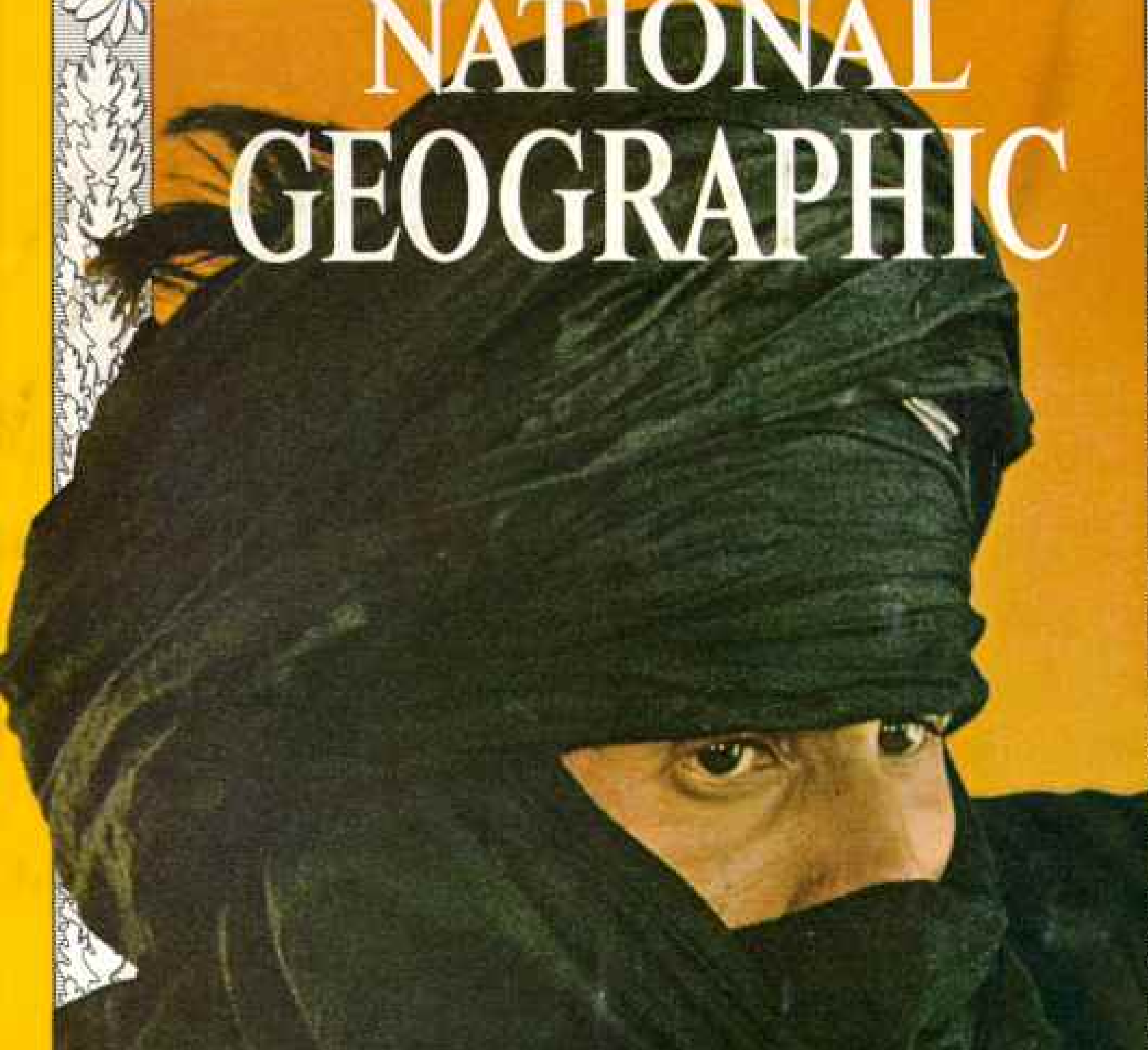


# NATIONAL GEOGRAPHIC



## ST. LOUIS

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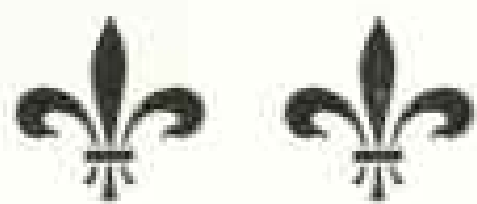


November, 1965

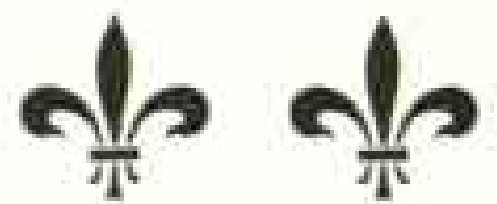
# NATIONAL GEOGRAPHIC

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New spirit soars in  
Mid-America's proud old city



## ST. LOUIS



By ROBERT PAUL JORDAN

*Photographs by BRUCE DALE*

Both National Geographic Staff

**W**E DROVE WEST from the river through the choked streets of downtown St. Louis, making slow headway—slower even than the ponderous barges creeping upstream against the Mississippi's strong current. Soon after we crossed busy Twelfth Boulevard, the scene suddenly changed.

Before us lay a wasteland, a vast expanse of desolation: block after block of rubble in the heart of the metropolis. My newspaperman friend stopped his car and waved out the window, pleased at the destruction.

"We're taking St. Louis apart and putting it together again," he said, surveying the debris. "*This*," he added, "is a great improvement over what used to be here."

I shook my head, awed. I remembered the smoke-stained old river town fondly from World War II days, a haven to me and thousands of other servicemen on weekend passes from nearby bases. Now, after more than 20 years, I had returned to a St. Louis I never knew. Moving about the central business section, I concluded that its most striking aspect indeed was the cr-r-runch of the wrecking crew's steel "headache ball." Wherever I looked, it was smashing the ribs of weary hotels, grimy warehouses, sagging tenements.

And now we found ourselves in a great swath of

Modern-day flag and medieval king symbolize St. Louis, whose name honors France's Crusader Louis IX. Adopted last year, the flag features a fleur-de-lis on rippling lines representing the merging Mississippi and Missouri Rivers.



PHOTOGRAPHS BY KUDU HAYEK (LEFT)  
AND BRUCE DALE (R)

cleared land, treeless and bleak. Tumbleweeds bounded across it, worried by the wind.

"Mill Creek Valley was our worst slum," my companion went on. "It had the city's highest crime rate and highest incidence of disease. Two-thirds of its buildings lacked running water. When we demolished it, starting in 1959, we fought rats every inch of the way.

"Today, Mill Creek Valley is the largest urban-renewal project of its kind in the country—454 acres—and it's finally beginning to take shape. It's a ten-year job. Come back in a few years and you'll see a near miracle."

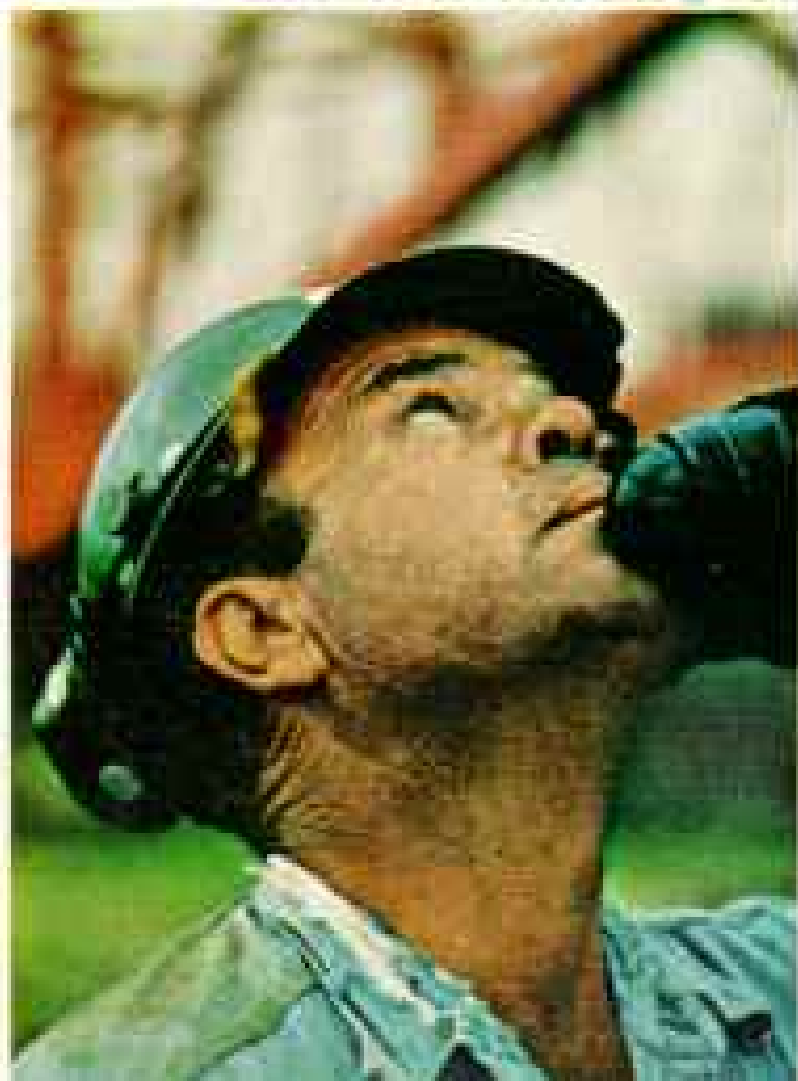
I was even then viewing one—the rejuvenation of a dying city (pages 608-9).

And that was nearly two years ago. I have continued to marvel at its progress on subsequent visits. I hardly recognized Mill Creek Valley when I saw it recently. Expressways were being carved; townhouses and a multi-story motel had sprung up, with more buildings under way. By 1970, St. Louis will have torn down and rebuilt a fifth of its 61 square miles at a cost of more than a billion dollars.

I began reacquainting myself with St. Louis as the city prepared to launch a two-year observance of its 200th birthday. In those two centuries a Nation had funneled through here, pushing the frontier to the Pacific. It seemed an appropriate time to take the city's

**"Creeper crane,"** clinging to the north leg of the Gateway Arch, responds to a steelworker's telephoned instructions. The derrick gently hoists a stainless-steel section to the 500-foot level. Central feature of the Jefferson National Expansion Memorial, the arch commemorates St. Louis as gateway to the West. Nearly vertical tracks and other rigging in the foreground of this Fisheye-lens view enable the crane to crawl upward as the leg grows taller.

PHOTOGRAPHS BY BRUCE DALE © N.Y.C.





## St. Louis builds for tomorrow

FIFTEEN YEARS AGO the late Joseph Pulitzer, editor and publisher of the *St. Louis Post-Dispatch*, launched a crusade entitled "Progress or Decay," a cause taken up by his son and successor Joseph Pulitzer, Jr. (below). With the *Globe-Democrat* and civic leaders adding momentum, St. Louis tackled the blight that has beset most American cities: slums, traffic congestion, stagnation. Today the old river town rips out decrepit buildings by the block. In their place rise urban-renewal projects such as colorful Plaza Square Apartments on Memorial Plaza. Gateway Arch climbs beyond the Civil Courts Building at the mall's east end. Traffic-filled Market Street heads west toward Mill Creek Valley, where townhouses, motels, industrial plants, and expressways supplant rat-infested tenements that once produced the city's highest crime and disease rates. A result: The youth of St. Louis steps off to a brighter future.



EXTRACHROMES (ARDELL AND FORD) © K.A.S.



measure. To size it up, I rode on the river; visited shoe plant, brewery, and raw-fur house; enjoyed ball game, ballet, and botanical garden; dined on sauerbraten, lobster, steak, and catfish; strolled spacious Forest Park and gay Gaslight Square; roamed the metropolis length and breadth, and talked with its leaders—and its cab drivers, newspapermen, and other historians.

I learned that St. Louis shares the problems of most American hubs—traffic congestion, air pollution, flight of middle-class families to

suburbs, arrival of low-income families from rural areas. A dozen years ago more than half its homes stood in areas declared substandard. Good neighborhoods had become blighted; blighted ones had become slums.

I found out something else, too: St. Louis has earned the right to give itself a large pat on the back. I heard President Lyndon B. Johnson sum it up aptly. Launching the bicentennial events on February 14, 1964, he characterized the city in these words:

"As the Gateway to the West, St. Louis

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became one of the finest and most important cities of the world. But at the very summit of her glory, the blight that was to deface dozens of American cities also struck St. Louis. The incredible vitality of this proud Queen of Mid-America began to erode. . . .

"You faced a hard choice," the President continued, "and you made it. The people of St. Louis chose progress—not decay. A new spirit of St. Louis was born. And today, you look forward to the future with new pride and new confidence."

I can offer a personal illustration of what President Johnson meant. Visiting the city not long ago, I stayed at the new Downtowner Motor Inn, at the bustling intersection of Twelfth and Washington. Completed last year, the inn covered a deep hole in the ground that had been there more than 30 years, the eyesore reminder of a long-abandoned office-building project.

The President's words pointed out that the key to present and future St. Louis is to be found in the city's unique history. Today's metropolis is built on its yesterdays.

Before the white man came, this was just one more wooded bluff along the Mississippi River. Then, in 1762, the French governor of Louisiana franchised the New Orleans firm of Maxent, Laclède & Company to trade in furs with Indian tribes far up the Mississippi and Missouri Rivers.

#### Choice of Site Assures Greatness

Pierre Laclède Liguist (familiarily called Laclède) went upriver to select a site for a fur-trading post. He found it near the meeting of the two mighty streams. It lay about midway along the length of the Mississippi, 1,049 miles north of New Orleans as the river meanders today. Laclède named it after King Louis IX of France, patron saint of the then-reigning monarch, Louis XV.

On February 14, 1764, Auguste Chouteau, Laclède's 14-year-old aide, stepped ashore there to set men building the first rude huts. Thus began what was to become the gateway to the rich and beckoning land beyond the Mississippi, and to all the tomorrows that made the United States what it is today. (See "So Long, St. Louis, We're Heading West," by William C. Everhart, beginning on page 643.)

In 1804, a thousand or so people were living in St. Louis. That was the year Meriwether Lewis and William Clark outfitted an expedition there and headed up the Missouri to determine for President Jefferson what his new Louisiana Purchase amounted to.\* From this newly acquired wilderness would be sliced six states and parts of 11 others. The United States paid France 2½ cents an acre for it.

Indian, trapper, explorer, trader, riverman, gold seeker, adventurer, soldier, sodbuster, railroader—all passed through St. Louis in their time. Frenchman, Spaniard, Yankee, Irishman, German, Negro, Pole, Italian—all came seeking a better life, and many stayed.

#### World's Fair Marked City's Peak

St. Louis boasted more than 300,000 residents by 1870, making it the Nation's third largest city after New York and Philadelphia. In 1904, this water and rail terminus, this thriving trading post, celebrated its well-being in a splendid world's fair, the famed Louisiana Purchase Exposition.

Perhaps St. Louis rested on its laurels after that. Capital investments dropped off; major improvements were few. In a 12-year period as mayor, ending last spring, Raymond R. Tucker spearheaded the city's comeback. He was still in office when I called at City Hall, a salmon-brick and pink-granite edifice with carved gables and Renaissance roofs, modeled after the Hôtel de Ville, Paris's city hall.

"One of the greatest changes I've seen," the silver-haired official told me, "is the interest people are showing in the city's revitalization—whether for or against it. Take my own case. I'm a native of St. Louis. I live half a mile from where I was born. I've lived in the same house for more than half a century—in an area my own Planning Commission now calls blighted. I don't agree."

In a changing city like St. Louis, it is natural that disagreements should arise. Many a St. Louisan deplores the extensive tearing down and rebuilding. But at least the city's pleasant Old World flavor lingers. You'll bump into a lot of Poles along Cass Avenue, on the north side; you'll find the Gallaghers, Murphys, and O'Briens in the nearby "Kerry Patch" section.

\*GEOGRAPHIC writer Ralph Gray told of "Following the Trail of Lewis and Clark" in the June, 1953, issue.

"Meeting of the Waters," Aloe Plaza's famous fountain group, welcomes travelers at Union Station. Bronze figures by the late Carl Milles, Swedish-American sculptor, symbolize the flowing together of the Mississippi and Missouri Rivers.







Little Italy lies to the south, on "The Hill."

Everywhere you'll meet the second-, third-, and fourth-generation descendants of the Germans who flocked there in the 1800's. They set the tone for the city: solid, conservative. I asked a St. Louisan whose grandparents came from Germany to elaborate on this.

"We go to work, come home, go to church, entertain quietly," he said. "When we invite friends in, we're *klatchin'*; when we visit others, we're *bummin'*. We're prudent. If we carpet the house, we put down runners to protect the carpet."

#### "Pops" Concerts Replace *Biergärten*

Turn-of-the-century *Gemütlichkeit*, with its beer gardens, brass bands, and steamy good fellowship, has pretty much disappeared. But

St. Louis has a substitute that pleases a good many of its citizens, whatever their extraction: the beer-and-pretzels "Pops" concerts of the St. Louis Symphony. As many as 1,500 concertgoers pack the huge Khorassan Room of the Chase-Park Plaza Hotel at these monthly affairs. Red-jacketed waiters hustle among them, lugging buckets crammed with bottles of cold beer.

Hearty conviviality soon prevails. I recall an evening when my neighbor kept time with his beer bottle to a particularly rousing tune, banging it on the table. He was not dismayed when it broke. I was, though. I got drenched.

I found the most striking symbol of St. Louis, old *and* new, in the magnificent 630-foot Gateway Arch soaring high above the old Mississippi levee. This gleaming modern



ATTACHMENT © NATIONAL GEOGRAPHIC SOCIETY

Mississippi pilot Francis Meyer points his 12 barges upstream, bound for Chicago with a cargo of sulphur. Beyond the cloud of pigeons lie 91-year-old Eads Bridge—world's first steel-truss span—and Veterans Memorial Bridge, appearing as one structure. St. Louis barges transport nine million tons annually along the broad waterway that divides the Missouri metropolis from its sister city, East St. Louis, Illinois (maps, above).

Muscles straining, a deck hand tightens steel cables that bind the barges together; a barge loose in the channel could wreak havoc. Safety regulations of many barge lines require life jackets.

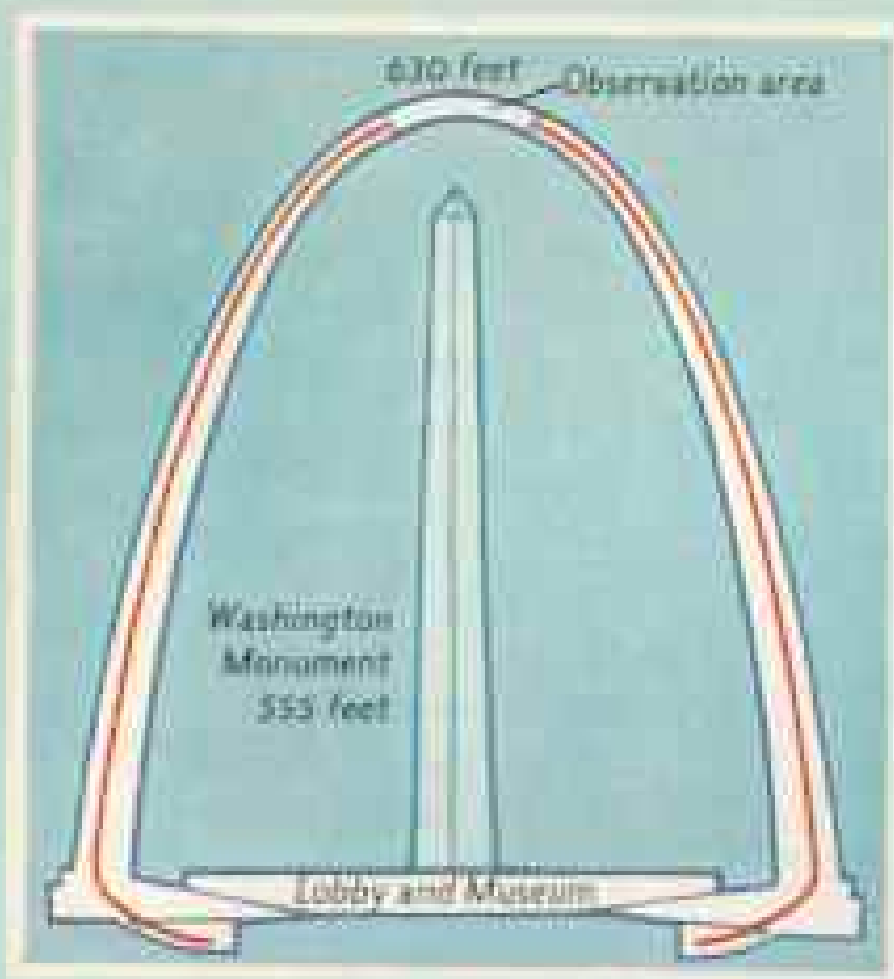


Reborn in sections, St. Louis wears splashes of redevelopment and rehabilitation, a concept devoted to preserving all structures worth saving. In such a section as Murphy, for example, many homes built before the Civil War proved salvageable. Where necessity dictates demolition, public housing fills the gaps.



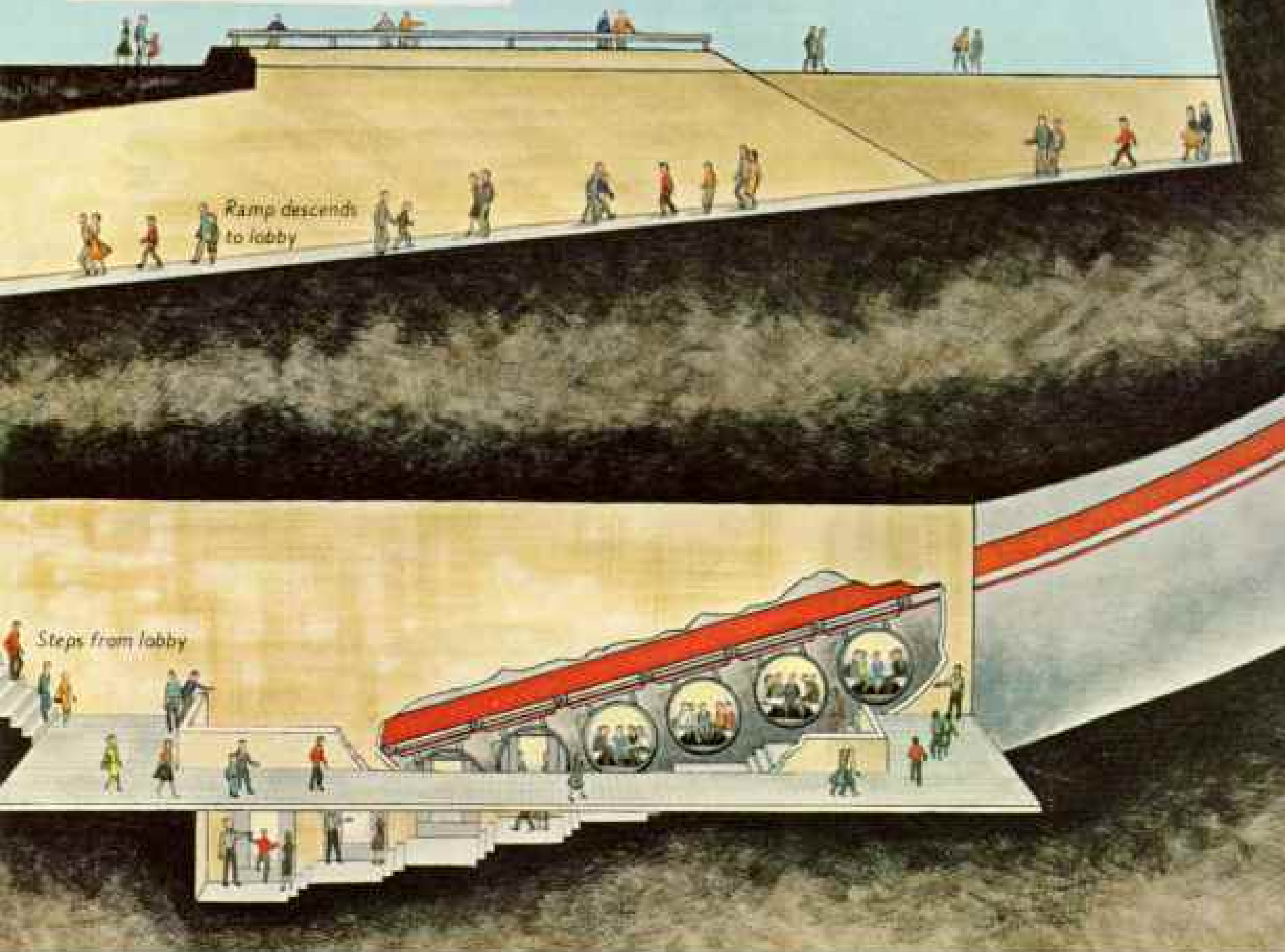
URBAN RENEWAL AREAS:  
 REDEVELOPMENT PUBLIC HOUSING  
 REHABILITATION





Half train, half Ferris wheel, an elevator will lift sightseers to the Gateway Arch's observation room at the apex, 75 feet higher than the Washington Monument (drawing left). Departing from underground loading zones, eight-car trains in each leg will change course 145 degrees on their way to the top; stabilizing motors will rotate capsules, keeping passengers level.

In the painting below, capsules hang by railroad-type wheels from channeled tracks while riders take seats in five-passenger cars. Beginning its ascent, train curves skyward to dart up the arching leg. The unique conveyance will transport a maximum of 440 visitors an hour.



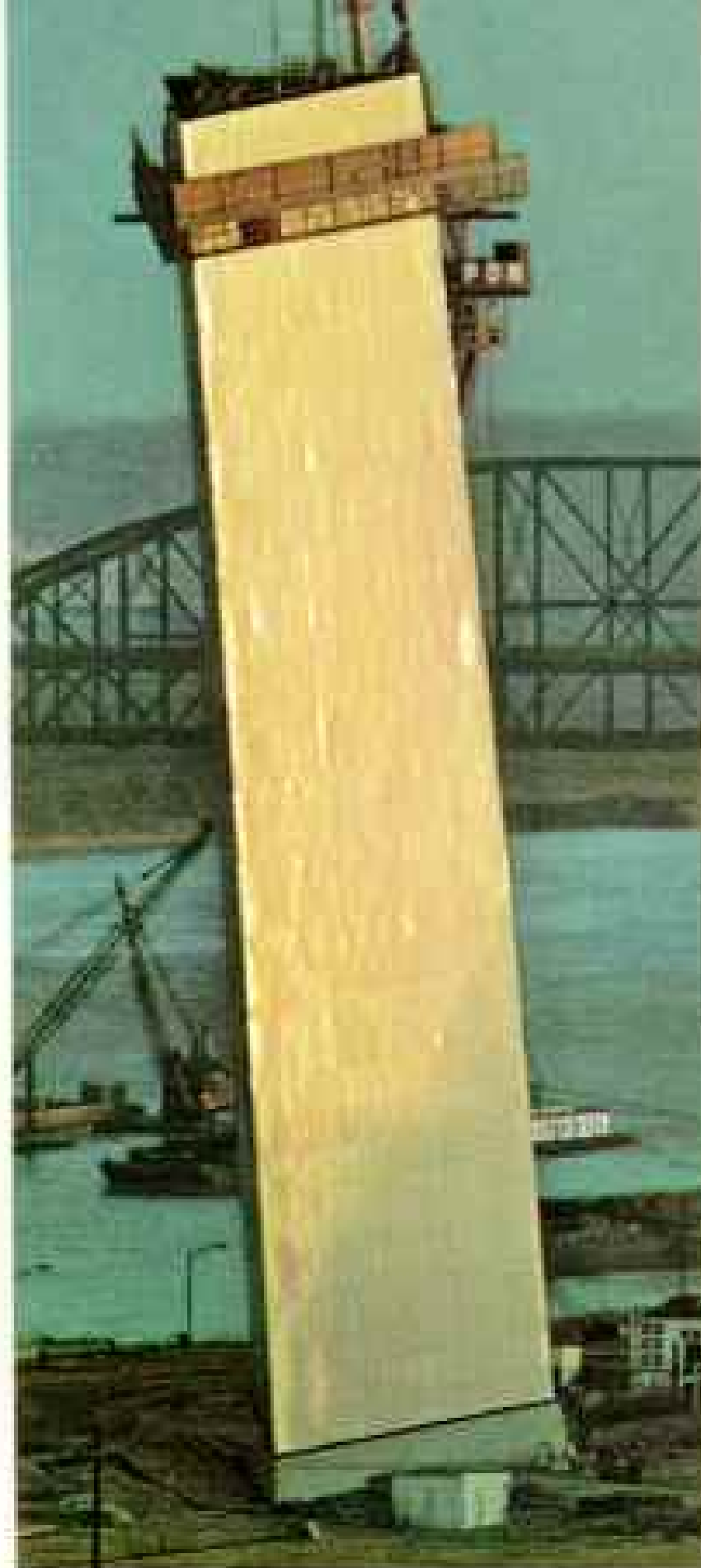
monument—the Nation's tallest, standing 75 feet higher than the Washington Monument—majestically salutes St. Louis as gateway to the West.

Soon to be opened, the \$12,000,000 Gateway Arch is the centerpiece of the National Park Service's 82-acre Jefferson National Expansion Memorial, a tribute to the men and women who settled the new lands. Fronting the river for almost a mile, and three blocks deep, this \$30,000,000 development includes the site of Laclède's fur-trading post. Here St. Louis,

child of the river, became father of the West.

The late Eero Saarinen designed the Gateway Arch. He once told an interviewer that he was "trying to reach for an absolutely permanent form—a high form. Stainless steel would seem to be the most permanent of the materials we have, and it seemed the thing one could trust most."

Architect Saarinen had to choose well; nothing like this arch had ever been built. His design is an inverted catenary—the curve a chain takes when it hangs freely between



RESEARCHED BY NATIONAL GEOGRAPHIC PHOTOGRAPHERS GEORGE HOOLEY (BELOW) AND BRUCE OWEN (TOP)



Agleam in a fading sun, the Gateway Arch's south leg approaches its halfway point in May, 1964. Pittsburgh-Des Moines Steel Company, fabricator of the arch, used 900 tons of polished stainless steel—largest amount ever employed in a single project.

**First step:** digging foundations that penetrate to bedrock 60 feet below ground. The arch would deflect no more than 18 inches in a 150-mile-an-hour wind. Says project manager Kenneth J. Kolkmeier: "It will withstand an earthquake."



**Milky mists of early morning enfold the feet of the growing monument. In the distance,**

two points. It is structurally the soundest arch of all, in which the thrust passes downward through the legs and is absorbed by the foundations.

I watched men put the monument together much as a child builds with blocks: 12-foot-high sections were hoisted one on top of another and welded together. "On a job this big the welds have to be perfect," a young engineer at the site told me. "We X-ray every one."

#### **Visitors Will Speed Aloft in Capsules**

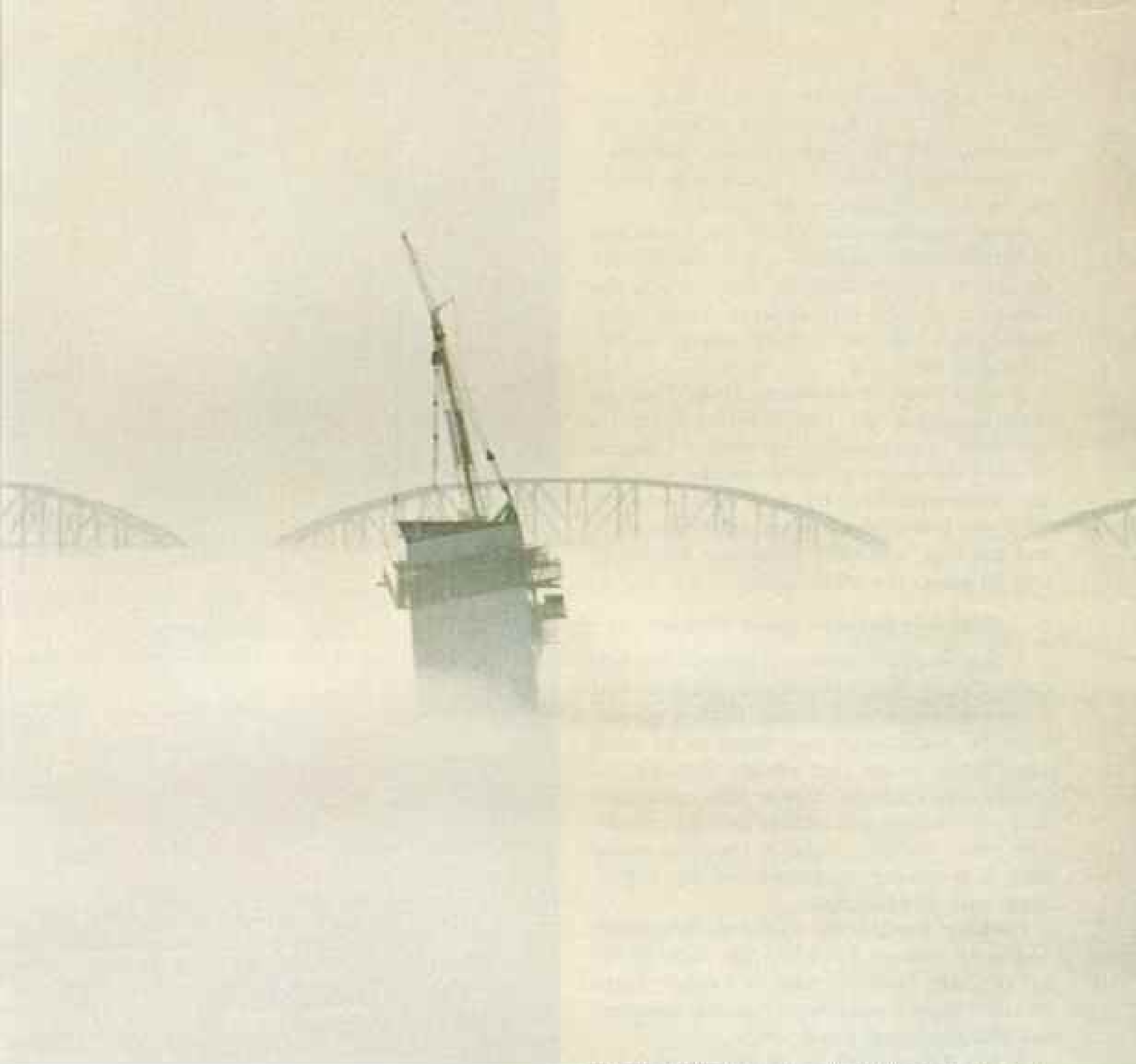
St. Louisans are not reluctant to poke fun at the huge arch—the "stupendous hairpin," some call it. The "Yankee leg" is the north one, of course, and the "Rebel leg" is the south. "They'll never get them to join at the top," I heard one sidewalk superintendent predict direly, crossing his forefingers by

way of illustration. Happily, he was wrong.

When the arch opens early in 1966, visitors will ride either of the novel passenger trains (one in each leg) to the 65-foot-long observation room at the top.

From the top you'll be able to look east 33 miles across the Illinois prairie, taking in at a glance the turbid Mississippi, the freight yards and grain elevators of East St. Louis, and the spewing smokestacks of industry—steelworks, chemical complexes, oil refineries, meat-packing houses, and generating plants. Looking westward across the gentle Missouri hills, the craggy city and suburbia beyond will fill the eye.

And beneath the arch, underground, will be a large Visitor Center. The center will feature an extensive Museum of Westward Expansion, still to be constructed.



PHOTOGRAPH BY NATIONAL GEOGRAPHIC PHOTOGRAPHER BRUCE DALL © N.G.S.

arches of MacArthur Bridge undulate across the horizon like the humps of a roller coaster.

President Johnson will be invited to dedicate the Jefferson National Expansion Memorial next year, possibly in the spring. And by dedication time, the new St. Louis growing up around it will be clearly visible.

But the old St. Louis will live on in its midst. On the memorial grounds, for instance, stands the Basilica of St. Louis, King of France—the Old Cathedral. Completed in 1834 on the church block designated by Laclède, this venerable cut-stone building still echoes to Masses and weddings.

A block west rises the white cruciform Old Courthouse, an outstanding example of Greek Revival architecture. Begun in 1839, its 128-ton cast-iron dome towers nearly 200 feet; steamboaters used it as a landmark. Through its halls strode men like Ulysses S. Grant, Thomas Hart Benton, Henry Clay.

A little more than a century ago, slaves were auctioned on its east steps. In one of its courtrooms, in 1847, Dred Scott's right to be a free man was first pleaded; a decade later the United States Supreme Court ruled that he was still a slave, and America heard the distant drums of civil war.

Long the city's main meeting place, the Old Courthouse quartered Union soldiers during the war. Divided in sympathies at the outset, St. Louis became a Union stronghold.

Today the gracious old building is both museum and headquarters of the Jefferson National Expansion Memorial. When I visited Superintendent LeRoy R. Brown in his second-floor corner office, he led me to a window. We looked out at the tract and its shining monument.

"What is happening here," he began, "is

almost unbelievable. We estimate that three million visitors a year will be admiring the memorial. And the old riverfront," the quiet-spoken official added, "is going to be one of the finest landscapes in the country."

Along the site's west boundary, I watched giant machines scoop out a new roadbed for the Third Street Memorial Drive. Now the highway is below ground level, out of sight; traffic noise will not mar the serenity of basilica and memorial.

A short distance southeast, I could see the skeletal steel of the Poplar Street Bridge, a new-type span in which reinforced I beams beneath the roadway eliminate the need for any superstructure. By late 1966 or early 1967, the low-profile bridge, eight lanes wide and toll free, will carry Interstate Routes 55 and 70 across the Mississippi.

#### Diners to Revolve Above Stadium

A few blocks southwest, the \$24,000,000 Civic Center Busch Memorial Stadium and other structures were rising. Here in downtown St. Louis, dust was flying as 82 acres were being razed and rebuilt. Besides the 55,000-seat stadium, which will open next year, the complex will include parking garages and office buildings, and a towering motel with a revolving restaurant on top (right). Total cost: \$89,000,000.

Looking toward the national memorial's northwest corner, I spotted the start of the \$52,000,000 Mansion House Center: three 28-story luxury apartment towers, commercial buildings, and retail shops.

A handsome mall is to extend about a quarter mile west; someday it may run all the way to renovated Mill Creek Valley. And across the river will be the new home of the nonprofit National Museum of Transport,



ILLUSTRATION BY ARTHUR L. WITKIN © 1967



Daring in concept, awesome in execution, Gateway Arch dominates the city's skyline in this artist's rendition of the completed structure. Its graceful curve frames the Old Courthouse; new stadium and columnar motel stand at left.

Scissor jack, a temporary support, connects the two legs as the arch nears completion. The jack can expand or contract to facilitate fitting of the keystone segment. Excursion boat *S.S. Admiral* heads downriver.



PRODUCED BY NATIONAL GEOGRAPHIC SOCIETY, JOSEPH S. BARNETT, STAFF ARTIST © N.G.S.

displaying one of the world's most comprehensive collections of locomotives, buses, carriages, and other vehicles.

I had already seen this outdoor transport display at its St. Louis County site. I outlasted a horde of small boys to sit at the controls of one of the largest steam locomotives ever built—more than 130 feet long.

#### Vitality Returns to City's Heart

Why all this drastic urban surgery? To keep the city vital, and to attract both people and industry, the city's leaders told me. In 1950 the census counted a city population of 856,796; today it has dropped to 711,000.

"But the day of the headache ball is just about over," declared the city's new mayor, 44-year-old A. J. Cervantes, a handsome, outspoken former businessman. Soon after his election, I went to City Hall to visit him. "People are beginning to move back into the city," he added. "We've made the room. Now the city can grow again."

Nevertheless, the old river town is unlikely to expand geographically. Its boundaries were fixed in 1876, when the city seceded from St. Louis County. The City of the Sainted King will almost certainly remain a football-shaped enclave, 19 miles north to south along the river, seven miles wide at its widest.





Though the city proper has declined in population, the metropolitan area around it has experienced a healthy growth. In Missouri, the metropolis consists of the city of St. Louis and the counties of St. Louis, St. Charles, Jefferson, and Franklin; the Illinois elements are Madison and St. Clair Counties. In 1950, 1,755,334 persons were living here; today there are 2,180,000. More than \$2,200,000,000 worth of major building projects are in various stages of construction.

My friend Francis J. O'Keefe, a public relations man and a lifelong St. Louisan, took a couple of days off to show me the area

(maps, page 613). From his car he pointed out heavy and light industry, huge manufacturing plants, utilities, transportation facilities, the marts of trade. "We make chemicals, feeds, shoes, beer, apparel, automobiles, aircraft, space capsules, steel," he said. "You name it, we make it."

"We've always been a great transportation center," Frank observed as we crossed the Mississippi. "Only Chicago outranks us in railroads, and we are a leading center of trucking and automobile-making."

We also toured the home plant of the world's largest brewery: Anheuser-Busch,



PHOTOGRAPH BY BRUCE DALE © NATIONAL GEOGRAPHIC SOCIETY

Inc., with its buildings spreading over 70 city blocks in south St. Louis. I could have found it without a guide by following the pleasant aroma of mash and hops.

One is bound to bump into sharp contrasts in such a place. Consider the climate itself, which consists of four distinct seasons—all capricious. I drove into St. Louis in January as a blizzard wore out, and played golf at nearby Scott Air Force Base a few days later in 70-degree sunshine.

Consider the cultural climate, graced by fine museums, world-famous medical schools, excellent public and private libraries, art

**Offspring of St. Louis**, the miniature city of Clayton has sprung up west of the historic town, whose towers touch the horizon in this helicopter view. Limited to 61 square miles in 1876, St. Louis can never extend its boundaries without the approval of a majority of its own citizens and those of neighboring St. Louis County, to which the city once belonged. Meanwhile, the metropolitan area—four counties in Missouri and two in Illinois—burgeons. Mostly farmland three decades ago, St. Louis County alone now contains 96 municipalities; Clayton serves as the county seat.



exhibits, chorales, ballet, and the Nation's second oldest symphony orchestra after the New York Philharmonic. I sat enthralled one night in Kiel Auditorium, enjoying a symphony with a couple of thousand others in the Music Hall. Beyond the stage, out of sight and sound in adjacent Kiel Arena, thousands more St. Louisans yelled for their professional basketball team, the Hawks.

I doubt if any town follows sports more avidly than St. Louis. Mention the football or baseball Cardinals, the Hawks, or the hockey Braves, and you've got a conversation—and possibly an argument. The St. Louisan's No. 1 St. Louisan, native son or adopted, isn't the late poet T. S. Eliot or even Charles A. Lindbergh. He is the Cardinals' recently retired star batter, "Stan the Man" Musial (page 639).

#### Old Man River Has Ups and Downs

Remarkable for inconsistency is the mighty Mississippi itself. During my visit early in 1964, the river had remained so low for so long—a total of 130 low-water days—that it set a 24-year record. Barges slid along half empty, lightened to a five-foot draft to avoid dragging the bottom. A nine-foot depth is minimum for most fully loaded barges.

When I returned last spring, the river had rampaged through Minnesota, Iowa, and Illinois, and swelled to within five feet of flood stage at St. Louis, covering the granite cobblestones of the wide levee.

At dusk one day, in a cold rain, I boarded the most powerful river towboat in the world, bound out of St. Louis for New Orleans with a cargo of asbestos pipe, corn, and soybeans.

She was Federal Barge Lines' M.V. *United States*, and her four diesel engines could develop 9,000 horsepower. She could easily propel 40 barges carrying 40,000 tons of cargo—equal to the payload of a thousand railroad freight cars—making 12 miles an hour with the current, or five against it. This trip, we would push 26 barges. Our load, still called a "tow" even though it's pushed, spread 215 feet wide and a little less than a quarter of a mile long—a flotilla more than six acres in size, lashed together with steel cables.

I stood in the pilothouse, peering into the murky night. In front of me, Capt. David C. Stein reached overhead and pulled a line, sounding three blasts like an ocean liner's, and we churned downstream into a nasty rain squall.

Driving four spirited horses, civic leader August A. Busch, Jr., gives his wife, son Andrew, and friends a ride around Grant's Farm, his estate south of St. Louis. Comedian Danny Kaye, smoking a pipe, sits behind. Maintained by Anheuser-Busch as a tourist attraction, the estate features a wildlife sanctuary, zoo, and Ulysses S. Grant's log cabin, his Missouri farm home from 1856 to 1858.

Cooling off in Forest Park, Washington University art student Sandy Rosenfeld wades across the pool of a waterfall. The 1,380-acre recreation area, one of the largest city parks in the Nation, held the 1904 Louisiana Purchase Exposition.



FORACHOWES BY BRUCE DALL © A.S.S.



**Turn-of-the-century elegance** mellows an evening in Gaslight Square. Music from nightclubs and restaurants floats out to the street, and antique shops beckon. Patrons of such places as the Golden Eagle, Gilded Cage, and Mr. D's steak house dine amid crystal

I asked Captain Stein, a trim veteran of more than 30 years on the river, if the weather would hinder us. Gusts were kicking up spray over the front barges.

"In a strong wind," he said, "you'll see waves hitting back over the leading four or five barges. But no weather bothers us—except fog. I think we'll be running into some later on, and I'll probably lay the tow against the bank until it lifts."

Watching the captain steer his monstrous train, I thought of river pilot Mark Twain and the romantic packet boats. In the mid-1800's, they moored two and three deep along the St.

Louis levee—3,000 or more paddle-wheelers in a good year. Dangerous craft they were; explosion and fire sank them by the hundreds, and navigational hazards sent still more to the bottom. The railroads sealed their doom.

Mark Twain, I am sure, would find today's towboats unbelievable. I did, myself. And I think today's river captain must be one of the busiest men alive. He occupies the pilothouse six hours on, six off, during each 30-day cruise. His eyes, ears, hands, mind never relax.

At night the pilothouse stays unlighted. The captain glances at radarscope, compass, and depth-measuring gear. He plays a huge



chandeliers, wood paneling, and grillwork salvaged from once-stylish Mill Creek Valley homes now torn down.

Ardent Romeo woos demure Juliet in a painted window—and sets the mood at the Three Fountains, a Gaslight Square restaurant featuring French cuisine.

spotlight on the far-off bow as it noses around a horseshoe bend—and throws another spotlight on the river bank. Too close?

“How many barges you got?” The voice of another tow’s master crackles over ship-to-ship radio. “We just got 15.”

Captain Stein replies promptly. “Twenty-six.” Then he explains to me. “That’s the *Fort Jackson*,” he says. “She’s overtaking us.”

The skipper touches the controls of the four steering rudders and delicately adjusts the speed of each of the four engines until he is satisfied. We have given the approaching tow a wide-enough berth.

I grew weary, though the skipper showed no signs of fatigue. Next morning, well rested, I was glad to see sparkling sunlight filling the fertile Mississippi Valley to the horizon. The brown river’s banks were tall with cottonwood, sycamore, and willow. We moved smoothly downstream; to me it seemed a peaceful painting, a rich pastoral.

