as affected by manures: U. S. Dept. Agr. Bur. Soils Bull. 48, 1908.

need lime. Thus, some of the common plants may be classified according to the extent to which they are benefited by lime, as follows:[1]

Plants benefited or injured by lime.

Benefited.	Slightly benefited.	Slightly injured.	Injured.
Spinach	Indian corn	Cotton	Radish.
Lettuce		Tomato	Flax.
Beet		Cowpea	Blackberry.
Celery		Concord grape	Black raspberry.
Onion		Peach	Cranberry.
Cucumber		Apple	
Cantaloupe		Pear	
Asparagus			
Cabbage			
Peanut			
Rhubarb			
Pea			
Pumpkin			
Bean			
Tobacco			
Alfalfa			
Clover			
Barley			
Wheat			
Oats			
Timothy			
Gooseberry			
Currant			
Orange			
Quince			
Cherry			

Whether a soil will respond to liming or not depends on the amount of available calcium oxide which it already contains. Unfortunately chemical analysis does not distinguish between the total calcium oxide and that which is available to plants. Probably the best indication of the need of lime is the failure to obtain a good crop of clover.[2]

Whether high-calcium or magnesian lime should be used as a fertilizer is a question which has received wide attention from agricultural chemists. It is generally conceded that some magnesia is necessary for the growth of most plants, but that too much of it acts as a poison. However, magnesium carbonate is more soluble than calcium carbonate (in the laboratory, 1 part of the former dissolving in about 5,000 parts of pure water, and 1 of the latter in about 10,000 parts of pure water) and therefore may be more apt to be leached out of the soil by rain. Hence most soils contain more calcium than magnesium, and the use of a magnesian lime should be at least not detrimental. This has been found to be the fact.[3] It may be stated that, for the crops ordinarily raised, the lime to be used as a fertilizer should be so selected that the final ratio of lime to magnesia available in the soil should be about 7 to 4.[4]

The question as to whether lime should be applied to the soil as quicklime, hydrated lime, air-slaked lime, or ground limestone is still the subject of a great deal of controversy. The advocates of ground limestone claim that the caustic properties of quick or hydrated lime will burn up and destroy the organic matter in the soil, whereas lime-

[1] Wheeler, H. J., Liming of soils: U. S. Dept. Agr. Farmers' Bull. 77, 1905.
[2] Thorne, C. E., Liming the soil: Ohio Agr. Exper. Sta. Bull. 159, 1905.
[3] Thorne, C. E., loc. cit. Frear, William, Pennsylvania State Coll. Agr. Exper. Sta. Bull. 127, 1913.
[4] Loew, Oscar, and May, D. W., Relation of lime and magnesia to plant growth: U. S. Dept. Agr. Bur. Plant Industry Bull. 1.

stone can be applied in large quantities at long intervals and will therefore produce a more or less permanent fertility.[1] The advocates of lime claim that one of the main functions which lime has to perform is the destruction of the organic matter and the liberation of the nitrogen in a form such that the plant can use it; that the frequent and judicious use of lime, together with some organic fertilizer, will bring immediate results.[2] Of course the local conditions of each particular case must be considered before a final conclusion can be reached. Thus, it is rational to use quicklime on soils which are exceedingly rich in organic matter, such as peaty or swamp soils.[3] Limestone is safer than quicklime when applied just before planting a crop which is little helped by liming, or when applied to a light sandy soil in hot dry weather.[4]

It will be noted that the value of lime as a fertilizer depends largely on the available calcium oxide which it adds to the soil. This depends partly on the calcium oxide present in the material and partly on the size of the grain, which governs its immediate availability. Pure quicklime contains 100 per cent calcium oxide; pure hydrated lime, 76 per cent; and ground pure limestone, 56 per cent. The farmer must pay the cost of freight, hauling, and distribution on 0 per cent, 24 per cent, or 44 per cent of inert material. It costs least to apply ground limestone and most to apply quicklime. It is generally not economical to grind limestone to the same degree of fineness as burned or hydrated lime. Based on these considerations, the statements have been made that 50 pounds of quicklime are equivalent as a fertilizer to about 60 pounds of hydrated lime, 100 pounds of air-slaked lime, or 250 pounds of ground limestone; and that at present prices, and taking into account the freight and hauling, quicklime will be found the most economical.[5]

CHEMICAL LIME.

