

AT MICROFICHE
REFERENCE
LIBRARY

A project of Volunteers in Asia

Small Gas Engines

by: James Gray and Richard Barrow

Published by:

Prentice-Hall, Inc.

Englewood Cliffs, NJ 07632 USA

Paper copies are \$12.95.

Available from:

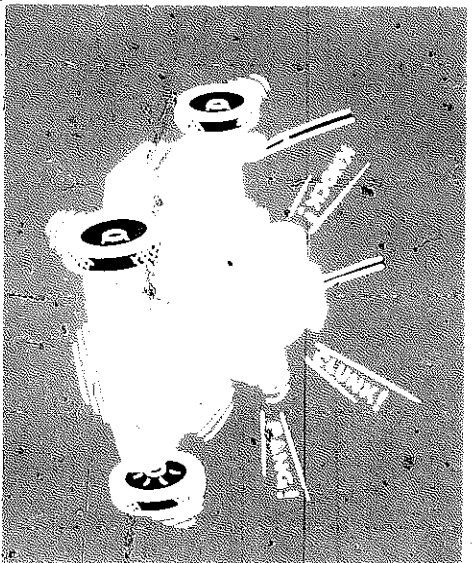
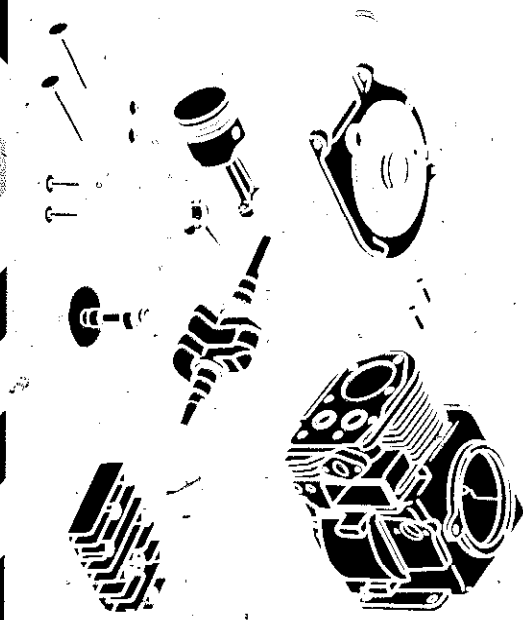
Prentice-Hall, Inc.

Englewood Cliffs, NJ 07632 USA

Reproduced by permission of Prentice-Hall, Inc.

Reproduction of this microfiche document in any form is subject to the same restrictions as those of the original document.

SMALL GAS ENGINES



SMALL GAS ENGINES

1974-75 Catalog

[The following text is extremely faint and illegible due to the low contrast of the scan. It appears to be a list of engine specifications or a detailed description of the product line.]

© 1974 Deere & Company

SMALL GAS ENGINES

James A. Gray and Richard W. Barrow

*School of Technology
Indiana State University*

Prentice-Hall, Inc., *Englewood Cliffs, New Jersey*

Library of Congress Cataloging in Publication Data

Gray, James A. (date).

Small gas engines.

Includes index.

I. Gas and oil engines--Maintenance and repair.

I. Barrow, Richard W. (date) joint author.

II. Title.

TJ789.G66 621.43'4 75-20245

ISBN 0-13-813121-X

ISBN 0-13-813113-9 pbk.

© 1976 by Prentice-Hall, Inc.
Englewood Cliffs, New Jersey

All rights reserved. No part of this book
may be reproduced in any form or by any means
without permission in writing from the publisher.

10 9 8 7 6

Printed in the United States of America

Drawings by *Robert F. MacFarlane*

PRENTICE-HALL INTERNATIONAL, INC., *London*
PRENTICE-HALL OF AUSTRALIA, PTY. LTD., *Sydney*
PRENTICE-HALL OF CANADA, LTD., *Toronto*
PRENTICE-HALL OF INDIA PRIVATE LIMITED, *New Delhi*
PRENTICE-HALL OF JAPAN, INC., *Tokyo*
PRENTICE-HALL OF SOUTHEAST ASIA (PTE.) LTD., *Singapore*

PREFACE

The intent of this manual is to provide the individual with enough information and guidance so that he can become actively involved with engines. The manual explains and illustrates the basic operational theory and service procedures for single-cylinder, air-cooled gasoline engines. The content is organized so that it can be used as a guide in diagnosing as well as performing minor and major engine service.