But not to Captain Stein. Danger of running aground was ever present. “I’d rather have an overcast day,” he said, sweeping the river with binoculars. “It’s easier on the eyes.”

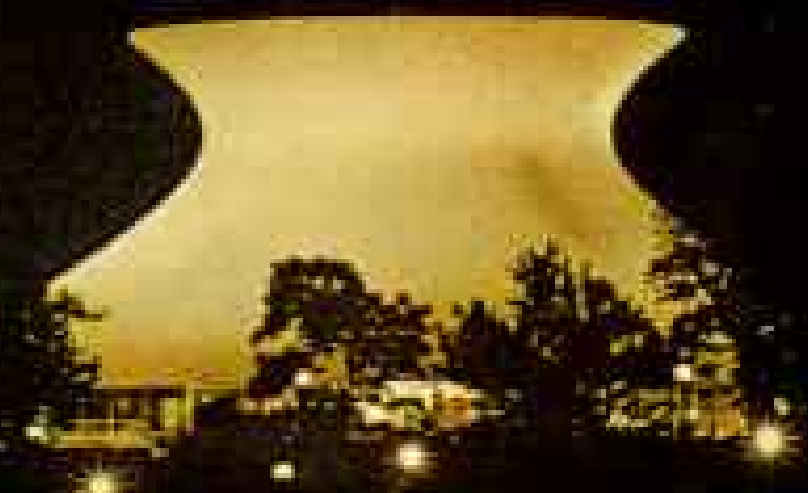
The United States Coast Guard and Army Corps of Engineers scrupulously mark the

RESTORATION AND RENOVATION (ARND BRONKHORST) © N.H.S.

**STARGAZERS STUDY THE FIRMAMENT**  
*as it appears over St. Louis. The  
McDonnell Planetarium's projector  
(center), operated from the console  
at right, can show star positions at  
any point in time and from any  
place on earth. Here Polaris, the  
North Star, indicates the city's latitude  
by its position on the calibrated  
meridian at upper right—38 degrees  
38 minutes above the horizon.  
Dotted line traces the sun's apparent  
path among the stars as seen from  
the orbiting earth. In foreground,  
the rising sun casts a fiery glow.*

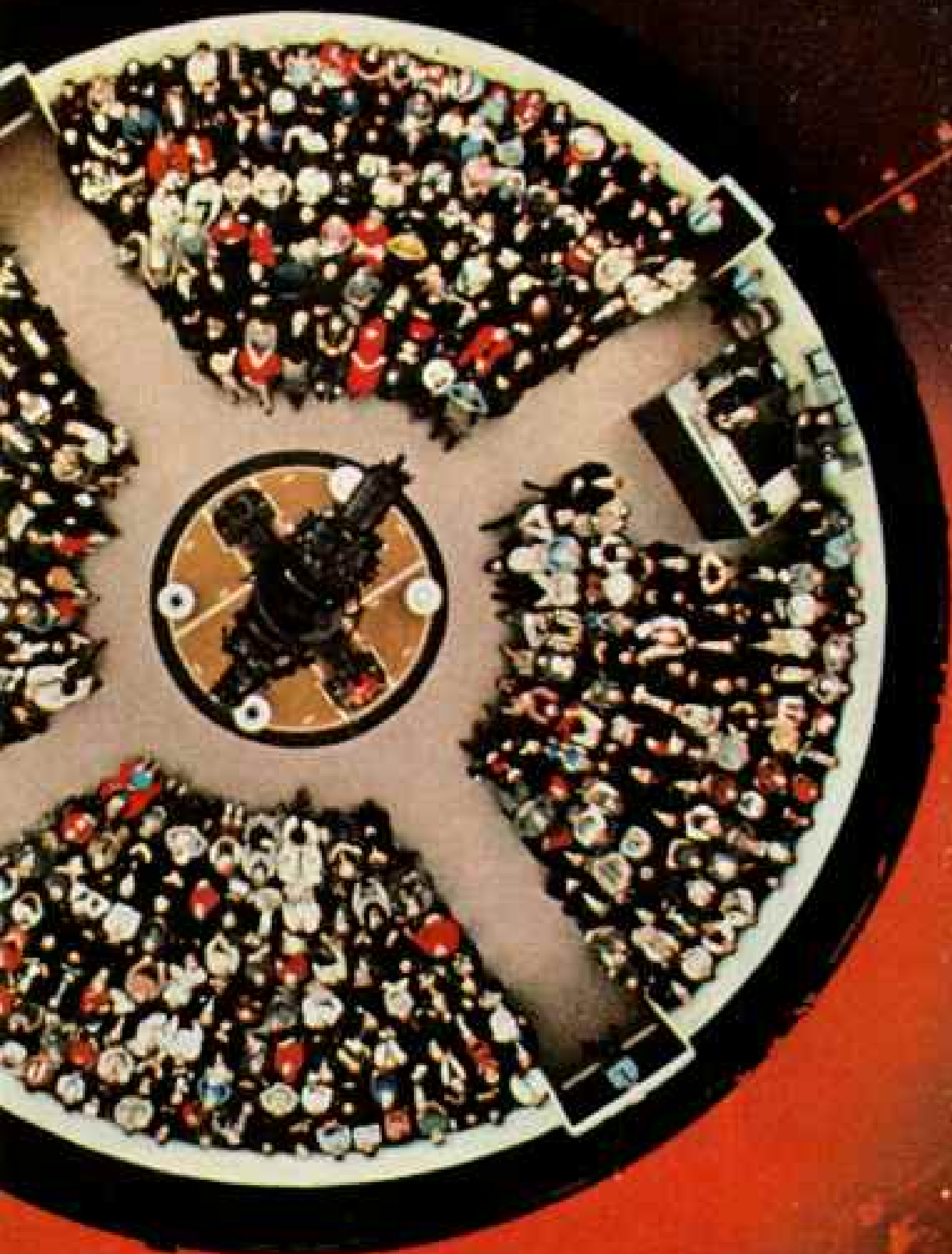
*To make this montage, Bruce Dale  
aimed a Fisheye lens through a  
hole in the top of the inner dome.  
A four-hour exposure produced the  
star spectacular but left the  
spectator area black. Then, during  
a regular showing, a two-second  
exposure filled in the details.*

ENTACHROMES AND KODACHROME  
(BELOW) BY BRUCE DALE © H.S.S.



**LIKE A SPACECRAFT** newly landed  
*on earth, McDonnell Planetarium  
crowns a hill in Forest Park. The  
floodlighted hyperbolic curves of  
architect Gyo Obata's design seem  
to reach out to the universe itself.*







**Break from books:** Boy and girl relax on the 165-acre campus of Washington University, founded in 1853. Some 14,200 students attend the university, more than half of them in night classes.



**Page out of the past**—a St. Louis University coed studies a rare manuscript, projected from microfilm, in the Pius XII Memorial Library. Its riches include microfilm copies of more than 11 million handwritten pages from the Vatican Library, the most complete reproduction of Vatican manuscripts in the Western Hemisphere.

**Mortarboards and tassels** cap candidates for Master of Science degrees in nursing at Washington University's 104th commencement.

ENTACHROME (ARCHE) AND RODACHROME © N.E.S.



river channel with red and black buoys, and the rivermen steer scrupulously by the buoys.

Rounding sharp bends, the captain slowed our tow to a walk; sometimes he halted and backed up, swinging the bow out from shore—a maneuver he called a "flank tow." "It's like going around a curve in your automobile," he explained. "Your car slides if it's going too fast. So will a tow—right into the bank."

A little later, Pilot Marvin Barnes took over the helm. Presently a northbound tow moved into view as we gingerly navigated a narrow turn. "This old river's getting to be a

regular highway," the peppery pilot declared.

It always had been a highway, I thought; a highway that drained a continent. But never more than now.

Today's ungainly steel barges haul millions more tons of freight every year than the steamboats did in their heyday. The mighty river system serves as the Nation's highway for steel goods, coal and coke, oil and gasoline, grain, sand and gravel, chemicals.\*

\*The *GEOGRAPHIC* detailed the river's story in "The Upper Mississippi" (November, 1958) and "The Lower Mississippi" (November, 1960), both by Willard Price.

Grid star Charley Johnson, dynamic quarterback of the St. Louis Cardinals professional football team, studies between seasons for a doctorate in chemical engineering at Washington University. A superlative passer, he led the Cardinals to second place in the National Football League's Eastern Conference in 1964.



STRECKFUS © N. A. S.

I debarked from *United States* at the confluence of the Mississippi and Ohio Rivers, stepping ashore on the muddy Illinois bank at Cairo (pronounced kay-ro). I caught a bus back to St. Louis. Next day I returned to the levee and boarded S.S. *Admiral*, the world's largest inland excursion steamer. White-haired Capt. Roy M. Streckfus, a riverman most of his 75 years, was my host.

Captain Streckfus showed me around *Admiral* with unconcealed pride. "She can carry up to 4,000 passengers," he said, "and draws only eight feet of water. The ballroom

is 300 feet long and 92 feet wide. She rides so smoothly that lots of dancers don't even know they've left the dock."

On a clear night when the band plays the blues or ragtime, the bespectacled captain likes to recall the old-time excursion steamers he knew and the musicians who brought jazz up the river on them from New Orleans. Boats like the old *J. S.* (owned by his father, John Streckfus), with pianist Fate Marable struggling to master its calliope, which he did; and Louis Armstrong blowing his trumpet so sweet and strong that you could hear him in Missouri and Illinois both, on a summer night.

Back on the levee, I thanked Captain Streckfus and strolled to the Chamber of Commerce, a ten-minute transition back into today. Chamber President Aloys P. Kaufmann, wartime mayor of St. Louis, enthusiastically made a greater transition for me in far less time.

"St. Louis has come a long way from the fur trader, from Mark Twain and the steamboats," he said. "Today we're making space capsules. The city has a brilliant future. We're on our way."

#### St. Louis Backed Lindbergh's Flight

In a sense, I found, the metropolis is reaching all the way to the moon. At the McDonnell Aircraft Corporation, adjoining Lambert-St. Louis Municipal Airport, men are building the two-seat Gemini spaceships, 13 in all. The United States hopes to land astronauts on the moon by 1970, thanks to the experience and knowledge gained in the Gemini program.

St. Louis and flight have strong historic association. As far back as the 1840's, daredevils were making balloon ascensions here. One of the city's finest moments came in 1927, when a slender young pilot on the Chicago-St. Louis mail run persuaded some St. Louis businessmen to finance him on the first transatlantic solo flight. Charles A. Lindbergh named his fragile plane *Spirit of St. Louis*.

Now St. Louis builds the vehicle that points the way to the stars, just as it made—also at McDonnell—the one-man Mercury space capsules that carried America's first astronauts beyond earth.

McDonnell also produces one of the finest, fastest military airplanes in the world—the famed Phantom II. The United States Navy, Air Force, and Marine Corps use it for various missions: interceptor, fighter-bomber, reconnaissance (page 632).

To aerospace manufacturer and philosopher James S. McDonnell, transportation has



always been the lifeblood of St. Louis. Just over a quarter century ago, this onetime Arkansas farm boy founded his company in rented 40-by-40-foot quarters at Lambert Field. There were two employees. Now the firm is Missouri's largest employer, with nearly 35,000 on its payroll.

"St. Louis can use some new images," he observed. "I see it as a great center of space science for man's creative evolution into the universe. St. Louis can become the gateway to the galaxy."

If it does, "Mr. Mac"—as his teammates at McDonnell call him—will have made a large contribution. One of the city's outstanding educational assets is the new McDonnell Planetarium in Forest Park. In this striking hyperbola of a building you can take a three-year-long lecture course on the mysteries of

the universe (pages 626-7). Education will lead man to the stars, believes Mr. McDonnell, who is chairman of Washington University's Board of Trustees.

"We need many outlets for man's creative, adventurous spirit—outlets that will develop his best characteristics," he declared. "In space science, education is basic. We need all the known sciences and all the known technologies."

I took my leave of Mr. McDonnell and motored back into the city, speeding along the busy, limited-access Mark Twain Expressway. Somehow, the name didn't seem incongruous. Miles distant, I could see the Gateway Arch rising on the waterfront; it didn't strike me as strange either. Like the Mark Twain Expressway, it was very much a part of modern-day St. Louis.



ESTRICHENI, JARCELI ANO KODACHOWY BY REGIONAL SYMBADWIE PHOTOGRAPHY  
 ERDEZ SALL: 45 ESTICHOWY ZELADNY, ST. LOUIS POST-DISPATCH © 2011

Warm glow of hospitality illumines the Chatillon-DeMenil House during a reception given by Landmarks, Inc., the association that preserved this ante bellum mansion. Fur trader Henry Chatillon built the house in the 1840's. Dr. Nicholas DeMenil, who purchased it in 1856, added the entire east end, including the four Ionic columns and ornamental iron railings.

Master musicians of the St. Louis Symphony follow the baton of conductor Eleazar de Carvalho. The orchestra, second oldest symphony in the Nation, performs twice weekly during the winter season.

His mysterious majesty the Veiled Prophet and his Queen of Love and Beauty, Anne Newhard, reign at the Veiled Prophet Ball.





DETAILS (OPPOSITE) AND RESEARCHERS BY NATIONAL GEOGRAPHIC PHOTOGRAPHER BRUCE SAGE © N.G.E.





Shoes or supersonic aircraft, food products or rapid-transit cars—St. Louis makes them. More than 3,000 manufacturing firms dot the metropolitan area. At the Samuels Shoe Company, penetrating heat from banks of infrared lights speeds drying of glue in ladies' footwear. A Monsanto chemical plant employee (below), wearing an air-conditioned suit, takes samples from a foamy mountain of benzoic acid, a food preservative.



Versatile Phantom II fighters take shape at McDonnell Aircraft Corporation. The U. S. Navy, Marine Corps, and Air Force fly the 1,600-mile-an-hour planes. A New York City rapid-transit car (above) moves along the production line at the St. Louis Car Division of General Steel Industries, Inc.

Yet once this waterfront was redolent of stacked furs and hides; the world looked to St. Louis for beaver, muskrat, otter, red fox, raccoon, bear, buffalo, and deer. Today only two raw-fur houses remain in St. Louis. Stanley F. Abrams, president of Minner & Company, told me why, as he showed me through his century-old warehouse above the river.

"Women's fashions have changed, and so has transportation. Women used to wear red fox; now mink is the thing—pen-raised mink, shipped directly to the coatmaker in the East."

Plenty of pelts still come to Minner & Company, however. We paused beside stacks of muskrat and raccoon. "You know where those furs will end up?" Mr. Abrams asked. "Europe. Just about my only market."

#### 5,000 Skunk Skins Await a Buyer

In an adjoining room I saw hundreds of skunk furs dangling from the rafters. I asked where they would be going.

"Practically nowhere," he replied. "If you can figure out something to do with those furs, you can make a fortune. We must have 5,000 skunk skins just sitting. There's little demand for them. We haven't sold a skunk in years." I thought about Beetle wigs with white stripes, but decided against it.

I left the fur warehouse and took a short cab ride to 1508 Locust Street. The old Campbell House would afford another glimpse of the past. Built in 1851, the mansion's address then was No. 20 Lucas Place—and Lucas Place, with its fine brick-and-limestone homes, was the city's most fashionable residential area. Now commerce has engulfed it, and Robert Campbell's substantial home is a museum. Most of its furnishings are original: mirrors backed with diamond dust, whale-oil lamps on the old square piano in the parlor, Irish bog-oak dining-room furniture.

Irish-born Robert Campbell explored the West as a young man, made a fortune in furs, then added to it in St. Louis real estate and banking. The time came when he entertained President and Mrs. Ulysses S. Grant.

"Look at these sillabub cups," said Mrs. Vida L. Turner, curator of the Campbell House, as I admired the dining room. "After dinner, when the men retired to the library for their port and brandy and cigars, the ladies used these cups for sillabub—a sweet drink made of rum, sugar, and warm milk."

I didn't envy the ladies that potion.

Next morning I visited the Samuels Shoe Company in the city's western section, curious to see what time and fashion had dictated

for the making of fine shoes for women. Julian G. Samuels, president, had a ready answer.

"We roll with it," he said. "Seasonal changes may come swiftly, but fashion really goes in circles. The pointed shoe that ladies wear today is much like what they wore in the 1920's, except that it has gotten more pointed, and the heel thinner. Now we're gradually starting to go the other way."

To introduce me to "the art of shoemaking," Mr. Samuels conducted me through the plant. My host estimated that a complicated shoe style requires 100 or so different operations (page 632).

Besides being a leading shoemaker, St. Louis also is one of the Nation's biggest commercial printers. At the downtown Mercantile Library, established in 1846 and among the few private subscription libraries remaining in the country, I viewed an early product of St. Louis printing: the first city directory. Published in 1821, it listed 740 names.

Now, nearly a century and a half later, St. Louis has become a great metropolis, but I believe that something of the small town always will cling to it. I took this up with Morton D. May, a civic and cultural leader and head of the nationwide May Department Stores Company.

Leaning across his desk in his office at the Famous-Barr downtown store, he talked about it. "I'd rather live in St. Louis than any other place," he said. "It has most of the virtues of a big city—plus many of the virtues of a smaller one. You'll find a warmer feeling

of friendship here than in most cities this size."

I agree. I found it that night, for instance, just two floors below Mr. May's office, at Famous-Barr's 16th annual Children's Art Bazaar. It was heartwarming to realize that nearly 1,000 persons had donated \$15 a couple to attend this benefit preview, which displayed more than 5,000 art works by school children. They raised thousands of dollars for charity and enjoyed themselves thoroughly in the process.

Indeed, the city's bicentennial birthday party really amounts to a family affair, with the whole metropolis participating. Literally thousands of events, small and large, have been staged. August A. Busch, Jr., president of Anheuser-Busch and head of the St. Louis Bicentennial Corporation, explained the two-year celebration this way:

"We want people from everywhere to feel the warmth and hospitality that St. Louisans know so well how to share."

#### Old Jefferson Barracks Lives in Memory

I drove one morning to Jefferson Barracks, in the southern part of the county along the river. It was one of the country's first Army posts west of the Mississippi, and many great soldiers served here: Robert E. Lee, Ulysses S. Grant, Zachary Taylor, and William Tecumseh Sherman.

And some lesser soldiers, too. I was the Army's guest here in 1942's sweltering summer, undergoing basic training. We called it "Pneumonia Gulch"; I can still see the ground



EDUCATED BY BRUCE DALE (ABOVE) AND JACK ZENNY (C) N.G.S.

Mosaic masterpieces adorn the vast interior of St. Louis Cathedral. The golden dome of the main altar gleams beneath images of the Twelve Apostles. Begun 51 years ago, the mammoth art project represents one of the world's largest collections of mosaics.

His Eminence Joseph Cardinal Ritter, Archbishop of St. Louis, extends his hand to Sister Jacqueline Grennan, president of Webster College, at the 1965 spring graduation exercises. The Very Reverend Senton J. Runge and Sister Francetta Barberis, special consultant to the women's division of the Job Corps, flank the Cardinal. Roman Catholics comprise a quarter of St. Louis's population.



SCOTUS  
MARTINUS  
LUCAS

ST. MARTINUS

ST. MARTINUS

ST. MARTINUS

ST. MARTINUS



fog swirling knee-deep about us when we emerged groggily from our tents for reveille.

Like old soldiers, old campgrounds just fade away. Declared surplus in 1946, Jefferson Barracks is now partly state-owned, partly a St. Louis County historical park. Its brick headquarters buildings stand forlorn, and the parade ground lies fallow where once I saw many a tender young recruit keel over in the cruel July heat.

#### No Place for Daniel Boone

I pointed my car west from the old Army post, to inspect more of the beehive named St. Louis County—and to pay my respects to Daniel Boone. Dan'l and Mrs. Boone settled in 1799 in what is now St. Charles County, part of the metropolis. On the gentle slope of the Femme Osage Valley, he helped his son Nathan build a commodious limestone home with portholes in its 30-inch walls. There the frontiersman died in 1820 at the age of 86.

Gazing at the old home and its wide, tree-bordered valley, I recalled Daniel Boone's dislike of crowds. He would not be at all happy now, I thought.

I returned to the city on the Daniel Boone Expressway, termed "the longest parking lot in the world" by motorists caught in its tie-ups. Presently, at the west end of Mill Creek Valley, I spotted the construction work on St. Louis University's 22-acre site there.

Seven buildings are rising on the land, which lies just across Grand Boulevard from the university's existing campus. Part of a \$53,000,000 expansion program, the project is providing new classrooms, laboratories, and the Busch Memorial Student Center. The university has more than 10,000 students now; it expects 16,000 within a decade.

To the northwest I came on one of the most unusual night-life areas in the United States—Gaslight Square. Some 35 night clubs and restaurants, most of them decked out in turn-of-the-century trappings, are distributed over a three-block area; interspersed are numerous antique shops. With flickering gas streetlamps lighting the way, I almost expected horse-drawn carriages to roll past (pages 624-5).

Gaslight Square attained its elegance after a tornado almost demolished it in February, 1959. As buildings were replaced, owners installed fine wood paneling, chandeliers, iron-work, and other items salvaged from old town houses being razed in Mill Creek Valley.

"Once this building was a carriage house," said quiet young Jack Neuman as we listened to folk music in his dimly lit Jacks or Better



STYLING BY BRUCE DALL © W.E.C.

Spring rain dampens spirits of young equestrienne, a participant in the Bridlespur Hunt Club's horse show. Proceeds from the annual affair aid St. Louis charities and civic works.

Begun in 1928 by the late August A. Busch, Sr., the club lists many prominent citizens on its roster. Hunters ride to hounds twice a week; originally they ranged over 40,000 acres of farms and woodland. Now, from a new clubhouse and kennels, they hunt over more than twice that area.

Drenched and mud-spattered, undaunted majorettes lead the Central Methodist College band of Fayette, Missouri, during the half-time show at a St. Louis Cardinals professional football game.



COORDINATED BY MISS HARPER (FELLOW) AND BRUCE DALE (R.H.S.)





club. "Then it became a machine shop."

Now plangent guitar and reedy voice filled the small room. Elsewhere on Gaslight Square, strollers could hear fine ragtime piano spilling out into the street.

The Negro long ago made his mark on St. Louis with his music. Ragtime piano flowered there before this century began. The world has been singing "St. Louis Blues" since 1914, when the late W. C. Handy wrote the song. Twenty-five years ago, St. Louis had a Negro population of about 13 percent; today it has grown to about 30 percent.

Gay night life and good food have long been hallmarks of the old river town. Back in 1889, at famed Faust's Restaurant and Oyster House downtown, you could get the best steak on the menu—"Filet Chateaubriand a la Parisienne"—for \$1.60 (with mushrooms, \$2.00). Maybe you arrived at Faust's in your carriage; maybe you took a cable car.

Faust's has vanished. You can still ride a trolley in St. Louis, though, if you hurry. There are nine streetcars left, all on one line. Buses soon will replace them.

I guess the one thing that stays the same in this changing city is the way you pronounce its name. You sound the final "s". Only one exception is permitted: when you sing the old favorite—"Meet me in St. Loo-ey, Loo-ey, meet me at the fair."

And twenty million people did meet one



"Stan the Man" Musial, retired St. Louis Cardinal baseball star and seven times National League batting champion, presents an autographed picture to Jay De Shelter, the St. Louis United Fund poster boy, at the 1964 World Series. Musial serves as consultant to the President on physical fitness.

ENTRANCE BY WINFIELD PRAS LABOVE; ENTRANCE OPPOSITE AND KIDSCORNER BY BRUCE DALE © M.S.L.

Underwater stroll through the "aquatunnel" gives visitors to the Missouri Botanical Garden's Climatron an unusual view of water lilies. The Climatron, world's first climate-controlled, geodesic-dome greenhouse, provides ideal growing conditions for plants of the tropics. Landscaping gives the effect of an old tropical garden being engulfed by the jungle.

Hungry giraffe gets a mid-day snack from St. Louis Zoo Director Marlin Perkins, host of television's network program, "Wild Kingdom." Animal watching, one of the city's favorite pastimes, lures 2½ million each year to the zoo's 83 acres in Forest Park, home for more than 2,000 birds, mammals, and reptiles.





**Muddy Missouri** meets mighty Mississippi 15 miles north of downtown St. Louis. Each river retains its identity for more than 35 miles before blending into a uniform color. Lewis and Clark wintered alongside Wood River, near smoke at upper right, before pointing their boats up the Missouri in May, 1804. An Illinois state monument (in triangle, lower left) honors the explorers.

**Outmoded artillery** provides a perch for youngsters waiting for a Memorial Day parade at Jefferson Barracks. Established in 1826, the post served as jumping-off point for troops who tamed the West. Jefferson Barracks is now partly state-owned, partly a county historical park. Excursion steamer *S.S. Admiral* glides past.



another at the 1904 fair in Forest Park: Dr. Arthur Proetz, author of *I Remember You, St. Louis*, told me about the Louisiana Purchase Exposition. "The most magnificent party of all," he called it.

#### Fairgoers Discover the Hot Dog

A lovely party it was. Here many people ate their first ice-cream cones and hot dogs, and drank their first iced tea. But they didn't really meet St. Louis.

Today in Forest Park one does meet St. Louis: people, culture, spirit. This natural preserve of 1,380 acres on the city's west side is one of the finest parks in the world.

St. Louisans make the most of it. Ice skating in winter, roller skating in summer; golf,



PHOTOGRAPHER BY NATIONAL GEOGRAPHIC PHOTOGRAPHER BRUCE BALE © N.G.S.

baseball, football, tennis, soccer, Rugby—even cricket. Parents cover as much of the zoo's 83 acres as they can (page 639), their children begging to watch the lion tamer stick his head between the lion's jaws. He does, too, all through the summer (with Thursdays and Saturdays off).

People linger at the spring flower show in the steel-and-glass conservatory known as the Jewel Box, and see white and red azaleas, snapdragons, marigolds, bougainvillea, cineraria. They forget that February waits beyond the door and snow is falling.

They roam the City Art Museum, which ranks among the finest in the land. And for 13 summer weeks, up to 12,000 of them nightly attend the seven-acre open-air Municipal


Opera. The 47th annual season opened last June with a musical entitled, appropriately enough, *Meet Me in St. Louis*.

The Missouri Historical Society's evocative displays also lure people in droves. There I pored over the thousand and one gifts a grateful world sent Lindbergh after he flew across the Atlantic, and I particularly liked the River Room, with its gingerbread-trimmed pilot-house from the sunken packet *Golden Eagle*.

The river and the stars . . . with them St. Louis begins and ends. Walking along the old levee, I watched the gathering dusk soften the sullen Mississippi, highway to America, and give it sweetness. Towering overhead, the Gateway Arch pointed as much to tomorrow as to the past.

THE END





*Explorer, gold seeker, sodbuster surge through the gateway to the plains, and artists follow, recording the slash and sweep of westward expansion*

# So Long, St. Louis, We're Heading West

By WILLIAM C. EVERHART

Chief, Visitor Services, National Park Service

“**T**HE MAJESTIC RISE of our city is morally certain; the causes of its prosperity are inscribed upon the very face of the Earth, and are as permanent as the foundations of the soil and the sources of the Mississippi,” proclaimed the first mayor of St. Louis, Dr. William Carr Lane, in the 1820’s.

More than fifty years earlier the Father of Waters had brought St. Louis its founders. But it was the Missouri River, emptying into the Mississippi 15 miles north of the city, that made St. Louis a headland of empire from which a young Nation looked west.

At first, only the red man knew where the Missouri—Big Muddy—flowed. No white man knew how many mountain ranges stood between its uttermost source and the Pacific Ocean. No one knew the temper of the land it cut or what riches lay beyond its shores. But there were daring men to find out—and they came, harvesting the furs, fighting the Indians, farming the valleys, setting countless railroad ties, and carving the trans-Mississippi West into 22 new states.

As the West opened, St. Louis built and grew, and by 1846 the Missouri city sat snug and prosperous on the river front. Henry Lewis painted steamboats nuzzling the wharves along the levee. Beyond them, fur company warehouses lie packed with the redolent wealth of prairie lair and mountain den. The spired cathedral (far left) and domed courthouse break the skyline—only landmarks remaining in the riverside area where the Gateway Arch rises today (pages 618-19). Preparing to cross the river, emigrants pause to glory in the vision of this city in the wilderness.





MISSOURI HISTORICAL SOCIETY, ST. LOUIS



## City starts as trading post

**T**HEY CAME UPRIVER from New Orleans in 1763 —French trader Pierre Laclède Liguist and a 14-year-old companion, Auguste Chouteau, whose portrait as an adult appears at left. They came to establish a settlement “which might hereafter become one of the finest cities in America,” said Laclède, as he was called.

With elk skull and antlers for a figurehead, the adventurers' keelboat comes ashore at the chosen site in this oil painting by August H. Becker, after a fresco by his half brother, Carl Wimar, in the dome of St. Louis's Old Courthouse. In friendly greeting, Laclède extends his hand to the Indians, who proffer a peace pipe in return.

Laclède and Chouteau represented a company holding an eight-year monopoly on the Indian trade of the Mississippi and Missouri country, and the following February young Chouteau and a party of 30 settlers erected the first cabins and warehouses for the trading post to be known as St. Louis. Business boomed from the beginning, and by the early 1800's the city's fame was established.



St. Louis was the jumping-off point for the pioneers. Explorers such as Zebulon M. Pike and Jedediah S. Smith outfitted here for expeditions to peaks, rivers, and passes that were not yet on any map. Street corners and taverns echoed to the babel of English, French, Spanish, and a dozen Indian tongues. Fur was the subject—usually beaver, whose glossy pelt supplied material for the gentleman's top hat of the day.

Tracking the beaver to his remote haunts, the deerskin-clad "mountain men"—who wouldn't have been caught dead in beaver hats—crisscrossed the West, showing the way for gold hunters, ranchers, and sodbusters.

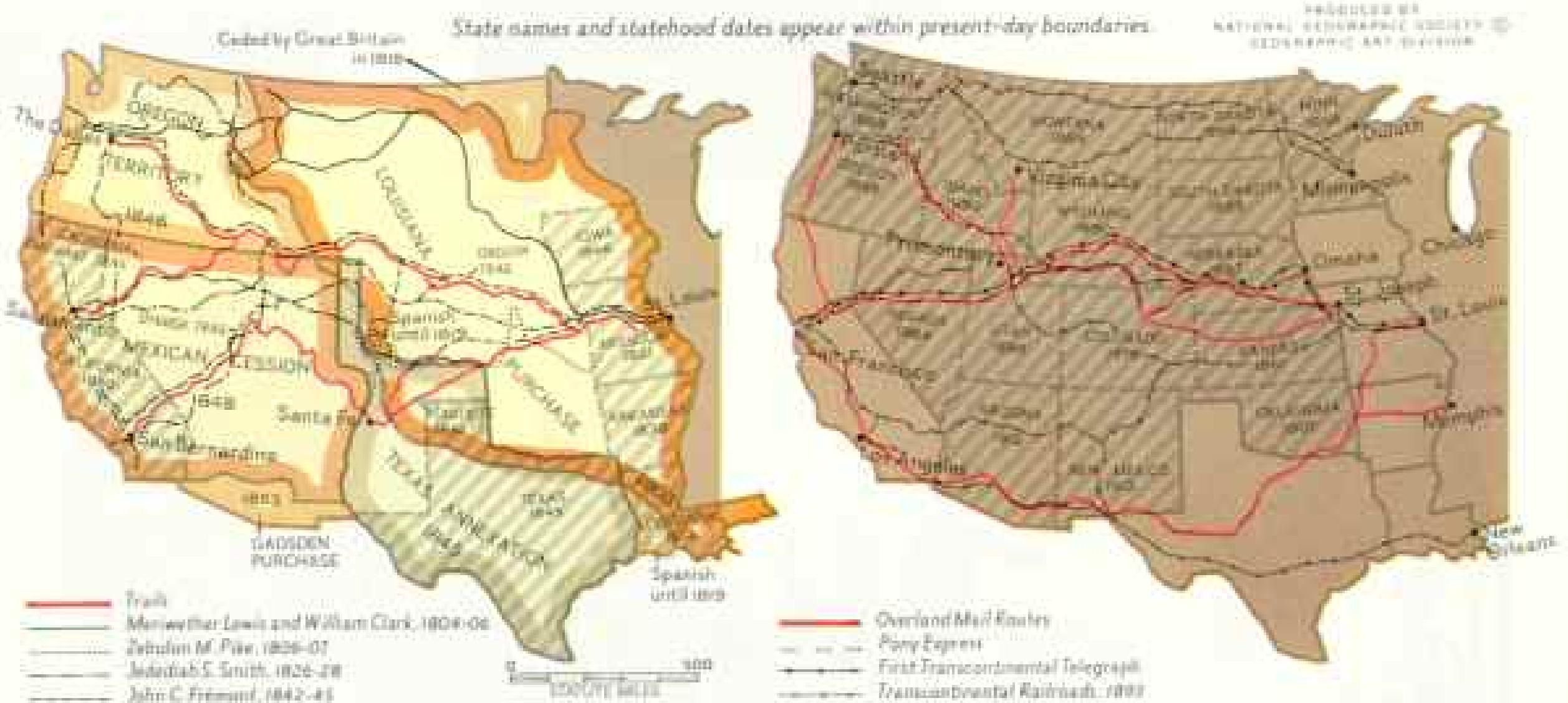
From St. Louis, trails fanned out across the vast plains and mountains to the Pacific (maps, below). For a century and more, the city was a funnel for a Nation pursuing its "manifest destiny"—a phrase first used in 1845 by John L. O'Sullivan, editor of the *Democratic Review*, when he propounded that the United States should "overspread the continent allotted by Providence for the free development of our yearly multiplying millions."

Every man would have "Room! Room to turn round in, to breathe and be free," shouted poet Joaquin Miller. Asked what he sought in the New World, Swiss immigrant John Augustus Sutter replied that he wanted to live in total wilderness, "where I should be absolute master."

The national urge to move west was a powerful thing—and a tremendous inspiration for artists and writers. Rosemary and Stephen Vincent Benét summed it up in four lines:

*The cowards never started and the weak died on the road,  
And all across the continent the endless campfires glowed.  
We'd taken land and settled—but a traveler passed by—  
And we're going West tomorrow—Lordy, never ask us why!\**

\*REPRODUCED FROM *A Book of America*, BY PERMISSION OF GILL, BINGHAM, AND WORTON, INC.



**WINNING THE WEST:** After President Jefferson made the Louisiana Purchase in 1803, explorers and emigrants beat trails along rivers and Indian paths to the Pacific coast. Six trans-Mississippi states joined the Union before the Gadsden Purchase in 1853 rounded out the conterminous area of the United States.

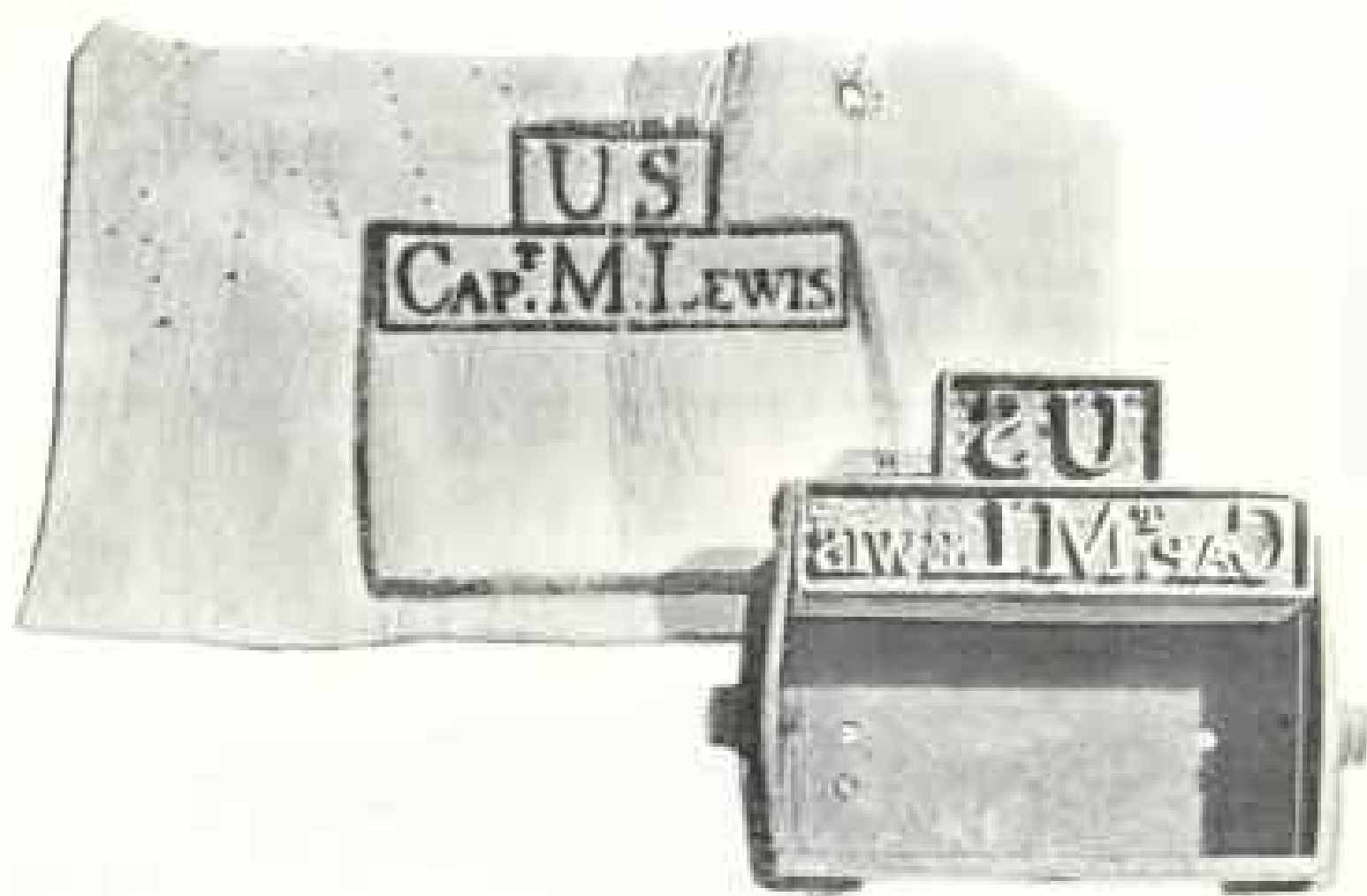
**TAMING THE WEST:** In the steps of the trail blazers, stages and pony riders carried the mail. Then came telegraph wires and railroads—precious and lasting links with relatives and markets in the East. Frontier population swelled; between 1853 and 1912, sixteen states brought to 48 the number of stars in Old Glory.

## Sacagawea helps open a continent

“THE OBJECT OF YOUR MISSION,” President Thomas Jefferson instructed Capt. Meriwether Lewis, “is to explore the Missouri river, & such principal stream of it, as . . . may offer the most direct & practicable water communication across this continent, for the purposes of commerce.” Lewis and his co-leader William Clark were veteran soldiers and Indian fighters; both were incomparable woodsmen. The President had picked the best men known for his pet project.

In May, 1804, the explorers shoved off from camp near the mouth of the Missouri. Winter found them 1,600 miles upriver at Fort Mandan. There a Shoshoni squaw, Sacagawea, joined them and acted more as an intermediary with the Indians than as a guide. Her tribe was to supply horses that Lewis branded with his iron (below).

A major purpose of the journey was to establish cordial relations with the Indians. In the engraving, Lewis makes a speech of friendship “which became monotonously familiar as the expedition counceled with one tribe after another,” according to Patrick Gass, one of Lewis’s sergeants. At such gatherings Indian chiefs received Jefferson peace medals; workers in 1899 uncovered the one shown here (obverse and reverse) while building the Northern Pacific Railroad.



© GREEN HISTORICAL SOCIETY (TOP), LIBRARY OF CONGRESS (BOTTOM), AND SMITHSONIAN INSTITUTION





ARTHUR CARTER MUSEUM OF WESTERN ART, FORT WORTH, TEXAS

Midway in the second summer the explorers waded the Missouri's icy headwaters, pushing their canoes. The snowcapped Rocky Mountains waited, and unless they met friendly Indians and acquired horses, they could not surmount the barrier.

Ranging ahead, Lewis encountered a band of Shoshoni with fine horses. He persuaded the Indians to accompany him back to his main group. Sacagawea danced with "extravagant joy." She began sucking her fingers, indicating that these were her own people among whom she had been suckled. Stolen from this tribe at about the age of 12, she now found her brother its chief! In this friendly atmosphere, the expedition successfully bartered with the Indians for 29 horses.

Once across the Rockies, the expedition

built canoes and sped down the Clearwater, Snake, and Columbia Rivers. Here in a painting by Charles Russell, Sacagawea talks by hand with the Indians on the lower Columbia. Clark stands alongside her.

Sacagawea "reconciles all the Indians, as to our friendly intentions," Clark wrote, "a woman with a party of men is a token of peace." Ben York, Clark's Negro servant, sits amidships. He also was a helpful ambassador; the Indians' curiosity about his color often overcame their fear of his companions.

In November, 1805, the expedition beheld the broad Pacific—a moment of triumph.

The "Corps of Discovery" headed homeward the following spring. The quest for a continent ended at St. Louis; Lewis and Clark had traveled 8,000 miles in 28 months.



BRITISH MUSEUM INSTITUTION



## Last days of the red man's reign

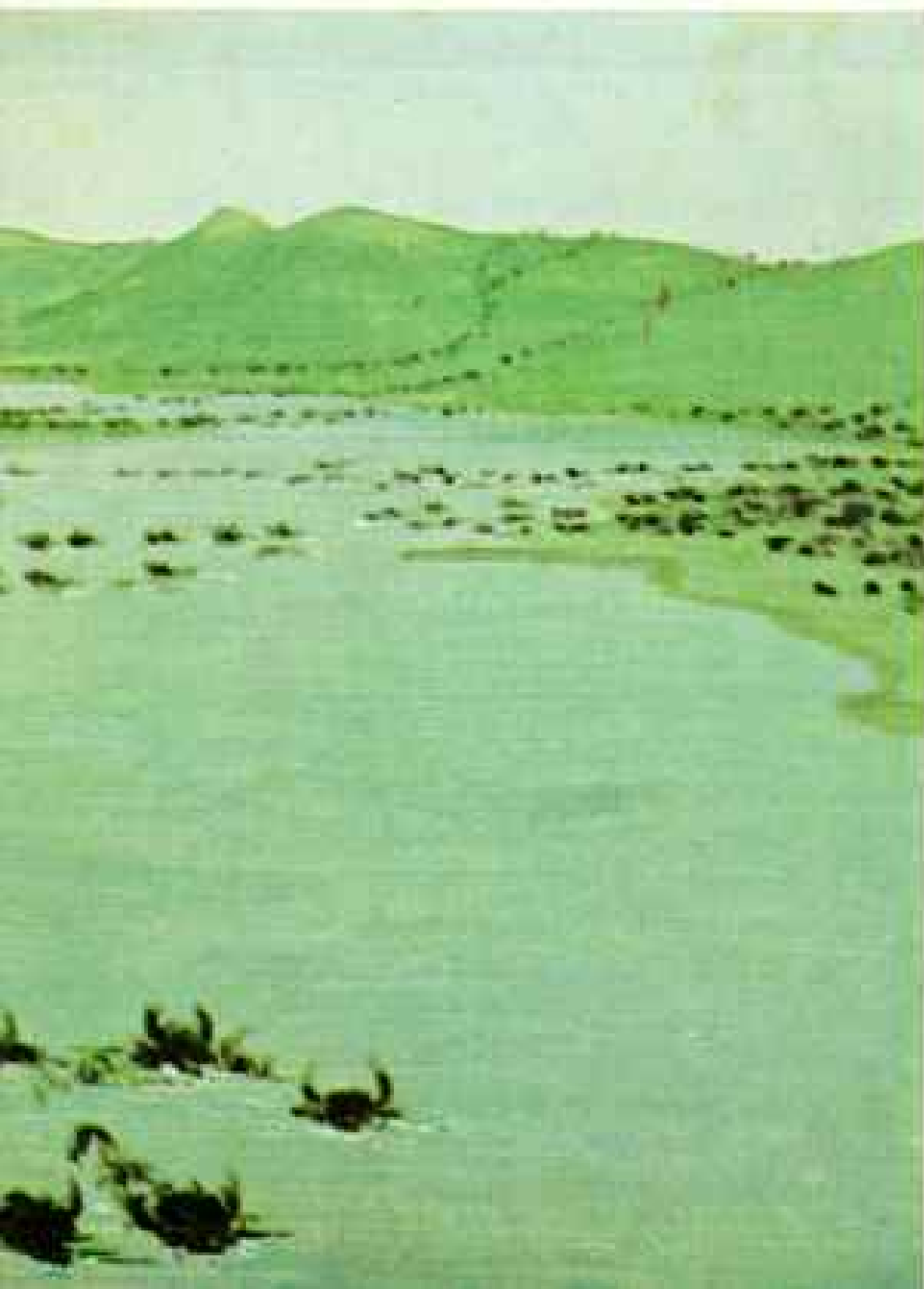
**B**EFORE the white man obliterated the color and excitement of the West as the Indian knew it, artist George Catlin dedicated a part of his life "to use my art . . . in rescuing from oblivion the looks and customs of the vanishing races of native man in America."

The Indian was doomed. His dangerous but free-roving life, the buffalo he fed upon, the nearly trackless aspect of the land—all would disappear. But Catlin's record remains.

Spacious tepees loom behind Sioux warriors feasting two representatives of John Jacob Astor's American Fur Company, together with Indian agent John F. A. Sanford and the artist. Chief One Horn says to Major Sanford: "My father—we offer you today, not the best



*Even North American Indians, vol. 1, by George Catlin*



we have . . . but we give you our hearts in this feast . . . and the Great Spirit will seal our friendship. I have no more to say."

Buffalo—food, clothing, and housing to the Indian—roamed the plains in vast herds that stretched from horizon to horizon. The artist painted his small skiff beleaguered by buffalo on the Missouri River (left). Migrating herds crossed the upper waters of the Missouri each spring, many drowning. One such crossing was called Stinking Water by the Indians who had been forced to abandon their campsite because of the large number of buffalo mired in the mud.

Unhappy faces of onlooking Mandan warriors (above) reveal their fear that bad luck must certainly descend on anyone, even a chief, who posed for an artist and allowed his body and soul to be put in such form.

For four years George Catlin roamed the West, often employing a "field-sketch" style—a kind of pictorial shorthand quickly grasping essential details of a scene. The Smithsonian Institution preserves more than 400 of his paintings and drawings.



THOMAS HILLHARDT (INSTITUTE OF AMERICAN HISTORY AND ART, TULLA, OKLAHOMA)

## Boisterous rendezvous — climax to a year's toil

**D**AY AND NIGHT, month after month, mountain men lived with incredible danger and hardship. Once a year they claimed their reward—cash and supplies from the sale of their pelts, transacted at a summer gathering known as the rendezvous. Above, some 250 Shoshoni warriors parade in honor of Sir William Drummond Stewart at the 1837 Green River rendezvous. A Scottish nobleman and adventurer who loved western life, he engaged Alfred Jacob Miller, a Baltimore artist, to paint these scenes for his castle in Scotland.