Lime has found a wide use in the chemical industries because it is the cheapest base known. Obviously, the kind of lime desired depends on the purpose for which it is to be used and is therefore extremely variable. Thus, for some industries quicklime, hydrated lime, or ground limestone will be found equally suitable. Under some conditions either magnesian or high-calcium limes can be used with equal success; in other cases, the presence of magnesia in large proportions can not be tolerated. For most purposes the silica, iron, and alumina are to be considered merely as diluents, although they sometimes cause mechanical difficulties by forming a sludge which must be removed. If the lime is to be slaked before use and if the heat generated is not essential to the process, it will probably be found more economical to purchase hydrated lime, because it can be stored and handled with greater facility.

The uses of chemical lime are so numerous that it would be impossible to describe all of them, but a few of the more important ones can be outlined briefly.

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[1] Hopkins, C. G., Ground limestone for acid soils: Illinois Univ. Agr. Exper. Sta. Circ. 110, 1907.
[2] Wheeler, H. J., Is the recommendation that only ground limestone should be used for agricultural purposes a sound and rational one?: Nat. Lime Mfrs. Assoc. Trans., 1912.
[3] Hopkins, C. G., loc. cit.
[4] Wheeler, H. J., loc. cit.
[5] Fippin, E. O., Relation of lime to soil improvement: Cornell Univ. Agr. Exper. Sta. Circ. 7, 1910.

SAND-LIME BRICK.

Sand-lime brick is a building material of growing importance. It consists essentially of a mixture of sand and lime, which is pressed into brick form and then treated with high pressure steam. The lime combines with a part of the sand, forming a calcium silicate, which binds the rest of the sand together. The lime must be completely hydrated before the mixture is pressed, or else the subsequent hydration and expansion will distort or disrupt the brick.

A process has been patented for making sand-lime brick from a magnesian lime, but did not prove successful because it was found impracticable to hydrate the magnesia completely before the brick were pressed.[1] Most of the purchasers of hydrated lime do not demand absolutely complete hydration, so that the manufacturers have not been called upon to give serious attention to this problem. Commercial hydrated lime sometimes contains small percentages of quicklime. For this reason, the manufacturer of sand-lime brick has found it safer to buy quicklime and hydrate it himself.

The presence of small amounts of impurities, especially silica or kaolin, in the lime has been found to be beneficial.[2]

GLASS.

Calcium oxide is a necessary constituent of plate, sheet, and bottle glass, and of a large proportion of the pressed and blown glass. It acts as a flux. Magnesia makes the glass more difficult to melt[3] but is sometimes a valuable constituent when particular optical properties are to be obtained. The calcium oxide is generally introduced as ground limestone, but the use of lime or hydrated lime is sometimes necessary in order to avoid the evolution of gas at high temperatures.

The ordinary impurities of limestone are, in general, of no importance to the manufacturer of common glass. For white glass, however, the content of oxide of iron must be less than 0.3 per cent of the stone.[4]

CERAMICS.

Lime and magnesia, generally as carbonates, are used to some extent as fluxes in the manufacture of pottery and porcelain. It has been found that for wares burned at moderate temperatures, calcium oxide tends to bring the points of vitrification and fusion close together, whereas magnesia tends to separate them, to lower the temperature of vitrification, and to decrease the change of shape due to burning.[5] On the other hand, if the ware is to be burned at higher temperatures, magnesia has little effect on vitrification and fusion and increases the shrinkage.[6] In a series of experiments to determine the values of different bases when used as fluxes for a mixture of feldspar, flint, and clay, it was found that magnesia gave the best results of the five bases tried (oxides of calcium, magnesium,

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[1] Field, H. H., Hydrated lime in the manufacture of sand-lime brick: Sand-Lime Brick Assoc. Proc., 1910.
[2] Peppel, S. V., Sand-lime brick: Ohio Geol. Survey Bull. 5, 1906.
[3] Gelstharp, Frederick, Fallacies and facts pertaining to glass manufacture: Am. Ceramic Soc. Trans., vol. 12, p. 327, 1910.
[4] Rosenhain, Walter, Glass manufacture, p. 45, Van Nostrand, 1908.
[5] Hottinger, A. E., The influence of magnesia on clays: Am. Ceramic Soc. Trans., vol. 5, p. 130, 1903.
[6] Barringer, L. E., Influence of magnesia on clays: Am. Ceramic Soc. Trans., vol. 6, p. 86, 1904.

barium, strontium, and zinc). It gave excellent color, high tensile strength, and only moderate shrinkage.[1]

These results all indicate that magnesia is better than calcium oxide as a flux for ceramic bodies.