The manual is a resource for individuals actively engaged in the maintenance and repair of the small engine and a reference manual for academic instruction and reference.

Numerous tips and checks are presented which should help bridge the gap between theory and actual practice. Handbooks containing specific instructions and specifications are available from the engine manufacturers. These are an invaluable aid to the person servicing the small gas engine.

This book presents the "why" and the "how to" in individual packages with illustrations to tell the story. In depth scientific theory is *minimized* in favor of a fundamental understanding of how it works.

The manual also is intended for the home mechanic who performs his own maintenance and service on the small-engine-powered, labor-saving equipment common today.

Appreciation is expressed to the wives of the authors, Phyllis A. Gray and Virginia L. Barrow, who provided invaluable assistance in the preparation and typing of the manuscript. Sincere gratitude is also expressed to Doug Petry who prepared original illustrations and to George Lambert who assisted with the organization of the written materials.

*James A. Gray
Richard W. Barrow*

TABLE OF CHARTS

Section 1

Introduction to Single-Cylinder, Air-Cooled Engines

1 The Basic Engine	2	5 Compression Stroke	10
2 Principles of Combustion	4	6 Power Stroke	12
3 Engine Identification	6	7 Exhaust Stroke	14
4 Four-Stroke Cycle Theory and Intake Stroke	8	8 Two-Stroke Cycle Theory	16

Section 2

Basic Engine Testing

9 Compression Testing	20
10 Spark Testing	22
11 Basic Carburetor Adjustments	24

Section 3

Periodic Maintenance, Engine Tune-Up Procedures, and Storage

12 Lubrication	28	28 Carburetion	62
13 Cooling System	30	29 Air-Fuel Mixture	64
14 Spark Plug Service	32	30 The High and Intermediate Speed Circuit	66
15 The Ignition Circuit	34	31 The Idle Circuit	68
16 Electrical Terms	36	32 Carburetor Fuel Supply	70
17 Electrical Fundamentals	38	33 Built-In Fuel Pump	72
18 Ignition Primary Circuit	40	34 Engine Speed Controls	74
19 Producing Secondary Voltage	42	35 Fuel System Service	76
20 Flywheel Removal	44	36 Carburetor Service	78
21 Inspect Flywheel and Key	46	37 Air Cleaner Service	80
22 Breaker Points	48	38 Small Gas Engine Storage	82
23 Replace Breaker Points	50	39 Measuring Devices	88
24 Adjust Armature Air Gap	52	40 The Micrometer	90
25 Ignition Timing	54	41 Disassemble and Reassemble Instructions and Precautions	92
26 Parts of the Electronic Ignition	56		
27 Electronic Ignition	58		

Section 4

Four-Stroke Cycle Engine Service and Overhaul

42 Basic Components	94	51 Crankshaft Checks	120
43 Head Gasket Replacement	96	52 Main Bearing and Camshaft Checks	124
44 Engine Overhaul Preliminary Steps	98	53 Valve Lifter and Valve Guide Checks	126
45 Ring Ridge Removal and Basic Disassembly	100	54 Valve Seat Service	128
46 External Crankshaft Checks and Valve Removal	102	55 Valve Service	130
47 Opening the Crankcase and Piston Removal	106	56 Reassembly Procedure	132
48 Cylinder Measurements and Checks	110	57 Installing Piston Rings	136
49 Piston Checks	114	58 Installing the Piston Assembly	138
50 Piston Pin and Connecting Rod Checks	118	59 Camshaft and Crankcase Cover Installation	140
		60 Valve Adjustment and Installation	142
		61 Head Replacement and Final Reassembly	144

Section 5

Two-Stroke Cycle Engine Service and Overhaul

62	Basic Components	150	68	Piston Pin and Connecting Rod Checks	164
63	Minor Engine Service	152	69	Piston Checks	166
64	Reed Valve Inspection and Service	154	70	Piston Ring Checks and Installation	168
65	Engine Overhaul (Two-Stroke Cycle Engine)	156	71	Seal Replacement and Crankshaft Installation	170
66	Cylinder, Piston, and Crankshaft Removal	160	72	Cylinder and Crankcase Reassembly	172
67	Checking Wear of Engine Components	162	73	Final Steps of Reassembly	174