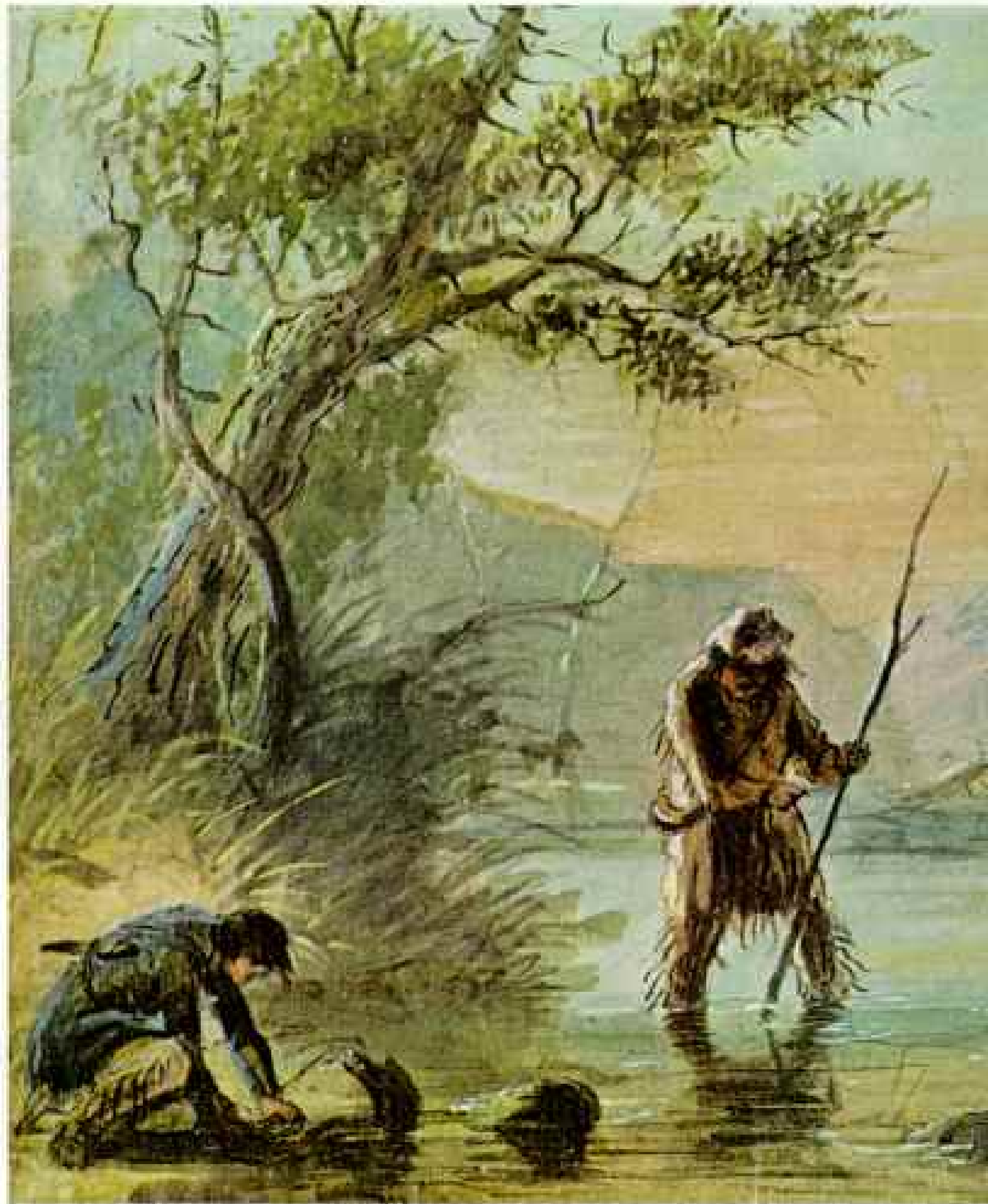
The rendezvous at a predetermined place in present-day Wyoming, Utah, or Idaho has been likened to a medieval fair. “It was a place of buying, selling, haggling, cheating, gambling, fighting, drinking, palavering, racing, shooting, and carousing,” wrote Robert

Glass Cleland in *This Reckless Breed of Men*.

John Colter, member of the Lewis and Clark Expedition, helped start the infant fur trade. Instead of returning to St. Louis, he stayed in the wilderness, joining Joseph Dixon and Forest Hancock—a pair of Illinois trappers—heading up the Missouri. He guided them to rich beaver streams in the far mountains. They became the first of the legendary mountain men—a breed whose heyday lasted from 1825 to 1840.

Upon the skillful setting of traps depended the success of the year's work. Trappers put them out at dusk, in great secrecy (upper right). One mountain man explained that “it was not good policy . . . to let too many know where he intends to set his traps . . .”

Cow buffalo provided plentiful camp fare. Artist Miller catches the moment (right) when “hump and boss boil in a kettle, cracked marrow bones sizzle . . .” Hungry trappers in fire-blackened elkskins await the repast.



NORTHERN NATURAL AND COMPANY COLLECTION, JOSEPH ART MUSEUM, OREGON. NEBRASKA (LEFT) AND WYOMING







EDWARD HILDEBRAND INSTITUTE OF AMERICAN HISTORY AND ART



M. JACKSON



CRENSHAW AND NATIONAL PARK SERVICE, NORTH PLATTE NATIONAL MONUMENT, WYOMING



## Way stop on the Oregon Trail

FORT LARAMIE LOOMED UP "of a quadrangular form," wrote artist Alfred Jacob Miller, "with block houses at diagonal corners to sweep the fronts in case of attack. . . . The Indians encamp in great numbers here 3 or 4 times a year, bringing peltries to be exchanged for dry goods, tobacco, beads and alcohol." Miller painted the only known pictures of the old fort.

Two St. Louis fur traders, Robert Campbell and William Sublette, built the rude citadel on the Oregon Trail in 1834. En route to a rendezvous—at Hams Fork in what is now southwestern Wyoming—they paused at the confluence of the North Platte and Laramie Rivers and threw up their hand-bewn log fortress, naming it Fort William.

The American Fur Company bought the stockade in 1836 and five years later rebuilt it of adobe. Although rechristened Fort John, the fur-trade center came to be known as Fort Laramie. The United States Government acquired the site in 1849, and it became the Oregon Trail's most famous stopover point, a station for Pony Express and Overland Stage as well as a military post.

Such bases, together with the annual rendezvous itself, provided the frontier's meager social life. To them flowed the wares of the East. Every spring, long pack trains—and wagons in later years—left St. Louis for posts like Fort Laramie.

In "Fur Traders' Caravan Leaving St. Louis (1830)," William Henry Jackson, a painter and pioneer photographer of the West, shows a heavily laden party as it snakes out of the city (left). Jackson himself crossed the plains in 1866 as a wagon-train bullwhacker.

Trains consisted of 200 or more mules and horses pulling wagons burdened with trade goods representing the commerce of the globe. There were beaver traps from England, mirrors from Germany, brightly colored beads from Italy, calicoes from France, gunpowder from the Du Pont works in Delaware, and the famous Hawken plains rifles from the shop in St. Louis. During Sam Hawken's lifetime, his name stamped on a rifle was the equivalent of "sterling" on silver.

One other item of transport bulked large: flat casks of whiskey shrewdly included by the fur companies to increase the profits of trading with mountain men and Indians.



LIBRARY OF CONGRESS

## Tragedy spurs Congress

**A**FTER THE EXPLORERS and trappers came the missionaries, eager to convert the savage red man to Christianity. In 1836, led by Marcus and Narcissa Whitman, a small party of missionaries joined a fur caravan leaving St. Louis. Mrs. Whitman and another wife in the group, Eliza Spalding, became the first white women to cross the continent. At Waiilatpu, "Place of Rye Grass," near today's Walla Walla, Washington, the Whitmans began their almost hopeless task of teaching the Cayuse to give up nomadic ways, farm by irrigation, and accept the Christian faith.

An epidemic of measles broke out among the Indians in 1847. Many were nursed by the mission. Thinking the missionaries were sorcerers who had deliberately made them ill, the Indians attacked in a frenzy. Wild-eyed Tomahas (above) brings his tomahawk down upon Marcus Whitman's head. The Oregon Historical Society preserves the actual weapon (opposite, upper).

After the blow was struck, yelling Cayuses ran amuck, killing Dr. Whitman's wife and 12 other members of the Presbyterian mission. The tragedy spurred Congress to create the Oregon Territory in 1848, bringing settlers under U. S. protection.





## Long trail to Santa Fe and fortune

THOUGH LONG NEGLECTED by Spanish authority in distant Mexico City, Santa Fe—the history-steeped capital of present-day New Mexico—was closed to Americans in the early 1800's. The few traders who reached Santa Fe were arrested, their goods confiscated. Then, in 1821, William Becknell, a Missouri merchant, ran into Mexican troops outside Santa Fe. Greeted hospitably, he soon learned that Mexico had won its independence from Spain; Americans were welcome. Becknell came back with fabulous profits.

Within a few years Santa Fe trade burgeoned. In 1824, a wagon train set out from Missouri with 150 pack horses and \$30,000 worth of goods, and returned from Santa Fe carrying silver and furs valued at \$190,000. Traveling at a mile an hour over the 800-mile route, wagoners turned the Santa Fe Trail into a highway to fortune.

"Arrival of the Caravan at Santa Fe" (below) vividly conveys the traders' excitement as they first glimpse the city's sun-baked adobe walls after safely traversing the rugged road—constantly threatened by marauding Comanche and Kiowa. There a noisy welcome awaited them. Shawls, guns, cutlery, beaver skins, mules, and Spanish dollars changed hands before the caravan headed back to Missouri.



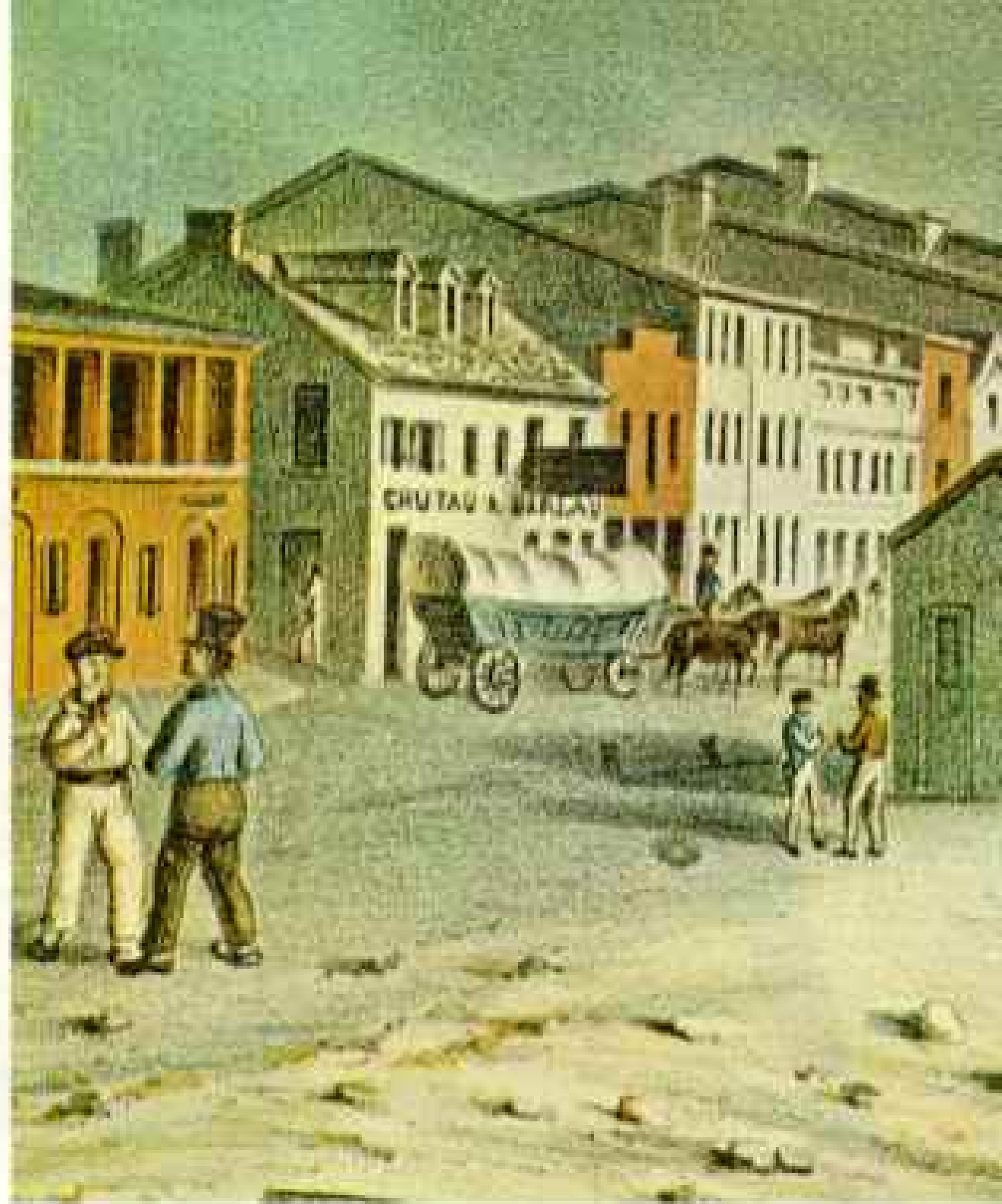
## “Manifest destiny” draws Old Glory westward

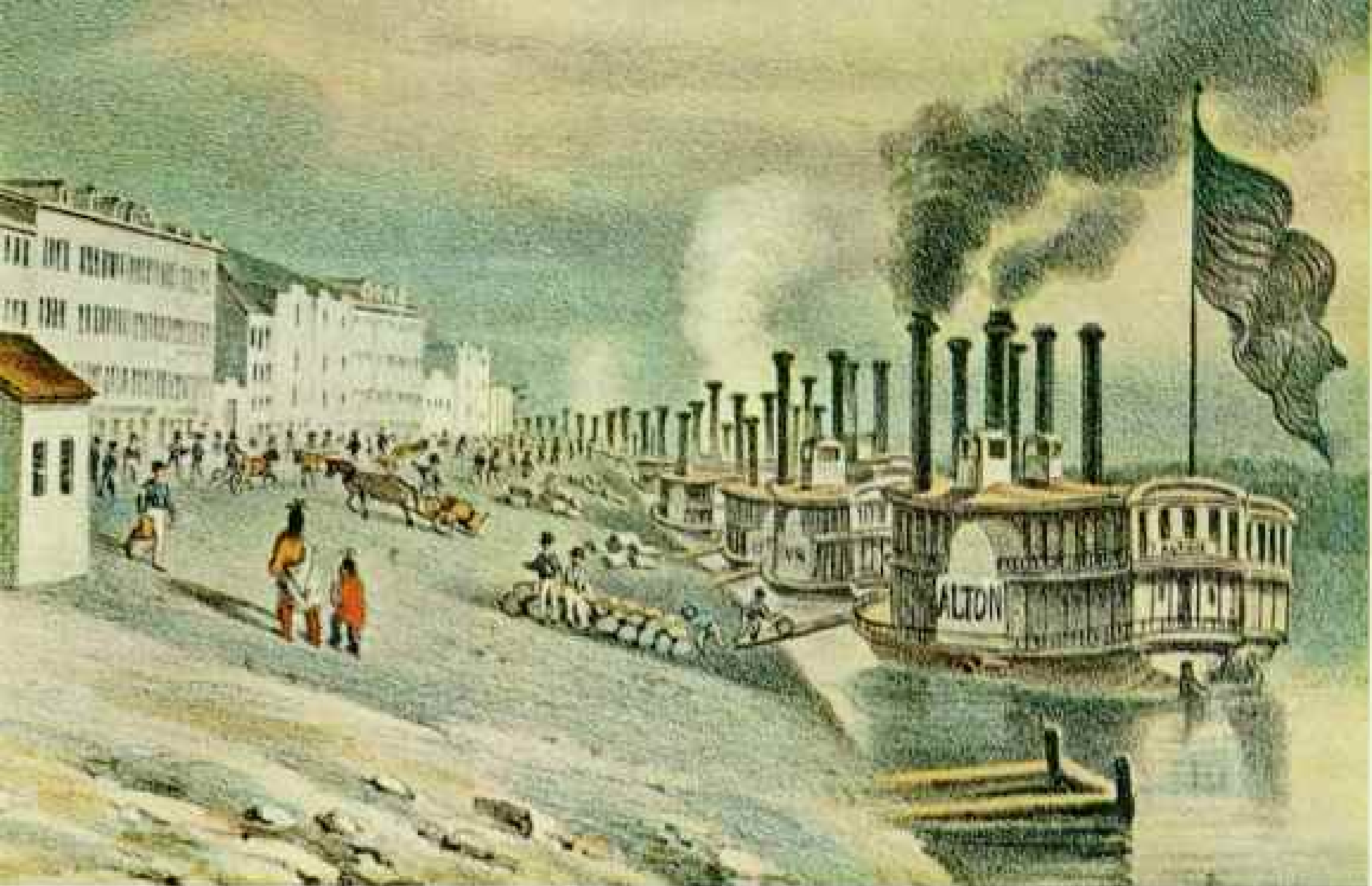
ST. LOUIS presented this “View of Front Street” to John Casper Wild in 1840. The levee rings with cries of teamsters and the whistles of steamboats jammed with baled cotton, sheep, cattle, apples, corn. Traders, land speculators, Indian agents, hunters, and settlers with wide-eyed children stream through toward the setting sun.

Military conquest was not far behind. The regimental history of the First Missouri Mounted Volunteers tells of a group of traders, returning from Santa Fe in 1846, who watched a prairie sunset after a storm. Suddenly the image of an eagle seemed to engrave itself on the sinking red orb.

Everyone interpreted this vision as meaning that soon “the eagle of liberty would spread his broad pinions over the plains of the west, and that the flag of our country

would wave over the cities of New Mexico and Chihuahua.” The Mexican War started that year to cries of “manifest destiny.” Primitive paintings by 16-year-old Samuel Emery





MUSEUM HISTORICAL SOCIETY, ST. LOUIS (BROWN) AND THE BEALE COLLECTION, SAN RAFAEL, CALIFORNIA

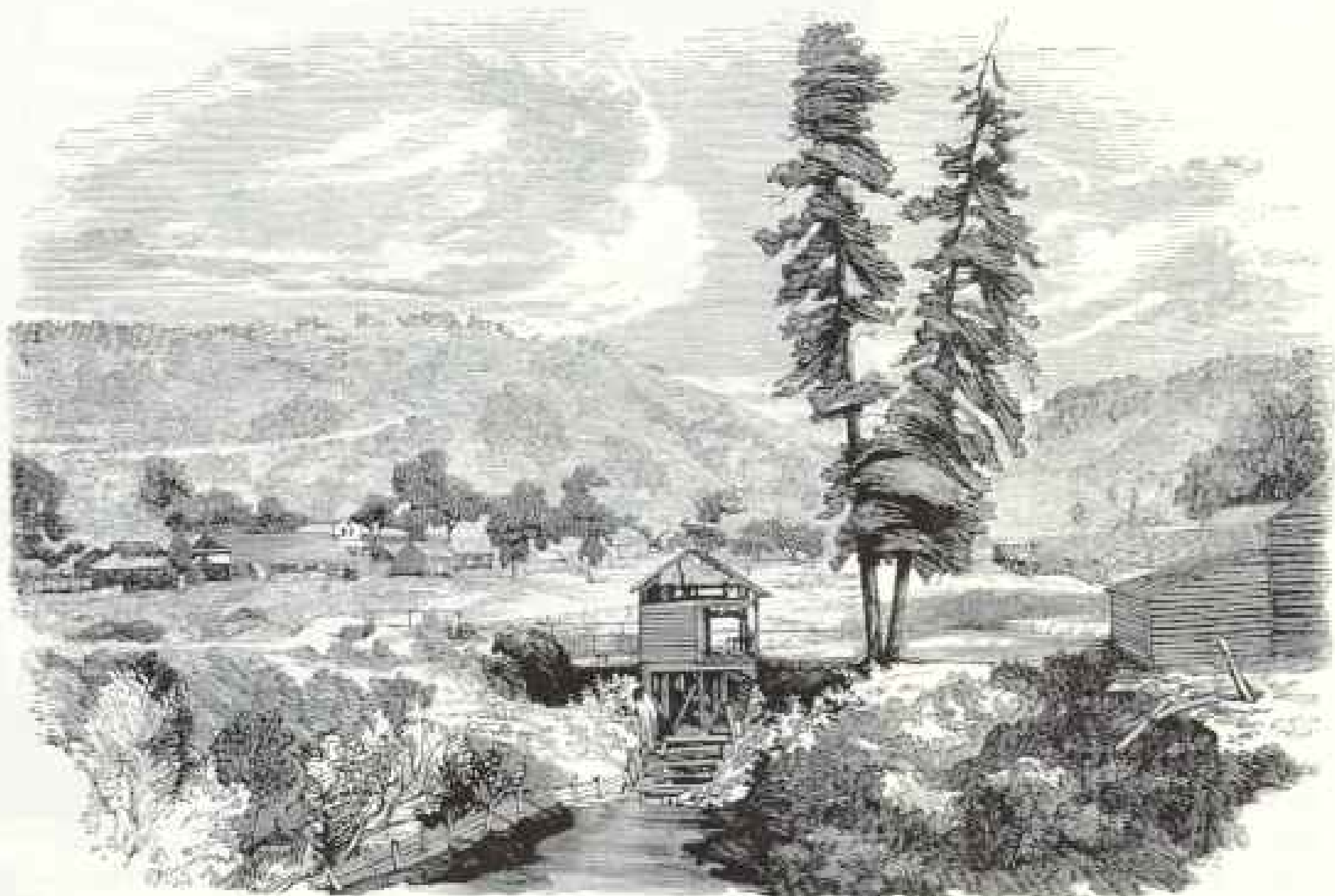
Chamberlain, volunteer from Boston, stand as a unique documentary of the war.

"Storming the Bishop's Palace" reveals fighting still raging at Monterrey in Mexico, even as the United States flag replaces the Mexican tricolor (left).

Government expeditions systematically explored the blank areas of the map. One of the first trained topographers to chart the Far West, John C. Frémont became known as the Pathfinder.

In the painting at right by Joseph Boggs Beale, Frémont plants the Stars and Stripes in the central Rockies, August 15, 1842. Two years later he crossed the Sierra Nevada in midwinter, a feat that even the Indians said could not be done. In June, 1846, while ostensibly exploring northern California, Frémont helped instigate a successful insurrection against Mexican rule that culminated in the California Republic. Four years later, California entered the Union as the 31st state.







MUSEUM OF FINE ARTS, BOSTON

## “California, here I come!”

**T**HE CALIFORNIA RUSH began early in 1848 on the South Fork of the American River in the Sierra Nevada foothills. James W. Marshall was building a sawmill at Coloma (left) to supply lumber for Sutter’s Fort. Inspecting the millrace one January morning, Marshall spotted some yellow flakes. He put them in the dented crown of his hat and took them to John Sutter, boss of the Sacramento area. The pair tried to keep the discovery secret, to no avail. Gold turned the trickle of western immigration into a torrent of humanity.

Once you had caught gold fever, only one cure existed: Head for the diggings!

See the elephant! Men the world over, by the tens of thousands, contracted the disease; one victim spied the elephant when he saw a prospector, newly returned from the California strike, open a leather poke and spill out nuggets in a pile.

“A frenzy seized my soul,” the man reported, “unbidden my legs performed some entirely

new movements of polka steps—I took several [drinks]—houses were too small for me to stay in; I was soon in the street in search of necessary outfits; piles of gold rose up before me at every step. . . .”

Actually, life at the California diggings added up to monotonous drudgery, and the backbreaking labor seldom fetched pay dirt. Above, an unknown artist shows miners hopefully washing gravel on the Calaveras River, working the sluices in icy water, searching for “color.”

After the day’s labor, forty-niners returned to their filthy shacks and tents. Coffee cost \$4 a pound, pork \$6 a pound. For \$400 they could buy a barrel of flour.

As one mining camp petered out, gold fever drove its victims to the next. Artist Albertus Browere depicts a prospector with shiny new equipment and in red flannel shirt setting out on his quest (upper left). The forty-niner casts a wary glance at the forest, excellent hiding place for brigands. A miner himself, Browere knew how to use pick, shovel, and pan.





ILLUSTRATION LIBRARY, SAN MARINO, CALIFORNIA

## Danger and death stalk the trail

“**G**REAT RECORD OF THE DESERT,” missionary Father Pierre Jean De Smet called Independence Rock (above, foreground), still an eye-filling Wyoming landmark. Countless emigrants on the Oregon Trail scrambled up its sides to carve their names or daub them on with axle grease.

J. Goldsborough Bruff, a forty-niner who illustrated his diary with events of the day, sketched in chalk “A View from the Summit of Independence Rock.” His name appears on the granite boulder at bottom center. A protective ring of prairie schooners camps in the rock’s lee beside Sweetwater River. The saga written on the land by such wagoners carried its own melody—a “gay, forsaken lilt twanged on a banjo and a frying pan that bore the

footsore on for one more mile,” wrote poet Stephen Vincent Benét.

But danger lay everywhere, and the raw land forgave few mistakes. Hostile Indians, mountain blizzards, desert heat, and a hundred other perils dogged the pioneers. In William T. Ranney’s foreboding painting, “Advice on the Prairie” (opposite, upper), an old-timer regales tenderfoot travelers with stories of the disasters awaiting them.

Bruff sketched on the spot such terrors of the trail. A rickety log bridge collapses outside St. Joseph, Missouri, delaying his trip. Farther west, where injured oxen and mules were irreplaceable, the accident could spell death to a wagon train. Poisonous water meant trail’s end too. Bruff’s cattle (right) fell after drinking from death-dealing Rabbit Hole Springs, near present-day Sulphur, Nevada. “I counted 82 dead oxen, 2 dead horses, and 1 mule—in 1/10 of a mile,” he wrote.



COLLECTION OF J. BERNARD WOODS, JAFFREY



HURTINGTON LIBRARY, JAFFREY AND BELOW





UTAH STATE HISTORICAL SOCIETY

## Stagecoach west — a hard way to go

**H**ALF A CONTINENT separated St. Louis from California gold camps and Oregon settlements. Lonely pioneers and gold seekers demanded stage service for mail and passengers from the East. In 1858, John Butterfield sent his coaches thundering over the first great stage line to the west coast.

“Remember, boys, nothing on God’s earth must stop the United States mail!” With Butterfield’s words ringing in their ears, rugged stage drivers kept the Overland Mail galloping from St. Louis to San Francisco via El Paso, Tucson, and Los Angeles. The 2,800-mile journey took 22 jolting days.

The fierce Apache paid no heed to the boast. In “Downing the Nigh Leader,” by Frederic Remington, whooping Indians bring down the left, or nigh, horse. When this animal dropped, the others piled over it, the stage crashed, and any surviving passengers fell into the hands of the enemy.

Remington captured the hair-raising instant in Arizona Territory’s Apache Pass—a scene of frontier life that was vanishing even as the artist preserved it with his brush.



## “Talking wire” vanquishes the Pony Express

NOT ABLE to carry the mail fast enough, the stage gave way to the leathery young riders of the Pony Express. They had their moment of glory for 18 months as they made the Missouri-to-California run in 10 days.

“Away across the endless dead level of the prairie,” thrilled Mark Twain aboard a west-bound stage, “a black speck appears against the sky. . . . In a second or two it becomes a horse and rider. . . . and the flutter of the hoofs comes faintly to the ear—another instant a whoop and a hurrah. . . . a wave of the rider’s hand. . . . and man and horse burst past our excited faces, and go winging away like a belated fragment of a storm!”

In 1861 the telegraph doomed the Pony Express: Artist William H. Jackson thus draws a double meaning in “End of the Line,” as gauntleted rider and telegraph crew exchange salutes (opposite). Henry F. Farny’s stoic Indian listens to the “Song of the Talking Wire.”



TAFT MUSEUM, CINCINNATI, OHIO



FROM HAROLD MULLER'S *Fraser's Remington*, COURTESY J. B. LIPPINCOTT COMPANY

## Golden spike pins a Nation together

**W**EST FROM OMAHA crept the Union Pacific, more than 10,000 Irish immigrants spiking it down. East out of Sacramento inched the Central Pacific, pigtailed Chinese coolies carving it through the mountains. Criticized for putting puny-looking, rice-eating Chinese on the job, construction boss Charles Crocker retorted, "They built the Great Wall of China, didn't they?"

East and West joined iron arms on May 10, 1869, at Promontory, Utah Territory. Holding a silver mallet, Central Pacific's President Leland Stanford stands ready at the center of Phil Ellison's painting to drive the golden spike.

The U.P.'s "end-of-track" was an ever-moving, hard-working community, as shown below in A. R. Wand's "Building the Union Pacific Railroad in Nebraska." To lay one mile required 40 freight cars of supplies.

At St. Louis, Eads Bridge (bottom right), completed in 1874, replaced train-carrying ferries. Its picture embellishes a sheet-music cover. Still in use (pages 612-13), the famed span crosses near today's Gateway Arch.





CALIFORNIA HEREDITY AND MANAGEMENT AGENCY (ARQUEL) AND COLLECTION OF LESTER K. LYVE

To My Friend  
 CHANNING SWEET, ESQ

# WESTWARD HO!

GRANDE GALOP DE CONCERT  
 BY  
 C. D. WILSON.

SAINT LOUIS BRIDGE — LENGTH INCLUDING APPROACHES — 3200 FEET.





## Custer's luck runs out at Little Bighorn

PLAINS INDIANS thought their treaties with the Great White Father in Washington, D.C., assured them permanent possession of their lands. But after the Civil War, the westward tide ran beyond control. The solution: Put Indians on reservations.

The effort to transform nomads into "farmers, carpenters, herdsmen, users of soap, teetotalers, hymn-singers, monogamists, and newspaper-readers," as Bernard de Voto wrote, was the final degradation. The Indians rebelled and two decades of warfare broke out.

Fortune favored George Armstrong Custer in the Civil War at Bull Run and Gettysburg. Now, he thought, it rode with him again at the Little Bighorn River in Montana Territory. But Sitting Bull, Sioux medicine man, saw a vision: Yellow Hair's luck had run out.

Custer saw the hostile Sioux and Cheyenne—led by chiefs Gall, Two Moons, and Crazy Horse—advancing from their camp along the stream. When the red man's onslaught came, Custer confidently expected his carbines would rule. After the Indians attacked, the flamboyant colonel dismounted his command—some 260 well-disciplined Seventh Cavalry troopers—and took a stand along a barren ridge. The Indians outnumbered him ten to one.

Howling braves on horseback circled the troopers, then swarmed over them in two charges. They stampeded Custer's horses, cutting off all escape.

The slaughter on that June day in 1876 could not have taken long. "The dust and smoke was black as evening," an Indian survivor recalled. Custer and his brave men died on that brown hill to the last man.

For the Plains Indians, once called the "finest light cavalry in the world," Little Bighorn was the greatest—and the last—of their major victories.

After years of research on the scene, Edgar S. Paxson committed "Custer's Last Stand" to canvas. Western historian Harold McCracken believes the painting, completed in 1899, presents the most accurate reconstruction of the controversial battle.





## Great Plains yield

PROMISING PLENTIFUL land, the Homestead Act of 1862 set the sodbuster on his way. And Horace Greeley was his prophet. "If you strike off into the broad, free West," he declared, "and make yourself a farm from Uncle Sam's generous domain, you will crowd nobody, starve nobody, and neither you nor your children need ever beg for something to do."

Fired by prospects of a better life in the "garden of the West," settlers swarmed the plains; more land was taken up in the last three decades of the 19th century



## to the homemaking sodbuster

than in the Nation's first two and a half centuries of settlement.

What kind of house can a man provide for his family when he settles on the treeless prairie? A long-lasting home indeed, built from the very rind of the earth. Never broken by the plow, the sod lay thick and tough with entangled roots of plains grasses. Sodbusters simply peeled it back like peat and sliced it into building blocks.

John Steuart Curry painted such a "soddy." At the doorway, mother and daughter prepare potatoes for the evening meal. The rest of the children help father fence his lonely farm in the unbounded sea of prairie.

Despite visiting field mice pursued by

hungry bull snakes, and constant fleas and dirt, sod houses remained common shelters into the early 1900's. The parents of many living Americans grew up in them.

Railroad poster (left) advertises acres waiting for customers, nearly half of whom were Europeans—Irish, German, Scandinavian. They soon learned a song of the West: "The clover there grows nine feet tall, There's buttered bread and cheese for all."

And in time, for the strong, bread and cheese and a better life did come. The explorer and the pathfinder may have swept the frontier into the sea, but it was the homesteader with his plow who turned the West into a land of milk and honey.

THE END

# Scientists Ride Ice Islands on Arctic Odysseys

By LOWELL THOMAS, Jr.

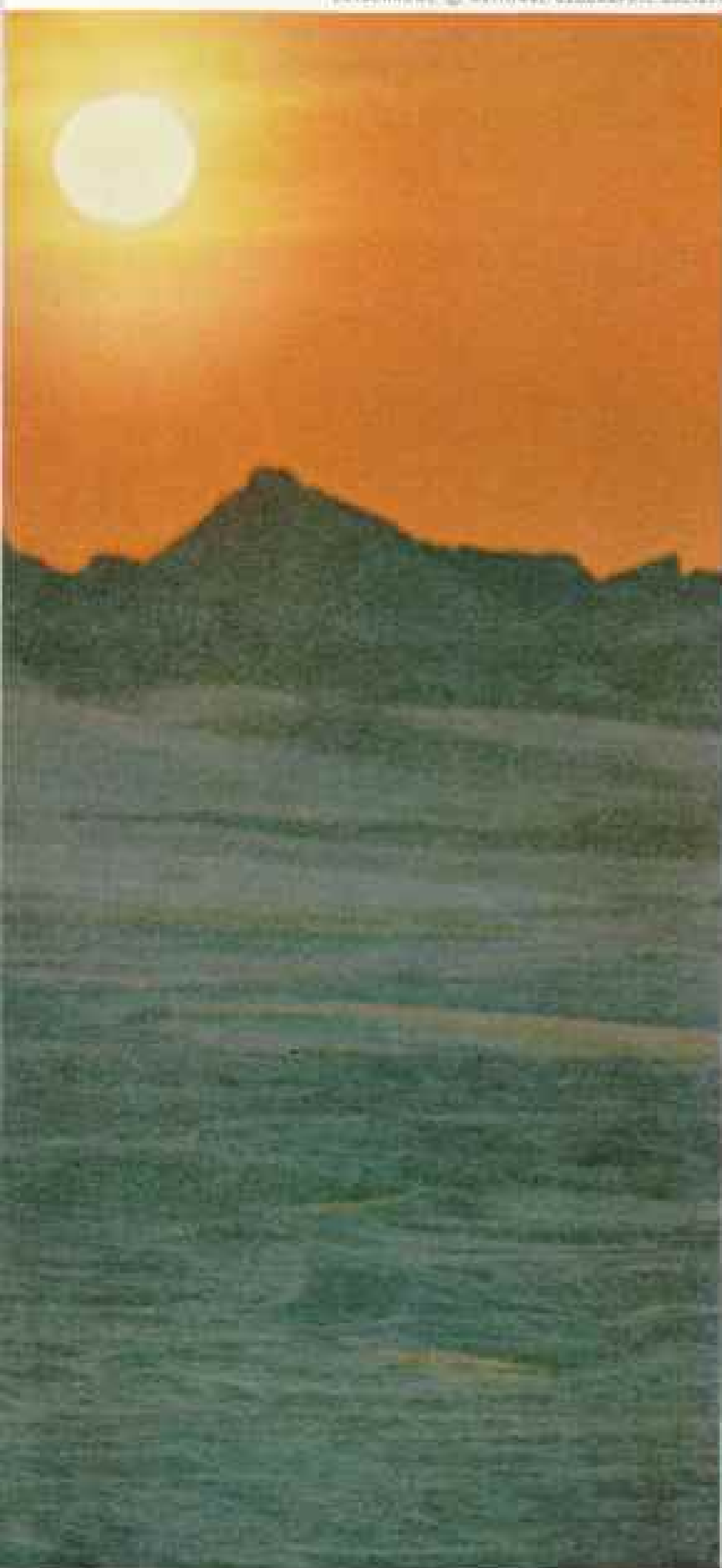
*Photographs by TED SPIEGEL*



**T**HE STARS AND STRIPES snapped briskly in the wind. Seldom had the United States flag flown over a stranger piece of real estate: an island of ice, doomed to die, adrift in the Denmark Strait.

As Arlis II, a raft of heavy ice 2½ miles long by 1½ wide, drifted inexorably southward between Greenland and Iceland, a score of men in foul-weather gear waited quietly beside the flagpole. The icebreaker U.S.S. *Edisto* stood seven miles "offshore" in the surrounding pack ice. Its helicopter had just brought visitors to join in a brief but impressive ceremony as the colors fluttered down.

ENTOURAGE © NATIONAL GEOGRAPHIC SOCIETY



Comdr. Norval E. Nickerson, USN, *Edisto's* skipper, addressed the little group:

"We had the privilege and honor, less than six months ago, of establishing the newest United States station in the Antarctic. And here we find ourselves at the other end of the earth at the evacuation of Arlis II, an ice island that has been manned continuously since late May, 1961.

"We all consider it a distinct honor to be here to evacuate the station, to welcome you aboard *Edisto*, and to take you back to civilization as fast as we possibly can."

It was "decommissioning day," May 9, 1965, and time for farewells by the 20 scientists and staff members manning the super-iceberg known as Arlis II—short for Arctic Research Laboratory Ice Station No. 2.

### Island Drifts to Certain Doom

The maverick ice island had escaped from the Arctic Ocean last January. Now, a southward current had captured it, and soon it would sunder and melt in the open North Atlantic. So, by tractor train and helicopter, its men, scientific data, and valuable equipment were transferred to *Edisto*. Then, after an occupation that had lasted four years, it was farewell to Arlis II.

The news of the ice island's abandonment saddened me, for I had known Arlis II as a cheerful place of human habitation, an oasis of hospitality amid polar desolation. I had visited this relic of ancient ice two times, to watch scientists probe the full spectrum of the Arctic environment, from sea-floor muds to outermost atmosphere.

After World War II the discovery of ice islands (the first found by the United States was "T-1," picked up by an Air Force plane's radar in 1946) offered dependable drifting platforms for scientists.

And why is it important that America have scientific platforms in the Arctic Ocean?

**Adrift on the Arctic Ocean**, a scientist makes his frosty rounds. Silhouetted against a pale polar sun, Ron Priebe measures snow depth on floes edging ice island Arlis II. He carries a rifle as insurance against polar bears. The island, beyond the jagged pressure ridge in background, supported a research station from May, 1961, to May, 1965. Braving 50°-below-zero extremes, furious gales, and months of winter darkness, scientists have manned seven U. S. floating laboratories on ice islands and floes since 1952.



**COLD FIRE OF THE NORTHERN LIGHTS** gleams above Arlis III, casting a ghostly glow over the ice station. Like a pearl set in a priceless brooch, the planet Venus shines on one horn of the shimmer-

ing crescent. An Arctic Research Laboratory party established the camp on 10-foot-thick floe ice one bitter day in February, 1964. Planes brought in everything—prefabricated huts, generators,



ENTACHROME BY V. P. HESSLER © N.G.S.

supplies, and laboratory equipment—from Barrow, Alaska, 160 miles to the southwest. This temporary station served science until its abandonment three months later, on May 16. A team led by

Professor Victor P. Hessler of the University of Alaska's Geophysical Institute studied auroras and magnetic storms here. Other scientists measured gravity and observed ice-crystal formation.



Simply because there is so much still to learn about this fourth largest ocean, across which lie the shortest air routes between the Soviet Union and North America. As the late H. H. (Hap) Arnold, Commanding General of our Army Air Forces during World War II, once said: "If World War III should come, its strategic center will be the North Pole" (see **Top of the World**, a new Atlas Supplement Map distributed with this issue).

Still, there is far more than the military consideration. Famed Arctic explorer and aerial pioneer Bernt Balchen, the first man to pilot a plane over both Poles, has written in his book *Come North With Me*: "In Roman times the Mediterranean Sea was considered the center of the world; but our new Mediterranean is the Arctic Ocean, and the North Pole is the crossroads of tomorrow's travel."

To my mind the most dramatic possibilities of man's use of this new middle sea have been created by the under-ice, underwater transits of our Navy's nuclear-powered submarines. Not only have the exploits of *Nautilus*, *Skate*, *Sargo*, and *Seadragon* been important militarily, they have stirred up serious discussion of submarine commerce—undersea freighters and tankers propelled by nuclear energy,

plying the Arctic Ocean. When this day comes, as many as 7,000 miles will have been clipped from the distance now traveled by surface ships between Europe and Asia.\*

#### Barrow: the Jumping-off Point

Most exciting to us here in Alaska, submarine Arctic tankers may be the answer to marketing the petroleum wealth of our Arctic Slope—that vast portion of our state which lies north of the Brooks Range and borders the Arctic Ocean for more than 1,000 miles.

For these reasons, and many others, we must gain a competence in the Arctic Ocean, no less than in space, and to do so will require research.

A filming assignment for the University of Alaska—I have made my home in Anchorage since 1960—gave me my first opportunity to set foot on Arlis II in February of 1962. In the late spring of 1963 I was back again for memorable weeks on Arlis II and on its sister station, T-3, or Fletcher's Ice Island.†

\**Nautilus* skipper Comdr. William R. Anderson discussed "The Arctic as a Sea Route of the Future" in the January, 1959, NATIONAL GEOGRAPHIC.

†See "Three Months on an Arctic Ice Island," by Lt. Col. Joseph O. Fletcher, USAF, NATIONAL GEOGRAPHIC, April, 1953.



More recently, in 1964, I landed my own airplane on Arlis III, a station built on drifting sea ice six to ten feet thick. Stations on floes furnish fragile roosts, habitable for months only, but true ice islands like Arlis II—massive blocks 80 to 200 feet thick—accommodate men for decades. Such islands apparently form along the north coast of Ellesmere Island, or possibly Greenland (map and diagram, page 679).

Before flying out over the ice, I stopped at Barrow, Alaska, for briefing at the Arctic Research Laboratory (page 683). Operated by the University of Alaska for the Office of Naval Research, ARL provides facilities and support not only to scientific stations drifting on the Arctic ice, but also to mainland stations scattered from the shores of the Chukchi Sea to the Canadian border.

“Welcome aboard!” ARL Director Max Brewer (right) met me on the steps with a broad smile and

**Sea-going settlement** in the Arctic Ocean, the camp on Arlis II huddles beyond a moraine of rocks and gravel deposited by glaciers before the ice shelf broke off from a true island, probably the northern coast of Ellesmere. Such deposits may explain early explorers’ reports of phantom shores.

**Dynamic doer**—ARL Director Max Brewer—never says no to any reasonable request for help from scientists. Here he assists in launching a research balloon.

EXTRACRUISE (BELOW) BY TED SPENGL; PHOTOGRAPHY BY WILLIAM W. BRONN III © N.A.S.







EDDACHROME BY TED SPRENGEL © N.A.S.

Japanese scientists on Arlis II reflect international interest in Arctic research. Dr. Kou Kusunoki of Hokkaido University, right, spent two winters on the ice island. An assistant, Akito Kawamura, measures salinity of Arctic Ocean water. Heaviest salt content lies in a subsurface layer from the Atlantic.

Bob Fischer handed me his earphones and I was amazed to hear the voice of a woman speaking Russian; then a man answering. One of the Soviet Union's ice-floe stations was wandering along a few hundred miles from Arlis.

Later that spring Bob and copilot-mechanic Frank Quates spotted a Russian station, North Pole 11, and circled it. There were men down there waving them in—so they landed!

The first time either nation had paid the other a visit at the top of the world did not produce a talkative get-together; neither guests nor hosts knew the others' language. There was much

firm handshake on that bone-chilling February day and led me into the warm indoors. "I can see you're your father's son," he said, "nosing out things that go on in far places!"

I could feel immediately the good humor and hospitality that have made Max equally popular with Eskimo employees and learned scientists. As I grew to know him on later trips, I observed the energy and resourcefulness that earned him the Navy's Distinguished Public Service Award.

#### U. S. Flyers Visit Russians

From Max, I learned that T-3 (short for "Target 3," the third ice island located by aerial search) was then riding within 150 miles of Alaska, but was temporarily unoccupied. Arlis II was plodding along 350 miles farther north, close to latitude 80°.

We were not alone up here near the top of the world. On the flight out to Arlis II, pilot

cordial handshaking, good-natured pantomime, and posing for pictures. The visit was quickly repaid. That very day a Russian twin-engine plane buzzed Arlis, circling as low as 50 feet. But though the crew waved to our men, the plane did not land.

In the growing search for knowledge about the Arctic, the Soviet Union's scientific effort exceeds our own. This is understandable because a sixth of the U.S.S.R. lies north of the Arctic Circle, and Russia has 10,850 miles of coast on the Arctic Ocean, compared to Canada's 5,770 and this country's 1,060.

Between 1937 and 1958, Russia airlifted the astonishing total of 565 temporary scientific stations onto Arctic Ocean pack ice (ice islands are rare on the Soviet side of the Pole). Most of these were occupied for only a few days, the plane remaining with the scientists.

Canadian flyers in 1961 spotted buildings and tents on a large piece of floe ice grounded

**Icy pincushion** of newly frozen water bristles with needle-sharp crystals. Mike Kuhn of Innsbruck, Austria, scrapes them onto a glass slide; later, he will make plastic models for study. Crystals are formed of pure water; in time, brine trapped between them drains off, leaving palatable ice.

on Baffin Island's eastern coast. They found worn-out gear and abandoned food, with a note inviting visitors to help themselves. The base had been the Soviet's North Pole 7.

"The boulder-strewn hills of Arlis are unique in the Arctic Ocean. You won't believe your eyes," Max Brewer had forewarned me.

He was right. As our DC-3 bumped to a halt on a packed-snow landing strip, I found the ice island's appearance astonishing: dark rock-covered hills amid a flat white world. These strange humps strewn with boulders, rubble, and silt rose no more than 43 feet, but they appeared much higher. It was hard to believe that these were not hills on solid land (pages 674-5).

The rocks on Arlis II were debris that had been spilled by small glaciers onto the Ellesmere ice shelf. The piles of stone actually helped create the island's hills, because rock and gravel insulate the ice beneath, which retards the rate of melting.

Certainly it was an ice island—perhaps *this* island, Arlis II—that led early explorers to report land in the Arctic Ocean where none exists. In 1906 Peary thought he saw land with snow-clad summits some 120 miles northwest of Cape Stallworthy on Axel Heiberg Island. He called it Crocker Land.

Over the years the mystery deepened with other reports. In 1931 "Takpuk Island" was discovered, examined, and photographed by Eskimos. Max speculates that what they actually saw was Arlis II.