The carbonates are generally used, since they are the cheapest forms. Levigated natural whiting is preferred on account of high colloidal content.[2]

In some cases, however, vitrification sets in before the carbonates are all decomposed and further evolution of gas may cause pinholing or internal strain. Under these circumstances it is necessary to use either the oxide or the hydrate. It is sometimes desirable to use the carbonates in wares burned at lower temperatures in order to obtain a porous body.[3]

Since the quantity of carbonate used is generally small and the chemical composition of the mixture may vary slightly, it follows that the impurities generally found in limestones are entirely negligible.

In glazes, magnesium oxide tends to absorb SO_3 from the kiln gases with production of a scum appearance. Although this can be overcome by skillful firing, it makes a low magnesia content desirable in most glazes.

WATER SOFTENING.

"Temporary hardness" of water is caused by the presence of calcium carbonate. This substance is practically insoluble in pure water, but is held in solution by the presence of carbon dioxide, which is found in practically all natural water. If this carbon dioxide is removed, the calcium carbonate will be thrown out of solution. The carbonic acid may be removed by boiling, but it is cheaper to neutralize it with lime. The lime reacts with the carbon dioxide to form calcium carbonate and, since the carbon dioxide is thus removed, this calcium carbonate, together with that originally present in the water, will be removed by the same process, the magnesium oxide in the lime will take no part in the reaction and must be considered as an impurity.

According to the usual method of procedure the lime is slaked to a cream, which is fed in an automatically regulated stream into the main body of water. Experience has shown that a well-burned, high-calcium lime will produce the greatest quantity of cream, which is also of better quality, because the lime stays in suspension longer and can be more thoroughly disseminated throughout the main body of water.

SODA ASH AND CAUSTIC SODA.

Most of the soda ash sold in this country is made by the "ammonia-soda" process. A solution of common salt is saturated with ammonia, and the mixture is treated with carbon dioxide. When the resultant solution is evaporated the soda ash is obtained by crystallization. Ammonia is expensive, and consequently the gas must be recovered and used over again. For this purpose the mother liquor is treated with lime and distilled. The lime replaces the ammonia in its compounds, and thus the gas is set free to distill off.

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[1] Hope, Herford, Comparative effects of CaO, MgO, BaO, SrO, and ZnO on some china bodies: Am. Ceramic Soc. Trans., vol. 11, p. 494, 1909.
[2] Ashley, H. E., The requirements of pottery materials: Am. Ceramic Soc. Trans., vol. 12, p. 445, 1910.
[3] Bourry, Emile, Treatise on ceramic industries, p. 79, 1901.

It is evident that this industry demands limestone, for both the lime and the carbon dioxide are used. The impurities in the stone are not harmful. It would seem that magnesium oxide should be as effective as calcium oxide in breaking up the compounds of ammonia, yet Lunge makes the statement that "magnesium limestone is not suitable for this industry." [1]

Caustic soda is made by dissolving soda ash in water and adding lime. Insoluble calcium carbonate is precipitated, and caustic soda is left in solution. In this reaction the magnesia is entirely inert.[2] The impurities are undesirable because they form a gelatinous precipitate which does not settle clear, and therefore leads to a contamination of the finished product. In this industry quicklime is preferable to hydrated lime because it hastens the reaction.

BLEACHING POWDER.

Bleaching powder is an oxychloride of calcium which is formed by the action of chlorine gas on moist slaked lime. The resultant product is sold on the basis of available chlorine. Any impurities in the lime will lower the quantity of chlorine absorbed, and consequently the value of the product. Magnesia is especially objectionable because it forms magnesium chloride.[3] This substance absorbs water from the air and makes the powder sticky and hard to handle.

Hydrated lime is better suited for this industry than quicklime, because it contains fewer impurities, is easier to handle, and requires no preparation before using.

CALCIUM CARBIDE.

This substance, the source of acetylene, is made by heating a mixture of lime and coke in an electric furnace. For this purpose the only useful ingredient of the lime is calcium oxide.[4] Magnesia and other impurities are objectionable because the whole charge must be fused, and electric power is too expensive to waste it by heating useless material. For the same reason, quicklime is preferable to either hydrated lime or limestone.

ILLUMINATING GAS AND AMMONIA.