Section 6

Battery and Starter Testing

74	The Storage Battery	180	79	Rewind Starters	190
75	Battery Tests	182	80	Electric Starter—Bendix Drive	192
76	Battery Capacity Tests	184	81	Electric Starter Tests	194
77	Test Results	186	82	The Starter-Generator	196
78	Rewind Starters	188	83	Starter-Generator Tests	198

Section 7

Generator and Alternator Testing

84	Magnets	204	94	Regulated Flywheel Alternator	228
85	Electromagnets	206	95	A.C. Lighting Circuit	230
86	Residual Magnetism	208	96	The Generator	232
87	The Charging Circuit	210	97	The Generator Charging Circuit	234
88	Creating Current Flow	212	98	Generator Circuit Variations	238
89	Diodes	214	99	The Generator and Alternator Compared	242
90	Basic Alternator	218	100	Basic Generator Tests	244
91	Low Current Alternators	220			
92	Flywheel Alternator System Testing	222			
93	Flywheel Alternator Component Testing	226			

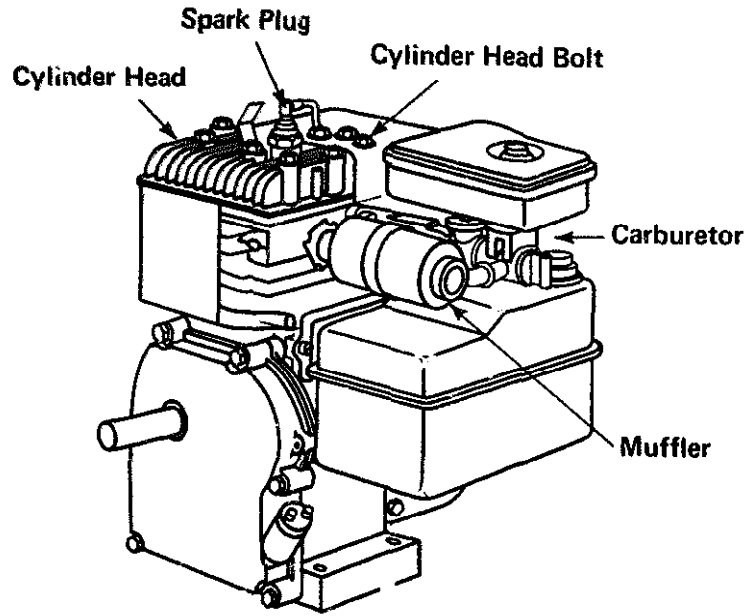
Note: For coverage of specific subjects, see index, pages 247–248

Section I

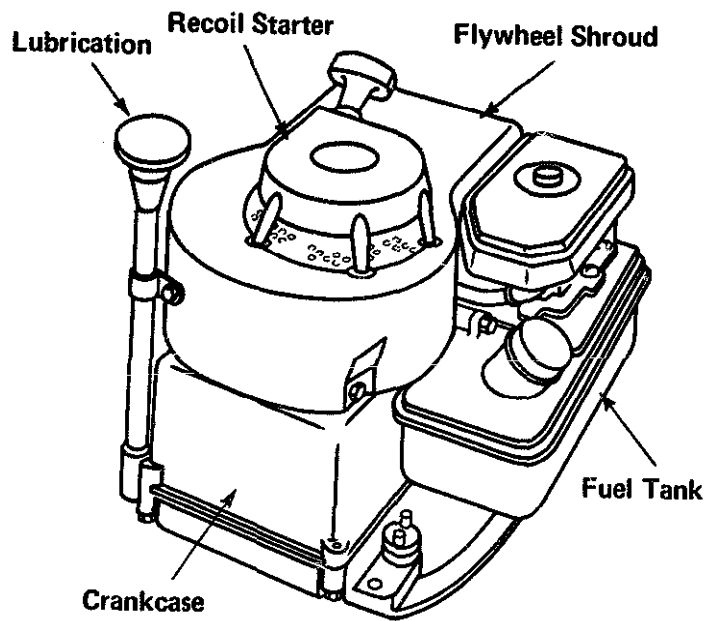
**INTRODUCTION TO
SINGLE-CYLINDER
AIR-COOLED ENGINES**

Chart 1

THE BASIC ENGINE



HORIZONTAL CRANKSHAFT ENGINE



VERTICAL CRANKSHAFT ENGINE

Chart 1

THE BASIC ENGINE

Small engines are classified as being either vertical or horizontal shaft types. This identification refers to the position of the crankshaft of the engine.