Another factor responsible for the reporting of phantom lands in the Arctic may well have been the phenomenon of "looming." I encountered it first on Arlis II while taking a walk with micrometeorologist Arnold Hanson as the temperature hovered around 20 degrees below zero. To my amazement the pack ice in the distance appeared to slope gently uphill, culminating in a plateau.

"It's an illusion," said Arne, "a mirage



STYCE/PHOTO © NATIONAL GEOGRAPHIC SOCIETY

caused by temperature inversion—a matter of bent light rays, or refraction."

During this first visit to Arlis II, I looked over scientists' shoulders as they studied mysteries of the Arctic depths. Inside a heated hut I watched marine biologists George Kabacy and Gary Bruska net plankton and amphipods, an occasional tomcod, even jellyfish through a hole in the ice. Their catch was confirming the surprising abundance of sea life in Arctic waters.

### Sea Bottom Reveals Balmy Past

In another ocean study, a coring device sampled sea-floor sediment, a limestone paste made up of dust fall and the bodies of microscopic animals. Each core told a story about our planet reaching back hundreds of thousands of years.

"Just the top 10 centimeters of these three-meter-long cores span a period of 25,000 years," a geophysicist said. Startling to me was evidence that the Arctic had a temperate past. Remnants of sea-bottom life prove it, as do petrified logs and deposits of coal.

To me the most fascinating project was Carl Milner's study of underwater sounds, using a new, extremely sensitive hydrophone suspended in the sea. Carl's "sea ears" could pick up noises hundreds of miles away.

Carl amplified the strange racket for me through a loudspeaker. I listened to the weird orchestration produced by pack ice in motion—squeaks and groans, loud crashes and thumps, grinding and rumbling noises.

We were startled once by a loud metallic clank. My mind's eye pictured a sailor—American? Russian?—slamming a hatch on a submarine. But Carl said no, it was just a slab of ice toppling over.



On tape Carl recorded the voices of seals, walruses, and even fishes. A shrill, irregular sound he identified as probably the bugling of a beluga whale.

Three days would have sufficed for my filming assignment on Arlis II, but wild weather that made flying impossible held me marooned there for three and a half weeks.

Being stuck on Arlis proved a blessing: I had time to discover what life really was like on an ice island. I had time to roam far out on the pack ice until Arlis was a mere thin line on the horizon and I was a wanderer in a chaos of fractured, up-ended ice that took the shapes of people and animals, all frozen still.

I had time to learn to build a snowhouse with only a hunting knife, and time to watch the onrush of spring in the polar world.

### Polar Bear Pays a Call

When I first set foot on Arlis, in February, the sun had just returned to those far northern skies. It arched into view for a couple of hours each day. By the end of my stay, it swung above the horizon for ten hours, and the nights no longer were completely dark. In the beginning the aurora still danced and flickered overhead—but soon it was overpowered by the ascendant sun.

Once, on a walk with two companions, I spied a yellow patch on the whiteness. It was a polar bear, and he was studying us. I was amazed at his yellowness, for I had thought that polar bears were pure white and nearly invisible amid pack ice.

From a distance of a hundred yards, the bear peered at us and sniffed, then wheeled indifferently and ambled away.

The fragrance of Arlis's garbage dump lured the bears, which range the Arctic Ocean on floe ice. But the camp staff never became blasé about the hungry prowlers: Polar bears are powerful and unpredictable.

One of the more curious of these four-footed residents left her mark on the little prefab hut where I was quartered. The window frame over my cot was stuffed with rags.

**Abyssal plains** of the Arctic Ocean floor resulted from sediment accumulation (left). Tracks of bottom-feeding animals scar the 13,000-foot-deep flats off Canada. Thorndike camera (above) made the unusual picture, part of a research project led by Dr. Kenneth Hunkins of Lamont Geological Observatory, Palisades, New York. Assistants Bob Friedman, at left, and Al Gill raise the camera through a hole in ice island T-3.

KENNETH HUNKINS, LAMONT GEOLOGICAL OBSERVATORY;  
 RESEARCHER BY TED SPIZZI © N.C.S.

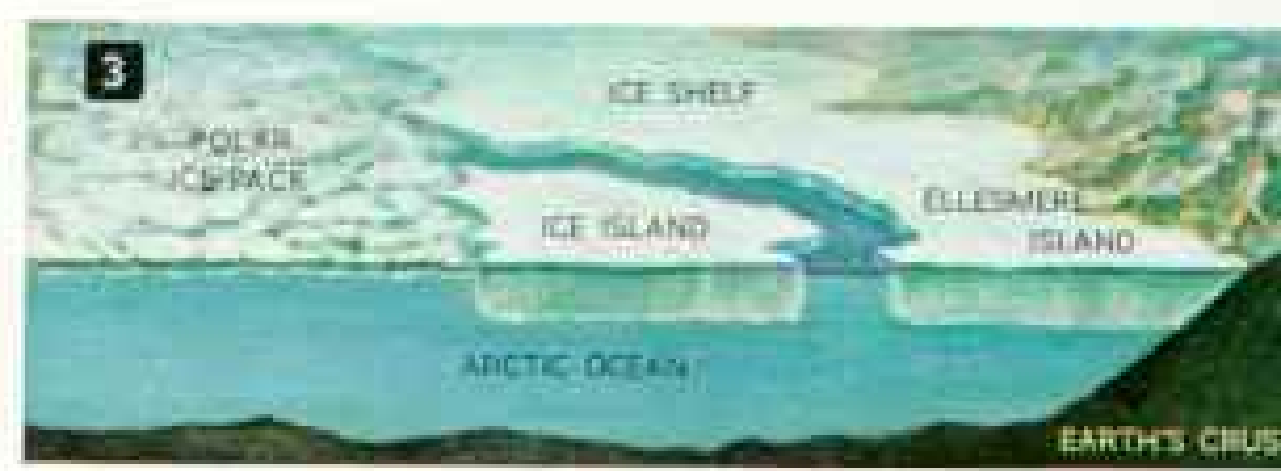


8000 B.C. After a period of warm climate, the winters steadily become longer and colder. A sheet of ice several feet thick freezes fast to the coast of Ellesmere Island.



4000 B.C. As the cold period continues, accumulating snow and freezing sea water increase the ice shelf's thickness to 100 to 200 feet. Wind action ripples its surface.

Far-ranging wanderers, Arctic ice islands 80 to 200 feet thick drift along with the thinner polar pack (map, above). Wind and current drive the frozen domains at speeds of two to three miles a day, about 1/50th the wind's speed. During one storm T-3 logged 10 miles in 24 hours. Before scientists occupied their floating laboratories, aerial observers could only estimate the course of T-3 and Arlis II, so tracks appear smooth. Later, when inhabitants charted daily movements, they found the paths to be zigzag.



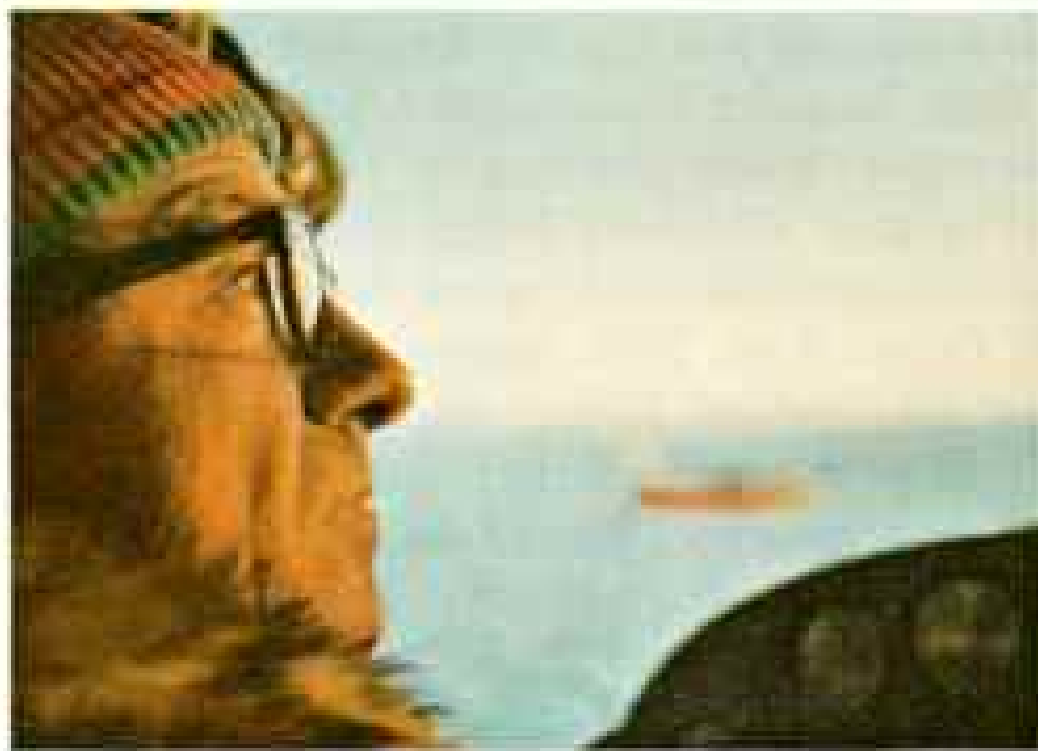
Today. With a warmer climate, the shelf thins. Under pressure from the polar ice pack, tidal action, and storms, a portion breaks away and begins its drifting ice island career.



**TINY IN THE VASTNESS** of the Arctic, two Cessna 180 aircraft ferry scientists to an ice station. Airplanes have revolutionized research in the north, making possible the establishment and maintenance of isolated outposts. A lead of open water (right) separates the ice island T-3 from floe ice in foreground. Snow-packed airstrip (upper left) leads to T-3's lonely encampment.

KODACHROMES BY LOWELL THOMAS, JR. (RIGHT)  
AND TED SPIEGEL © NATIONAL GEOGRAPHIC SOCIETY





EXHIBITION BY TED SPIGEL © N.A.A.

"A scene of broken, crumbled beauty, like some whitewashed ancient city." Thus the author (above) described the spectacle of ice islands spread below the wings of his plane. Now a resident of Alaska, Lowell Thomas, Jr., explored the Far North as the latest chapter in a flying and reporting career that has covered the deserts and mountains of Asia and Africa.

"How come?" I asked. "Polar bear," was the prompt reply.

Just a few weeks earlier, Navy oceanographers Lindsey Redin and Dick Ketchum were asleep in these quarters when the shattering of a window and a blast of frigid air awakened them. Redin stopped the hole with clothing. Something yanked it out again. Another icy blast. Redin reached through to retrieve the stuffing—and nearly grabbed a polar bear by the snout!

Ketchum seized a magnum pistol and ran out to warn the others. On the way he met the marauding bear, fired, and wounded it. The beast reared, then turned and fled.

Armed with a rifle, Ketchum and a staff man went searching for the bear. They spotted an Arctic fox—often a scavenger on polar bear kills—and followed it to the wounded animal. Fleeing at first, the bear at last wheeled to charge, making one final lunge even after being shot between the eyes. An autopsy explained its aggressiveness: It was a two-year-old female, just learning to hunt, and lean from undernourishment.

### Mountains Rise From Floor of the Ocean

In May of 1963 Max Brewer invited me north again, this time on a supply flight to T-3 (Fletcher's Ice Island).

Much larger than Arlis, this giant ice chunk measures 6 miles long and 3 miles wide. T-3 was manned intermittently from March, 1952, to February, 1962, and has been continuously occupied since then.

On T-3 I found five busy investigators, backed up by four staff men from the Arctic Research Laboratory. One of these was an Eskimo, Percy Nusunginya. In the fall he would return to the University of Alaska. He wanted to study Oriental languages, because, as he put it, Chinese are the world's most numerous people. "We need people who can speak the language," he said, "especially people like us Eskimos with an Oriental background."

The scientific leader on T-3 was Dr. Kenneth Hunkins, a researcher with Lamont Geological Observatory of Columbia University. While drifting in 1957 on a floe station, he had located Fletcher's Ridge (Alpha Rise), a range of sunken mountains rising more than 6,000 feet from the Arctic Ocean floor. This chain roughly parallels the even higher Lomonosov Ridge, discovered by Russian scientists almost a decade earlier.

Lowering a pressure-proof camera on a cable a mile and a half down, Dr. Hunkins had taken the first photographs of the Arctic Ocean floor (page 678). They showed the bottom littered with rocks. How did they get there? The answer seems to be that over the centuries ice islands like Arlis II rafted boulders and rubble out from land and, melting and fracturing, dumped them into the sea.

One morning I walked with Ken Hunkins to his laboratory hut at the edge of the island. On an instrument panel, a stylus marked a revolving drum with readings from a sensitive fathometer, which recorded the ocean depth to an accuracy of one meter.

"You might call it reading the grain of the land," said Ken. We were floating over one of our planet's most level surfaces, he explained, an abyssal plain as flat as a billiard table, characteristic of ocean floors.



Flaming springtime sun, riding low on the horizon, lights the Distant Early Warning (DEW) Line station near Barrow, Alaska, a sentinel keeping round-the-clock electronic vigil.



©2004 HOMES BY AL HUTCHINGS (RELUKI) AND TED SPICEL © S.C.S.



**Noontime** winter moon silvers the nearly deserted "Main Street" of the Arctic Research Laboratory at Barrow, Alaska. Operated by the University of Alaska for the Office of Naval Research, ARL feeds, clothes, and transports students of the Arctic environment scattered from northwesternmost Point Hope to the Canadian border and from the southern limits of the Brooks Range to the Arctic Ocean, as far as 1,200 miles out to sea.

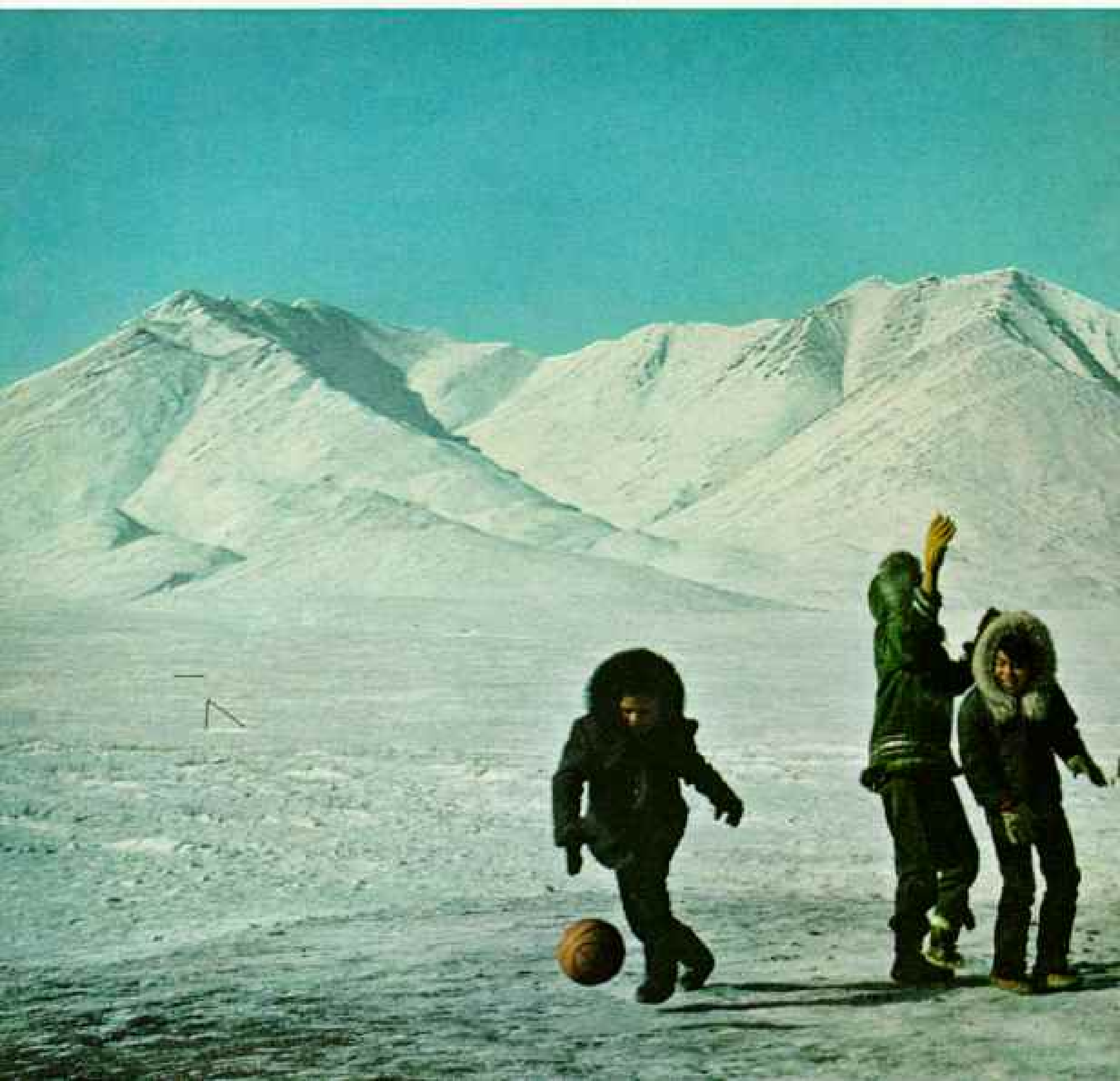




Concern for the welfare of Eskimos impels scientist Wayne C. Hanson of Battelle-Northwest Laboratory to conduct radiation tests in Kotzebue. He found that radiation in northern Alaska Eskimos—though within safe limits—increases with the amount of caribou they eat. Caribou absorb radioactivity from lichens, which, because of their long life, accumulate more fallout materials than other Arctic vegetation.

Almond-eyed Eskimo girl attends first grade at the Bureau of Indian Affairs School in Barrow. About 35 of Barrow's 1,500 Eskimos work at ARL.

Thirty-below weather fails to halt basketball at Anaktuvuk Pass, 240 miles south of Barrow. Once-nomadic Eskimos converted this former hunting camp into a village and began a school.





Later I saw a team of men lower meters equipped with propellerlike vanes through the ice to record even the slightest current at various levels. Relatively warm Atlantic currents flow north toward the Arctic, mostly between Iceland and Greenland. Becoming cooler, they sink and enter the polar ocean below the surface. Cold currents flowing south, also east of Greenland, carry icebergs into Atlantic shipping lanes. This was the path Arlis II was to follow to its demise.

U. S. and Russian scientists have located two main current systems in the Arctic. One sweeps west from the East Siberian and Laptev Seas toward Vest Spitsbergen and Greenland. The other broad stream swirls clockwise around the Beaufort Sea on the North American side of the ocean (see **Top of the World** map).

It is this last current that holds the ice islands in "orbit." This is no rapid stream: T-3 has taken more than ten years to make one circuit.

Arctic Ocean ice islands average two to three miles 685

ENTRANCE (TOP) AND FIDELITY (BY TED SPIGEL) © W.H.E.





RESEARCHED BY LOWELL THOMAS JR., LOEWY AND TED SPIGEL © N. A.





in 24 hours, although speeds sometimes vary greatly. During storms T-3 may whiz along at ten miles a day.

"We have found that Nansen's rule—that the Arctic Ocean ice is driven at about 1/50th the speed of the wind—generally holds true," Ken Hunkins told me.

Ken had just started a project on T-3 that may help to track storms across the top of the world. To record the long ocean waves of the Arctic, he placed three seismometers half a mile apart in a triangular pattern. Normally these waves are imperceptible, damped out by the lid of floating ice. Nevertheless, the waves are there, even though they may kick up a "sea" no more than a millimeter high. Ken's instruments indicate that they follow each other at intervals of from 20 to 40 seconds—twice as long as waves in the open ocean. The devices thus record wave fronts from a storm and provide a fix by figuring time differentials.

As we watched the seismometer readings being recorded on rotating drums, Ken quite excitedly noticed a large squiggle of red ink on each, betraying some unusual disturbance within the last hour or two. "Probably a local earthquake," said Ken.

Later, in Anchorage, my wife Tay told me of a sharp earthquake she had felt while I was gone. Its force focused on Cook Inlet in southern Alaska. I checked with Ken Hunkins after he studied his data and learned that this was indeed the same quake. His instruments had sensed it, centered 1,500 miles away, through 200 feet of ice and two miles of ocean.

#### Record Flight to the North Pole

During my stay on T-3 I witnessed the return of two pilots from a remarkable pioneer flight to the North Pole, 500 miles away. Bob Fischer and Cliff Alderfer had flown two single-engined Cessna 180's on skis to the first—and so far the only—landing of light planes at the northern axis of the globe.

The Cessnas used T-3 and Arlis II as steppingstones—in fact, the ice islands made the flight possible. A scientist rode with each pilot. Sitting next to Bob Fischer was Arne Hanson. With Cliff was Jan Black, an expert on gravity and magnetics.

As they neared the Pole, a gray wall of cloud—what Eskimos call "water smoke"—loomed ahead. A few minutes later a light snow began to fall. Through the partial whiteout, Bob spotted a strip of refrozen ice—the best bet for a smooth landing. When Bob got down safely, Cliff followed him in.

"It was a little after midnight, Alaska time, on May 24, 1963," Bob said. "Arne Hanson remembered it was his birthday. How about that? The North Pole for a birthday present!"

Jan Black quickly read his gravity meter. Then, in a hole drilled through the ice, he fired a small explosive charge.

Wham! The charge seemed to lift the ice. In six seconds the

**Making its own blizzard,** a Hercules C-130 supply plane slows down on Arlis II's snowy, flag-marked runway by reversing the pitch of its propellers. This ski-fitted transport delivers a load of diesel oil—the Arctic's vital fluid that powers electric generators for light and warmth.

**Changing times** dictate a new mode of life in the frozen north, where stouthearted huskies—once indispensable—give way to sledge-pulling weasels. This tracked vehicle moves equipment from the airstrip on Arlis II to the encampment.



Buried to their roofs by screeching storms, huts of Arlis II look like steppingstones in the snow. On evacuation day, May 11, 1965, a helicopter from the U. S. Navy icebreaker *Edisto* arrives to help take the remaining men and equipment from the island. Earlier, weasel trains removed valuable gear to the ship moored seven miles away.

echo bounced back from the bottom. From that time lapse Jan could calculate his sounding precisely. He got the same two-and-a-half-mile depth that the nuclear submarine *Nautilus* measured in 1958. Peary, in 1909, had been unable to reach the ocean floor. "Our sounding apparatus gave us 1,500 fathoms of water," he noted, "with no bottom."

Half an hour after landing, the two Cessnas were back in the air, bound south for T-3, where the crews told me their story.

#### Strange Arctic Hazard—Sunburn

June is a month of poor weather in the Arctic Basin—low overcast and fog prevail, because of more open water. But one day, T-3 became a sparkling fairyland, and the glare from sun, sea, and ice gave me a painful burn. On a clear summer day at these high latitudes, the amount of sun's heat received on the ground approaches that measured at the Equator. The 24-hour sunshine does it.

The season was growing late, and ice airstrips were becoming mushier every day. If T-3's sister island, Arlis II, was to be resupplied for another season, it must be done now. The planes would use T-3 as a way station, thus giving me a chance to revisit Arlis,

now 500 miles farther northwest, past 87°. I hopped aboard the first DC-3 shuttle flight.

"You're as much trouble as the pilgrims I used to fly to Mecca," pilot Bob Murphy growled amiably. "They brewed tea in the plane over camel-dung fires; you roam around like the Columbus of the Arctic Ocean."

When Arlis appeared dead ahead, something seemed wrong. Surely we were coming in from the *north* instead of the south! The buildings were in the right place, but the directions were reversed from my previous visit.

"How come we're approaching from the wrong direction?" I asked Murphy.

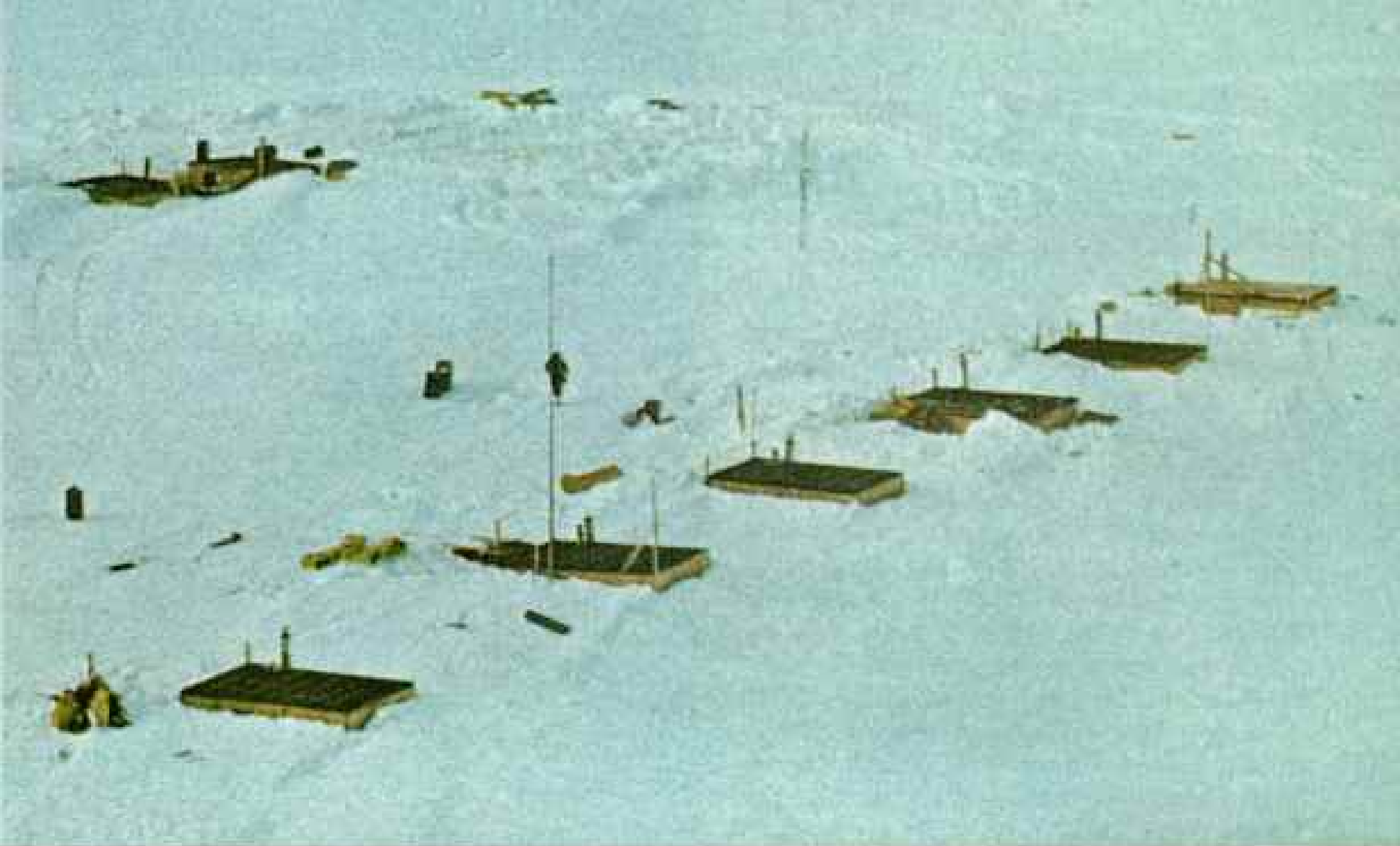
"Joke's on you," he answered. "The island's simply turned around since you were here."

One low swing over the island, gear and flaps down, and Murphy brought the plane in. It was the longest day of the year—June 21—and the latest landing ever made on Arlis.

Carl Johnston drove out in a weasel to meet us. Carl, station leader, was listed for vacation, but he was getting uneasy, as was I. The airstrip was a morass of slush.

"Staying for the summer are you, Lowell?" Carl ribbed. "Can't get enough of this ice, eh?"

"Yep, I'll probably be here until September, but so will you, Carl!" He winced. He had



ATTACHED BY BOB KRUEGER FOR A.G. HAYS & SONS, H. S. S.

**Crack of doom,** a widening gap appears between floe ice, left, and ice island. This break in late April marked the separation of Arlis II from the thinner floes.

already spent a total of more than two years on that lonely ice cube.

Those of us who *had* to get out before the summer thaw closed the airstrip just managed to make it. Barrow never looked so good to me, but it looked even better to Carl.

The Arctic Research Laboratory pilots, despite rutted airstrips, fog, and total lack of landing aids, made seven round-trip runs between T-3 and Arlis. Often the cloud ceiling was below 100 feet and visibility less than a mile. I've never seen anything like it, and I've seen a lot of flying.

#### Visitors to Island Arrive on Skis

Almost a year after I left Arlis II there was a dramatic arrival at the station. The young Norwegian explorer Bjørn Staib and his party came "ashore" from the polar pack on May 8, 1964, ending their unsuccessful attempt to match Peary's dash to the Pole. It was the only time an ice-island station far at sea has been reached from land by surface travel.\*

In February, 1964, ARL set up a new ice-floe station, Arlis III (pages 672-3). Max Brewer told me I could fly out there in my own

\*The explorer's own account, "North Toward the Pole on Skis," appeared in the February, 1965, *GEOGRAPHIC*.



Dripping icicles signal the approaching end of Arlis II. Drifting into warmer latitudes, the island eventually broke up in the heaving swells of the Denmark Strait. Its abandoned village and glacial debris dropped to the ocean floor.

ski-equipped Cessna 180—the same small plane that my wife Tay and I piloted over Africa and the Middle East ten years earlier.\*

On March 11, the day after I reached Barrow, the mercury skidded to minus 40 degrees—"too cold to fly 180's safely," Max Brewer told us. Survival would be touch and go for a plane crew forced down in such weather.

As Max put it: "You have to learn to be a little bit lazy in the Arctic." I knew what he meant; you must be infinitely patient until conditions tip the odds in your favor.

For five days we waited at Barrow. Then, at last, on the afternoon of March 15, our three Cessnas headed northeast across the Arctic Ocean. Bob Fischer flew one ARL plane and Mal Staheli the other.

About 200 miles from Barrow, the target came in sight—four tiny brown specks on the ice. When we landed, the temperature read minus 36. Bob and Mal dumped out their cargo of fuel and food.

Muffled in his parka, Dr. Victor Hessler, aurora expert and station leader, came out to greet us. "Looks like the tourist season is here," he joked. "The birds are flying north."

We stepped into the warm hut which served both as lab and mess hall, although only 12 by 16 feet. Total population at the time was three—two scientists and one ARL staff man.

As we gulped cups of hot tea, Vic explained the choice of this location: The pack here floated over deep water—about 12,000 feet of ocean under ten feet of ice. Here the interaction of electrical currents between atmosphere and conductive sea water could be studied without the distortions caused by irregular land masses.

Soon the late winter day drew toward its close. "Better head for home," said Bob.

By the time we zoomed in over Barrow, it was dark enough to flick on our wing lights.

#### Arlis II Makes Fatal Turn South

Now, more than a year later, my old friend is gone. Warm water has wiped out Arlis II.

When this renegade drift station made its fateful move around the northeast corner of Greenland and swung south toward the Atlantic, it was caught up in the enormous river of pack ice in the Greenland Sea. Arlis II fairly skimmed, at times making 20 miles a day, a



speed that proved a headache to Vaughn Marshall of the U. S. Geological Survey. Marshall was taking bottom temperatures and cores to learn the rate of heat flow into the ocean from the sea bottom, as part of a world-wide study of the heat loss through the earth's crust. When Arlis picked up speed, the movement bent Marshall's steel-pipe probe, jabbed into the ocean floor.

As the latitudes got lower and lower—80°, 75°, 70°—pinochle and paperbacks lost their charm. Word came by radio that an icebreaker would meet the island somewhere between

\*The Thomases recounted these journeys in "Flight to Adventure," in the *GEOGRAPHIC* for July, 1957, and in "Sky Road East," January, 1960.



PHOTOGRAPH BY WILLIAM W. BROWN III © N.S.C.

Iceland and Greenland. The ship would evacuate men, valuable equipment, and records.

Position reports from the *Edisto* came in regularly. But some perverse force seemed to keep ship and ice island apart.

#### Ice Pack Delays Rendezvous

"One day the breaker would be 70 miles away," reported Marshall. "Next day we'd make 10 miles south—and *Edisto*, hemmed by pack ice, would check in 73 miles away.

"Carl Johnston, our cook, said that if the icebreaker would just stay put, we'd come down and rescue them."

On May 6, a helicopter from the *Edisto* landed at the Arlis camp. On May 9, the flag

came down and on May 11 the base was officially deactivated.

Last man to leave the camp was Carl Johnston. Carl had been cook and station leader on Arlis II for 41 months. He spent his last day on the island washing down the mess hall.

The Navy left two radio homing beacons on Arlis II. Tracking by this means, and visually, planes followed the storied chunk of ice into the open Atlantic southwest of Iceland.

On June 4, 1965, Arlis broke up; 13 days later the fragments numbered eight to a dozen. By July 25, they had rounded Greenland and headed north again toward Baffin Bay.

Arlis's buildings are at the bottom, but its great record is in the books. THE END



# Top of the World map focuses

FROM A FADED PAGE of Peary's journal the words, written on April 6, 1909, still leap to life: "The Pole at last!!! The prize of 3 centuries, my dream & ambition for 23 years: *Mine* at last."

Half a century later a terse radio message sang triumphantly through Arctic air to the world: "NAUTILUS NINETY NORTH."

To reach his goal, explorer Robert E. Peary fought a cruel, frozen sea; the crew of the nuclear submarine, U.S.S. *Nautilus*, traversed it comfortably in shirt sleeves. The Arctic Ocean is gradually changing from a hostile barrier to a polar "Mediterranean," a shortening link between East and West. Hence it becomes the focal point of the new 11-color Atlas Supplement Map, **Top of the World**, distributed with this issue of the *GEOGRAPHIC*.\*

Today, contrails crisscross polar skies as jets shave hours from intercontinental flights. Nuclear submarines have cruised the Arctic's frigid waters and poked inquisitively up through its pack ice, foretoking tomorrow's undersea shipping lanes between the Atlantic and Pacific. Research teams probe, study,

and solve the Arctic's mysteries (page 670).

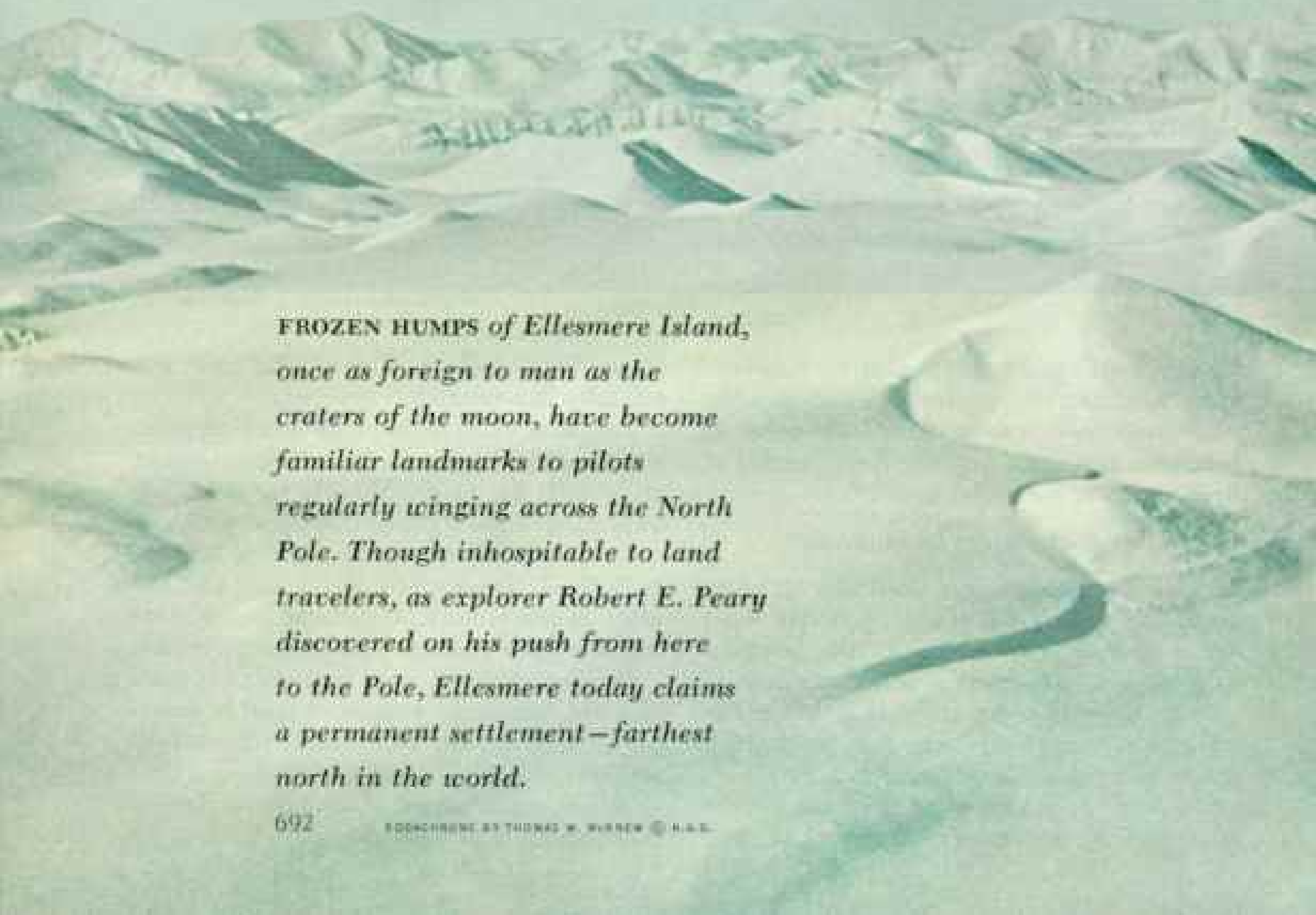
Overriding the excitement of scientific discovery, however, is the tense awareness of the region's strategic position in a world divided by Communism. The new map reflects this tension by locating North America's DEW (Distant Early Warning) Line and BMEWS (Ballistic Missile Early Warning System), whose radar eyes sweep polar horizons.

## Frontiers Inch Northward

The 19-by-25-inch map, portraying one-sixth of the earth's surface, extends far into the Northern Hemisphere, encompassing such great cities as Tokyo, Los Angeles, and Cairo. Within its scope lies the bulk of the world's industry, commerce, and military might.

Some of the Northern Hemisphere's coldest land masses include areas rich in petroleum and coal—remnants of a temperate past. Yet more than half the land shown by the map remains inhospitable to settlement. Of Canada's 19,516,000 people, 90 percent cluster within 200 miles of the United States border.

Still, frontiers slowly creep northward,



*FROZEN HUMPS of Ellesmere Island, once as foreign to man as the craters of the moon, have become familiar landmarks to pilots regularly winging across the North Pole. Though inhospitable to land travelers, as explorer Robert E. Peary discovered on his push from here to the Pole, Ellesmere today claims a permanent settlement—farthest north in the world.*

# on intercontinental crossroads

notably in Siberia. In this vast, desolate region opposite the world's northernmost land-based station—Alert, on Ellesmere Island—the Soviet nickel-mining town of Noril'sk, 200 miles above the Arctic Circle, has mushroomed into a city of more than 115,000.

Evocative new names appear on the map: Mount Kennedy in Canada's Yukon; Mount Churchill in Alaska. Off Iceland, Surtsey—a 1½-square-mile cone of cooling lava—marks an infant island born of earth's fire far beneath the sea.

## Deep Features Come to Light

The Arctic Ocean, too, is revealed in greater detail. Even after World War II, Arctic maps depicted a nearly featureless ocean floor. The new one shows two plainlike basins divided by undersea mountains—Lomonosov Ridge, discovered by Russians in 1948, and Fletchers Ridge, delineated by United States scientists on ice island T-3.

A trough between Greenland and Vest Spitsbergen, also discovered by the Russians, appears on the new map. Oceanographers be-

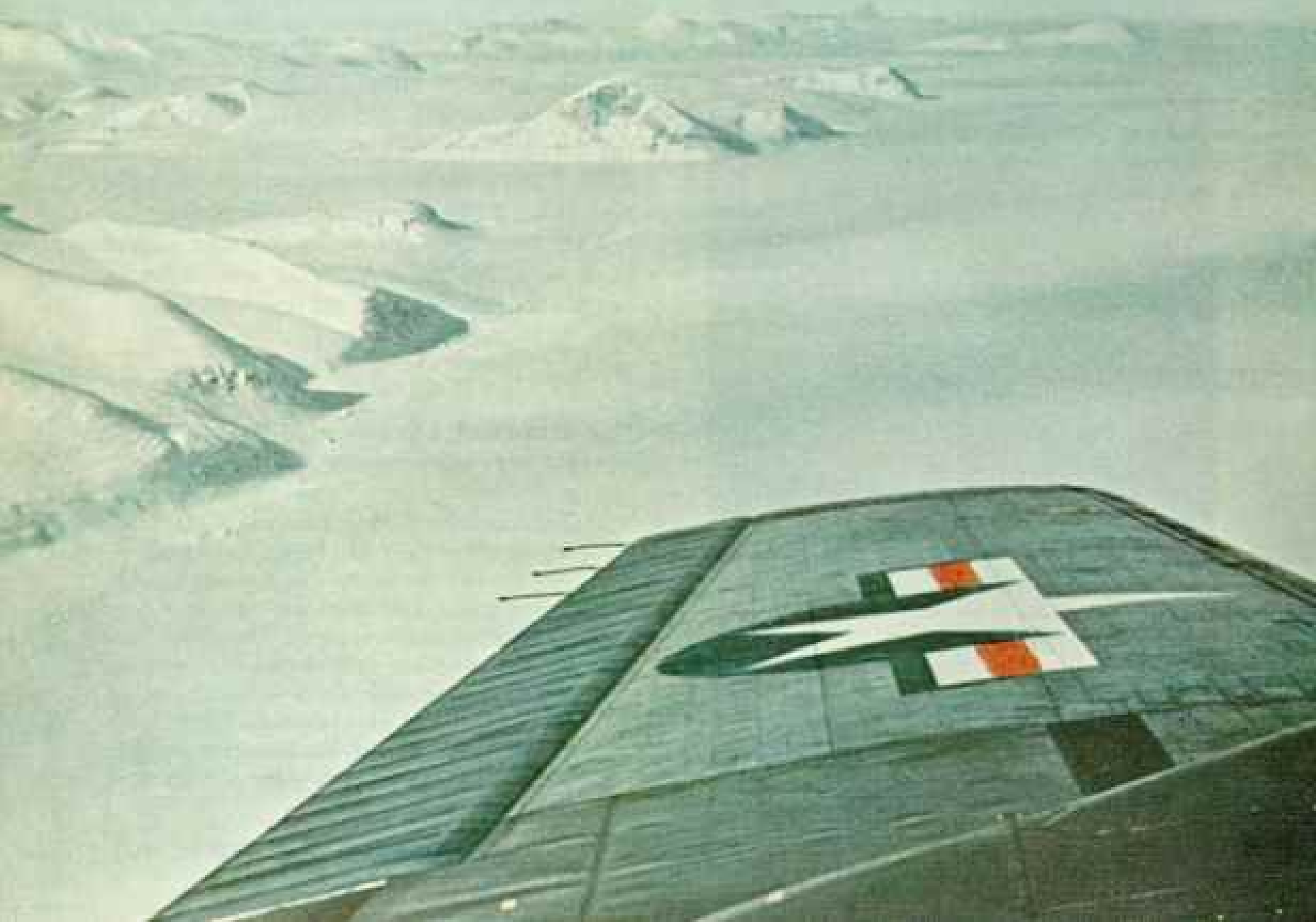
lieve this depression explains how the North Atlantic and Arctic Oceans exchange water.

Charles and Anne Lindbergh, in 1933, blazed a northern aerial trail across the Atlantic via Nova Scotia, Newfoundland, Labrador, Greenland, and Iceland. Their flight pioneered a great circle route, the shortest distance to Europe. The strip map adjacent to Top of the World illustrates this northern beeline, and traces telephone cables roughly following the great circle.

In the August, 1922, GEOGRAPHIC, Arctic explorer Vilhjalmur Stefansson wrote, "We shall 'soon' be booking our passage from New York to Liverpool, or London to Tokyo, by dirigible or plane in as matter-of-course a way as we now book our passage by steamer." The table listing airline great circle distances among far-flung cities points up the fulfillment of his prophecy.

THE END

\*Additional copies of the Top of the World—and all other Atlas Series Maps published as supplements to NATIONAL GEOGRAPHIC—may be ordered for 50 cents each, postage prepaid, by writing to Dept. 87, National Geographic Society, Washington, D. C. 20036.



# I Joined a Sahara Salt Caravan

Article and photographs  
by VICTOR ENGLEBERT



I AM PROUD of my new desert *tagilmust*, but I cannot authoritatively wind its 20 feet of cotton cloth around my head.

"Zut!" I cry in exasperation, and shorten it to a third of itself. Now it adjusts readily. Veiled to the eyes, standing beside a camel, I feel that one could not tell me from my companions, although I am a Belgian and they are Tuareg of the southern Sahara.

The Tuareg. The best cameleers on earth. Proud, tall Berber warriors whose ancestors lived long ago on North Africa's Mediterranean littoral but, either for room or for freedom from Arab invaders, migrated south to the bitter deserts they inhabit to this day.

Reversing the usual practice of Islam, Tuareg men swathe themselves in heavy veils, whereas their wives go about with faces bared. I have lived much among them, but I have no explanation for the practice.

## Vanquished "Blue Men" Hold No Grudge

It began, I imagine, as a practical matter of protection against the glaring Sahara sun and evolved into tradition. I can only say that one must know adult Tuareg men quite well before one is permitted to see them without the veil covering all but the eyes.

When Tuareg can afford dyed cloth, the veil is blue. The dye rubs off on their skin, and for this reason writers have dubbed them the "Blue Men." With skill and courage they resisted French invasion of the Sahara. In the end, their swords and spears lost to firearms.

Happily for me, they bear no malice toward the Europeans who defeated them. The Tuareg accepts the decisions of Allah with grace. Thus I am safer in Tuareg tents than in the rush-hour traffic of my native Brussels.

I am especially safe at the moment. I have been accepted as a working member of a camel caravan. For the next few weeks, therefore, I am myself a Tuareg.

**Man of the veil**, a Tuareg noble covers his face to the eyes before women and strangers.

**Toiling across the Ténéré**, a stove-hot corner of the Sahara in Niger, Tuareg cameleers dine on the move. The menu: a gruel of water, millet, and dried goat cheese.

A Berber people of North Africa, the Tuareg centuries ago drifted into the southern desert, where their fierce, camel-mounted warriors preyed on caravans. Today, with plundering outlawed, the blue-clad nomads transport salt across one of the world's most forbidding landscapes.



**DROMEDARY ARMY** assaults the infinity of sand stretching from the salt pits at Bilma toward distant Agadès. Once, combined caravans 30,000 camels strong traveled the 400-mile route together for safety. Now small groups split off to move at their own speed.

The author teamed with Saïdu, a devout Moslem, and led the way whenever his partner paused to pray. He was guided by other files of camels in the caravan, never having mastered the Tuareg talent for navigating by the sun, stars, and dunes.