When illuminating gas is made by the distillation of coal, the crude product contains, among other compounds, carbon dioxide, hydrogen sulphide, and hydrocyanic acid. All of these would be objectionable to the consumer. Their removal may be effected by passing the gas through layers of moist slaked lime. For this purpose calcium oxide only is useful, although the magnesia and impurities are not harmful.[5] Hydrated lime is to be preferred to quicklime, because it is easier to handle and requires no preparation.

Crude coal gas is the chief source of ammonia. This is removed by washing the gas with water before it has reached the lime purifiers. The solution thus obtained carries both free ammonia gas and some compounds of ammonia. The free gas is driven off by heat and col-

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[1] Lunge, George, Manufacture of sulphuric acid and alkali, 2d ed., vol. 3, p. 37, 1891-1896.
[2] Idem, vol. 2, p. 799.
[3] Idem, vol. 3, p. 440.
[4] Thompson, G. F., Acetylene gas and calcium carbide, p. 47, 1898.
[5] Hunt, Charles, Gas lighting, p. 136, 1900.

lected. Lime is then added to break up the compounds and the ammonia thus liberated is also distilled and collected.

Calcium and magnesium oxides should act with equal facility in liberating the ammonia, but, according to Lunge, magnesium limestone is not applicable to this industry. The impurities are not harmful. Either quick or hydrated lime may be used, with little advantage in favor of either.

CALCIUM CYANAMIDE AND CALCIUM NITRATE.

These substances, known technically as "lime-nitrogen" and "nitrate-lime" have recently been put on the market as commercial fertilizers. They represent means of converting the nitrogen of the air into plant food.

Calcium cyanamide is prepared by heating a mixture of lime and coke in an electric arc furnace, and treating the fused mass with nitrogen. The nitrogen is obtained from the fractional distillation of liquid air. Pure, high-calcium quicklime is required for this industry.[1] Any impurities are undesirable on account of the expense required to heat them.

If air is passed through an electric arc, the nitrogen and oxygen contained in it will combine. The oxide of nitrogen thus formed, when dissolved in water, produces nitric acid. This will combine with any base to form the corresponding nitrate. Since lime is the cheapest of all bases, and has a fertilizing value of its own, it is obviously the base to use. Hence calcium nitrate is formed. Magnesia acts in a similar manner, and its use is dependent on whether or not it would be harmful as a fertilizer. The presence of impurities in the lime is a matter of indifference, and quicklime, hydrated lime, or limestone will produce identical results. Hydrated lime is probably the most economical.

SPRAYING.

Lime enters into the preparation of a number of insecticides used in spraying vegetation. For such purpose calcium oxide is the only useful constituent of the lime. Magnesia and impurities are not harmful. The physical quality of the lime is of paramount importance. The material is sprayed on the vegetation through some form of atomizer, and therefore must contain no coarse particles or grit. For this reason hydrated lime screened to pass 150 or 200 mesh (a commercial article) would certainly give better satisfaction than lump lime.

SUGAR.

In the manufacture of sugar, both carbon dioxide and lime are used. Therefore, sugar manufacturers prefer to buy limestone and burn their own lime.

The juice extracted from either sugar beet or sugar cane contains various impurities. Some of these could discolor the sugar, and others (organic acids) would invert it, that is, they would change the sugar into uncrystallizable glucose, and thus reduce the yield. In order to remove these impurities the juice is heated almost to boiling in the presence of an excess of lime. This lime combines with the

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[1] Kershaw, J. B. C., Calcium cyanamide: The Electrician, vol. 60, p. 548, 1907-1908.

acids, breaks up the other organic compounds, and forms insoluble salts. But it also forms an insoluble compound with the sugar itself. For this reason after the lime has completed its action, carbon dioxide is forced into the liquid. This breaks up the combination between the lime and the sugar, and throws down all the lime as calcium carbonate. This precipitate carries with it all suspended matter, leaving a clear solution of sugar.

For these purposes calcium oxide only is useful. Impurities are apt to cause trouble. Thus, magnesium carbonate is more soluble in sugar solutions than calcium carbonate, and the salt so dissolved is later deposited on the tubes in the evaporating pans, thus making it necessary to clean them more frequently. Any silica present is thrown down as a gelatinous precipitate. This becomes a general nuisance by coating the cloth in the filter presses.[1]

DISTILLATION OF WOOD.