Most rotary lawnmowers use a vertical shaft engine.

The small engine is made up of several systems. The basic systems are as follows:

1. Fuel and carburetion
2. Ignition
3. Lubrication
4. Cooling
5. Exhaust

These systems all work together to convert air and fuel into mechanical energy. Each must serve its own function and be timed properly to the other systems as well as to the piston-crankshaft assemblies.

The FUEL and CARBURETION system provides the proper air-fuel mixture for the engine to operate under all conditions. Proper operation of this system is dependent upon a supply of clean, fresh fuel in the tank and proper adjustments at the carburetor.

The IGNITION system must provide the voltage necessary to jump the spark plug gap at exactly the right time. For this system to do its job, the spark plug, wires, and all other electrical components must be in good condition and properly adjusted.

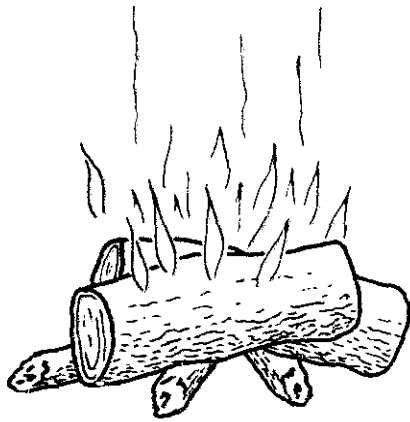
The LUBRICATION system delivers oil to all moving parts inside the engine. The oil in the crankcase is either circulated by a pump or splashed through the engine. The lubricating oil seals the rings in the cylinder, removes some heat from the piston, crankshaft, and valve train, cushions the shock experienced by the bearings, cleans particles and dirt from the bearings and the cylinder, and reduces friction. The importance of keeping the engine properly filled with clean oil is apparent.

The COOLING system removes the excess heat from the engine. The flywheel causes air to circulate over the fins of the engine where the excess heat is removed. This system requires periodic service because accumulated dust and grass can cause the engine to overheat.

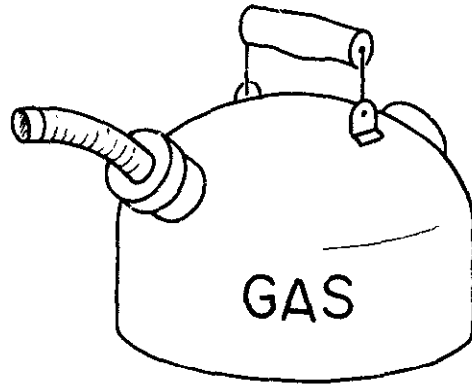
The EXHAUST system removes the burned gases from the engine and muffles the noise of combustion. On most units the exhaust system consists of a muffler attached to the engine block. A clogged or internally collapsed muffler can cause a loss of power and poor engine performance.