RODCHROME BY VICTOR GILLESPIE © N. G. S.

We are in Niger, in the oasis of Bilma (map, page 705). More than 600 miles to the northwest, in Algeria, some Tuareg now work for the French atomic energy installation at In Ekker. Others even conduct parties of tourists.

But in Niger no Tuareg ever heard of the atom. Tourists? They do not visit the sands of the Ténéré, an especially inhospitable part of the southern Sahara into which I am now about to venture. Here in Niger the Blue Man knows only the primitive ways of his forefathers. He keeps camels, goats, sheep. Most importantly, he carries the salt from the Sahara, where it is abundant, to areas of the cattle-raising south where it is not.

The salt our caravan will carry comes from pits outside Bilma worked by Negroes known as Kanuri. They pour water into the pits to loosen the salt and add natron (sodium carbonate) to remove impurities. They cast the moist salt in wooden molds; the dried blocks weigh perhaps 40 pounds. Resembling long-stemmed mushrooms with flat tops, they are difficult to tie to camels, and break into impossible pieces when they fall (pages 702-3).

Why the Kanuri do not cast convenient bars, I do not know. Neither do the Tuareg. They look at me with blank faces when I ask.

Preparing for the march, we pound millet—food for the journey; plait ropes of date-palm fiber; load salt. I repair my baggy pants, which have broken.

The Tuareg watch me closely but casually. They approve my veil; they do not know I scissored it. They smile at my shout when a camel bites my *derrière*.

They approve the way I load my camels and laugh at my many errors in Tamahaq, their language. They see I do not mind the dreadful green camel spit, for no more than they, who rarely wash, do I keep myself clean in the desert where water is only for drinking.

I like and admire camels. I think them funny. I roar with laughter at the sight of them kneeling at night, all in a ring like old women, around a pile of fodder, looking down their rubbery noses, occasionally nipping a neighbor, superciliously peering into the desert when a jackal howls beyond the campfire.

The Tuareg also like camels, which make

life possible for them in the desert, but they do not think them funny. Instead, they think I am funny for laughing at camels.

Now at last we start. Each dromedary is made to stand up after it is loaded, and the beasts are roped tail to nose (below). The Tuareg shout, the camels roar and make gargling sounds. The strings move off immediately, for a camel left standing with nothing to occupy its thoughts will surely do something disruptive.

#### Barefoot Across the Sands

The strings move in no precise order. Sometimes they march in line, sometimes in parallel rows. There is no path to encourage single file across the Ténéré. We will guide by day upon the wind and the blazing sun and the fetch of the dunes; the stars point our way in the cold of Sahara winter nights.

In the beginning we walk to spare the camels, and also to rearrange loads that slip in the first few miles. We travel interminable corridors between dunes. It is good to feel the sand on one's bare feet.



Walking, I take stock of the men with whom I am crossing one of earth's most sinister deserts, a place in which scarcely a blade of grass grows or a drop of water moistens the sands.

My new friends number ten. Six are veiled Igdalen tribesmen, and one an Igdalen youth who will don the veil only when he becomes 15 or 16. Their features are regular, their skin is as white as my own. Two are Negroes, small boys. They are *iklan*. This Tamahaq word means "slaves," but slavery here is not slavery as we knew it in the West.

The Tuareg once captured and still hold slaves, but never bought or sold them. These days the *iklan* are free to go if they choose, but most remain, for they know no other life. Thus, instead of slaves, one might call them servants who work for their keep—the humblest caste in the stratified Tuareg society.

Most respected Tuareg caste is that of the *imajeghan*, the nobles, who in the old days raided caravans and fought other tribes and the French invaders. A tall Tuareg noble is still a most imposing specimen: He strides, he does not walk, and even when he begs a cig-

arette, he does so with the air of a king conferring an honor upon a subject.

The most numerous caste is that of vassals, who to this day pay annual tribute to the nobles. Apparently they never stop to think that the necessity for doing so no longer exists.

My Igdalen companions of the caravan are neither nobles nor vassals, but come from what I can describe only as a "religious tribe." They practice the Moslem faith more scrupulously than most Tuareg, who are not very religious. My caravaners pray the required five times a day. Also, from their people come the Tuareg *Marabouts*, or Islamic holy men.

I almost forgot the tenth companion. He has regular features and a dark skin. He is halfway between Berber and Negro, a not-unexpected mixture in a slaveholding society.

I make team with Saïdu, our leader. I am our "Tail-end Charlie." I walk behind our camel string to see that all goes well. Especially I watch the ropes tying the animals together. No pack camel will continue to go forward unless something is leading him.

I learn the times Saïdu must stop to pray.



and I run forward to take his place at the head of the file. This pleases everyone, for the caravan must not pause even for a moment until the long halt of the night. If it did, the camels would kneel, a jerking movement that can pitch the loads over the animals' heads.

As we walk, we eat our lunch. I should say we drink our lunch: It is a mixture of water, pounded dried goat cheese, and millet.

We do not march very fast. In the yellow glare we make  $1\frac{1}{2}$ , perhaps  $2\frac{1}{2}$  miles an hour. Still it grows difficult, this walking in

soft sand, and I tire. When will someone mount his camel? I will not be first.

Finally Saïdu grasps his lead camel by the hide and one ear. The beast roars and shies away, but Saïdu gives a spring and bounds to the top of the load.

Immediately I mount as Saïdu did. All the others do the same. We had plodded for four hours without pause. Only on this first day, thank heaven, would we proceed for so long on our own feet.

Darkness arrives. Still we go onward. Stars



REYNOLDS © N.A.A.

**Sultry daughter of the desert** lies swathed in imported indigo-dyed cloth. The sheen marks her turban as new. Its dye rubs off blue on her skin. Tuareg prize the color; outsiders call them the "Blue Men."

**Wind screen of park saddles** shelters caravaneers at Fachi oasis. While comrades make rope, a nomad pours tea. If strangers were present, he would drink it under his veil rather than expose his mouth.

**Complaining camel** objects to the lasso of Rabedu, one of the Tuareg *iklan*. Although *iklan* means "slaves" in Tamahaq, the nomads no longer hold people in bondage. Rabedu may leave if he wishes.



blaze. Saïdu is guiding on one, and points it out to me: "Allah's gift to us."

"Thanks to Allah," I reply.

"*Ehwalla*, Yes." Saïdu nods in understanding. We are very much *d'accord*, this desert man and I.

#### Campers Unburden Camels

But, *ma foi*, my back hurts from constant camel rocking! Will we never make camp?

At last we halt, at precisely the time we must in order to guard the camels against

irreversible damage from fatigue. It is a thing the Tuareg has known from time immemorial, like what to carry on the journey and what to do for a sick camel.

We unload, as we will unload at every halt—unload completely. Everything.

Then we hobble the camels and give them the forage we have brought. Here, at least, one can be sure they will not wander three-legged into the desert night in search of grass, no need to waste the entire next morning in finding and catching them.

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PHOTOGRAPH BY VICTOR ENALBERT © NATIONAL GEOGRAPHIC SOCIETY





We cook over tiny fires of sticks carried on the camels. But first we brew our tea, sticky-sweet, marvelous both for quenching thirst and restoring energy. Without his tea, a caravaner quickly loses his usual good nature.

Tea is prepared with care and drunk ceremoniously, three small glasses for each man. Then we eat from a common bowl, everyone serving himself with his own wooden spoon. But always one or two have no spoons, and the others pass theirs around the group. Mine they scorn: A metal one, it is too small.

I marvel at the thoughtless way they gulp their precious water. In all other caravan matters they are so careful, these desert men, and take so few chances. Yet with the water, the most important thing of all, they are rash. Almost they seem to be proving their faith. Allah will provide.

*Très bien.* They know what they are doing. But I was to learn that Allah occasionally is busy elsewhere, and I was to wish that my friends gave him a little more assistance.

Though I suffer from thirst more than they, I take only one gulp before I must pause. This has nothing to do with Allah, but with a terrible taste and a certain solidity of the water.

I look closely and find it contains goat and camel hairs, an ample quantity of mud, and green vegetation of a sort the Tuareg use in making new water containers leak-proof. It would appear that the goatskin I bought at Bilma had too recently covered a goat.

#### Thirst Stifles Tuareg Song

We are four days into the Ténéré. Every day has been the same. The pitiless sun, the sand, the cloudless sky never change.

Monotony. "Swish, swish, swish." The platter-size camel feet make soft sounds in the sand. The cadence never varies.

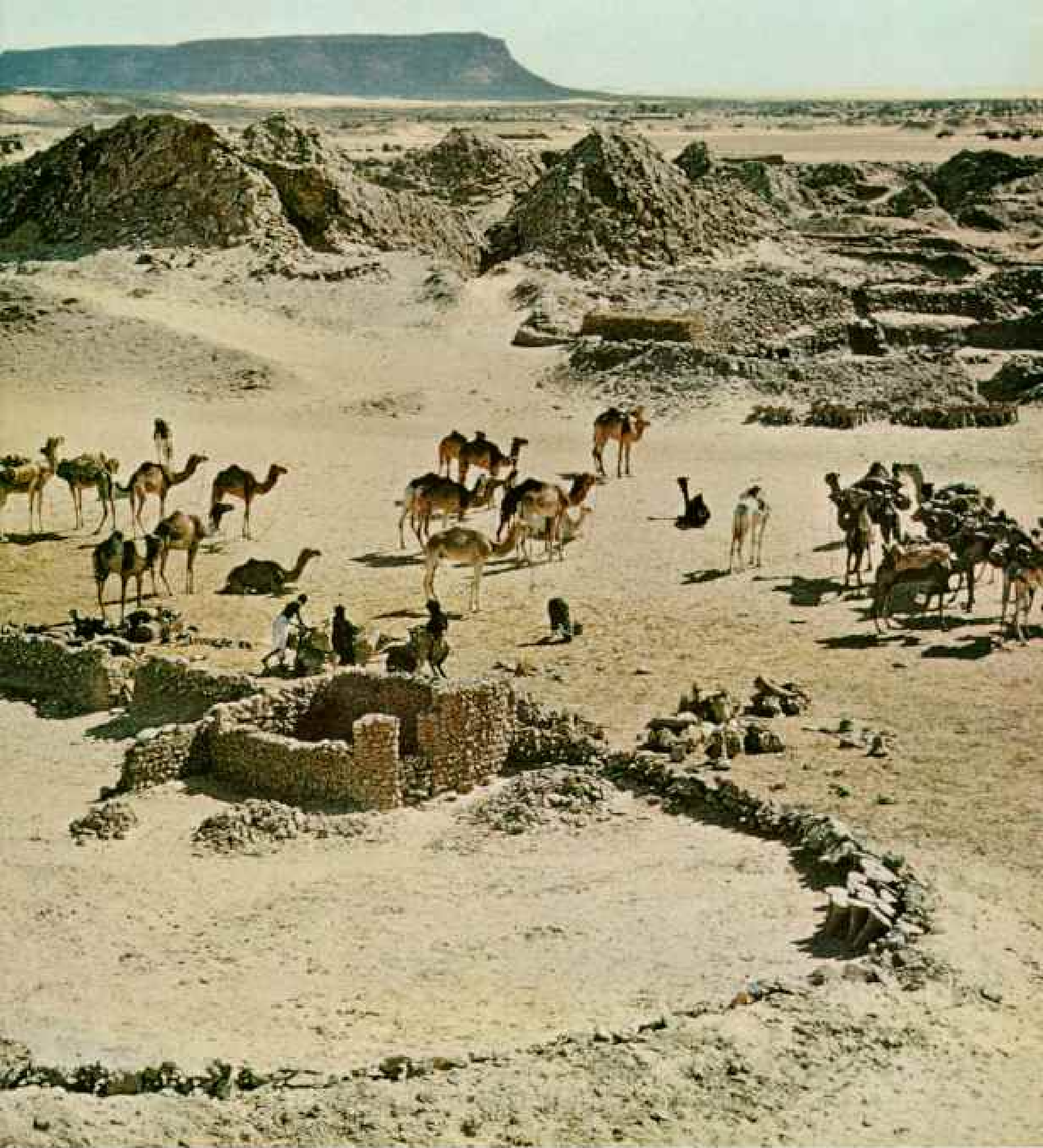
Tuareg often sing on the march—songs of love, ballads of battles. I imitate them, fumbling the words and doing great harm to the unfamiliar pentatonic music. My efforts amuse my friends, and I gain stature in their eyes.

But singing soon ceases, and conversation also, for using the voice makes thirst. As the water in the goatskins dwindles, Saïdu announces we must ration ourselves. At last he has aided Allah.

After the backbreaking unloading, after I have scooped my bed in the sand, I take one sip of water and wrap my blanket around me, ready for sleep. No matter now the taste of the water—I could have swallowed the goatskin. But I sleep as one dead.

*(Continued on page 707)*





PHOTOGRAPH BY © NATIONAL GEOGRAPHIC SOCIETY



Daring Niger's desert wastes, caravans gather beside the salt pits of Bilma. Jagged heaps of rubble from abandoned diggings rise between the camels and the palm-shaded oasis (background). Rough stone abodes, now in ruins, once sheltered salt workers. When late summer brings rainfall, Bilma's Kanuri tribesmen coax salt from the earth by flooding shallow pits. The laborers press the crusty residue into mushroom-shaped molds and let it dry rock-hard in the sun. Tuareg nomads come in the dry winter season to buy all the 40-pound cones their camels can carry, usually six per beast. They bundle the cargo in straw matting (left), balance the heavy loads on their animals, and head for markets in the cattle country far to the south.

At Bilma the author joined a party of 10 men and some 100 camels for a three-week, sun-baked trek to Agadès. No one man led; all shared the decisions and the work. The enterprise was successful; at southern markets each cone was bartered for the equivalent of at least \$1.50—ten times its cost.



**Sahara sandstorm!** Blasted by grit, travelers cower under blankets behind a fort of packs and mats. As the rare winter storm blew up, the Tuareg unloaded their animals and loosed them to fend for themselves.

**Camels drink first.** A nomad scoops a hole in a stream bed known to hide water. Riding one of these saddle camels, the author penetrated remote Tuareg camps on side trips into the Air Mountains and to Abalak well. Map traces the heat-blistered route of his journey with the salt caravan.

STOCKPHOTOS © W.A.L.





Tasseled tent shelters wives and children waiting for their menfolk who are away on caravan. With servants at their command, Tuareg women have time to make fancy leathercraft like the open-sided goatskin tent and bed cushion. Free and equal, they marry the men they choose and inherit property. Unlike most Moslem women, they wear no veils. Low bed of tamarisk wood collapses for travel.





ENTRANCE (LEFT) AND ENCAMPMENT © H. S. S.

Like phantoms from an age gone by, camels thread a corridor of dunes. Aircraft and trucks crisscross the Sahara, but here in the desert's heart the camel remains the indispensable carrier.



The fifth morning is different. Miracle of miracles, grass is nearby. A lost cloud has dropped some water here, and seed asleep since the last such miracle has burst into life.

Searching out the fragile shoots, our untethered camels have wandered far. It takes us the morning to find them, to pull down their heads by the tufts on their throats, to attach the lead ropes to their lower jaws.

They are tired, it is hot, and they object to being captured. They are more disagreeable than usual. I undergo three solid kicks and one exceptionally vigorous bite. I, too, am growing short of temper and punch the biting camel on its rubbery nose. He respects me for this, although surely he does not like me.

I know now we may expect water soon. Saïdu has pointed to a cliff in the distance, a mere blip upon the horizon.

"Fachi," he says. Fachi. A true oasis, the only one we will see between Bilma and Agadès. All other watering places are but wells or stagnant ponds. This goal in sight, I am in a tremendous hurry. The Tuareg, however, are not. Thirsty as we are, their custom permits no display of anxiety or fear.

At sundown the cliff of Fachi seems little nearer, although now we plainly see a notch leading to the oasis beyond. I know we will not reach Fachi for many hours. My friends have not tidied themselves as they would do if they were to encounter strangers by the light of day.

I have traveled in the Hoggar Mountains of Algeria with Tuareg nobles. Always, without a word spoken, I knew when we were nearing an encampment. My companions would put on their best veils, strap on their

Trail-worn toe, toughened by burning sands, serves as a peg for ropemaking. Cameleer twists strands of palm frond.





swords if they had them, pull their best *gandurah*—the long robe of the desert—down over their heads.

No, they would not wash, or comb their hair, or take off the several filthy robes they already wore. It is a Tuareg point of honor only to *look* well when meeting others, not to scrub the skin.

At 9 p.m. we pass through the notch in the cliff and slowly descend a long slope. At midnight, by the light of a crescent moon, we see palm trees.

The thump of wooden pestles grinding millet in wooden mortars comes down the wind. I listen for dogs. To me it is a matter of

importance. Me only the vicious, gaunt *salukis* would attack; they know somehow I am different. Happily there are no dogs.

A Kanuri with a goatskin of water and a wooden bowl greets us as we pad softly in from the desert. The people of the oases know how the Tuareg stretch Allah's mercy.

I wait until several others have drunk their fill, then I all but empty the goatskin. If this goatskin also is new, I gulp the water too quickly to find out.

We stay two days in Fachi while we rest the camels and ourselves, make new ropes, and repair our clothes (page 700). Other caravans are here. We visit with them and plan to



KODACHROME © N.A.S.

Carrying all she owns, a Tuareg woman, her children, and servants seek fresh pasture for their livestock. Each month her camp of nine families moves a few miles, always within its tribal area near Abalak well. Her husband may have to search for his new home when he returns from a long caravan journey. Here in southern Niger, Tuareg women and children wear as little clothing as their Negro neighbors.

Author Victor Englebert controls a saddle camel with his foot and a single rope. Long a student of Africa, the Belgian writer-photographer learned the language and customs of the Tuareg and lived among them as a Blue Man.

move together when we go on. I find myself wishing the caravaneers had their families with them. I like the Tuareg encampments, changed every month as the nomads move in search of new pasture.

I like the children, although at first they fear me and run away. I am struck by the beauty and grace of the women, open and friendly and not oppressed by their husbands as Arab wives seem to be.

I like the Tuareg eagerness to learn of my strange customs, and their willingness to explain their own ways—all in an atmosphere of open-mindedness and good humor.

#### More Camels, More Ticks

"We have heard that in your country," once said a man whose tea I was sharing, "men descend to pressing their lips against those of their wives. Is this true?"

"Is it true," I retorted, "that Tuareg men descend to exchanging sniffs of the noses with their wives?" We stared at each other a moment, and then burst into laughter.

The day we leave Fachi we count at least 200 camels. I cannot say the increase improves matters for us. There are more animals to look after. More camels mean more camel ticks.

The ticks leave the camels and come to me at night, crawling and biting. I do not get much sleep,





but neither do the Tuareg. Not because of the ticks—they are used to them—but because now there are more people with whom to talk when all should be resting.

In the end, only a day behind schedule, we come to the Tree of Ténéré. It is a tree like an umbrella, absolutely the only one in this part of the desert (below).

And yet we almost miss it in the dark, which would have caused us much discomfort, for we are again out of water. We almost miss it because we lag behind the others, who are spread out in a wide front so that someone is sure to see the Tree.

We lag because Saïdu's principal camel has become impossible. It keeps kneeling and refusing to arise without drastic urging.

We almost go by the Tree, but someone fortunately lights a campfire and we guide upon it.

As we leave for Tazolé, I do not for once mind that the Tuareg fill only half the goat-skins. The next water lies but three days' march, Saïdu tells me. The dread Ténéré is behind, and all will be easy.

One of our camels breaks its leg in the in-

creasingly rough ground of the foothills of the Air Mountains, and we are forced to destroy it. Our mourning is not wholehearted. It is that accursed principal camel of Saïdu's.

Other delays follow. First we find good grass in a wadi, a dry stream, and give the camels a full day to eat it. Two stray so far it takes us most of next day to find them.

#### Camels Halted by Desert Storm

By now, naturally, we are out of water. Saïdu knows of a place in the wadi bed where one may dig and find a little water; we lose the rest of the day in going to it. We find enough water to keep us one more day.

The wind increases. The very desert rises and moves. Nothing living can find its way in the unseasonable winter sandstorm; nothing can face it without pain from flying grit.

We unload and free the camels, then take shelter behind packs and straw mats. Wrapped head to foot in our blankets (pages 704-5), we remain the entire day, scarcely moving. Next morning the wind has dropped; we catch our camels and go on.

I am so thirsty I can scarcely talk.



"Shall we reach Tazolé?" I ask Saïdu, hoping my inquiry sounds like a jest.

"If Allah so wills," he says in all seriousness.

A camel sidesteps something in its path. We look down, and there lies a goatskin taut with water, dropped by someone who has gone before.

"Thanks be to Allah," says Saïdu, passing the goatskin first to me.

Agadès lies a five-day walk from Tazolé, an easy five days with grass and water in abundance. Yet it takes us a week.

Each day the Tuareg load the camels and tie the pack knots with unusual deliberation. When at last they move out, the cadence of march is slower than ever.

"Swish . . . swish . . . swish," it says. Not "swish, swish, swish."

A suspicion crosses my mind. This is the month of Ramadan, the Moslem fast when the faithful must refrain from food, drink, and love during daylight hours.

The caravaner, however, enjoys a dispensation from fasting. So why not pass as much of Ramadan as possible on caravan? A man thus may at least eat and—hopefully—drink.

But eventually we come to the place and time of our parting, as humans are destined always to do. I am going to Agadès for a rest before visiting the Tuareg in other areas.

#### Caravaneers' Life an Endless Circle

We halt near Agadès. I have my small baggage on one camel. Four Kanuri who journeyed with us from Fachi have business in Agadès and will accompany me there.

My friends in the caravan will skirt the town and go to Assaouas, where they will stay two weeks with their families. Then they head south for the markets of Maradi and perhaps Kano. There they barter their salt for millet, sugar, tea, and cotton cloth, then turn once more to the weeks-distant salt pits of Bilma. The life of the Tuareg caravaner is a great circle in the sand.

I look at Saïdu. His eyes through the slit in his veil are warm with friendship.

"*Bellafia*," he says. "Farewell."

He starts away, but turns back.

"You are good with camels," he says, "but your tagilmust is much too short."

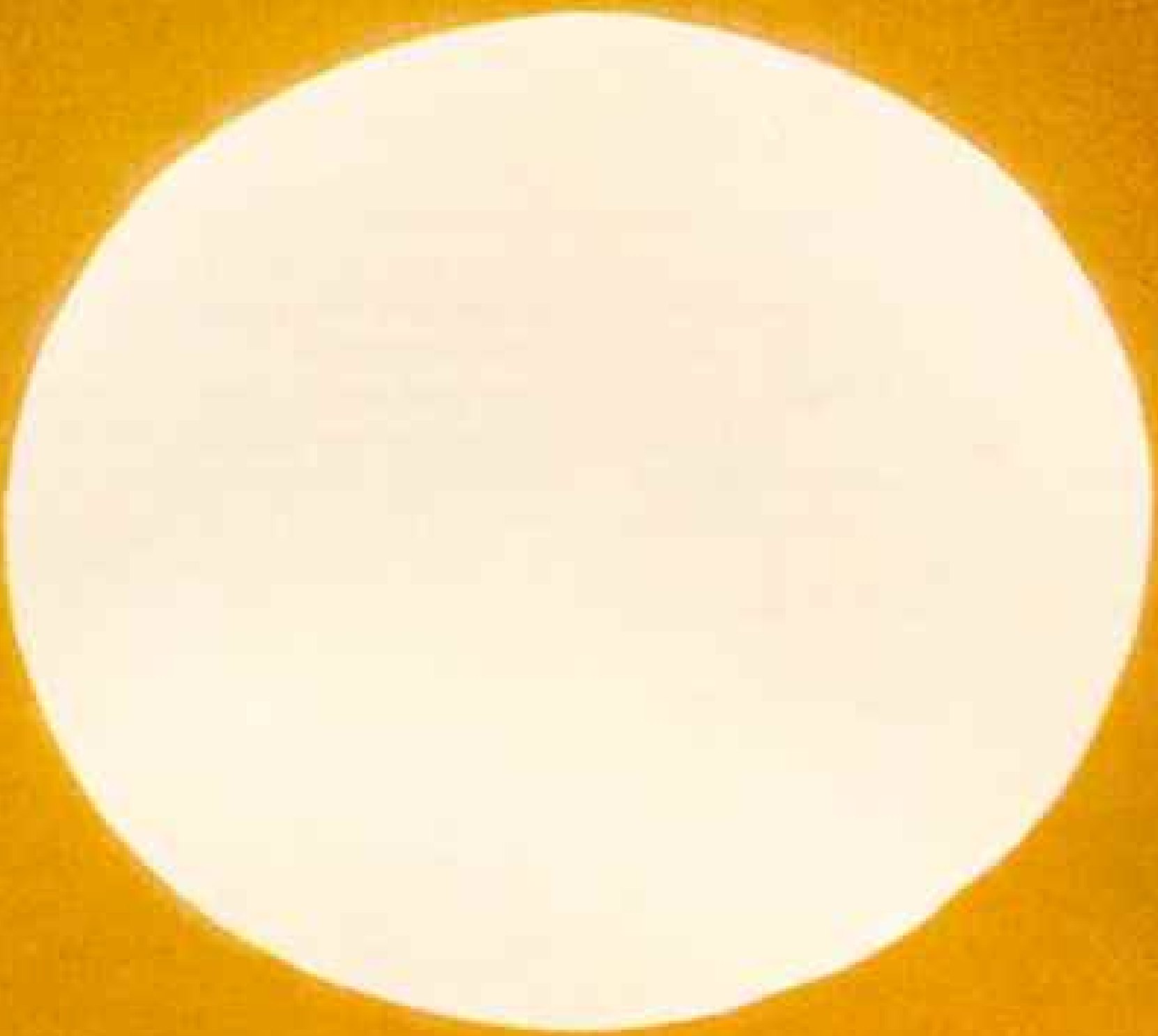
THE END

*WILDERNESS turns into paradise for one brief moment as sunrise silhouettes men and camels at the Tree of Ténéré. The scrawny acacia, only tree for a hundred miles, has become so important a landmark that it appears on maps. It guides caravaners to a well.*

EXTRACTS BY LUCY SARGENT © W.A.S.

711





*Life-sustaining power and  
violent electromagnetic storms  
flood to earth from our star.*

# THE SUN

By HERBERT FRIEDMAN

Chief Scientist, E. O. Hulburt Center for Space Research  
U. S. Naval Research Laboratory

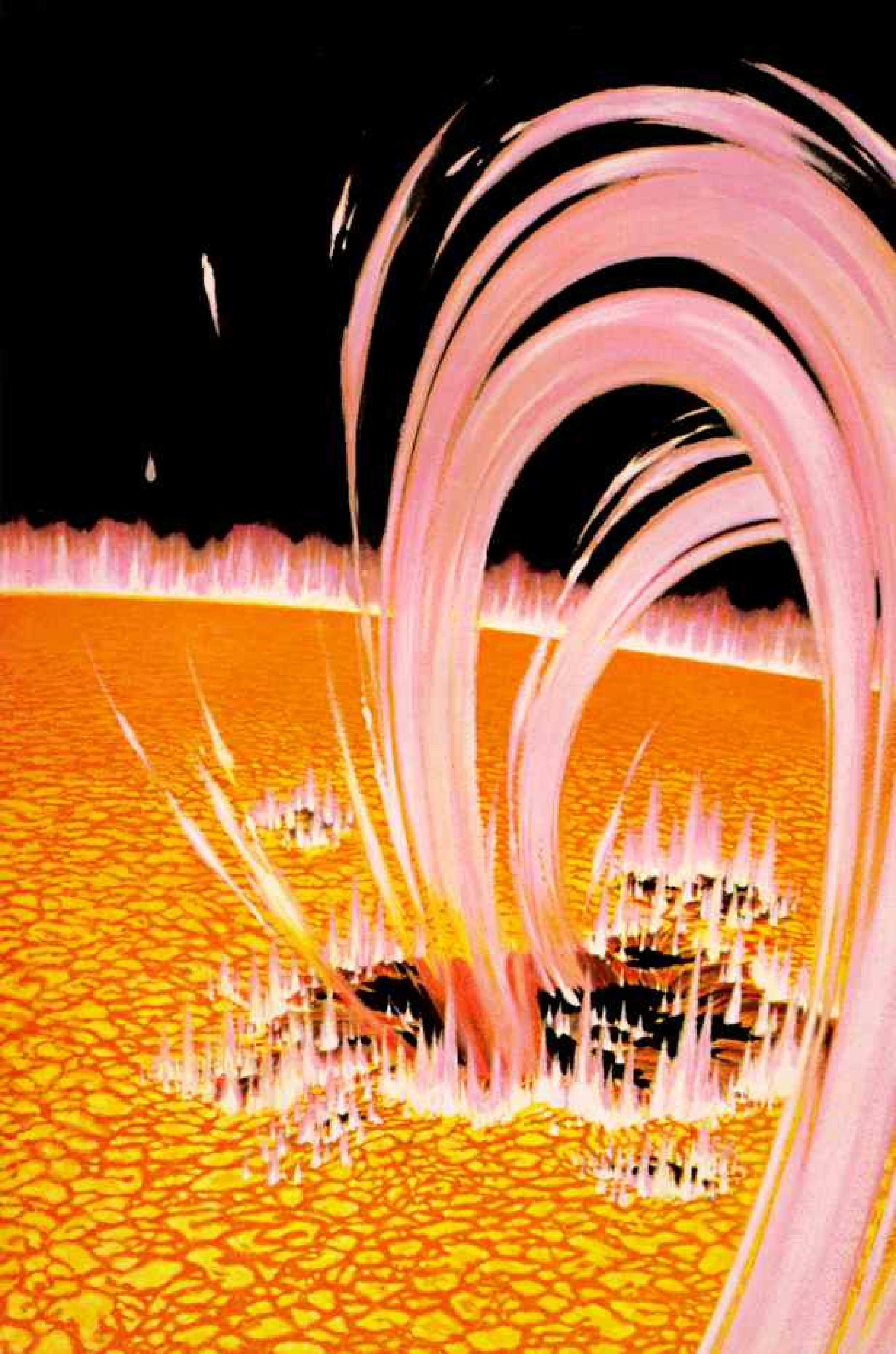
*Thou sun, of this great world both  
eye and soul—* JOHN MILTON

**E**IGHT MINUTES AGO, daylight now entering your window escaped the surface of the sun, but its energy was created deep within the solar furnace before the birth of civilization. Each second, four million tons of solar hydrogen transforms itself to radiant energy which eventually floods into space. Yet the sun is so huge that it can continue to consume itself at this rate for billions of years to come, as it has for five billion years past. Thus our star shines steadily over eons of time, to light the moon and planets and sustain all life on earth.

But the peaceful sun can erupt at times with a tremendous burst of energy. Then streams of invisible radiation and immense clouds of solar gas strike the high atmosphere above us. Shielded by a protective blanket of air, our senses receive no inkling of the storm above, but its power shows in a host of mysterious and awe-inspiring events.

Throughout history these effects went almost unnoticed by man, except for the spectacle of the

*INCANDESCENT ORB in a golden sky, the sun  
spreads the dawn of a new day over haze-softened  
mountains in Arizona. Thus, as it has done  
since the beginning of time, earth's star renews  
its gift of warmth and light—and of life itself.*





northern lights. But with the invention of telegraphy and radio, the electrical and magnetic disturbances became a matter of practical concern.

Today, scientists also worry about the hazard to man in space if he should be exposed to a blast of solar storm particles. Because of their enormous energy, they can damage and even destroy human cells.

Just such a solar outburst took place five years ago. At 2:37 p.m. on November 12, 1960, astronomers in Michigan detected a brilliant explosion on the face of the sun. Six hours later, a gigantic cloud of solar hydrogen gas, 10 million miles across and still trailing halfway back to the sun, 93,000,000 miles away, collided with earth at a speed of about 4,000 miles a second.

Though inaudible and invisible, the collision dissipated more energy in the earth's high atmosphere than the most destructive hurricane, covering every square mile of the globe. It started a violent chain of disturbances on earth, an electrical and magnetic storm of mammoth proportions.

Compass needles wavered erratically, and for hours all long-distance radio communications were blacked out. Teletypes printed gibberish. Airplane pilots lost contact with their control stations, and the Coast Guard could not reach its weather ships in the North Atlantic.

Overhead, sheets of flaming red northern lights flashed in the night sky, bright enough to be seen through overcast and clouds. In northern areas, electric lights flickered in farmhouses as if a thunderstorm raged, yet the air and sky were clear and silent.

For more than a week, such chaotic conditions continued. They were clearly the results of a sun on the rampage. But if this picture of the violent sun seems impressive to you, let me assure you that such a storm

amounts to no more than a tiny ripple in the usual steady flow of solar energy.

All too often we take the sun for granted, forgetting how totally we depend on its benign flood of heat and light. It is the sun whose radiation moves the atmosphere and makes weather and climate; causes ocean water to evaporate and then fall as rain; gives us most of our useful energy through coal, oil, and wind and water power; and produces our food through sunshine absorbed by plants.

#### City's Sunlight Could Warm Mankind

The sun's power staggers the imagination: In one second, this star of ours (the sun is, after all, just one of an estimated hundred billion stars in the Milky Way) radiates more energy than man has used since the beginning of civilization. The sun delivers to us in just three days as much heat and light as would be produced by burning the earth's entire oil and coal reserves and all the wood of its forests. Yet earth receives only about one two-billionth of the sun's radiant energy.

Engineers have developed solar cells that produce electric current when sunlight hits them. Such cells power electronic gear on spacecraft, such as TIROS and Mariner IV. Solar devices catch the sun's rays to heat homes, swimming pools (page 720), and ultrahigh-temperature furnaces (page 740), and a portable solar stove is being developed for use in fuel-poor countries.

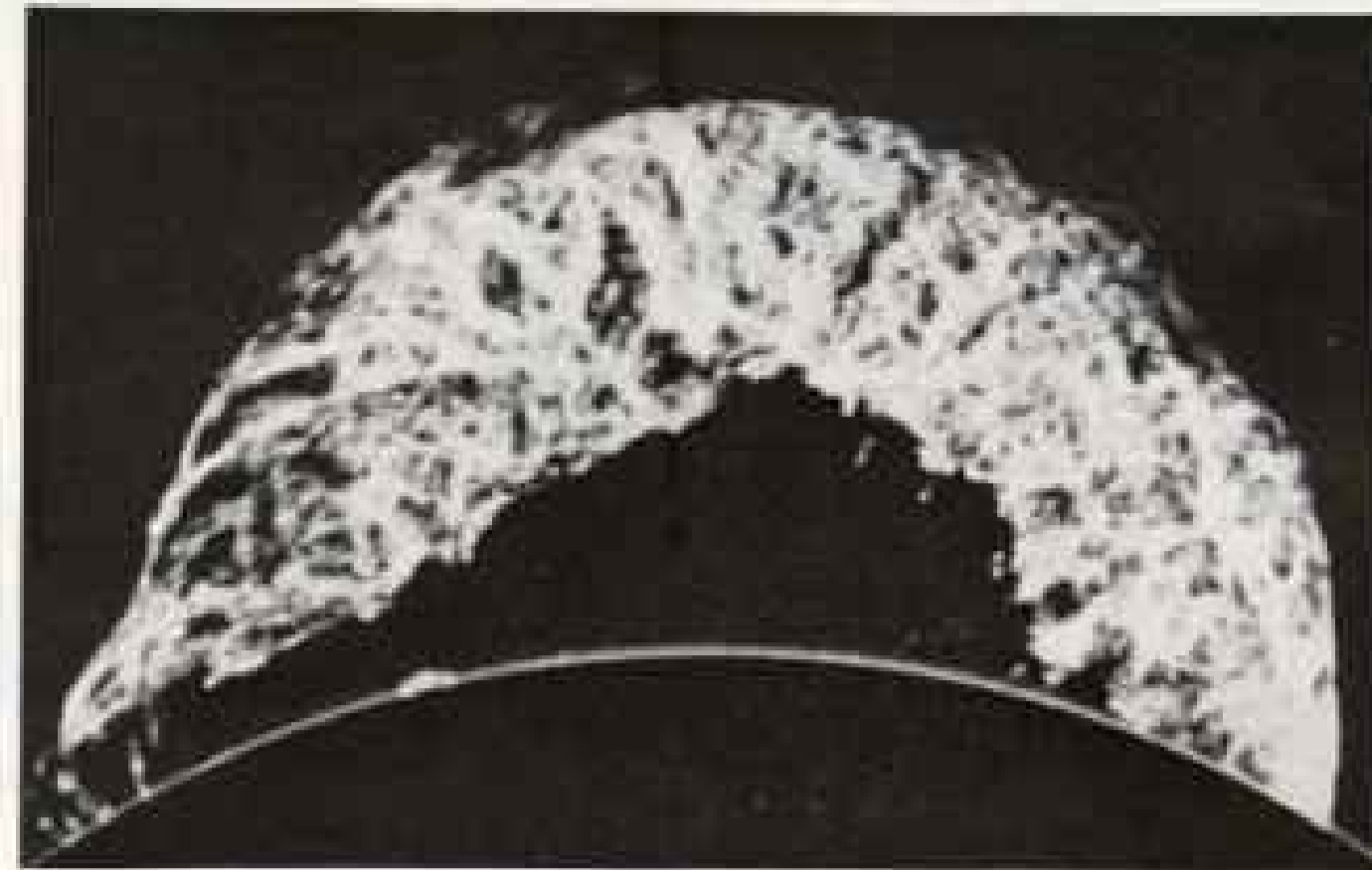
If in such a manner we could collect and efficiently use the sunlight falling on just the city of Los Angeles, it would supply more energy than is consumed in all the homes on earth. The sun produces this life-supporting energy so steadily that astronomers cannot detect with certainty as much as one percent variation in the total output.

What makes the sun shine so steadily?

## Monstrous streamers vault from the sun's face



FROM AFAR, man sees his star as a ball of flame. Close up, the sun, although entirely gaseous, resembles a caldron of seething lava, pock-marked by dark sunspots, fringed by fountainlike jets called spicules, and arched by streaming prominences. In this remarkable painting by Davis Meltzer, the details of which faithfully reflect the latest scientific thinking, the mottled surface consists of innumerable granules averaging hundreds of miles across, created by rising and falling currents of hot gases. The opaque surface is the base of the photosphere, the transparent but highly luminous shell that we see from earth. The larger prominence leaps perhaps 50,000 miles high. At the horizon in the painting, the sun's curve measures 170,000 miles; earth, shown here in scale, is 8,000 miles in diameter.



HIGH ALTITUDE OBSERVATORY, BOULDER, COLORADO



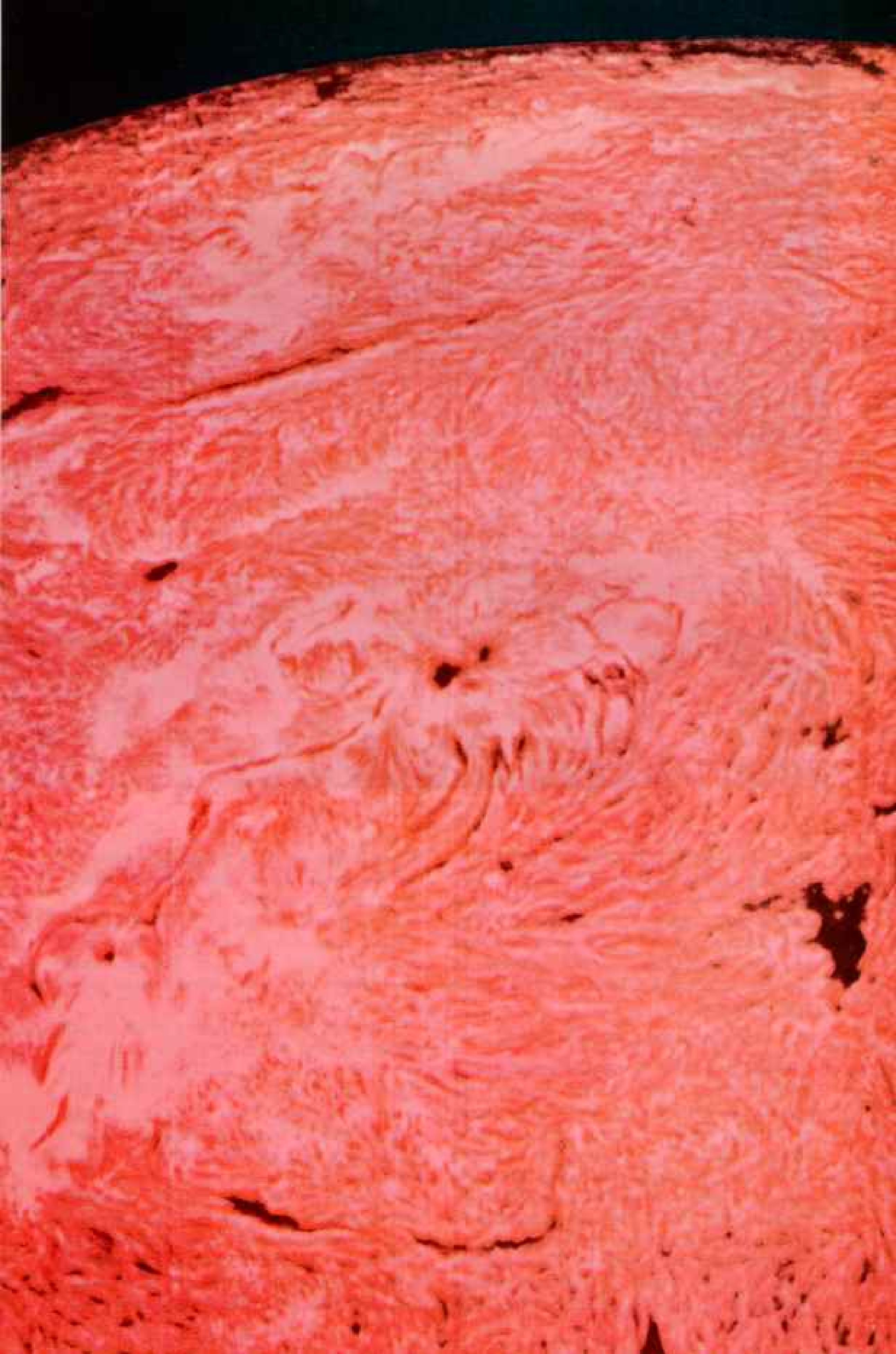
SACRAMENTO PEAK OBSERVATORY, SENECA, NEW MEXICO



HIGH ALTITUDE OBSERVATORY, BOULDER, COLORADO (ARROWS); MOUNT WILSON AND PALOMAR OBSERVATORIES © N.G.S.

Glowing in the red light of hydrogen in a spectroheliogram (right), the sun's tortured surface reveals prominences as twisting filaments radiating from the vicinity of sunspots.

Silhouetted by eclipse or coronagraph, prominences stage massive fireworks displays on the sun's edge, as seen in the photographs above. A 1946 eruption (top), largest on record, hurls a billion tons of gas a million miles. An 85,000-mile-high prominence (center) reveals a powerful magnetic field by its tight loop. Solar flare (lower) throws out a cloud of gas larger than the earth. When it smashed into our atmosphere in November, 1960, it disrupted radios and compasses and triggered brilliant auroral flashes.







Primitive man thought of the sun as a ball of fire, but scientists determined long ago that the sun was not merely burning like a great ball of coal. Indeed, if it were merely coal it would have burned for only a few thousand years, and would have turned to cold cinders billions of years ago. Some other explanation was required.

#### Stars Blaze With Nuclear Energy

Finally, in 1925, Sir Arthur Eddington, a brilliant British astronomer, proposed the answer now accepted as correct: It is atomic, or nuclear, energy that fires the stars. This energy—the same as that of the hydrogen bomb—comes from the process we call nuclear fusion, in which the nuclei, or cores, of hydrogen atoms collide, uniting to form helium nuclei and giving off bursts of energy.

No other process we know of could possibly pour out such sustained quantities of energy. Moreover, we know that for the sun to stabi-

lize at its present size, it must have a temperature and pressure at its core sufficient to support nuclear reactions.

Thus, deep within the sun, each second, 564 million tons of hydrogen are converted to 560 million tons of helium. The remaining four million tons each second radiate away as heat and light.

If the sun has been shining at its present brightness since the earth was formed nearly five billion years ago, each pound of solar matter must have yielded already at least 4,000,000 kilowatt-hours of energy. At that rate, a pound of the sun would keep a kitchen stove going with all burners on for several hundred years.

Fantastic as the sun's outflow of energy must appear, the nuclear fusion actually goes on at a slow pace, atomically speaking. The sun may be considered as a very slow-burning hydrogen bomb, since it takes, on the average, about a million years for two hydrogen nuclei



RESEARCHER BY DEAN LUNNEY (SCULPTURE) AND ANDREW BRIDGES © R. G. I.

to collide and fuse. These tiny particles, even in the sun's dense interior, are on the average almost as far apart, in proportion to their size, as the earth and Venus. Moreover, they require a head-on crash at extraordinarily high speeds in order to fuse.

#### Human Bodies "Hotter" Than the Sun

Only because the sun is so large is its total production of energy so enormous. *Pound for pound*, the sun actually produces less heat than the human body. If the mass of the sun could be matched with live bodies and if the normal human metabolism of those bodies could continue, they would generate more heat than the sun now radiates.

How do we know this? It's a simple matter of arithmetic: The sun's output of radiant energy, divided by the sun's mass, shows a daily production of two calories a pound. By contrast, the average human body generates something like 10 calories a pound each day.



Author Herbert Friedman adjusts the sun-seeking "eye" of a solar camera in the nose of an Aerobee rocket. At the Naval Research Laboratory in Washington, D. C., where he is Superintendent of the Atmosphere and Astrophysics Division, Dr. Friedman directs the Nation's largest solar rocket-astronomy program. His distinguished contributions to knowledge of the sun have earned numerous awards and citations.

**Cool air, warm swim:** Piping water through heat-absorbing solar panels on the roof, engineer John I. Yellott (left) raises water temperature some 10° for his pool in Phoenix, Arizona.

Mankind is now embarked on a great new adventure—the exploration of space. More than half the scientific satellites launched by agencies of the United States Government are, in one way or another, devoted to the study of the sun's activity and its close relationship to earth's environment.

My own agency, the Office of Naval Research, is deeply involved in studying the sun; we maintain a series of satellites called SOLRAD in orbit at all times for solar radiation measurements.

Until very recently, man's view of the heavens was seriously hampered by a murky, shimmering atmosphere, which distorts light beams and blots out the sun's atmospheric X-rays and much of its ultraviolet and infrared radiation. Henry Norris Russell, the noted Princeton astronomer, once jested, "All good astronomers go to the moon when they die so that they may observe the universe without the interference of a dirty atmosphere."

But beginning in 1946, rockets became available to carry small telescopes and spectrographs above the atmosphere, and for a few minutes of each rocket's flight the ultraviolet and X-ray emissions of the sun can be studied. Within recent years balloons have lifted heavy telescopes and cameras above 99 percent of the atmosphere, to an area where the distortion of visible light is largely eliminated (pages 730-31).