The destructive distillation of wood gives rise to four products: Gas, pyroligneous acid, tar, and charcoal. Of these pyroligneous acid is of most interest to the lime manufacturer. From this solution are prepared wood alcohol, acetic acid, and acetone, and lime is an essential ingredient in the manufacture of all these. First, the crude acid is treated with an excess of lime and distilled. Wood alcohol passes over, but acetic acid is held in the still in chemical combination with the lime. This mixture is known as "gray acetate of lime." Acetone may be produced from it simply by dry distillation; or it may be treated with sulphuric acid and the acetic acid distilled off. The wood alcohol is again treated with lime and redistilled in order to purify it.

For any of these purposes calcium oxide is the only useful constituent of the lime.[2] Magnesia and impurities are not harmful. Hydrated lime may be used instead of quicklime for any of these purposes, except the final distillation of the wood alcohol. For other purposes probably neither substance has any advantage over the other.

PAPER.

Wood pulp for the manufacture of paper is prepared by one of three processes—mechanical, soda, and sulphite, of which only the second and third interest the lime manufacturer.

In the soda process lime is used to causticize sodium carbonate, thus recovering the caustic soda used in cooking the wood.

Calcium oxide is the only constituent of the lime useful in the soda-pulp industry. The magnesia and the impurities are not harmful. Hydrated lime may be used instead of lump lime, but the latter is to be preferred, since the heat generated by its slaking hastens the reaction with the soda.

Another solution which may be used in place of caustic soda for dissolving the cementing constituents of wood is "bisulphite liquor." This is a mixture of calcium amd magnesium bisulphites held in solution by an excess of sulphur dioxide. The liquor is prepared by one of two methods: Limestone may be subjected to the solvent

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[1] Manufacture of sugar: Internat. Lib. of Technology, sec. 50, p. 36, Internat. Textbook Co., Scranton, Pa., 1902.

[2] Dumesny, P., and Moyer, J., Wood products, distillates, and extracts, p. 8.

action of sulphur dioxide and water, or milk of lime may be treated with sulphur dioxide; the resultant solution is the same in either case.

For the maker of sulphite pulp magnesia is a desirable constituent of the lime or limestone. Magnesium sulphite is more soluble than calcium sulphite (100 parts of water dissolving 1.25 parts of the former or 0.0043 parts of the latter), and consequently permits of making a stronger liquor. Moreover, the presence of magnesia in the liquor gives the pulp a better color and makes it softer to the touch, so that it will felt together better when made into paper. Therefore, magnesian lime is much preferable to the high-calcium lime. The impurities are not harmful.

If limestone is used, it should be as porous as possible to permit a rapid solution.

Hydrated lime is preferable to lump lime, because it is easier to handle and contains fewer impurities.

PAINTS.

Ground lime, air slaked lime, levigated chalk (natural whiting), and chemically precipitated calcium carbonate are used to a large extent in the paint and allied industries. For these purposes fineness of grain is essential; sometimes the color or chemical composition is of equal importance. It is difficult to obtain a limestone of sufficient whiteness or to grind it sufficiently fine to meet the requirements. It is therefore an advantage to use air-slaked lime or hydrated lime.

Cold-water paints consist essentially of hydrated lime, pigments, and casein ground together. From the nature of the substances it is obviously impossible to use quicklime, and magnesian hydrates are probably to be preferred over high-calcium hydrates on account of their better spreading qualities.

GLYCERIN, LUBRICANTS, AND CANDLES.

Most common fats are compounds of glycerin with various organic acids. These compounds can be broken up by heating the fat with lime and water under pressure. The glycerin is liberated, and the lime takes its place in the compounds. Practically all of the glycerin used in this country (mostly in the manufacture of explosives) is made in this way. The lime "soaps" formed by this process are sometimes mixed with heavy mineral oils and sold as lubricants or greases. They are of especial value for the lubrication of heavy machinery or for use at high temperatures. The soaps may be treated with sulphuric acid; the separated fatty acids are recovered and used in the manufacture of soap and allied products.

Calcium oxide is the only useful constituent of the lime, although the magnesia and impurities are not harmful.[1] Quicklime is probably preferable to hydrated lime, because the heat of slaking can be used.

TANNING.