Chart 2

PRINCIPLES OF COMBUSTION



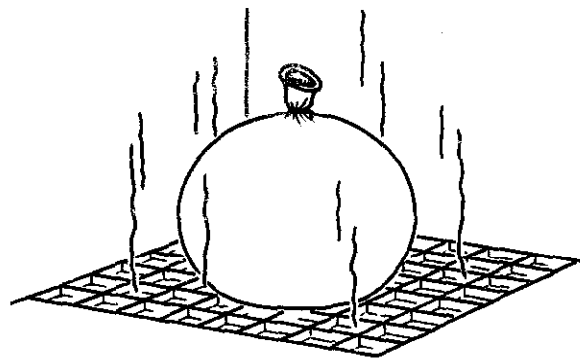
COMBUSTION



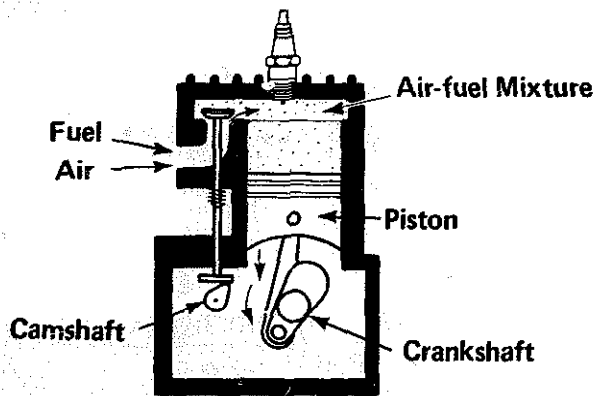
POTENTIAL ENERGY



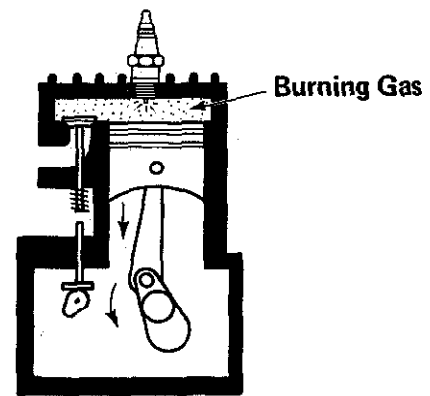
KINETIC ENERGY



HEAT EXPANDS AIR IN BALLOON



INTAKE OF GAS



EXPANSION OF BURNING GAS
PUSHES PISTON

Chart 2

PRINCIPLES OF COMBUSTION

Combustion is defined most simply as burning. Combustion in the internal-combustion engine refers to burning which takes place inside the engine.

The fuel stored in the fuel tank represents potential energy. This means that while in the tank little or no energy is released. If a drop of the fuel is placed in a pan and ignited, kinetic energy, or energy which has been released, is formed. The burning fuel gives off heat and light.

Pure fuel (gasoline) will provide heat when burned. If, however, the fuel is mixed properly with air to form a gas, it will give off more heat or burn more efficiently.

If heat is applied to air in a confinement, the air expands. If a balloon is placed over a heat duct, the balloon becomes "larger" because of the "expansion" of the air within. Burning the mixture in the cylinder in like manner expands the gases in the cylinder.

In the internal-combustion engine the fuel is mixed with the air by the carburetor. Approximately four gallons of air are mixed with each tablespoon of gasoline. The mixture enters the engine as a mist and changes to a gas or vapor when it reaches the hot port area of the engine. The mixture enters the engine because the piston creates a partial vacuum (suction) as it moves downward on the intake stroke.

At the end of the intake stroke, the intake valve closes trapping the gases in the cylinder. As the piston moves toward TDC (top dead center), the trapped gas is compressed.

The compressed gas will burn more violently than if it were not compressed. The violent burning creates heat, which causes expansion of the gas in the cylinder. The expanding gas exerts much pressure, which causes the piston to move down in the cylinder.

The gas acting upon the piston is the point at which the chemical energy (burning gas) is converted into mechanical energy. It is the mechanical energy which is used to turn the crankshaft.

Combustion, then, in terms of a piston engine means that an air-fuel mixture is drawn into the cylinder, is changed to a gas by heat, is compressed by the piston, and is ignited to provide heat which expands the gases in the cylinder. Expansion of the gases in the cylinder pushes the piston which transmits the force to the connecting rod and crankshaft.

It is important to note that the air-fuel mixture *does not* explode in the engine. Instead, it burns rapidly. If the engine is timed improperly or if the air-fuel mixture is incorrect, the mixture may "explode" or burn too fast. Operating the engine in this condition will produce "knocking" and excess heat which can damage the piston.