And now satellites, such as the Orbiting Solar Observatories of the National Aeronautics and Space Administration, provide stable platforms that can point 80 pounds of instruments steadily at the sun, with fine accuracy. Dozens of solar ultraviolet and X-ray pictures can be transmitted to earth daily.

### Wartime Puzzle Leads to a New Technique

Radio astronomy, which is only about a third of a century old, provides another effective tool for studying the higher levels of the solar atmosphere. During World War II, British radar engineers were puzzled when their instruments tracked intense static signals descending into the western ocean, instead of Nazi bombers coming from the east. They found that such ghost signals rose and fell with the rising and setting of the sun, which was sending out its own radio messages.

The sun's radio emanations constantly flicker and pulsate, with frequent violent outbursts. Astronomers tune in on these broadcasts with sensitive antennas. Using huge radar transmitters, they can bounce beams off the swollen outer atmosphere of the sun and probe its structure and movements.

Last year and this, 1964 and 1965, have been designated the International Quiet Sun Years (IQSY). Observers in 43 countries have been keeping a diary of the face of the sun at a time when it is relatively undisturbed by sunspots and solar storms.

The IQSY is sequel to the International Geophysical Year (1957-1958), when scientists studied the sun and earth under conditions of maximum solar activity.\* Changes since 1958 have been substantial, since solar activity goes from active to quiet to active again in an average cycle of about 11 years.

In these coordinated international surveys, solar telescopes take regular pictures of the sun through various filters; mountaintop observatories watch the sun's outer atmosphere through coronagraphs; magnetographs make magnetic maps of the sun's face (page 729); radio telescopes capture the sun's radio signals as wavy

\*See "The International Geophysical Year," by Hugh L. Dryden, NATIONAL GEOGRAPHIC, February, 1956.

## The sun takes center stage

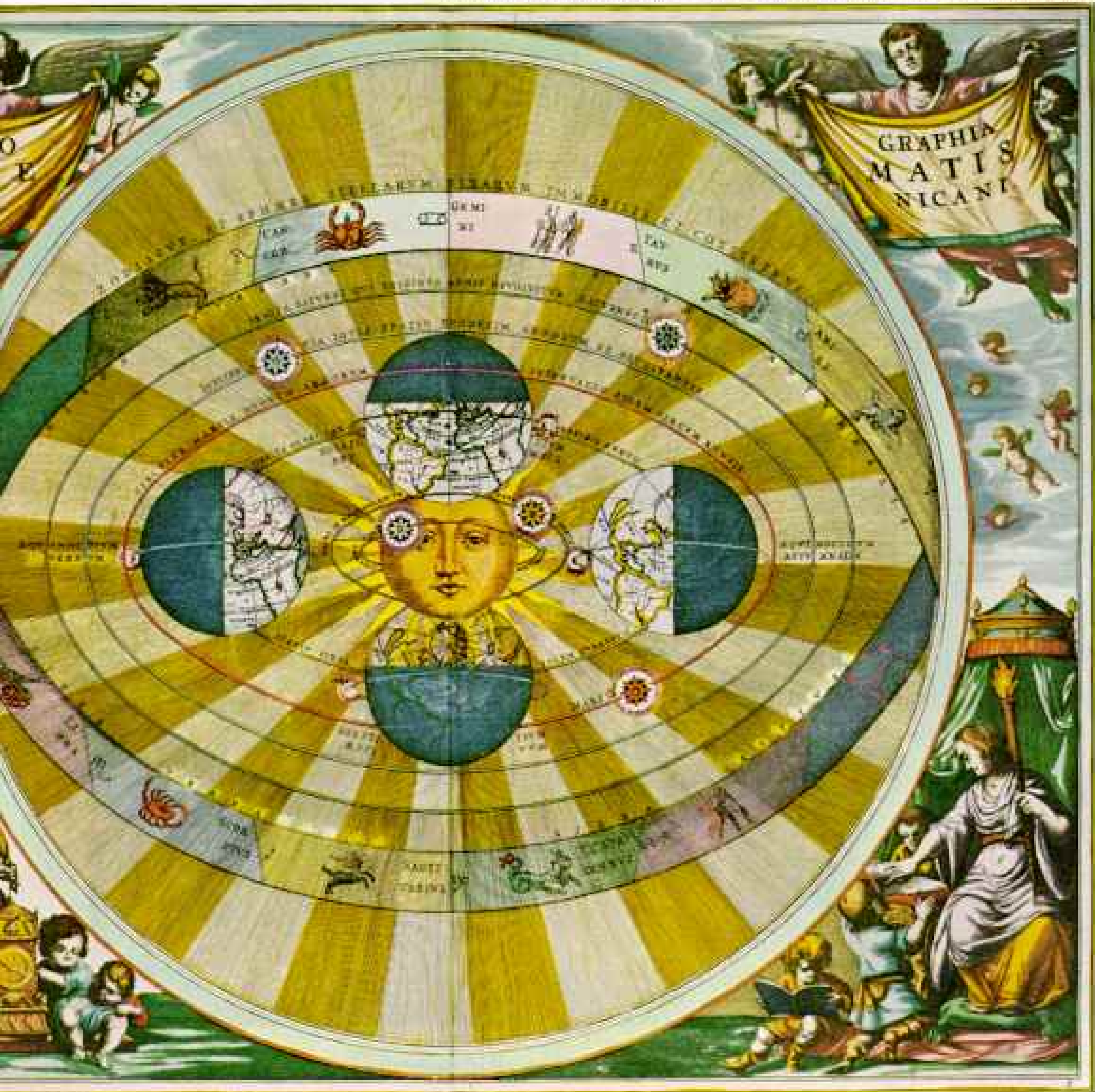
EACH EVENING when the sun sank into the scorching desert, the Egyptian of 3,000 years ago knew where it went: The sky goddess Nut, her star-spangled body arched over the earth in personification of the celestial vault (as shown in the funerary papyrus below), had swallowed the setting orb. During the night it journeyed through her body; each morning she gave birth to the sun anew.

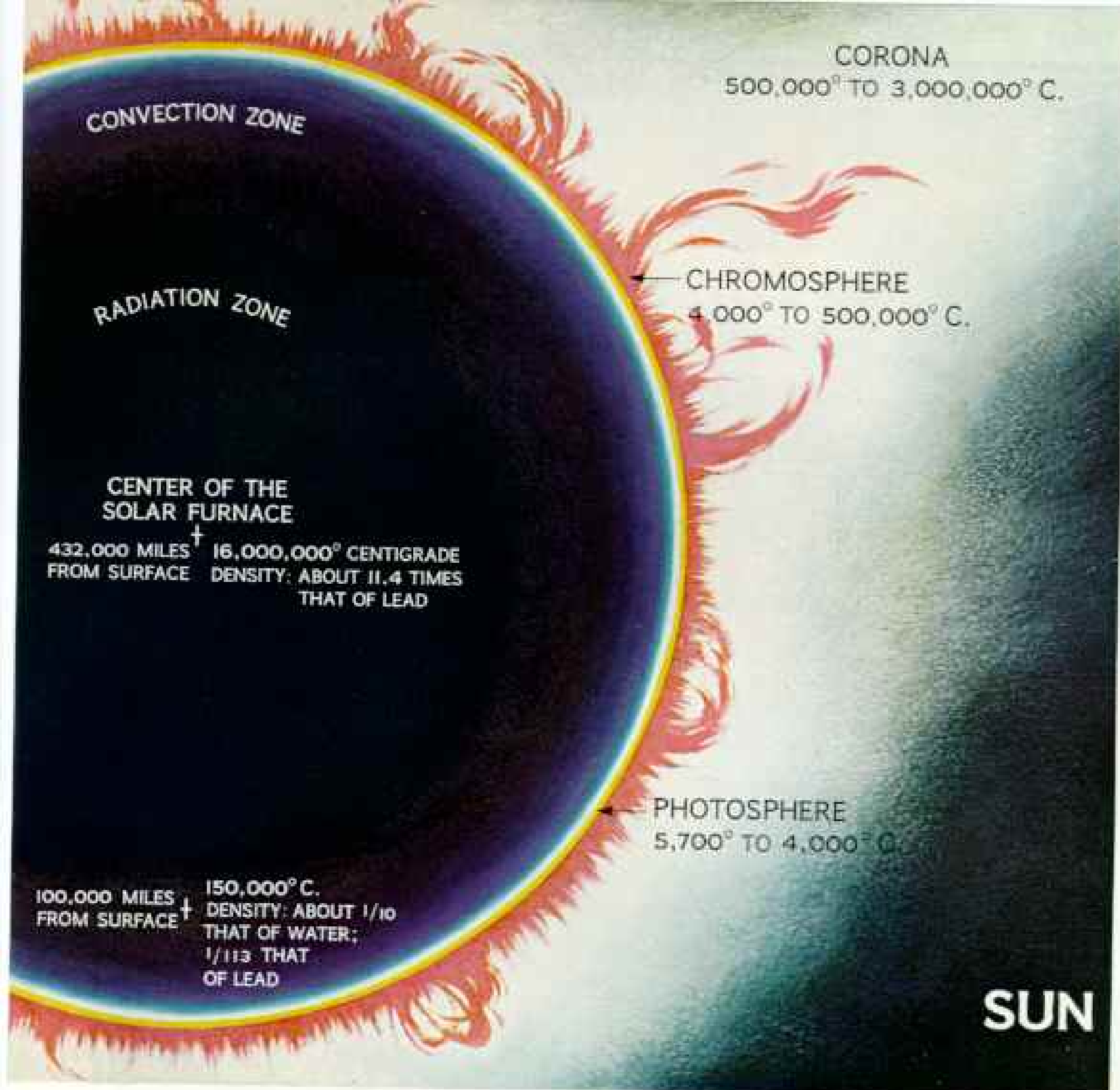
In such fashion did ancient man see earth at the center of his universe, dominating the sun.

Finally, in the 16th century, the Polish scientist Nicolaus Copernicus liberated astronomy—and outraged public sensibilities—with his thesis of a sun-centered system.

"As if seated upon a royal throne, the Sun rules the family of the planets as they circle round him," wrote Copernicus. That is how Andreas Cellarius, the Dutch geographer, depicted the Copernican system (right), in 1660, with the six then-known planets orbiting the sun. Four representations of earth advanced a slowly dawning concept: As daylight bathes half a planet, the other side sleeps in the night.







"Black-hot" gases of the sun's thermonuclear core yield powerful but invisible radiations.

lines and numbers on paper tapes; and satellites, rockets, and balloons monitor the solar winds and storms and the sun's output of high-energy radiations such as X-rays.

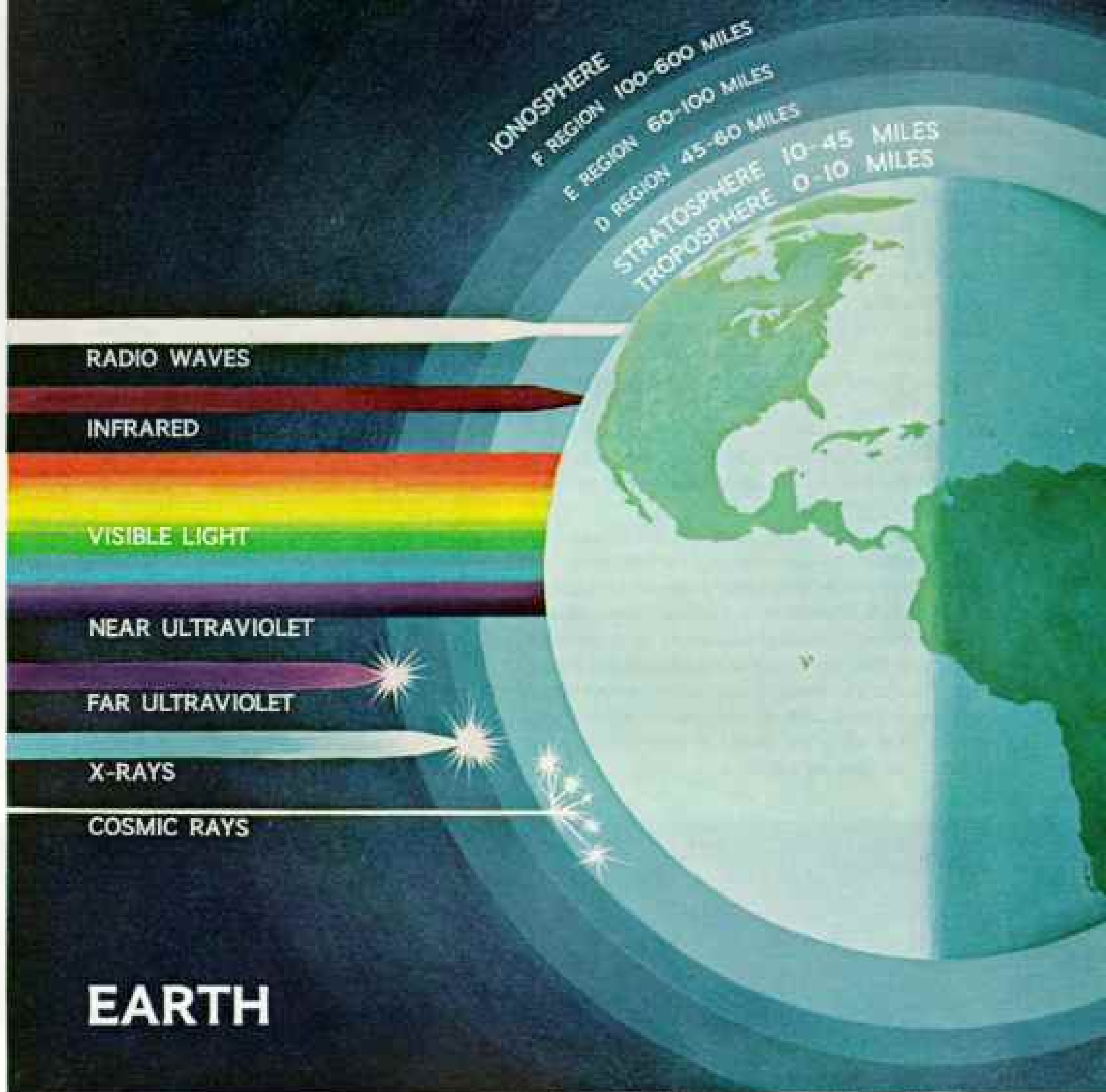
At the U. S. Naval Research Laboratory's E. O. Hulburt Center for Space Research in Washington, D. C., we are especially interested in rocket and satellite observation of X-rays, which can't be detected from the ground. They tell us much about the most energetic processes on the sun. In two decades at the laboratory, I suppose I have instrumented more than 50 rockets and a dozen satellites for this kind of research.

When astronomers examine the sun with a solar telescope (pages 734-5), its edge appears sharp, as if it marked a definite surface. This apparent surface is in fact a transparent, though highly luminous, layer of gas

about 200 miles thick, called the photosphere (above). From the photosphere comes most of the light we get from the sun. At the bottom of the photosphere, the gas becomes so opaque that no light from the interior can escape through it directly.

Thus the photosphere is a thin, bright shell that surrounds the main body of the sun like an onion skin. Outside this layer lie two others—a region of flamelike outbursts of gas called the chromosphere, and an almost endless outer atmosphere called the corona.

As we look at the sun from earth, we can "see" only these three layers directly—through visible light, infrared, and radio, observed by ground observatories, and through ultraviolet and X-rays detected by instruments in rockets and satellites. All that we know of the sun's hidden interior must, therefore, be deduced



Earth's atmospheric shield admits light and heat but blocks the sun's deadliest rays.

from observation of these external features.

The ancients held many strange notions about the flaming ball that courses daily across the sky. Epicurus, the Greek philosopher, estimated about 300 B.C. that the sun "is just as great as it appears"—that is, about two feet in diameter. To Anaxagoras, another Greek philosopher, the sun was "a mass of red-hot metal" larger than the Peloponnesus. Even some Eskimos, until recently, believed that after the sun set in the western ocean, "he" was paddled back in a kayak through the night, to the eastern horizon.

Modern astronomers can gauge the size and distance of the sun very accurately, using triangulation with other celestial objects. Its diameter of 864,000 miles compares with earth's 8,000. The sun's distance from earth averages 93,000,000 miles, a length scientists

Contrary to the usual conception, the sun's interior must be shown as dark despite its fantastic heat (opposite). Invisible radiations produced at the core, chiefly X-rays, do not convert to visible light until they approach the surface.

Here the sun's brilliant surface layer, the photosphere, shows yellow; the "flaming" chromosphere, red; the extremely rarefied outer corona, or atmosphere, pearly white.

From 93,000,000 miles away, the sun showers earth with cosmic rays and electromagnetic radiations (above). Fortunately for man, our atmosphere blocks the most dangerous high-energy rays, but lets through light and part of the heat (infrared). Near (low frequency) ultraviolet rays, which cause sunburn, filter through. So do shorter radio waves, but long radio waves bounce back off earth's electrified ionosphere.

## Newton unlocks the rainbow

“I PROCURED ME a Triangular glass-Prisme . . .” related Isaac Newton, “and made a small hole in my window-shuts, to let in . . . the Sun’s light.” The 23-year-old English genius, at Cambridge University in 1666, thus launched the famous experiments that split sunlight into its spectrum of colors and, in time, gave astronomers one of their most valuable instruments, the spectroscope.

Having taken the rainbow out of sunlight and displayed it on the wall, Newton (left) and his roommate, John Wickins, turn it back to white light with a convex lens. The light beam’s passage would ordinarily be invisible unless the air were full of dust or smoke.

Newton’s experiments with the spectrum gave man the key to the universe. A century and a half later, Joseph von Fraunhofer, a Bavarian optician, observed dark crosslines in the spectrum (below). Each chemical element produces its own combination of lines that can serve as an identifying fingerprint. Analyzing these lines, astronomers assay stars many thousands of trillions of miles away, learning that they are made of exactly the same elements we find on earth.



Hydrogen alpha

Sodium

use as the Astronomical Unit for measuring the solar system. Since earth’s orbit is slightly elliptical, the actual distance varies from 91 to 94 million miles.

When we compare earth’s size with that of the sun, we find that the sun would hold some 1,300,000 earths, and that it contains nearly 330,000 times as much mass as the earth. Since gravitational pull depends directly on the mass, but decreases with the square of the distance from the center of the body, a man on the sun would weigh some two tons.

### “Intellectual Boring” Bares Sun’s Secrets

Having determined the sun’s mass and diameter, the astrophysicist can then deduce the temperature, density, and pressure at all distances from the center to the surface, even though he is unable to see deeper than the 200 miles of the luminous photosphere. Sir Arthur Eddington described this deductive process as “intellectual boring.”

As a result of this boring, we have good

reason to believe that at the center of the sun, close to half a million miles deep, pressure reaches 100 billion atmospheres. (An “atmosphere” is 14.7 pounds per square inch, the weight of the column of air over a square inch of earth’s surface at sea level.)

To produce such great pressure, we know that gas must be heated to a temperature of about 16,000,000° C.\*

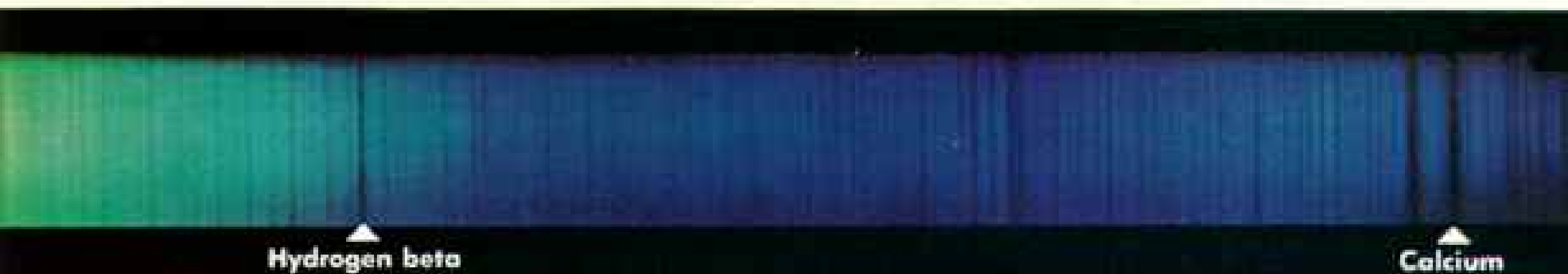
How hot is 16 million degrees? Sir James Jeans, in *The Universe Around Us*, calculates that a pinhead of material at the temperature of the sun’s core would emit enough heat to kill a man a hundred miles away.

Although the density at the center of the sun must be about 11.4 times that of solid lead, the sun remains gaseous everywhere. That is, the atoms are free to move about, unlike those in a solid, which are fixed in a regular pattern. However, the atoms in the core are not normal. Most of their outer electrons

\*Astronomers, like other scientists, use centigrade. To convert to Fahrenheit, multiply by 9/5 and add 32.



PRODUCED BY NATIONAL GEOGRAPHIC SOCIETY, ROBERT C. MARIE, STAFF ARTIST; SPECTRUM (BELOW) BY GEORGETOWN UNIVERSITY OBSERVATORY © N.G.S.



Hydrogen beta

Calcium

have been sloughed off by collisions of atoms, and rush about as free particles.

Normal atoms cannot get closer than about a hundred-millionth of an inch because their outer electrons would touch. Electrons, which are negatively charged, repel one another. Thus they keep atoms widely spaced—widely, that is, in atomic terms. But when electrons are stripped away, the remaining nuclei can approach very much closer. That is why the sun's inner core can be so extremely dense. The bare nuclei are more tightly squeezed.

#### X-rays Turn to Visible Light

If we could go into the sun's interior to make measurements, we would find that roughly 90 percent of the energy that eventually floods out into space is produced within a central core which reaches only one-quarter of the distance to the surface.

In this nuclear furnace the fantastically hot, dense gas is almost pitch black, since nearly all its radiation is invisible X-rays

produced by nuclear reactions and the collisions of fast-racing nuclei and electrons.

The path of an X-ray as it escapes from the core of the sun resembles the zigzagging track of the steel ball in a pinball machine. Even though the rays travel at the speed of light, 186,300 miles a second, the devious trip to the surface takes about 20,000 years!

During that long period the X-rays gradually change. Each time one is deflected, the frequency of its vibration is reduced slightly, and its wavelength is increased. In time, all the X-rays gradually turn into ultraviolet and visible light.

To understand this relationship, think of X-rays, ultraviolet, and visible light as all being cousins, or related forms of electromagnetic vibration, on a spectrum, or scale, like that of a piano. Just as each note on the piano varies from its neighbors by its frequency (the rate at which its string vibrates), so do vibrations in the electromagnetic spectrum. X-rays are comparable to high notes, ultraviolet



represents notes with a somewhat lower frequency, and visible light waves fall still lower, near the middle of the keyboard, so to speak. Farther down the scale come infrared and then radio waves, the "low notes." These, too, are electromagnetic vibrations, differing from light only in their rate of vibration.

At three-quarters of the distance to the surface, the solar interior has cooled to about  $150,000^{\circ}\text{C}$ ., and the density has fallen to about a tenth that of water. Up to this point, the sun's energy has been transferred in radiant form. Radiant energy travels directly by waves moving with the speed of light, as when one feels the heat of a fire at a distance.

Now, however, still more than 100,000 miles below the surface, the sun's gas begins to convect, like boiling water, and energy seethes upward in a turbulent flow of hot gas. Convection occurs when chaotic masses of gaseous atoms flow in currents, each atom carrying its own parcel of energy all the way.

Finally the sun's energy reaches the surface and there, in the photosphere, its form is again changed, being largely converted once more to radiation that leaves the sun to flood through space.

#### Sunspots Visible to the Naked Eye

Aristotle taught that the sun was a globe of pure fire without blemish. This belief persisted until Galileo's time, when the newly invented telescope showed that dark spots come and go across the face of the sun.

Normally, bright sun blinds the naked eye, but when fog and haze reduce the glare we can readily detect large sunspots, especially near sunrise or sunset. Two hundred years ago, people thought the spots were solid mountaintops protruding above an ocean of glowing lava, the photosphere. They reasoned that the photosphere would have high and low tides. As the tide ebbed, the higher mountaintops would show as dark bodies.

In 1774, however, Alexander Wilson, a Scottish astronomer, observed that spots had inclined edges, like the slopes of a crater, leading to a dark interior inside the brilliant shell. Sir William Herschel, the British court astronomer, proposed about 1800 that a spot reveals the surface of a cold, solid crust. Above this surface, he thought, were two cloud layers, the outer being brilliant and hot, and the inner, a cool, protective shield, shading the crust. According to this notion, a spot would appear when the clouds parted to reveal the underlying cool crust.

Herschel went so far as to suggest that the dark interior of the sun supported intelligent life. So great was his authority that the idea of a cool solar surface persisted through most of the first half of the nineteenth century, even though it is simple to calculate that such a sun could not shine for more than a day or two.

Actually, the surface of the sun, the photosphere, appears granular at its base, as though it were paved with cobblestones (pages 714-16). A sunspot begins to form as a dark pore in the midst of the fine granular pattern. Soon several pores coalesce with each other to form a spot. Sometimes the spot lasts only a few hours, but occasionally one will grow and persist for weeks or months.

#### Rotation Varies at Different Latitudes

The shape of the spot most often resembles a funnel 400 or 500 miles in depth. In the dark central area the temperature is only about  $4,200^{\circ}\text{C}$ . This is hotter than the hottest blast furnace on earth; yet compared to the  $5,700^{\circ}\text{C}$ . temperature of the surrounding photosphere, the spot appears cool and dark.

A relatively small spot measures only a few thousand miles in diameter, roughly the size of the earth. The largest spot group on record, in 1947, expanded to more than seven billion square miles.

Sunspots act as markers on the clear disk of the sun and show us that its globe rotates from east to west (opposite), but in a very peculiar way. Unlike the solid earth, the sun does not rotate uniformly at all latitudes. A spot close to the equator, for example, completes a rotation in 25 days; one at  $30^{\circ}$  latitude takes 26 days; the rotation of the polar zone may take as long as 34 days.

Thus the gaseous sun twists on its axis so that the equatorial regions rotate faster than the polar caps. Most of the changing features observed on the surface of the sun must be related in some way to this contortion.

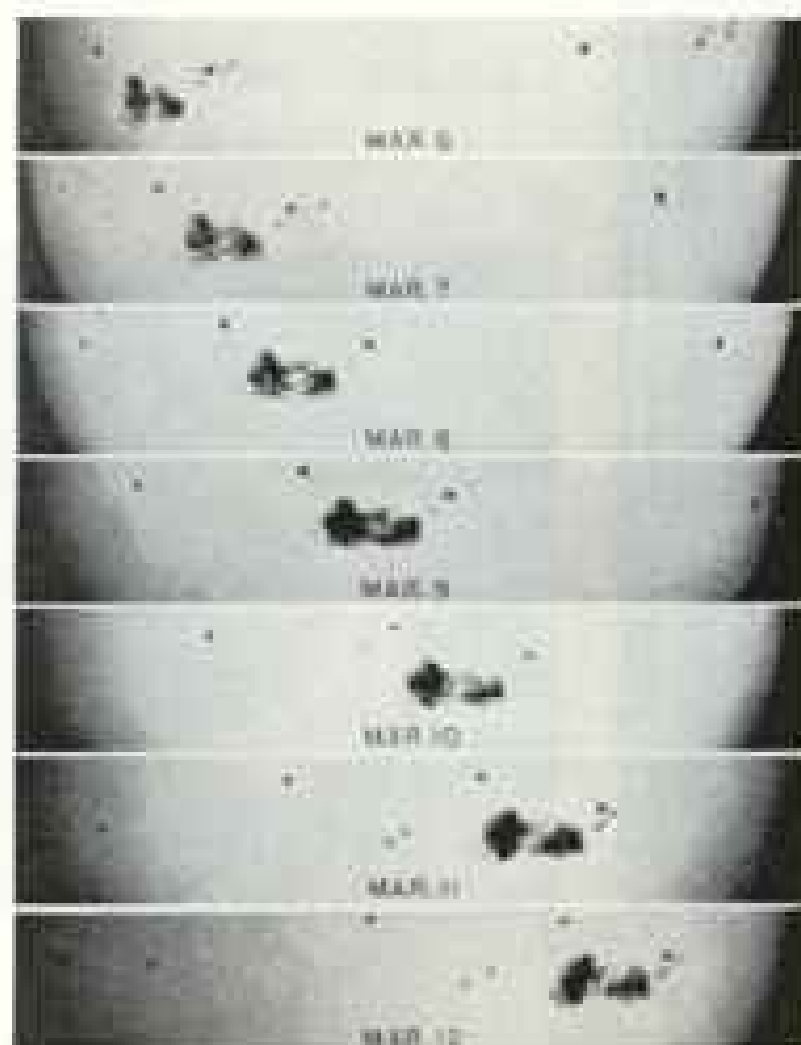
During quiet periods of the 11-year solar cycle, months may pass without visible spots. At peak periods, as in 1957, spots may number as many as 25 at one time.

Some people have tried to link the number of sunspots to the number of admissions of mental cases to psychiatric hospitals, to the behavior of the stock market, to the pattern of annual growth rings in trees, or to the catch of Atlantic salmon. None of these proves out. But sunspots are clearly connected with radio communications, magnetic storms, and the auroras, or northern and southern lights.

## Three ways to see the sun

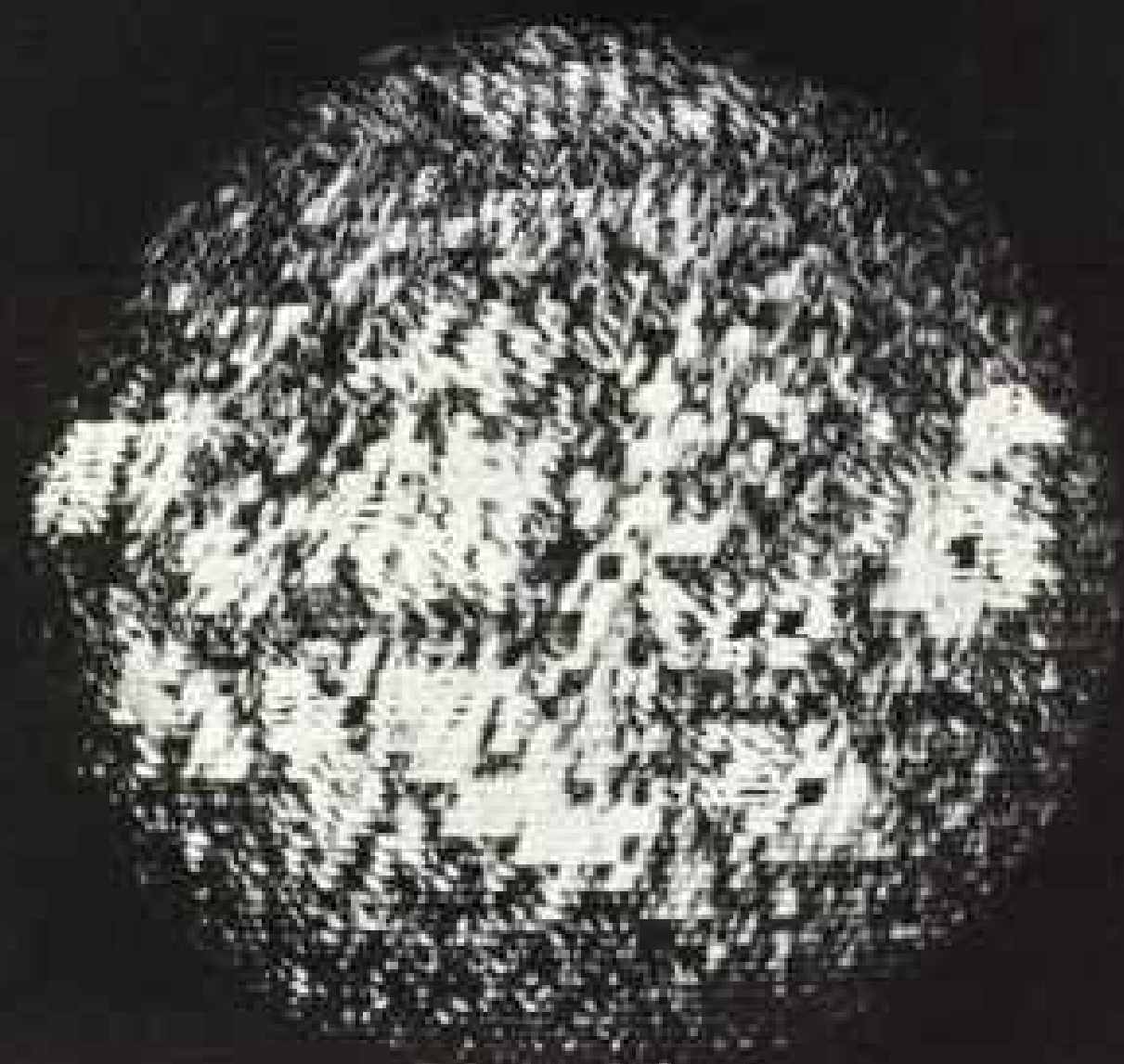
**T**HE FACE of the sun wears many expressions. Photographed in white light (right, top) through a solar telescope, it shows sunspots in the form of dark flecks. Viewed the same day in the violet light of radiant calcium ions, filtered by a spectroheliograph, the sun appears blotchy (center). Massive calcium clouds called plages hover over the sunspot areas visible in the top photograph, as well as over other sunspots that are waning or just beginning to form.

Mirrored in a magnetogram taken at a different time, the sun's magnetic face (bottom) shows that the sun is a relatively weak magnet. Shades of gray indicate low intensity, white areas are stronger, and heavy black blots mark small regions of intense activity. These blots often coincide with sunspots, which may measure thousands of times the magnetic intensity of the sun as a whole.



Sunspot movements prove that the sun rotates, as does the earth. This 1947 outbreak, largest sunspot group on record, covered seven billion square miles. Lacking rigidity, different parts of the sun spin at various speeds. Scientists believe that turbulence thus generated forces giant twisting loops of electrified gas to break through the surface, forming the sunspots.

U. S. NAVAL OBSERVATORY (RIGHT, UPPER), MCMAHON-HOLEBERT OBSERVATORY (CENTER), MT. WILSON AND PALOMAR OBSERVATORIES © U. S. N.

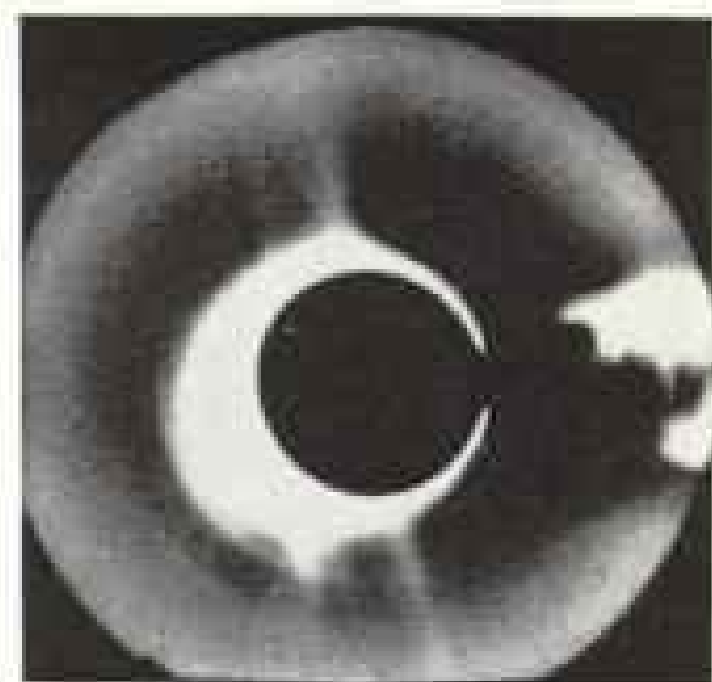




Some of the oldest indirect evidence of the cyclic nature of solar activity is documented in records of auroras, which are a direct product of solar bombardment. Unlike magnetic phenomena, which are revealed only by delicate instruments, the strange lights of the auroras can be seen at times by all the world.

Ancient peoples were terrified and awe-struck by the flaming, pulsating, brilliant red and green glows. Aristotle wrote about them as long ago as the fourth century B.C. In the Middle Ages, auroras were often described as fiery dragons, burning spears, beams of fire, or divine revelations. Superstitious folk interpreted the infrequent and sporadic nature of the heavenly spectacles as portents of the end of the world.

From such auroral accounts, science historians have traced the 11-year



## Balloon-borne cameras record man-made eclipses

**T**HRUSTING SILENTLY UPWARD, an unmanned balloon lifts instrument-laden Coronascope II above Palestine, Texas, in June, 1965. Only slightly expanded at 7,000 feet (above), the balloon bulged in the thinning air as it soared to 98,000 feet. There it drifted above 99 percent of earth's obscuring atmosphere, the instruments in its gondola locked on the sun. A coronagraph, which creates artificial eclipses by masking the sun, quenched the disk's brilliance, thus revealing the corona, an immense halo of glowing solar gas. The camera snapped more than 100 sun portraits, such as the coronagram above, right. Then the gondola descended by parachute. Landing near Sweetwater, Texas, 300 miles from the starting place, it plowed a bold furrow across a contoured field (opposite).

sunspot cycle back more than 2,000 years. By use of the spectroscope, an instrument which breaks white light into its familiar rainbow spectrum (pages 726-7), we measure the magnetism of sunspots. The magnetic field strength is enormous—comparable to the most intense fields produced in modern particle accelerators, such as the Brookhaven synchrotron. But Brookhaven produces such a powerful field over only a few thousand square feet. When we consider that the sunspot field often covers an area big enough to blanket ten earths, we know that a major portion of the energy in the solar atmosphere is bound up in magnetic fields.

### Light Yields the Stars' Secrets

As every high-school science student learns, a magnetic field can be established in the laboratory by a steel horseshoe magnet, or by an electric current flowing in a coil of wire. Now there are certainly no solid-steel magnets in sunspots, so their magnetism must come from tremendous electric currents, carrying as much as 10 million million amperes.

Some scientists suggest that these huge currents originate in the highly convective gas surrounding the inner nuclear furnace. The streams of hot gas carry burned nuclear fuel outward, and cooler gases carry fresh fuel toward the center. Because of the rota-

tion of the sun, these circulating streams may be twisted into whirls which detach like smoke rings, rising to break through the photosphere and thus to form pairs of spots.

Why are sunspots relatively cool? Possibly gas within a spot flows out along lines of magnetic force and cools by expansion.

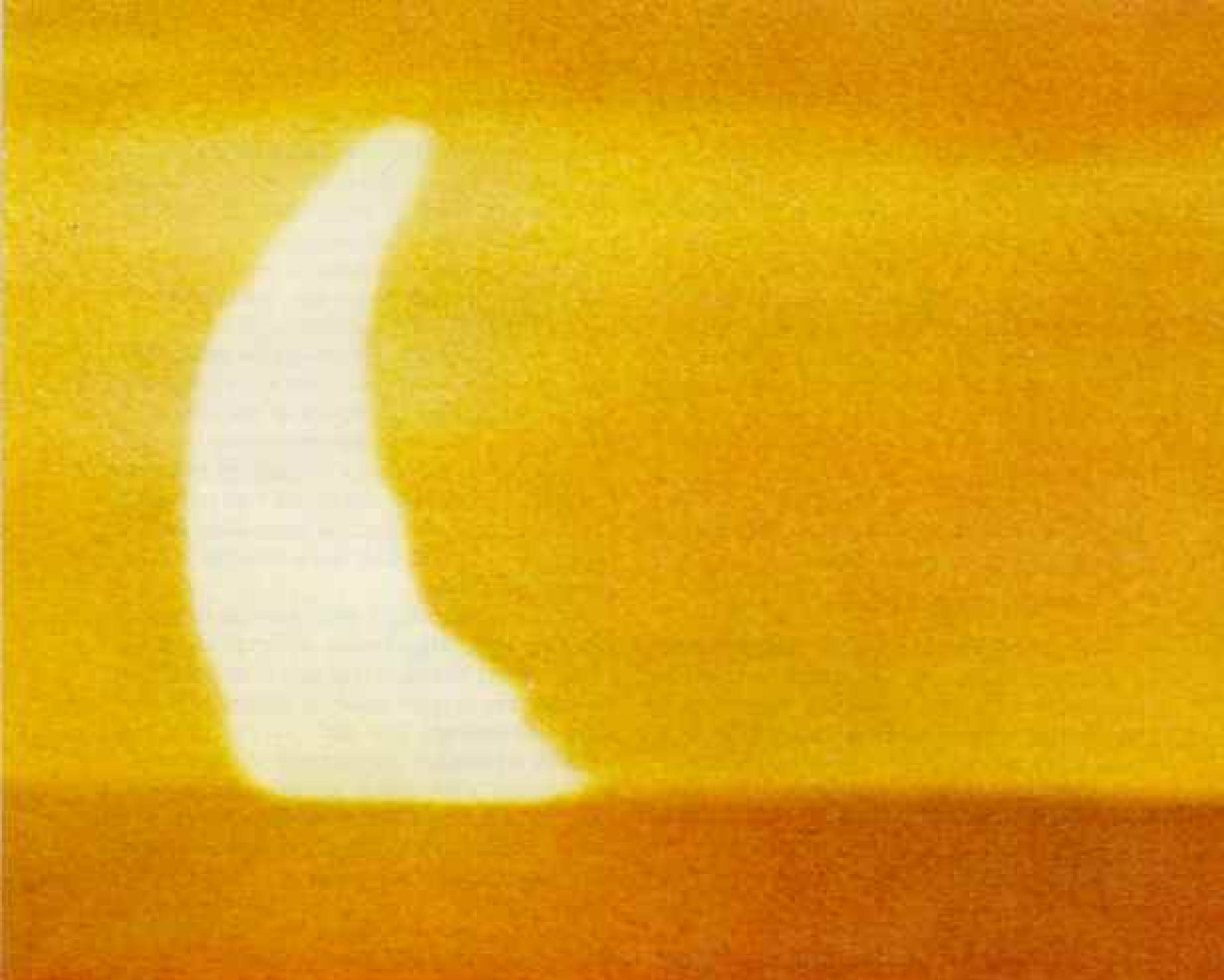
In the 1830's, the French philosopher Auguste Comte wrote that man must reconcile himself to eternal ignorance of the composition of the stars. How utterly wrong he was! By analyzing the quality of sunlight arriving from 93 million miles away, we can tell what the sun is made of just as accurately as if a sample of the star had been brought to our earthly laboratory.

Atoms radiate light with precise frequencies that uniquely identify different elements—somewhat like the tones and overtones that produce the specific color or quality of a musical instrument. The ear can pick out the various frequency components of instrumental sounds with much greater discernment than the eye can resolve the light waves in a color mixture. But one of the astronomer's key instruments, the optical spectroscope, does what the eye cannot, and permits us to isolate the different "tunes," or characteristic frequencies, of every known atom.

Perhaps the most remarkable accomplishment of astronomy is the spectroscopic

VIEW ALTITUDE OBSERVATORY, BOULDER, COLORADO CENTER. EXAGGERATED BY DEAN CONNER © R.S.S.





Glowing horns of a crescent sun cup an invisible moon above the Sahara in 1955. Seconds later the sun's disk slipped behind the moon, surrounding it with the thin, fiery ring of an annular eclipse.

discovery that all stars are made of the same atoms we find on earth.

In 1814, Joseph von Fraunhofer, a young Bavarian lens designer, stumbled upon a most surprising phenomenon. He was trying to isolate pure colors from sunlight, to test the refraction—the bending of light rays—by his telescope lenses. When Fraunhofer looked at the rainbow spectrum of sunlight with his instrument, he noticed many fine dark lines interrupting the smooth progression of color from red to violet (pages 726-7). At first he blamed his glass for imperfections, but soon he became convinced that the dark lines were a true feature of sunlight.

The solar Fraunhofer line spectrum can be used as a "fingerprint" of the elements in the sun, for each element shows its own combination of lines. Hydrogen, for example, produces a simple spectrum with just a few dark lines; iron has more than 3,000. By means of

Such rings occur about once in three eclipses, especially when earth's path comes closest to the sun and the moon swings farthest from earth. In a total eclipse the moon barely blots out the sun's face—an

Fraunhofer lines, about 70 of the 92 elements naturally occurring on earth have been identified in the sun.

Furthermore, the character of the spectral lines—whether they appear sharp or fuzzy, dark or only half-shaded, slightly shifted toward the red or toward the blue end of the color spectrum—offers the astrophysicist tremendous amounts of information: He can deduce temperature, pressure, density, and composition; the strength of gravity, density of radiation, electric force, magnetic force, degree of turbulence, and convective movements in the region of the sun where the spectrum line is produced.

The Fraunhofer spectrum tells us that the sun consists principally of hydrogen. Hydrogen atoms are roughly 10 times as abundant there as helium, the next most abundant element, and 1,000 times as abundant as carbon, nitrogen, or oxygen, which are so common on



AN ECLIPSE OF THE SUN AS SEEN THROUGH A TELESCOPE. PHOTOGRAPHED BY THOMAS A. SMITH (BOTTOM) AND ERIC SCHULTHEIS. © A. A. S.



amazing cosmic coincidence—and exposes the corona (upper right). Eclipse watchers may suffer eye damage unless they look through very dark film or heavily smoked glass (right).

earth. Except for the overabundance of hydrogen and helium, the chemical composition of the solar atmosphere is much the same as that of earth's crust.

Like the other close-in planets of the solar system—Mercury, Venus, and Mars—the earth has lost most of its hydrogen and helium. But the Jovian planets—Jupiter, Saturn, Uranus, and Neptune—because they are cold and very heavy, retain a great deal of the original hydrogen and helium and thus more closely resemble the sun.