In the leather industry lime is used in the "depilation" process. The hair is so loosened from the hide by soaking it in lime water that it can be removed by subsequent scraping. In regard to the quality of lime to be used the following statement is made:

> The presence of magnesia and clay is injurious, not only by diminishing the amount of lime present, but by making the lime much more difficult to slake; and iron oxides,

[1] Sadtler, S. P., Industrial organic chemistry, p. 58, Lippincott, 1906.

though quite insoluble, may become mechanically fixed in the grain of the hide, and may be the cause of subsequent stains.[1]

The use of hydrated lime would remove the above objections to magnesia, but not those to iron. Hydrated lime is probably preferable to quicklime for this reason, as well as for the fact that it is easier to handle.

For some particular grades of leather, such as morocco, the presence of magnesia has been found to be advantageous.

OTHER USES.

In addition to the uses outlined, limestone, quicklime, and hydrated lime play a part of more or less importance in a large number of industries, among which may be mentioned the following:[2]

The manufacture of dichromates, magnesia, bone ash, glue, and varnish; as a refining and purifying agent in the distillation of mercury, in the clarification of grain, in refining fats, greases, butter, linseed oil, and petroleum, in preserving eggs, and as a general disinfecting and deodorizing agent; as a filler in the paper, textile, linoleum, and rubber industries; as a mordant in dyeing; as an abrasive in polishing; in the manufacture of calcium-light pencils, and of magnesium for flashlight powders; as limewater in medicine; for the recovery of potassium cyanide used in extracting gold and silver from their ores; to neutralize the sulphuric acid used in pickling steel; and in a large number of other industries.

The following table summarizes the more important of the chemical uses of lime, together with the kind of lime most suitable to such purposes:

Chemical uses of lime.

- Agricultural industry:
  - As a soil amendment, c, m.[3]
  - As an insecticide, c, m.
  - As a fungicide, c, m.
- Bleaching industry:
  - Manufacture of bleaching powder, "Chloride of lime," c.
  - Bleaching and renovating of rags, jute, ramie, and various paper stocks, c, m.
- Caustic alkali industry:
  - Manufacture of soda, potash, and ammonia, c.
- Chemical industries:
  - Manufacture of ammonia, c.
  - Manufacture of calcium carbide, calcium cyanimid, and calcium nitrate, c.
  - Manufacture of potassium dichromate and sodium dichromate, c.
  - Manufacture of fertilizers, c, m.
  - Manufacture of magnesia, m.
  - Manufacture of acetate of lime, c.
  - Manufacture of wood alcohol, c.
  - Manufacture of bone ash, c, m.
  - Manufacture of calcium carbides, c.
- Chemical industries—Continued.
  - Manufacture of calcium-light pencils, c.
  - In refining mercury, c.
  - In dehydrating alcohol, c.
  - In distillation of wood, c.
- Gas manufacture:
  - Purification of coal gas and water gas, c, m.
- Glass manufacture:
  - Most varieties of glass and glazes, c.
- Milling industry:
  - Clarifying grain, c, m.
- Miscellaneous manufactures:
  - Rubber, c, m.
  - Glue, c, m,
  - Pottery and porcelain, c, m.
  - Dyeing fabrics, c, m.
  - Polishing material, c, m.
- Oil, fat, and soap manufacture:
  - Manufacture of soap, c.
  - Manufacture of glycerine, c.
  - Manufacture of candles, c.
  - Renovating fats, greases, tallow, butter, c, m.

[1] Proctor, H. R., Principles of leather manufacture, p. 121, Spon & Chamberlain, New York, 1903.
[2] Burchard, E. F., Production of lime in 1911: U. S. Geol. Survey Mineral Resources, 1911, pp. 645–718, 1912.
[3] High-calcium lime is indicated by "c," magnesian and dolomitic lime by "m."

Oil, fat, and soap manufacture—Contd.
- Removing the acidity of oils and petroleum, c, m.
- Lubricating greases, c, m.

Paint and varnish manufacture:
- Cold-water paint, c, m.
- Refining linseed oil, c, m.
- Manufacture of linoleum, c, m.
- Manufacture of varnish, c, m.

Paper industry:
- Soda method, c.
- Sulphite method, m.
- For strawboard, c, m.
- As a filler, c, m.

Preserving industry:
- Preserving eggs, c.

Sanitation:
- As a disinfectant and deodorizer, c.
- Purification of water for cities, c.
- Purification of sewage, c.

Smelting industry:
- Reduction of iron ores, c, m.

Sugar manufacture:
- Beet root, c.
- Molasses, c.

Tanning industry:
- Tanning cowhides, c.
- Tanning goat and kid hides, c, m.

Water softening and purifying, c.

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