Chart 3

ENGINE IDENTIFICATION

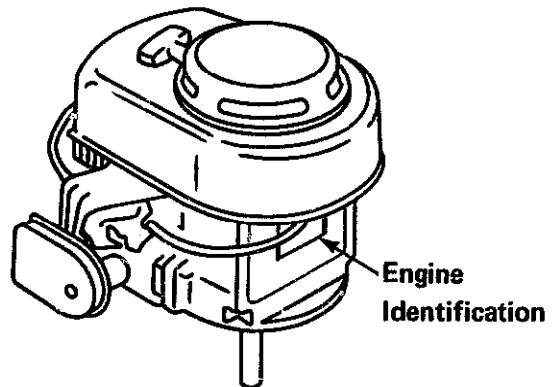
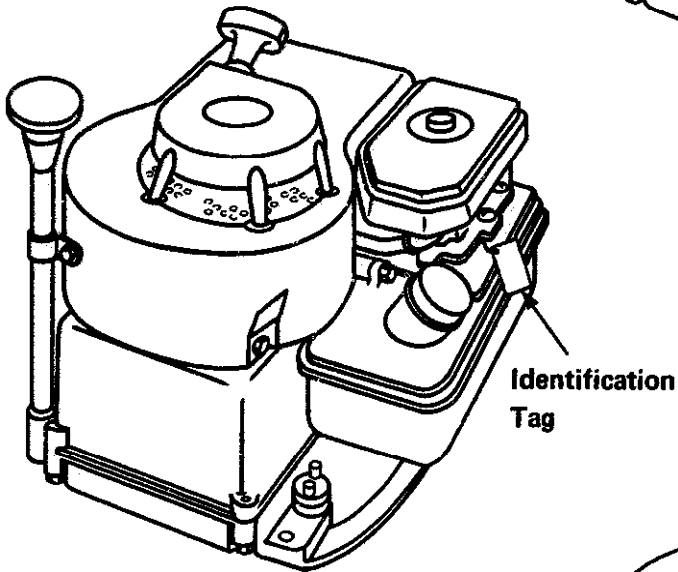
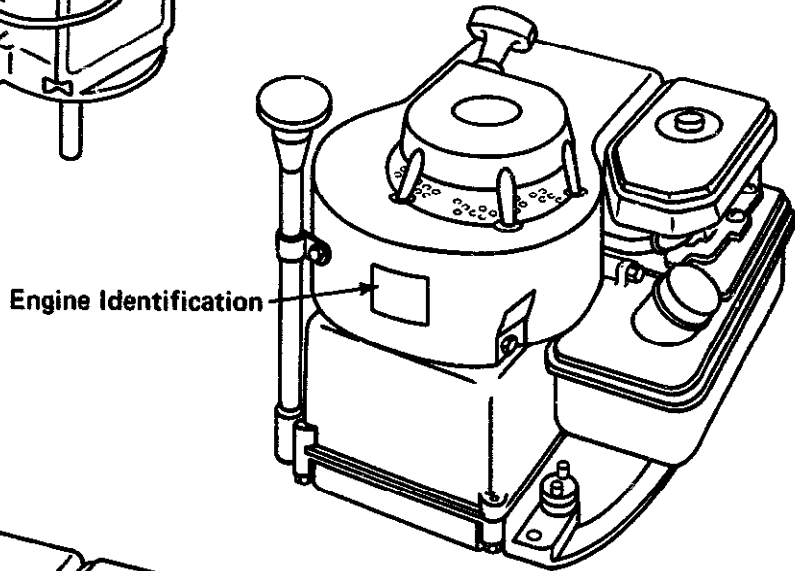
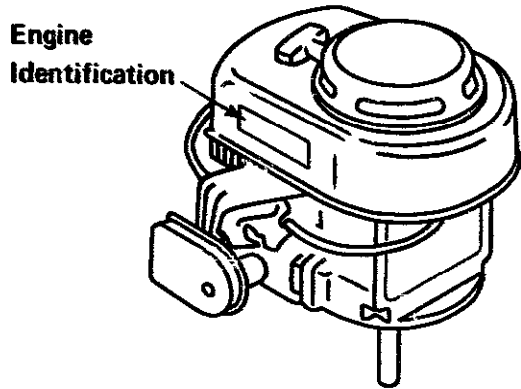


Chart 3

ENGINE IDENTIFICATION

The identification of the engine is necessary for locating specifications and for purchasing replacement parts.

The engine is usually identified by manufacturer's identification on the engine. This identification usually includes the model information and in some cases the serial number and type.