#### Sun's Expression Constantly Changing

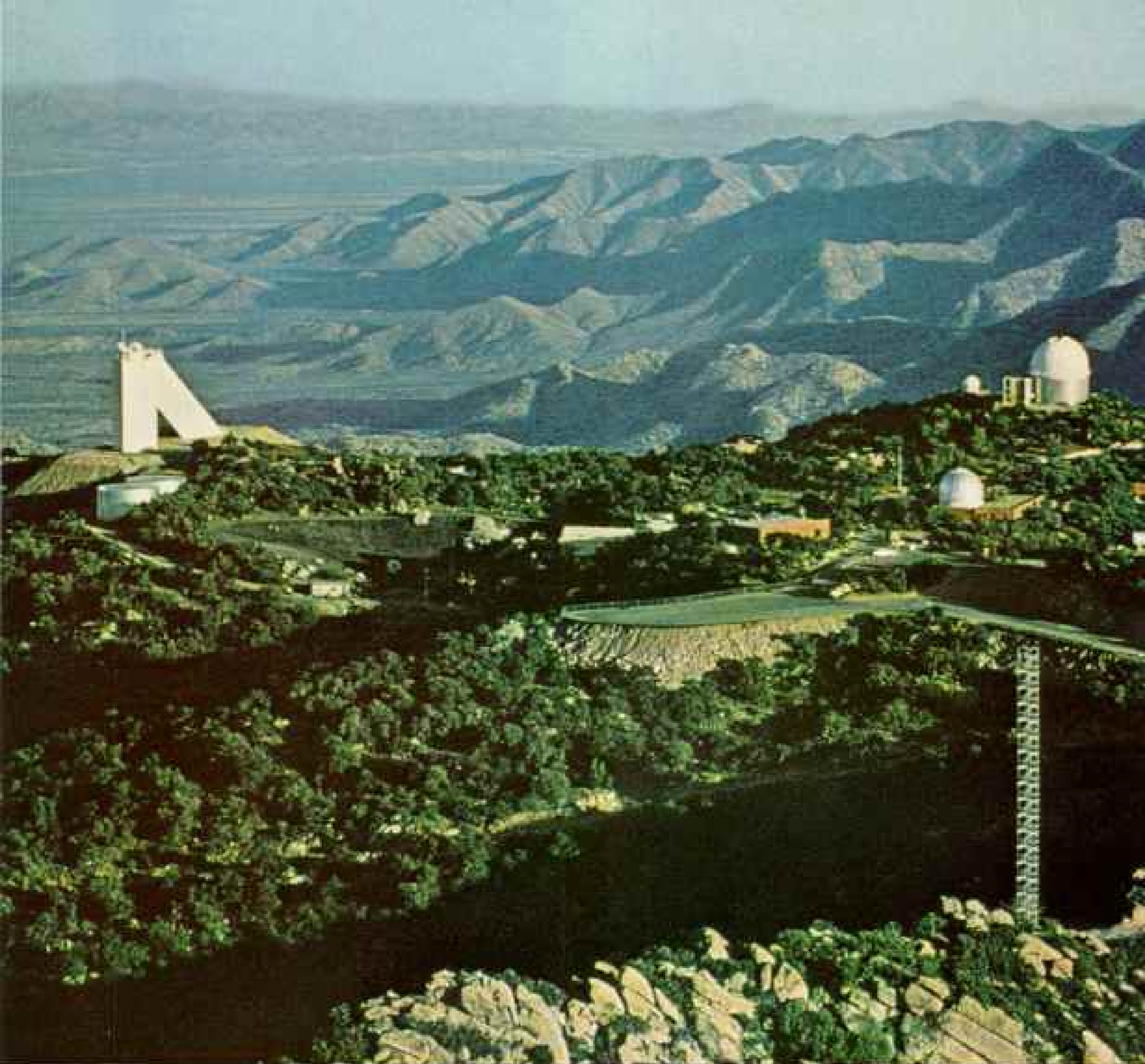
In white light we see mainly the lower levels of the photosphere with its granules and sunspots. The Fraunhofer lines originate in the higher portions of the photosphere where it is cooler—the darker the line, the higher and cooler its region of origin.

In 1889, George Ellery Hale, father of the

world's largest optical telescope, the 200-inch on California's Palomar Mountain, invented a most useful variation of the spectroscope called the spectroheliograph. In essence it is a highly selective filter that enables astronomers to narrow down their view of the sun to that of a single line of the color spectrum. Thus as the spectroheliograph scans the face of the sun, it sees only one color, such as the red line of hydrogen (pages 718-19) or the violet line of ionized calcium.

Each line is produced in the sun at a level where the temperature is just right. Thus the spectroheliograph can probe deeper and deeper into the sun's atmosphere, photographing the entire face of the sun at each level. And at each layer the face of the sun takes on a remarkably different complexion, and the expression is constantly changing.

Hovering near sunspots, self-luminous clouds resemble fluffs of wool in white light.



They are called faculae, Latin for "little torches." The surface of the sun, when photographed with a spectroheliograph in the violet light of ionized calcium, takes on a mottled appearance, like the skin of an orange (page 729). Near the sunspots the mottles concentrate into bright patches called plages, French for "beaches."

#### Careless Astronomers Lost Their Lives

A few thousand miles above the photosphere, the solar atmosphere is so thinned out that it becomes virtually invisible in the glare of the photosphere. But when an eclipse masks the face of the sun, we see a very interesting profile (page 733).

If the eclipse occurs at sunspot maximum, the corona assumes a symmetrical shape with petal-like streamers resembling a large dahlia with the black moon at the center. At sunspot

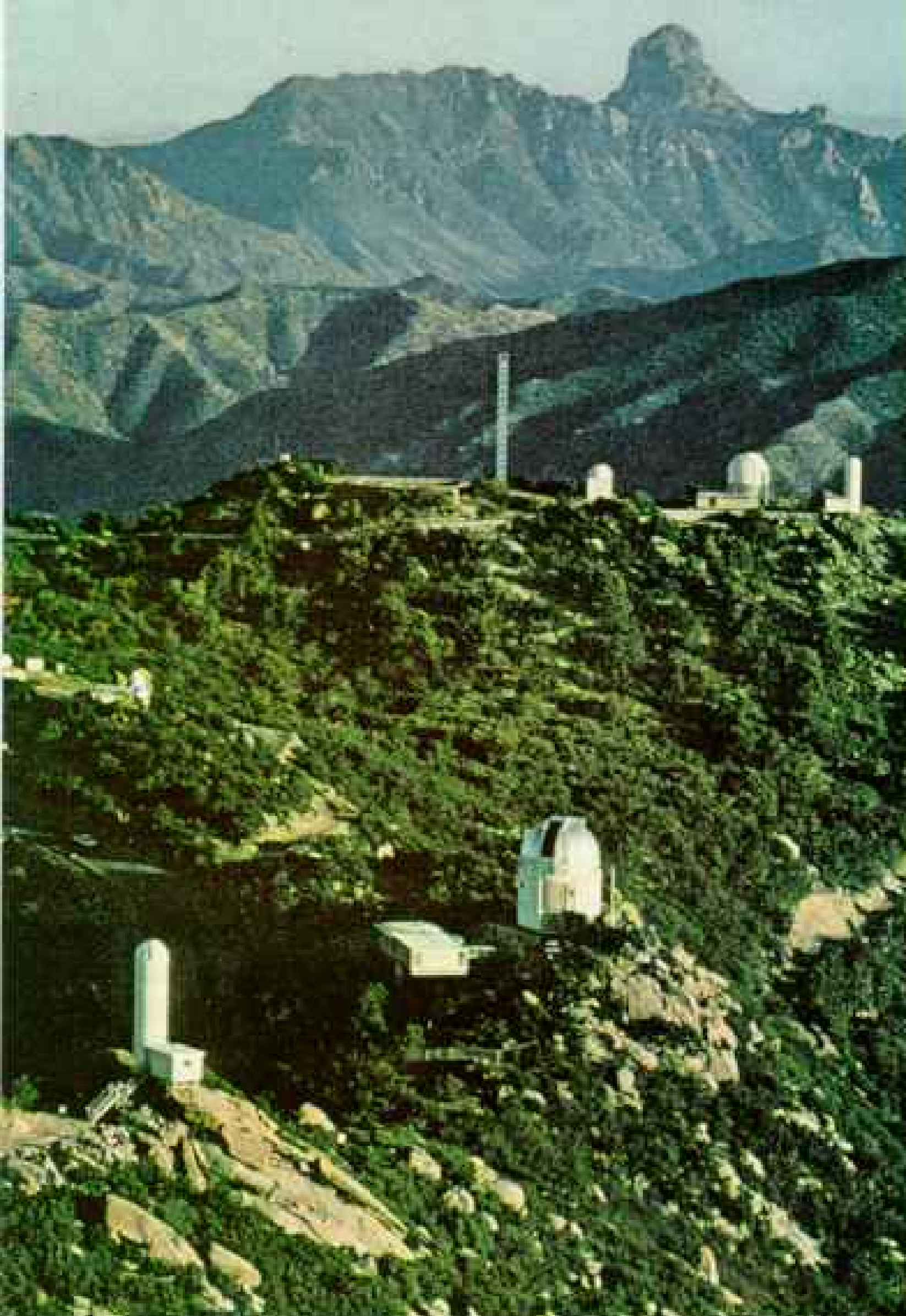
minimum, great equatorial streamers stretch millions of miles, distorting the symmetry.

Most of what we know of the sun's outer atmosphere comes from studies of the solar eclipse, perhaps the most dramatic of all nature's spectacles.

The earliest historical record of an eclipse dates back more than 4,000 years to October 22, 2157 B.C., and is documented in the Chinese classic *Shu Ching*. This book contains regulations of the emperor regarding his royal astronomers and their eclipse predictions:

"Being before the time, the astronomers are to be killed without respite; and being behind the time, they are to be slain without reprieve."

Although eclipsesmanship is no longer a matter of life or death, astronomers have often risked great personal danger in eclipse expeditions. One English astronomer traveled



Like a moon village, surrealistic shapes of Kitt Peak National Observatory dot the stark Quinlan Mountains, 56 miles west of Tucson, Arizona. Appropriately, the Nation's most diversified center for exploring the cosmos lies only 12 miles north of Baboquivere Peak (upper right), revered in legends of Arizona's Papago Indians as the center of the universe.

The Robert R. McMath solar telescope (far left), largest in the world, holds an 80-inch flat mirror 100 feet above ground to capture an image of the sun undistorted by ground-level air currents. Light reflects 500 feet down the sloping arm, which burrows 300 feet underground. Water circulates within the walls to prevent light-distorting temperature fluctuations in the air.

In the subterranean viewing room (below), mirrors flash a 33.5-inch image of the sun on a grid. A square hole visible in the grid's center admits a band of light to a spectrograph. In this way astronomers get sharp spectra of flares, sunspots, solar granulation, and prominences.

LETOCHROME (BELOW) AND EPOCHROME BY NATIONAL GEOGRAPHIC PHOTOGRAPHER DENZ CORNER © N.G.S.





75,000 miles to six eclipses, but because of clouds or rain saw only one. A French astronomer, Pierre Janssen, was so intent on photographing the eclipse of 1870, during the Franco-Prussian War, that he risked German rifle fire to escape from the siege of Paris in a balloon. Unhappily, when he reached the eclipse path over the African coast, rain hid the event.

In 1842, astronomers in southern Europe were the first to take careful note of the very faint, extended outer atmosphere of the sun. As the moon blocked out the brilliant disk, a pearly white corona with delicate streamers and curved arches stood revealed. Close to the black edge of the moon, a reddish ring encircled the sun, giving rise to the name "chromosphere." From this ring, luminous red clouds and streamers of gas called prominences looped high into the corona.

Each century sees about 237 solar eclipses. Approximately one-fourth are total, and on the average two total eclipses occur every three years. Among other institutions, the National Geographic Society has been active in eclipse observations, with nearly a dozen expeditions since the early '30's.\*

But in spite of the most persistent efforts, more than a century of eclipse studies has given us less than a hundred minutes' worth of observation! We still know relatively little about the true structure of the chromosphere and corona.

#### Temperature Rises in Solar Atmosphere

Presumably the temperature of the sun's atmosphere should get progressively cooler the farther one measures out from the sun's surface. Recall that the temperature deep in the thermonuclear furnace is about 16 million degrees, and drops steadily to about 5,700 degrees at the surface. In the solar atmosphere we would expect even cooler gas.

But the spectrum of the chromosphere and corona reveals a very interesting paradox: The temperature there begins to rise again, shooting up to above 100,000 degrees in less than 10,000 miles, and eventually climbing to several million degrees.

How can the chromosphere and corona derive their high temperatures through a much cooler photosphere?

Astrophysicists believe that the seething, bubbling granules at the sun's surface break like ocean waves and create a tremendous rumbling roar of sound. As these waves of

sound rush upward into more rarefied gas, they accelerate until supersonic shocks occur, which heat the gas to its high temperatures.

Pictures of the rim of the sun show a fountainlike structure. Thousands of tongues of gas, called spicules, spring as jets above the bursting granules. They surge up from the base of the chromosphere and fall back again in five to ten minutes, rising with speeds of 10 to 15 miles a second to heights as great as 6,000 miles. Some of the spicules seem to vanish into the corona.

At any instant as many as 100,000 spicules cover the face of the sun, and for this reason the chromosphere has been called "the spray of the photosphere."

#### Streamers Leap Thousands of Miles

With the coronagraph telescope, which artificially eclipses the sun's disk, we can see huge streamers of bright gas often looping as high as a hundred thousand miles into the corona, and dipping back to the photosphere as much as half a million miles away. These prominences, when photographed in time-lapse motion pictures, show continuous changes in their over-all shapes and complicated internal streaming.

Prominences usually appear to spring from sunspot groups. Their arched structure indicates strong magnetic fields—just as iron filings form curved lines on a sheet of paper when a magnet is placed under them. Where the streamers are anchored to the photosphere, violent convection twists and shifts the lines about, causing the arches to react in spectacular whipping, streaming, and eruptive patterns high into the corona.

The corona is not a static atmosphere that blankets the sun the way our own atmosphere hugs the earth. Because the corona is so hot, it continually expands into space—relatively slowly at first, perhaps a thousand feet per second. But the rising coronal gas accelerates rapidly, because there is almost no interplanetary gas pressure to resist the expansion. Ultimately it may reach 500 miles per second. This "solar wind" of hydrogen steadily blows out through space and races toward the earth and other planets.

The wind that reaches earth today left the solar surface about 10 days ago. Actually it never penetrates the atmosphere since it is deflected by earth's magnetic shield, which bulges out thousands of miles from the surface.

How far does the wind reach? We are not sure, but calculating from its speed and strength, it must travel at least to Neptune,

\*See "75 Years Exploring Earth, Sea, and Sky," by Melvin M. Payne, GEOGRAPHIC, January, 1963.

30 times farther than earth from the sun, and possibly to Pluto, 40 times farther than earth.

Modern eclipse expeditions took on a new look in 1958, when scientists first attempted to use rocket astronomy to determine which layers of the solar atmosphere emit X-rays and ultraviolet. The expedition was a joint venture of ground-based astronomers, under the leadership of Dr. John W. Evans of the Sacramento Peak Observatory in New Mexico, and a team of rocket specialists from the U. S. Naval Research Laboratory, under my direction.

The eclipse began at sunrise on the equator near New Guinea and raced across the Pacific Ocean for about 8,500 miles to the coast of Chile near Valparaiso, where it left the earth at sunset. In its long path—never more than 150 miles wide—the eclipse missed all the large South Pacific islands, and could be observed on land from only a few coral atolls.

#### Rocket Barrage Takes Solar Pulse

The astronomers chose the atoll Puka Puka in the Danger Islands—about 2,300 miles south of Honolulu—on which to set up their spectrographs. To support the rocket part of the expedition, the Navy provided a floating hotel, machine shop, and laboratory—a landing ship called the *Point Defiance*.

Our six solid-fuel rockets, 1,500-pound combinations of Nike-booster first stages and Asp second stages, pointed like arrows from the deck. The Asp second stages would enter the eclipse shadow about 100 miles up, reach a peak of 150 miles, and splash into the sea 60 miles astern about six minutes after firing.

Eclipse day dawned gray and overcast where the *Point Defiance* lay to, 30 miles off Puka Puka. At 8:38 we fired the first rocket, 10 minutes before totality. Two more were fired during the brief interval of totality. Sixteen minutes later No. 4 flashed into the sky. Rocket No. 5 balked, but the sixth rocket took off almost on schedule.

When the smoke had cleared, our thoughts shifted to our colleagues on Puka Puka. The sad story that we picked up shortly after on the radio told of rain and clouds that completely ruined their



## Birth and death of the solar system

SEVENTEENTH-CENTURY MAN found it easy to visualize the end of the world in flames from a passing comet, as shown in the engraving above. Today's scientists foresee a much different finale, as shown in Davis Meltzer's composite painting on the next two pages. Perhaps five billion years hence, they suggest, the sun will exhaust its hydrogen fuel and flare into a "red giant" star that will engulf the nearer planets.

The painting shows five stages in the life cycle of the solar system. Some five billion years ago, a dark supercloud of cosmic dust and gas, including debris of a giant exploded star, roiled like a turbulent thunderhead in the Milky Way (top).

Gravity contracted the cloud; contraction accelerated its rotary motion. It flattened like a fried egg (stage 2). As contraction continued and the protostar grew hotter, hydrogen atoms collided with increasing violence. They began to fuse, and the sun's thermonuclear furnace was ignited. Meanwhile, fringes of the cloud disk condensed into blobs of dust and gas—the planets (stage 3).

The planets cooled; the sun's heat balanced its gravity to halt contraction; and the solar system began to spin sedately as we know it today (stage 4). Finally, billions of years in the future (foreground), the solar reactor will devour its remaining hydrogen and swell into the red giant that swallows up and vaporizes earth.

PAINTING (FOLLOWING PAGES) PRODUCED BY NATIONAL GEOGRAPHIC SOCIETY, DAVIS MELTZER, ARTIST © N.G.S.







**Mechanical whirling dervish**, an Orbiting Solar Observatory spins in a test room at Bull Brothers Research Corporation, Boulder, Colorado. Hurlled into orbit some 350 miles above earth in February, 1965, this second in a series of NASA satellites helped to measure the sun's radiations.

**Concentrated sunlight** in a solar furnace at Mont Louis, France, can melt any substance. Several thousand flexible glass mirrors, arranged in a 34-foot parabolic bowl, focus the burning rays into a crucible, producing temperatures up to 6,300° F. Metallurgists use the device to process experimental heat-resisting materials and purify alloys.

observations. A year's preparation before embarking, months of effort on Puka Puka—all had come to naught.

When we scanned our radio telemetry records from the rockets, the signals clearly showed that X-rays are produced high in the corona. Even with the sun's disk covered, 13 percent of the X-rays remained unobscured. In contrast, the ultraviolet rays were completely eclipsed at totality, indicating that they originate at the fringe of the photosphere. Furthermore, as the moon blotted out individual sunspot areas, the X-ray flow diminished abruptly, proving that sunspot groups emit concentrated X-rays.

Sunspots, plages, prominences—these dramatic activities of a quiet sun pale into insignificance compared to the explosive phenomenon known as a solar flare. A large flare can erupt with the force of a billion hydrogen bombs within an hour's time, releasing enough

energy, if it could all reach earth, to melt the north and south polar ice.

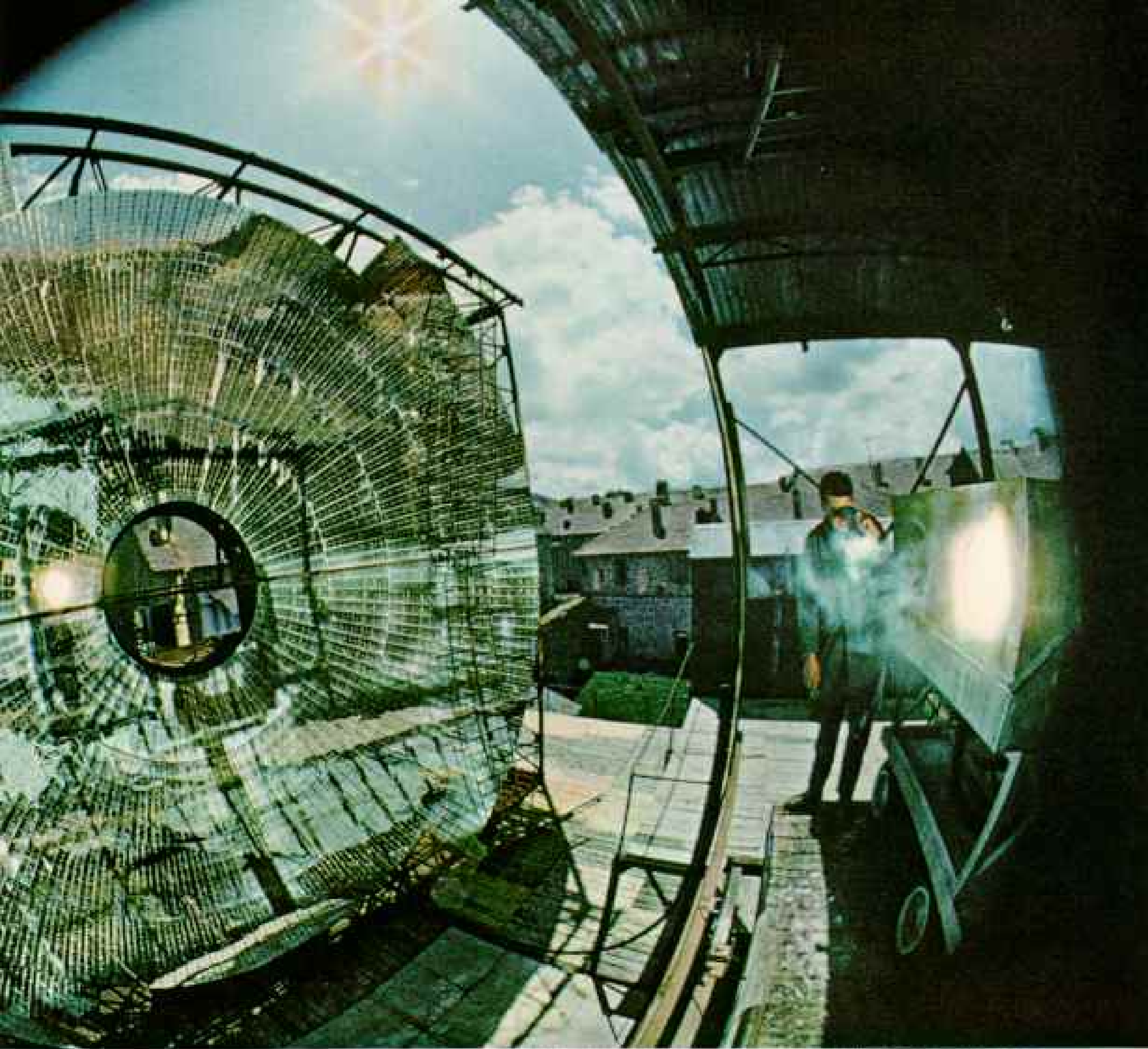
This tremendous power is released by a brilliant burst of light and all other electromagnetic wavelengths, from X-rays and ultraviolet to infrared and radio waves; by protons and electrons accelerated to more than half the speed of light; and by clouds of ionized, or electrified, gas that sweep through space at hundreds of miles per second. It was such a flare that disrupted earthly communications so strikingly in November, 1960.

#### **Solar System Born of a Gigantic Cloud**

Sometimes a large flare can be seen in white light; in fact, the earliest record of a flare is probably an 1859 account by an English astronomer named Richard Carrington, who thought he had witnessed the splash of a gigantic meteorite.

Only a generation ago, most astronomers





DETAILS (OPPOSITE) BY LOWELL G. BROWN; ASSEMBLY BY TYEE BERRIANE © A.C.S.

believed that the solar system originated in a near collision between the sun and another star, and that the material of the planets was torn loose from the sun by the tremendous gravitational pull of the passing star.

Today's view, however, holds that the sun and the planets condensed from an enormous turbulent cloud of gas and dust (pages 737-9). The sun grew steadily warmer because of its immense gravitational energy. In time the protostar began to glow brightly, and its core temperature rose millions of degrees.

Hydrogen nuclei, impelled by the tremendous heat, collided with such violence that thermonuclear fusion could occur, and nuclear energy, rather than gravitational energy, began to keep the star hot.

Some theoretical calculations indicate that the proportion of hydrogen in the core of the sun has decreased from about two-thirds to about one-third in the past five billion years.

Temperatures have risen somewhat, and the sun has grown about five percent larger in diameter and about 25 percent more luminous. The great majority of stars follow this gradual trend of evolution.

The sun today is a very ordinary star—a yellow dwarf midway between the largest and the smallest, and between the hottest blue stars and the coolest red stars. To earth-based observers, it is a hundred billion times brighter than any other star, though it would appear puny if it were matched at the same distance against the more brilliant stars. Rigel, for example, is 15,000 times more luminous, and 36 million suns could be fitted into Antares, a red supergiant.

What of the future? Will the sun burn out? In time the core will deplete its hydrogen. With the core spent, the thermonuclear reactions will spread to outer portions where unused hydrogen still exists.





As the reaction zone moves closer to the surface of the sun, the tremendous nuclear heat at its core will also move outward, forcing the sun to expand, and the total amount of radiated heat and light will increase. The sun will then become a giant red star like Antares: It will blow up to a monstrous ball of extremely rarefied, red-hot gas large enough to engulf Mercury, Venus, the earth, and Mars, the four nearest planets (pages 737-39).

When will the sun reach this stage? We have no cause for immediate concern—it may take another five billion years!

#### **Sun Will Turn From Giant to Dwarf**

Finally, when all its hydrogen has been converted to helium, the sun will cool and shrink, ultimately becoming a white dwarf no bigger than the earth but weighing several tons per cubic inch.

Not all stars reach this peaceful demise. Stars much more massive than the sun end their evolution in a catastrophic explosion which fills vast regions of space with debris. Eventually this material recondenses into new stars. Our sun is such a second-generation star, and man on earth is made of secondhand atoms left over from a star that exploded before the sun was born.

We know this because the sun contains an excess of heavy elements, such as iron, that could not have been produced by the simple nuclear burning of hydrogen, the primeval material of the universe.

Meanwhile, the sun is our bridge to the stars. It is the only star whose surface and atmosphere we can study in fine detail, and it typifies the great majority of stars in the Milky Way. In its spectacular flare outbursts, we can observe the interaction of hot gases, intense magnetic fields, and shock waves under conditions man cannot simulate in his laboratories.

But we stand today on the threshold of exciting new knowledge. Rockets and satellites will probe ever deeper toward the zones of intense solar activity. With such magnificent new tools to observe the sun, the coming years should bring a revolution in our understanding of earth's bright and awesome companion in the heavens—and the myriad greater and lesser stars beyond.

THE END

*FACE SQUEEZED by the bending of light rays in the thicker atmosphere near the horizon, a setting sun glows red and yellow. Scattering by air molecules filters out other hues. Kitt Peak National Observatory captured this image with its solar telescope.*





**H**IGH ON THE SLOPES of 8,271-foot Hualalai, third loftiest mountain on the island of Hawaii, our jeep rocketed along like a bucking bronco. The grassy boulder-strewn track was barely visible among the bushes and low trees. We had crossed the cinder-and-ash cone of the dormant volcano and were dipping down toward the 5,000-foot saddle that lies between Hualalai and huge Mauna Loa and Mauna Kea, both towering more than 13,000 feet.

The January sun shone warmly as we jounced past a fine stand of native gray-trunked koa trees. Suddenly Dave Woodside pointed, and at the same second we heard the thin *uck-uck* calls. Five nene (nay-nay, as the Hawaiians pronounce it) came flying straight toward us from the koa grove. We clattered to a stop and scrambled out. The geese flew easily and gently over our heads, 20 feet up, then landed on a nearby hillside. Three of them crowded together on a single boulder, as if to get a better look at us.

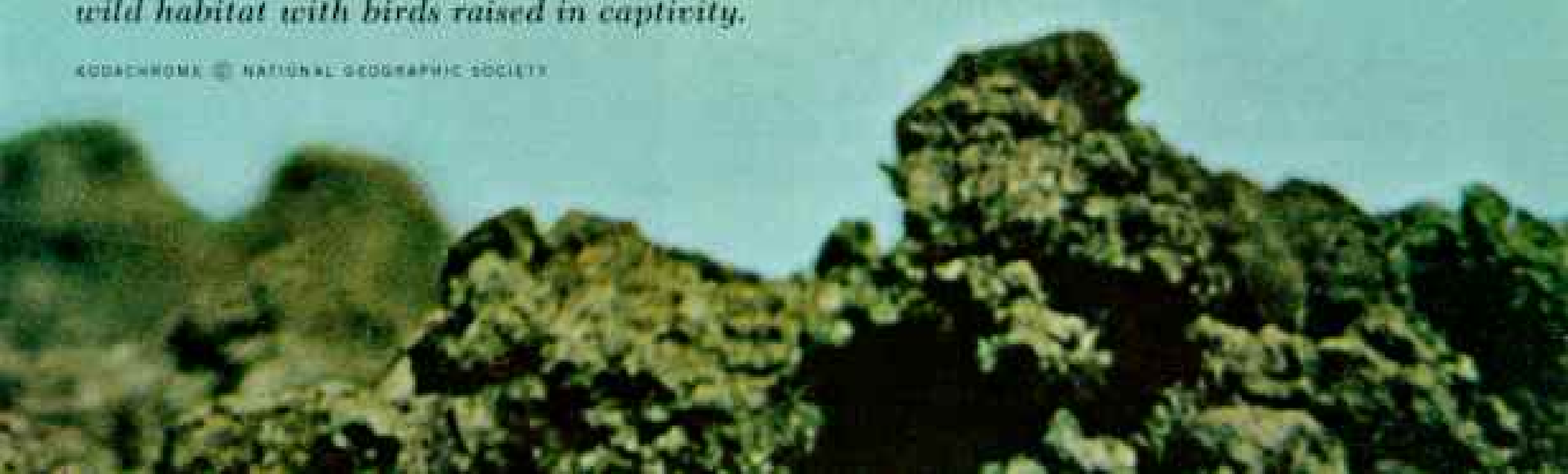
David H. Woodside, head of the Wildlife Branch, State Division of Fish and Game in Honolulu, has seen more of the world's rarest goose in its limited wild habitat than any other observer. For 12 years he has climbed the lava fields of Hawaii and Maui, the only two islands where the nene has ever occurred in nature, seeking traces of this once-vanishing

*CURIOUS AND ALERT, nene geese of Hawaii perch atop jagged lava. Slaughtered for food, the species neared extinction half a century ago. Now a joint British-American effort is restocking the wild habitat with birds raised in captivity.*

# Saving the Nene, World's Rarest Goose

By S. DILLON RIPLEY, Ph.D.  
Secretary, Smithsonian Institution

*Photographs by*  
JERRY CHONG





species. Dave had come with my wife Mary and me to show us some of the new wild flock.

What a thrill for us to see our first free-flying wild nene, for we are among the handful of people who have reared these geese, hoping to bring them back from the brink of extinction.

In the 1940's possibly fewer than a dozen wild birds remained from flocks that 150 years ago were estimated at 25,000. Now international salvage operations have increased the world population to 500 or more, and the nene is the inspiring first example of a rare bird whose wild population has been replenished through release of stock reared in captivity.

As we struggled over the rock-strewn grass, we tried to see whether the birds had colored leg bands. Were these geese that had been released from captivity to add to the tiny wild flock, or were they wild? They allowed a close approach (right), for nene are tame, whether hatched in the wild or in captivity.

The birds stood very still, and we came so near we heard the low conversational moan they use on the ground. It is a strange, faint sound which seems to orient them to each other. Finally they took wing again, circling and making their shrill calls, a thinner version of the cry of the Canada goose.

Before they flew, we observed the colored plastic bands on the legs, which serve as a code to identify the individual and the year in which it was released. The bands told us these were all birds of 1963.

#### Nene Never Leave Islands

The nene (*Branta sandvicensis*) is the oddest of geese. Other true geese live in the northern temperate zone and subarctic—the nene in tropical Hawaii. Continental geese migrate—nene do not. Other geese like water—nene dwell on dry lava beds.

When Westerners arrived, they noted that the geese were not greatly prized by Hawaiians. The dull plumes were no ornament to chieftains' cloaks. They were hunted for food, however, or made into pets.

The habitat of the nene seems to have been local,



Airborne skein of nene (pronounced nay-nay) glides over Hawaii Island on wings that span four feet. Ornithologists believe that *Branta sandvicensis* may have evolved from wandering North American birds stranded on the island's volcanic slopes at least half a million years ago.

**The author:** S. Dillon Ripley, Secretary of the Smithsonian Institution in Washington, D. C., rears nene at his Connecticut home to help restock the Hawaiian flocks. Here Dr. Ripley inspects a wild bird he caught in a patch of shrub-covered lava 6,000 feet high on Hawaii's Mauna Loa volcano.

Remarkably tame, nene permit the author's party to approach within a dozen feet, close enough for eavesdropping on their low, conversational moan.



KODACHROME © H. J. S.





near lava flows on Hawaii and Maui. Westerners first thought of these geese as migrants from some northern tundra, as are the geese of Europe and North America. Not until the late 19th century were the geese found nesting, making it clear that they were permanent residents (maps, page 751).

Ever since I first set eyes on a nene in 1939, it has been one of my favorite waterfowl. The Hawaiian goose stands rather erect, a good two feet high, and measures about two feet from bill to tail, with a wingspan of at least four feet. It is a highly distinct species, related to the Canada goose. But it differs in its ruffle-feathered neck, its plumage pattern, proportionally longer legs; feet with much-reduced webs (page 752), its voice, and, of course, its highly specialized environment and lack of migratory habit.

How did the Hawaiian goose evolve? Some biologists guess that a mammal or bird may need 500,000 years of isolation to develop as a distinct species. Hawaii is at least a million years old, and Maui is even older; both have always been volcanic. So an occasional northern continental goose, a stray Canada or its brant cousin, might well have found itself

**Help from Britain:** In 1952 the Wildfowl Trust in Slimbridge, Gloucestershire, began to breed nene in England with two females and a gander from Hawaii. Ten years later, the first of 93 offspring return home (below).

At Honolulu International Airport, the crated birds nibble lettuce. Later, Boy Scouts pack the geese across Maui's cindery Haleakala for eventual release in the wild (page 750).



at home on the tundra-like uplands of the lava flows. A pair or gaggle of such geese might have arrived on Hawaii and, through wing injury or similar accident, settled down to break the silver cord tying them to the age-old migratory habit. Isolation and fifty thousand generations would do the rest.

The history of the nene since Western settlement has been a sad one. They became sought as a table delicacy to relieve the tedium of salt pork, fish, and the tuberous island vegetables. Nene are delicious, but their tameness hardly qualifies them as game birds.

#### Species Near Extinction by 1911

Thousands of the birds were slaughtered and salted down in barrels to provision whaling ships. Legend holds that they also fed the forty-niners during California gold-rush days; the clipper-ship trade was so highly developed that laundry from California was brought to Hawaii to be washed. Along with the clean laundry, the ships took potatoes, fruit, pork, chickens, and nene back to the mainland.

By 1902 naturalists were already warning against the 4½-month hunting season on nene, which allowed each hunter six birds a

day. Not till 1911 was the season closed, but the damage had already been done. Nene flocks continued to dwindle.

An old-timer of Hilo on Hawaii, Herbert C. Shipman (page 751), had in his youth seen skeins of flying geese in the rugged lava uplands. He wondered: Could they be brought back? In 1918 he accepted a pair of nene offered him by a friend. Shipman had a coastal country place near Hilo, at Keaau. Why not keep the geese there?

In spite of mongooses, which ate a few fledglings, Shipman's pair multiplied and flourished. Another bird or two came his way a few years later, and by 1927 he had a small flock. The state of the wild nene was now so deplorable that the Territorial Commissioners of Agriculture and Forestry asked Shipman to give a few pairs to the new Mokapu Game Farm on the island of Oahu.

The game farm managed to rear 31 nene. Territorial legislators and their rancher friends vied for the privilege of obtaining for their home islands some of Hawaii's own geese. Pairs were shipped off to such islands as Kauai, Lanai, and Molokai—where the geese had never occurred in nature. No one

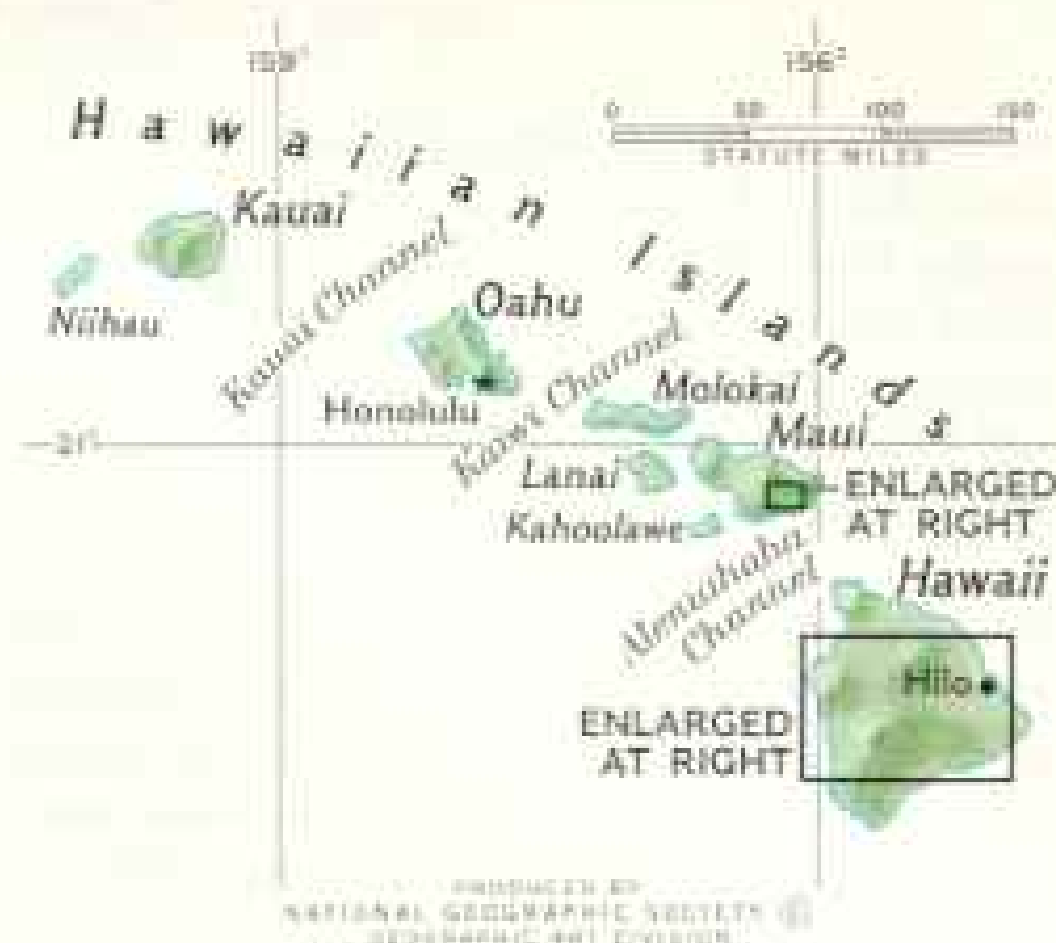
PHOTOGRAPHS BY DEEKE BAYEL, BLAKE STAN (OPPOSITE), GERRIE, AND JERRY CHUNG © 1983





PHOTOGRAPH BY JERRY CHONG © N.G.S.

**Journey's end:** Geese reared in captivity are freed on the secluded, rain-drenched eastern rim of Haleakala, on Maui Island, where trade winds form cloud rivers at the crater's edge. Here the nene, state bird of Hawaii, grows plump on grasses, herbs, and berries.



apparently bothered to study the ecology of this strange bird, and the attempted distribution was not a success.

When we called on Mr. Shipman last January in Hilo, he recalled the failure.

"I was distressed when they wasted those wonderful birds, but we still have others," he said. "Come up and see mine before you leave the island. The marvelous nene is coming back. That's what matters!"

#### Seismic Sea Wave Drowns Rare Flock

In the 1930's reports of wild nene on the island of Hawaii were few, and the Maui population was judged extinct. Twice during this time full-grown birds flew away from Mr. Shipman's estate at Keaau, first eight and then five. He has often speculated that some of the sightings on the rugged slopes of Mauna Loa 40 miles to the southwest may have been his escapees. From then on, sightings of wild nene were extremely rare.

On April 1, 1946, a tsunami, or great wave, struck Keaau, and most of Mr. Shipman's nene were drowned. Of 43 in his flock, only 11 survived. These he moved to Ainahou, an upland ranch not far from Kilauea Crater. Here his flock flourishes today. And here we found him surrounded by his famous nene—16, including one on a nest.

Mr. Shipman's mountain ranch house sits in a forest half an hour's drive from the Volcano House Hotel. The eastern slopes of Kilauea lie on a vast unstable volcanic rift, and craters with sheer walls as high as a thousand feet pock the jungle. Some have been inactive since prehistoric times; others, such as Kilauea Iki and Kilauea, have erupted in recent years.\*

\*NATIONAL GEOGRAPHIC reported on "Fountain of Fire in Hawaii" in the March, 1960, issue.

**Rugged island habitat:** Only on two of the Hawaiian Islands has the nene ever lived in the wild. In 1957 conservationists found and began protection of the principal breeding ground on Hawaii. Here most of the island's 220 geese nest from October through March, hidden in *kipukas*, swaths of meadow scattered through crumbling lava beds. When fledglings can fly, families move to nearby feeding grounds. The nene population was judged extinct on Maui in the 1930's. More than 120 geese raised in captivity have immigrated since 1962 to Maui's Haleakala National Park, but the elusive birds have yet to reveal nesting sites there. Today about 340 nene roam the two islands, where 150 years ago the shrill cries of 25,000 filled the skies.

Quakes and quivers still shake the earth—one occurred early this year—but in the forest of Ainahou the only sound is the drip of raindrops off the trees, the souging of wind in the twisted branches, and spurts of tinkling notes from little darting Hawaiian birds: the green amakihi, the raspberry apapane, and the vermilion-and-black iiwi. And, of course, at Mr. Shipman's the rarest sound of all: the under-the-breath, strangely conversational moan of the nene.

After seeing our first five nene on Hualalai, we bumped our way down to the saddle. Here on an open, desertlike plateau of red lava cinders, we saw an ancient shrine, Ahuaumi Heiau, a tumbled wall of rocks and boulders. We had stopped to examine the massive structure when Mary gasped, "Look! There are some nene!"

#### Breedings in Wild Lift Hopes

Sure enough, a pair of nene, the tall gander in the lead, walked around the pukiauwe bush (*Styphelia tameiameia*) with its white, pink, and red berries. The pair climbed over the boulders, scrambling up to a greater height, perhaps to get a better look at us (page 744). We stalked them for nearly a hundred yards before they took wing. With great satisfaction we saw that these were birds without leg bands—wild-bred nene on part of the ancestral range!

To Dave Woodside, Mary, and me, this wild-bred pair was a moving symbol of the success of a program that had absorbed us and other champions of the nene for almost two decades.

In a 1946 visit to Honolulu, I had met Mr. Colin G. Lennox, President of the Territorial Board of Commissioners of Agriculture and Forestry, and Mr. Vernon E. Brock, Director



HALEAKALA NATIONAL PARK, MAUI



THE SADDLE REGION, HAWAII



No man has done more to save the nene than rancher Herbert C. Shipman, who began raising the rare geese in 1918 at his country home, Keaau, near Hilo, Hawaii. Though a seismic sea wave in 1946 drowned most of his nene, Mr. Shipman saved 11, enough to replenish his flock.



of the Board's Division of Fish and Game. Mr. Lennox and Mr. Brock were keen to rear nene again, and a project was authorized.

I had been rearing wild waterfowl on our property in Connecticut since 1931 and was eager to participate. By 1947 Mr. Lennox and I were writing about the possibility of shipping nene eggs to Connecticut.

#### U. N. and Britain Join In

Instead, plans continued to develop for a rearing project on Hawaii. In 1949 a former Civilian Conservation Corps camp at Pohakuloa in the saddle area was taken over. Again four of Mr. Shipman's birds were available, as were two others, one from the Honolulu Zoo and the second a wild bird caught by a hunter's dog.

Now the nene goose affair became truly international. The UNESCO-sponsored International Union for the Protection of Nature in 1949 placed the nene on a list of the 13 most threatened bird species of the world. Then, in 1950, Peter Scott, Honorary Director

of the Wildfowl Trust in England, sent his curator, John Yealland, now curator of birds at the London Zoo, to spend a season at Pohakuloa and develop techniques for rearing young birds. That winter two goslings were hatched and reared there.

Mr. Shipman sent two of his precious birds—presumably a pair—back to England to the Trust with Mr. Yealland. The following year, to the consternation of all, both nene proceeded to sit down and make nests!

A proven gander was flown to England, and by 1952 Peter Scott's program was off to a fine start (page 748). The gander, called Kamehameha after the most famous of Hawaiian kings, mated with both geese, and nine young were reared.

Production has continued steadily in England ever since, and 195 descendants of the original three have been distributed to noted game breeders in Denmark, England, France, the Netherlands, Switzerland, West Germany, and the United States.

By 1958 Peter Scott had stock enough to

**Priceless clutch** of nene eggs requires frequent turning by the mother, who nudges them with her bill. Incubation takes 28 to 31 days.

PHOTOGRAPHS BY JERRY CHUNG (BELOW) AND ROBERT F. SIVON © N.A.C.



**Nene foot** (immediately above) shows little webbing compared with that of the Canada goose (upper) and reflects nonaquatic habits.

Young nene take to the air in 10 to 12 weeks; as adults they are annually grounded for four to six weeks because of molting. The wild goose is endangered by predators, poaching, and its shrinking habitat.

send a pair part way home—back across the Atlantic to our own farm in Litchfield, Connecticut. From this beginning we have so far reared 25 nene, the only breeding stock on the North American mainland.

### 28 Wild Geese Spark Revival

Meanwhile, the plight of the wild birds was still of great concern. While I was visiting Pohakuloa in 1954, Dave Woodside told me, "You know, it's been 12 years since any real flock of nene has been sighted."

We shook our heads, worrying. "If the wild flock is really gone, I don't know that the captive rearing program can work," Dave said.

In July, 1955, Dave dispelled his own doubt and dismay. He sighted 28 birds in a single flock and spent 17 rapt hours observing them. If there could be an unknown flock of that size, the nene might indeed survive.

The news encouraged interest in the birds. An unofficial nene committee was formed in Honolulu, and efforts were made to interest ranch owners of the "Big Island," as the is-

land of Hawaii is called, in setting aside land for a nene park. Legislation for a restoration survey was introduced. In 1958 the U. S. Bureau of Sport Fisheries and Wildlife approved a Federal grant for a five-year project. And the nene was officially designated the territorial—now the state—bird of Hawaii.

The previous year Prof. William H. Elder, working with Dave Woodside and Ah Fat Lee (below), present caretaker of nene at Pohakuloa, had discovered the long-sought principal nesting ground. They also found that a big flock—now perhaps well over 50—leaves the nesting area to loaf from June to early September in the saddle between Mauna Loa and Mauna Kea, at times flying over Route 20 where it winds up from Hilo. This summering area corresponds to a nonbreeding wintering range for migratory geese.

The nesting season may run from October through March. Pair by pair, the nene return to the higher slopes to seek out individual ancestral patches of meadow, called *kipukas*, islands in the deserts of lava.

Fuzzy gosling, eight days old, merits tender care of breeder Ah Fat Lee at the State Division of Fish and Game's Pohakuloa station. If present programs continue for ten more years, conservationists believe the world nene population will rise to a safe 2,000.



After February, danger surrounds the nene until late May. This is the flightless period for the young, and the molting time for the adults. But the little kipukas are about the safest place the geese can go. There is plenty of food: grasses, succulent herbs, and various berries. Here predators are seldom found—the mongoose, wild dog and cat, and the wild pig. The rare Hawaiian hawk occurs, but it is a vanishing native species and hardly a menace.

Last January we spent a sunny day clambering over some of the most jagged terrain this side of the moon. High on Mauna Loa, above 6,000 feet, lies a long eastward-stretching ridge of *aa*, tortured, friable brown lava that looks like giant shredded wheat. Over this we Lilliputians struggled, one foot at a time, fearful of dashing ourselves into a crevice at every step. Boulders disintegrated, flaked off, or turned underfoot. Here and there, half a mile or more apart, were kipukas around which the lava had flowed, leaving these smoother, older, shrub-covered lava patches intact as possible nene feeding and nesting sites.

On the wildest, bleakest stretches we found ten more nene, including a female with a featherless brood patch—a sign of recent nesting. Because this is the most secure home of the nene, the state so far has released more than 170 birds here to join their wild kin, now probably numbering more than 50.

#### To Nene Haven on a Mule

Leaving the Big Island, Mary and I flew over to nearby Maui. The island has only about 20 square miles of nene habitat in and around the crater of 10,000-foot dormant Haleakala, compared to the 600 square miles of such habitat on Hawaii. Maui was a known former home of nene, and it was here that four combined releases of English, Hawaiian, and my own Connecticut-reared geese were made in 1962, 1963, 1964, and 1965.

Ninety-three birds came from the Wildfowl Trust, 26 from the Hawaiian nene project, and I sent seven. As many as 40 have since been seen in the crater area at one time.

The release area on Maui is deep in Haleakala crater, 1,800 feet below the irregular rim. We rode down the steep trail on mules and horses with Jimmy Lindsay of the National Park Service in the lead; then came photographer Jerry Chong, Mary and I, and Joe Medeiros, state wildlife biologist on Maui. As we wound down the trail, hardly daring to look 1,800 feet down, Joe was singing "Hello,

Dolly!" into the wind, wisps of cloud swept up over the crater lip, and my mule kept stopping to kick me in a perfunctory, protesting manner on my left foot.

"Mary," I said, "this looks like the worst wild goose chase we've ever been on."

Five hours later we reached the farthest corner of the crater, beyond the bare slopes of reddish-brown ash and cinders. Here grew a cluster of old trees: ohia (*Metrosideros collina*) with their beautiful fuzzy red flowers, and kolea (*Suttonia lessertiana*), a dye tree used by the Hawaiians to color tapa cloth. The place is called Paliku and has a cabin for visitors to the national park.

#### War Against Extinction Appears Won

In an adjacent lush meadow of grass and gosmore, a favorite nene food which looks like dandelion, we saw the fenced-in release pen where nene are placed to feed and grow accustomed to their surroundings. Later they replace their plucked flight feathers and fly off into the vast reaches of the mountain—to breed and nest, we hope.

The four releases have all been made in midsummer, so that by October most of the birds are making short exploratory flights from the one-acre pen. Each year crated birds have been brought in by pack animals or on the backs of park naturalists, rangers, fish and game men, or Boy Scouts (pages 748-9).

On July 30, 1963, and again on July 28, 1964, when the weary party had finally straggled across the miles of crater to verdant Paliku, there on the boulders, peering at the new arrivals, were nene of the year before. They, too, had just arrived, how and by what alchemy no one knew. In all, 9 were sighted in 1963 and 13 in 1964.

Each year it has been this way. Old nene arrive to greet the new, to perch on the boulders, finally to fly into the pens to peck the newcomers gently and gabble before settling down on the lush grass. Four were on hand to welcome this year's party last August 9.

Thanks to the dedication of a few men, notably Herbert Shipman, Peter Scott, and Hawaii's conservation officials, there are today more than 500 nene in the world. Fifteen years ago there were fewer than 50. It is no small triumph to pull a species back from the brink, to save the habitat, and then to breed the numbers to replenish that habitat. In such achievements, man turns the tables on the relentless forces which he himself so often has unleashed.

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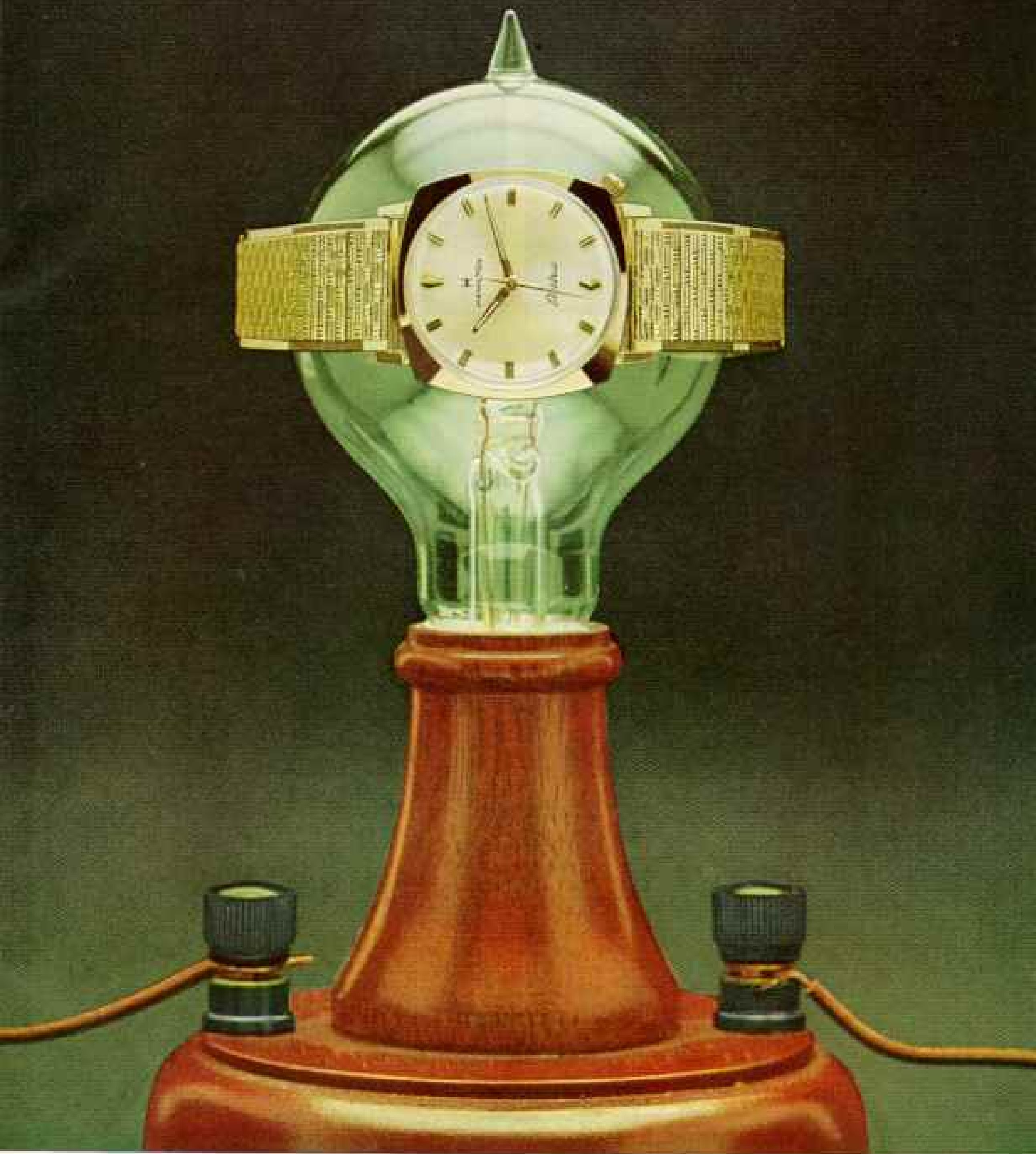
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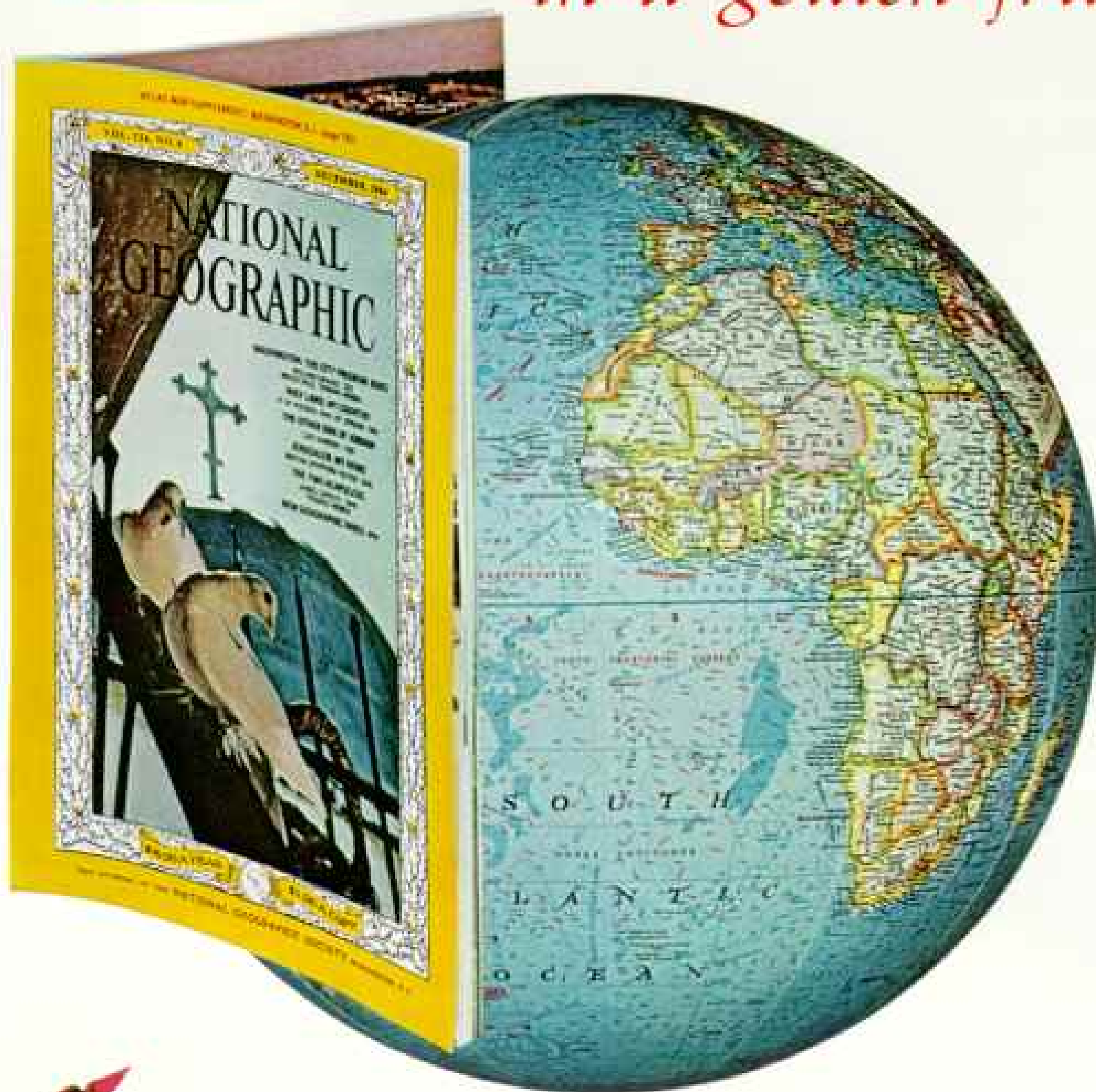
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A word about cabinet styles. See Spanish, Early American, Contemporary, Scandinavian, French or Italian Provincial—and more. All are faithful adaptations, rich in fine furniture detail, glowing with the deep beauty of magnificent woods and costly veneers.

Good reasons, aren't they, for looking at RCA Victor Color TV first? You'll see why more people own RCA Victor Color TV than any other kind. Shouldn't you?

\*21-inch tube (overall diameter)—265 sq. in. picture

\*\*25-inch tube (overall diagonal)—295 sq. in. picture



**COLOR**

# Bell & Howell would like to tell you about a great new achievement from its biggest competitor.



The new Kodak Super 8 movie film. That's it over there. In the little black cartridge. And that's how you buy it. Preloaded and ready to slip into a movie camera.

Great idea? We thought so too when Kodak first described it to us.

So for over a year now, while they've been perfecting the film, we've been designing a Bell & Howell camera for it.

It's ready: the Bell & Howell all-electric Super 8. Drop in the cartridge and you've not only loaded the camera, you've also set the film speed and filter. Automatically.

And that's where we could have stopped. Instead, we added a self-powered zoom. And a new kind of electric eye that lets you take pictures even in glaring daylight. And a highly sophisticated lens system.

And a few electronic safeguards that make the Bell & Howell Super 8 about as foolproof as a movie camera is likely to get.

Sure that kind of precision instrument is tougher to turn out than an ordinary camera. But we learned one thing a long time ago: the harder we make things for ourselves, the easier it is for you.

Now ready. Smile!



The Super 8 film cartridge



loads instantly

for push button movies.



Zoom out.



Zoom in.

## Bell & Howell

builds photographic instruments a little better than they really have to be.

# *Presenting the nineteen sixty-six Cadillac*

The finest of all Cadillacs is here! It greets you with an exciting new elegance, highlighted by a totally new split-level grille and new clean-swept body contours. Inside you'll admire breathtaking new leathers, fabrics and new appointments (with dramatic walnut paneling on all Fleetwood models). And Cadillac's traditional engineering excellence rewards you

with a number of suspension, chassis, and acoustical advances providing a new realm of quietness and relaxation. You'll marvel at the alert response of Cadillac's new variable ratio steering and easier handling. Today, tomorrow or very soon . . . discover the unmatched excitement of Cadillac for 1966—now on display at your authorized Cadillac dealer!

Top, the De Ville Convertible; bottom, the Fleetwood Bravado. Cadillac Motor Car Division • General Motors Corporation



*New elegance, new excellence, new excitement!*





## “A piece of your insurance? Buy me the lunch instead!”

If you hand out your business insurance in bits and pieces — as “favors” to several agents — you’re not doing any one of them a real favor. Actually, you’re just putting *yourself* on the spot.

All you’ve done is divide responsibility, leaving each agent in the dark on the extent and quality of your coverage. So unless you’re an insurance expert yourself, chances are you’re either paying too much or you’re inadequately protected.

You can be *overinsured* . . . paying for duplicate coverages that lead to confusion and delay in settling claims. You can be *underinsured* . . . with too little or no coverage in some important areas.

It just makes good sense to entrust all your insurance — for business and family — to *one responsible agent* who will *earn* the right to work with you and for you.

An Aetna Casualty agent will do just that. He is fully qualified to make a thorough, professional

analysis of your needs. He’ll design a program to fit these needs exactly, and then review it periodically to see that you remain both *adequately* and *efficiently* protected.

Aetna Casualty will back up your agent, too — with the wholehearted support of one of the largest and finest field organizations in the business. It’s all a part of what we call P.S. — *Personal Service*.

So why not let an Aetna Casualty agent *earn* the right to handle *your* insurance? If he doesn’t give you better insurance service than you ever knew existed — make *him* buy the lunch.



Are you using valuable working capital to pay insurance premiums a year in advance? With Budget-Rite, Aetna Casualty’s new, low-cost plan, you can pay monthly. It’s convenient and businesslike. Ask your agent about Budget-Rite.

**Aetna**  
LIFE & CASUALTY

Don't miss "National Geographic: Miss Gondal in Africa" on CBS-TV, Wednesday evening Dec. 22.



### New Westinghouse Jet Set.

It doesn't stare back at you when it's off.

It's considerate television. Beautiful off. Beautiful on. A new kind of picture that's easier to watch. It's Instant-On™ TV. Which means no waiting, no warm-up, no walk-back. And it's transistorized to be trouble-free. Now, if you can't stare your old set straight in the face and enjoy it... go see your Westinghouse dealer.



You can be sure if it's Westinghouse 



*1966 Thunderbird:  
America's  
Personal Luxury Car*

Of the world's great luxury cars, only Thunderbird is so completely dedicated to the idea of personal luxury.

Among many innovations for 1966, there is a new, more formal Town series with its own distinctive roofline. The classic Thunderbird look, in convertible and hard-top models, is still available.

This year, too, Thunderbird leads the way with unique features like a Safety Convenience Panel mounted overhead in the new Town models. This panel warns the driver if a door is ajar or fuel is low, and reminds him to fasten his seatbelt. A similar unit is dash-mounted, on





1966 Thunderbird Town Hardtop

other models. A new, more powerful Thunderbird V-8 engine is now standard. Or, if you wish, a remarkable new 428 cubic-inch V-8 is offered as optional equipment. Another distinctive Thunderbird option this year is an AM Radio/Stereo Tape system.

Let your Ford Dealer show you why Thunderbird continues to be America's one *Personal* Luxury Car.



This panel in Town models tells when doors are ajar, seatbelts unfastened, fuel low, emergency flasher is operating.



Smart new roofline for Town Landau and Town Hardtop is the newest of Thunderbird's 1966 styling innovations.



Highway Pilot Control switches are on the steering wheel to set, maintain and resume highway speed automatically.



Integrated AM Radio/Stereo-ionic Tape System is cartridge-loaded, snaps in, snaps out, needs no threading.



Thunderbird's unique Sequential Turn Signals in full-width taillights signal each turn with a ripple of light.

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Nassau's waterfront fruit market. Photograph by John Lewis Stage.

## Nassau's markets aren't super. Simply colourful.

You won't get a single trading stamp when you're shopping Nassau's colourful water-front markets.

You'll sample seafoods, fruits and spices from the outer islands and quickly discover that easygoing humour is the main produce of the Bahamas.

Laughter will follow you through the gay straw markets, on a carriage ride, through the cocktail hour and "over the hill" on your dusk-to-dawn tour of Nassau's gay native night clubs.

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**Bahamas**



## Missile chess

This may be the world's most serious game. Our ability to play it well can be the difference between whether we live in our own free world or behind someone else's walls.

So in Douglas laboratories, researchers are working on making missiles invisible to detecting devices. Every advance they make is communicated to another group of Douglas engineers and scientists engaged in developing systems that seek out and destroy "invisible" missiles. When the second group succeeds, those hiding missiles

in the sky go to work again to break the checkmate. Continuous improvement is needed if the U.S. is to maintain leadership in missile technology.

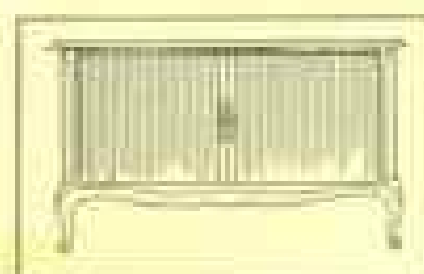
The Douglas approach grows out of experience gained in producing a greater number and diversity of missiles than any other company. These include such great performers as *Thor*, *Hercules*, *Sparrow*, *Genie*, *Zeus-Nike X*.

IN THE AIR OR OUTER SPACE

**DOUGLAS**  
GETS THINGS DONE

# MOTOROLA RECTANGULAR

## COLOR TV



*First  
with the  
big rectangular picture  
in the slim  
color set*

Touraine styling by Drexel

Motorola introduced the new generation of Color TV . . . the first with a big rectangular picture in a slim color set ever mass marketed in America.

The color pictures are full, bigger than on round-tube Color TV. The cabinets are thin, slim, elegant.

And, because Motorola's rectangular color tube is up to 5.2 inches shorter than round color tubes, cabinets fit close to the wall. Some are designed by Drexel, exclusively for

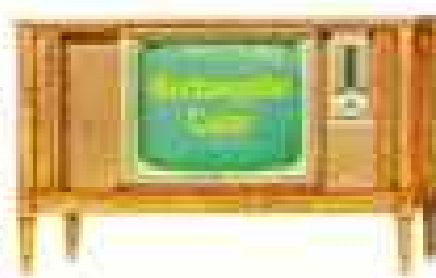
**MOTOROLA**

New leader in the lively art of electronics

Motorola, many models have push-button UHF tuners, and a number have full-function remote control. All have Motorola's power transformer chassis, color indicator light and many other features contributing to Motorola's famed dependability. So why settle for round-tube Color TV? Get the rectangular one with the big picture, the slim cabinet, the fresh features. From Motorola . . . the people to see for Color TV.



Over 20 color models to choose from



1, to 8: Early American; Triune styling by Drexel with doors; Compact cabinet with doors; Color TV-Stereo Combination.





## ***COMMUNICATOR***

*It's 8 a.m., Tuesday, in Melbourne. It's 5 p.m., Monday, in Detroit. And here—at the "heart" of General Motors' new world-wide communications network, an operator speeds a message on its way to Australia. At the start of the business day a GM executive group will have available a vital report—ready to act upon.*

Through advanced electronic switching gear in the GM Communications' network, virtually any GM location in the world may contact any other GM location, regardless of the type, or speed of equipment at the other end, whether by magnetic tape, punched paper tape, punched cards or printed copy. Speeds vary from 60 words per minute to 3,000 and more!

Approximately 23,000 messages of all kinds flow through Central Office in Detroit on an average day. This system puts the facts, figures, orders and ideas of GM people within brief minutes of other GM people reached through 72 regional communication centers in the U.S. and Canada, plus overseas locations as widely removed as Sweden and South Africa.

Interplay within the GM team is vital to its progress. Thus, the "Communicator" fills a keystone-position.

**General Motors Is People...**  
 making better things for you



## Why the man in Cabin 54



## is taking a great President Liner to the Orient

Taking *this* business trip is a pleasure. Aboard a President Liner he doesn't have to worry about connecting schedules, hurrying crowds, baggage limits and hotel reservations. He can relax.

A few steps away is a heated pool. One deck up are game courts for deck tennis and shuffleboard. Two decks down is his air-conditioned stateroom with bath, radio, telephone, 24-hour room service.

The only executive decisions he has to make are (1) what to choose

from each day's tempting new menu, and (2) whether to spend the evening at a party, a movie or a dance.

Every two weeks a President Liner sails from San Francisco to Hawaii, Japan, Hong Kong and the Philippines. Forty-day round trip fares start at \$1519 First Class; \$725 Economy Class (with special reduced fare cruises during the Holiday Season). Consult your local Travel Agent or American President Lines for full details.

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# The tiger scores again!

It's dramatically fresh and new, but still very, very Pontiac. That's written all over it, from the no-doubt-about-it new front end to the trimly tailored rear. (Did you think for one minute that we'd leave out the unique Pontiac styling character you like so well? Never!) Another nice thing about the '66 Pontiacs is that there are more of them—3 new super-

sumptuous Broughams and 4 Venturas. And of course for you other Pontiac lovers we've got a bright new Grand Prix, new Catalinas, new Star Chief Executives—all with new Wide-Track ride and improved cat-quick handling. But you'll discover those things when you turn one of our new '66 tigers loose. You'll find them where all the people are. Where else?

*The formidable 2+2, also available as a hardtop.*





# ...and again!

You're looking at the newest thing in tigers. Sleek, lean-muscled, new style. New power that starts with a revolutionary new kind of six and ranges through four V-8's. Crisp curves shape the new silhouette, and the sports coupe sports a new kind of smartly recessed rear window. Pontiac's revolutionary overhead cam six acts more like a V-8, looks like no six you

ever saw, and still remembers that saving is what six buyers buy sixes for. Delivers 165 hp. (or you can specify the sports package which includes the 207-hp version). And it's standard on all Tempests, Tempest Customs and Le Mans. V-8's? Up to 360 hp in the GTO. See all the '66 tigers. If you can resist buying one, maybe you just don't like cars.

## Wide-Track Pontiac/'66

*The ultimate tiger: GTO—also in sports coupe and convertible configurations.*





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## The Point

The point is reality. The reality of all the little things . . . the many, insistent echoes of a history that makes itself felt, heard, seen . . . and lived. They add up, in Williamsburg, to an enchanting haven of our colonial past where the eighteenth century lives on. When you come, enjoy a gracious stay at the Williamsburg Inn, Williamsburg Lodge, or The Motor House. And look for unusual, fascinating little things like this old newel post on a gate of yesterday.

*Where to stay:*

For color brochure, rates and reservations at Williamsburg Inn, Lodge, Colonial Houses, The Motor House, write F. G. Wright, Box C, Williamsburg, Va. 23155. Or call Reservation Offices: New York Circle 6-6800, Washington Federal 8-8828, Baltimore ask operator for ENTERprise 9-8855.

COLONIAL  
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# Finally, Perfected Color Television.

It's as easy to tune as  
black and white.



Up to now, there were two problems with color television sets.

One, they were hard to tune.

And two, once they were tuned almost any outside interference (airplanes, cars, electric shavers, vacuum cleaners, even aluminum siding) threw the picture out of whack.

General Electric has taken care of both.

#### **New Magic-Memory tuning.**

We developed a new kind of tuning system called Magic-Memory tuning.

What's magic about it is that it's ridiculously easy to tune. All you do is turn all the dials until their pointers point straight up.

That's it.

Some people say they can get a perfect color picture in less than 10 seconds.

#### **New color coaxial cable.**

Then we tracked down what was picking up all the outside interference.

It was the old flat lead-in wire that connected the set to the antenna.

So we redesigned our sets and added a coaxial cable lead-in.

(Coaxial cable is what TV studios use because it has two layers of plastic and one layer of woven metal to shield against outside interference.)

What we had when we finished was the first really Perfected Color Television set. Bright, clear, natural color with no more fuss than black and white.

And that's what a lot of people tell us they've been waiting for.

If you're one of them, see your G-E dealer.

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GENERAL  ELECTRIC

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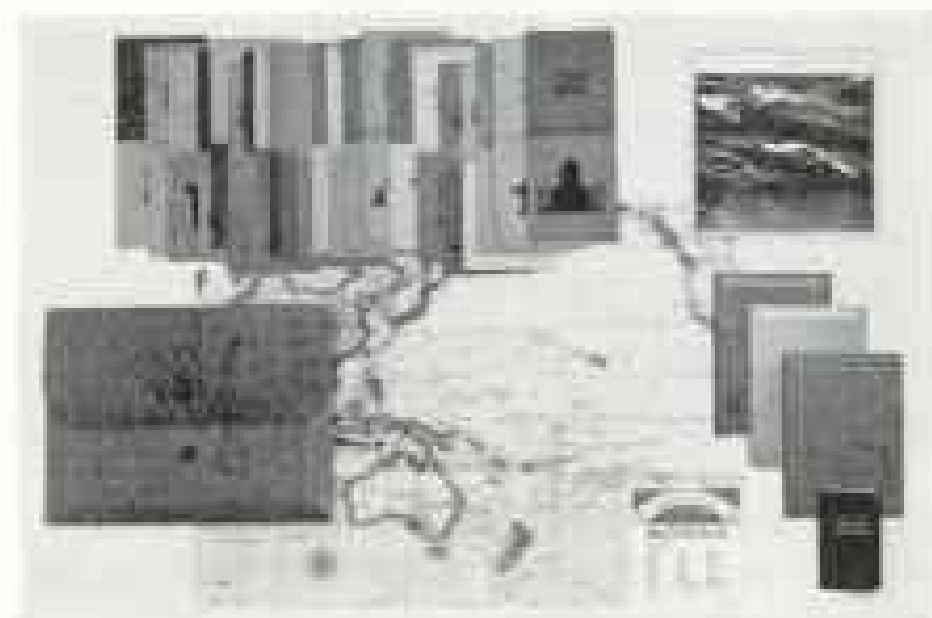
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Here is the ancient, first frontier, where East and West meet—and part.

Here it all began, and here is the all-there-is.

You may stand on the very spot of Creation itself—where in Hebron God talked to Abraham, where Noah's dove found an olive branch on the very hill you pause on to rest.

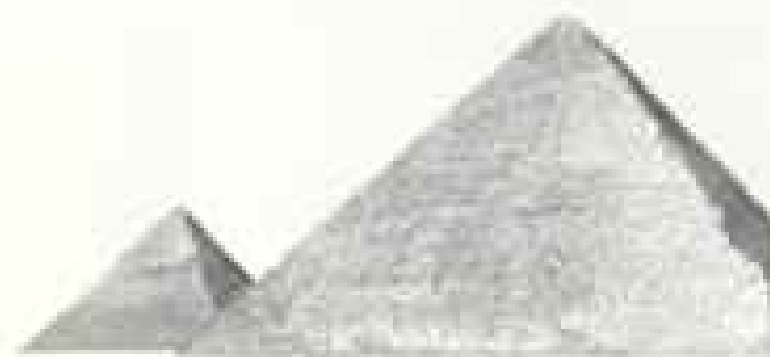
Yet, there is still the Orient of "A Thousand and One Nights."

The muezzin sounds, a hush falls, and the greatness of Allah endures. An aged Bedouin recounts the tale of a hero of old as his listeners sit in breathless silence. A chill wind blows off the desert, and in the starlight you see the ghosts of long-vanished nomads.

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And where a stable once stood in Bethlehem, where a cross once stood on a hill called Calvary, you stand in trembling wonder. Somehow your world will never be the same again.



Time takes on a very different dimension in this place, and you feel very close to Truth. Plan a trip to the Middle East now. What is more, the climate is perfect at this time of year, and rates are pleasingly reasonable.



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# \* Islands of hawaii \*



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HAWAII VISITORS BUREAU

# hawaii\*\*

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**COSTS**—Jet fares are as low as \$200 roundtrip from Pacific Coast; luxury ocean liner economy class from \$280, first class from \$414 roundtrip from California. Modern hotel accommodations on all islands start at just \$5 a day per person, double occupancy. And most of Hawaii's best attractions are free.

**WHAT TO BRING**—Average 74° weather means you only need clothes for one climate. Supplement your wardrobe with some of our colorful Hawaiian leisure fashions. Don't forget your camera! Naturally, you won't need passports, visas, inoculations.

**THINGS TO DO**—Lie on a beach, ride a wave, learn the hula, eat sushi, hit a hole-in-one, watch a sunset, go to a luau, sail a catamaran, sip a mai-tai, spear a fish, inspect a palace, give a lei, visit a Buddhist temple, study a volcano, wear a muu-muu, smile.

**WINTER EXCITEMENT**—This Winter is a fun-packed time in Hawaii. December: Christmas Festivals and International Surfing Championships. January: Hula Bowl, Chinese New Year, Narcissus Festival. February: Cherry Blossom Festival.

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Look at any map and you will find only one India. But come visit our country and you will find many. Each different. Each distinct. Yet each in accord with the others.

This is, you will forgive our boast, India's great fascination. It is a country of stunning dis-

similarities that, by some odd miracle, blend harmoniously together.

Therefore, it should not surprise you when an elephant lumbers past your air-conditioned hotel. Or when a new science building is dedicated on a date fixed by astrologers. Or when a golf course turns up on a hillside in Kashmir.

Nor should it surprise you to find a betel-chewing merchant sitting cross-legged in his shop reading *The Manchester Guardian*. Or to find a woman in a sari campaigning for Parliament from the back of a horse-drawn cart.

What should surprise you, however, is to be treated with anything less than the greatest

kindness and generosity by our people. Hospitality toward foreigners is something you will encounter all across India.

There is no disparity on that score.

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## India



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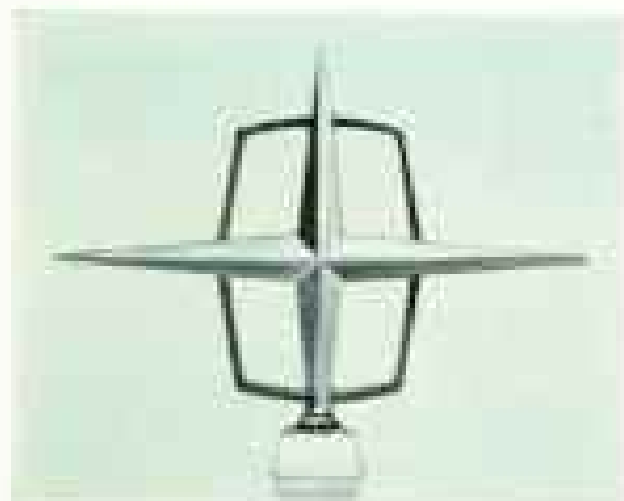
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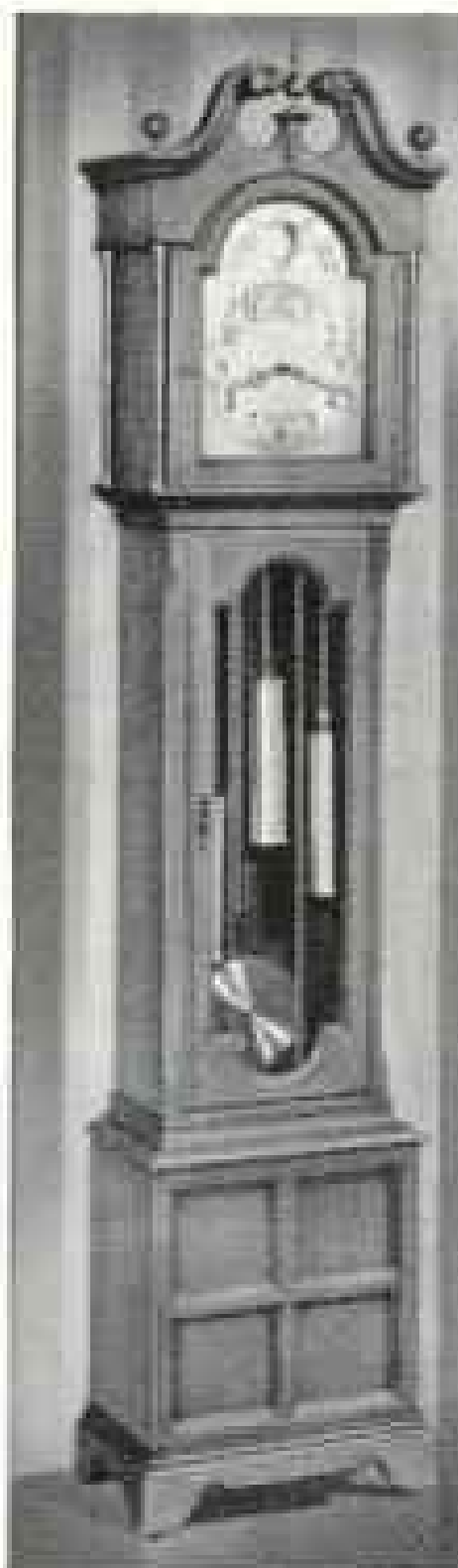
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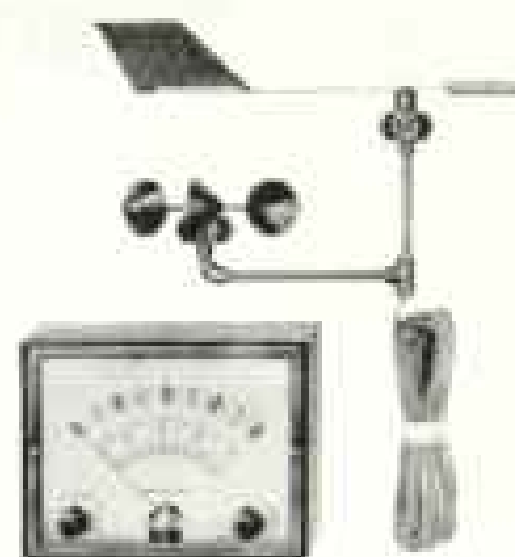
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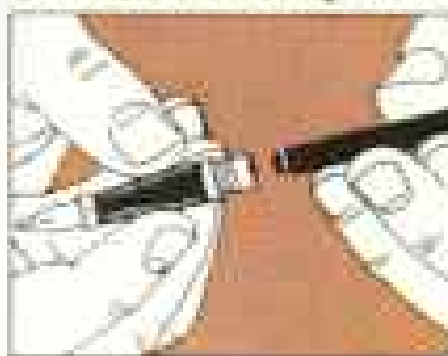
The Parker 75 is a gift both personal and memorable. No other gift can be so completely custom-fitted to its owner.

The beautifully sculptured grip nests his fingers in its curvatures. There is less pressure as he writes; his fingers do not tire.



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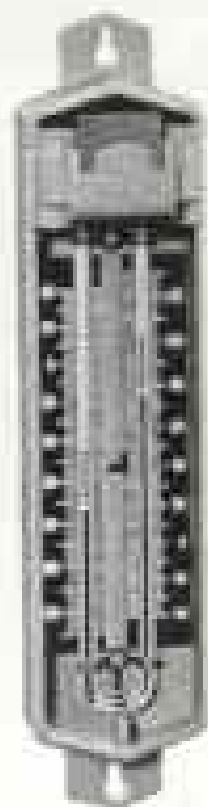
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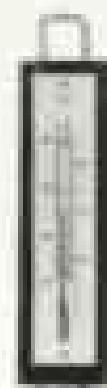
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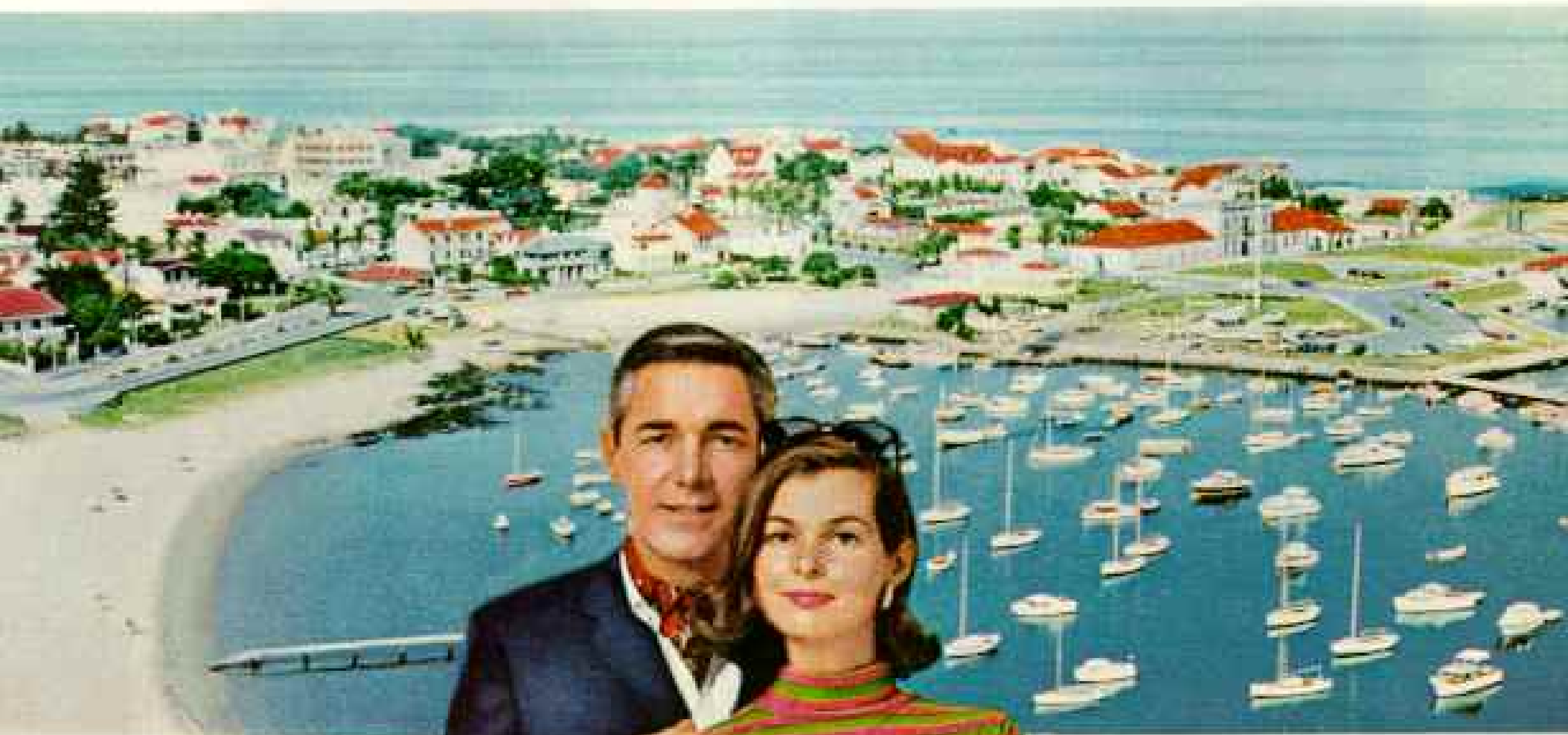
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Then, one cold day last December, a doctor friend embarked on a nonstop travelogue about a warm place called Punta del Este and, before he was through, we'd made up our minds to fly to South America to find it.

Punta del Este is, it turned out, just a short drive from Montevideo, the capital of Uruguay, which is a pleasant Pan Am flight from New York.

Like most of the shoreline around Montevideo, Punta del Este is miles of soft, white beaches, with temperatures rarely above 80, and life in general an utter whirl.

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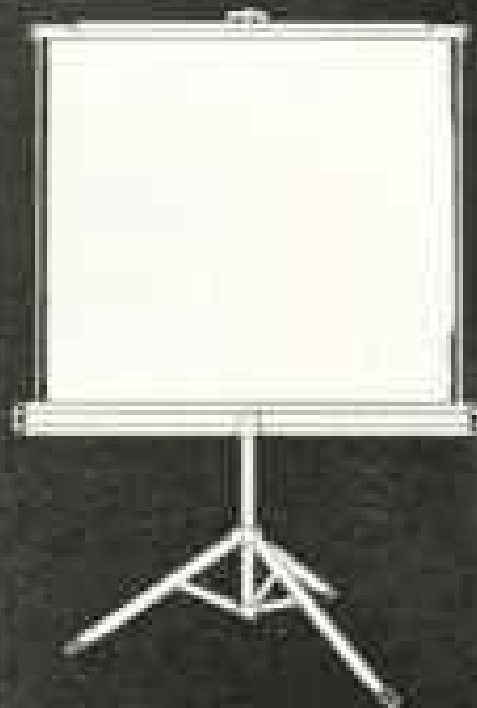
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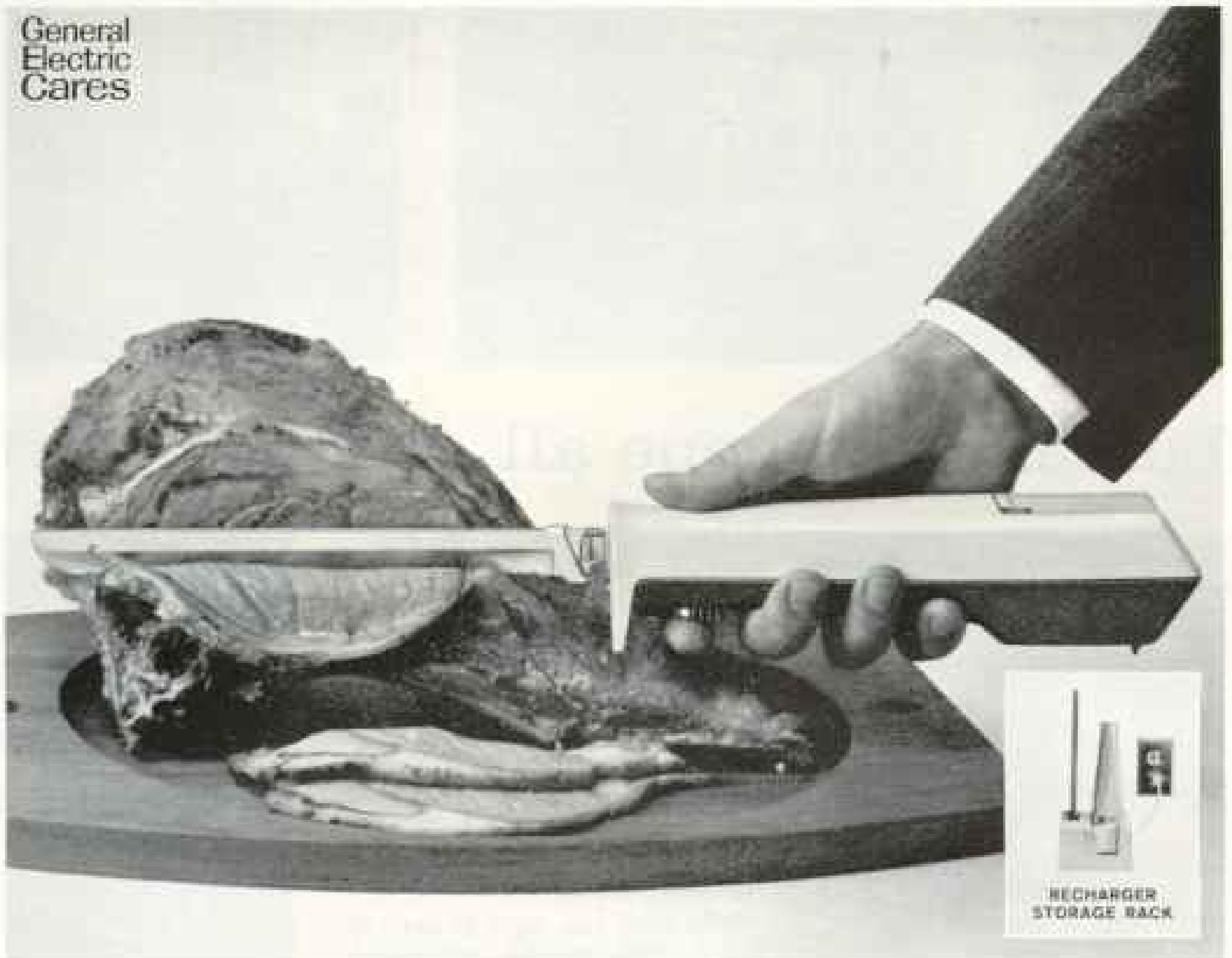
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## Introducing the tuned car. 1966 Buick.

*What makes a car a car is styling, performance, ride and handling. Only when they're all tuned together is the car a Buick. Like this 1966 Electra 225.*

*You know how well your car's engine runs after a tuneup? Buick tuning has the same effect on the whole car. Not just the engine. The whole Buick. Everything blends with everything else. Styling. Performance. Ride. Handling. All tuned to work together in harmony. That's what the tuned car is. A Buick.*

Can the tuned car really do anything for you that ordinary cars can't?

Stop, look and listen. And see.

**What you can learn from a look.** The beauty of a '66 Buick's beauty is that it goes beyond looks. Because we style the tuned car to look like a million dollars—and then build it as if looks didn't count.

So things fit on a Buick. The doors. The hood. Carpeting. You can see attention to detail wherever you look. (The reason we're so attentive is that Buick owners

have a long history of being attentive themselves. They're used to the best, and we aim to please.)

And things blend, too. You don't get the feeling that the rear deck doesn't belong with the grille, or that the interior doesn't really quite fit in. That's tuned styling.

**What a listen can tell you.** Buick thinks building a quiet car is more than a matter of insulation. In fact, we build our cars as if insulation never existed. We winnow out sound before it starts.

And when we have the car as silent as we can make it, we apply insulation. Just the right amount, just where it'll do the most good.

And so when you go driving, you don't hear a lot of little intrusions. But you do feel the road. We think road feel is important, in the tuned car. (Our engineers spend vast amounts of time out on the road, testing and checking and

re-testing. It's said that our chief engineer won't approve a design until we build it and he or his staff can test it.)

**A drive can do more.** Now that you've been introduced to the tuned car, you should meet it personally. The Electra 225 in our picture is perhaps the ultimate Buick. (It answers the question, "What do you move up to when you've been used to a Buick?") Among its standard features are power steering and brakes, Super Turbine automatic transmission and virtually everything you can think of to make driving pure pleasure.

Driving the tuned car will teach you more than you might suspect.

For one thing, you'll find out why Buick owners are so loyal. And so many.

**Wouldn't you really rather have a Buick?**