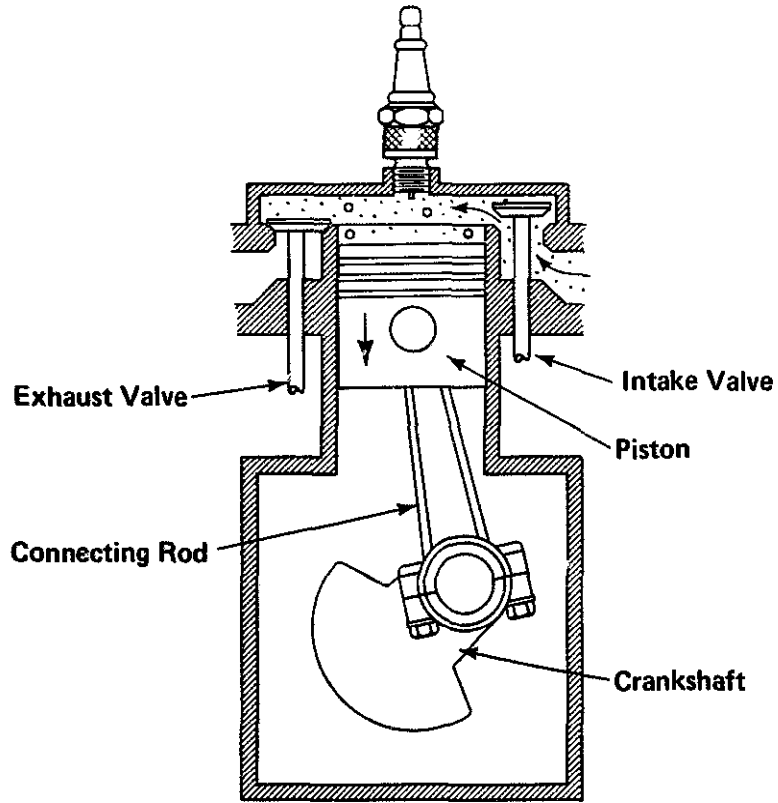
The identification plate or information may be located on the engine block or on the flywheel shroud. In some cases the number will be stamped on the shroud and no identification tag will be used.

Copy this identification information for your engine below for future reference when referring to specifications or ordering parts.

Manufacturer..... Model No.....
Serial No..... Type.....

Chart 4

FOUR-STROKE CYCLE THEORY AND INTAKE STROKE



INTAKE STROKE

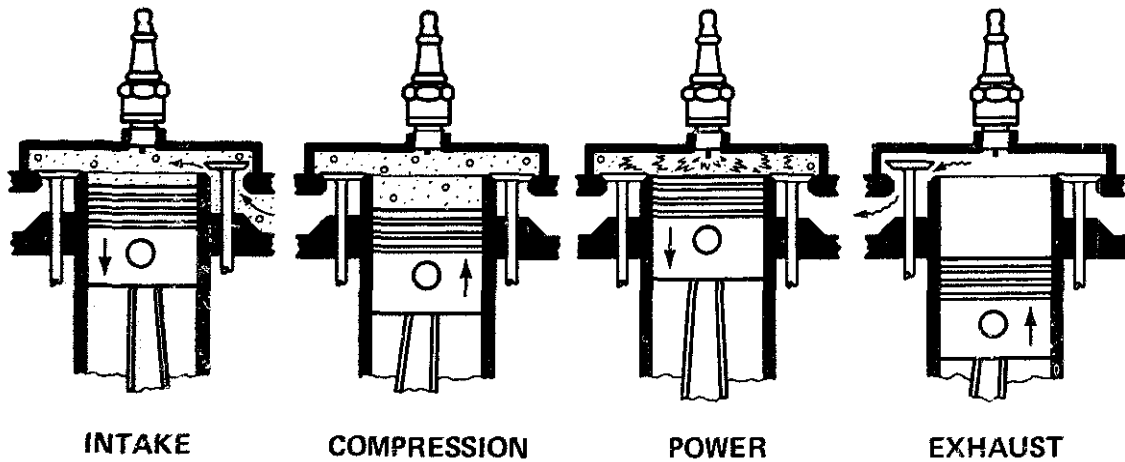


Chart 4

FOUR-STROKE CYCLE THEORY AND INTAKE STROKE

“Four-stroke cycle” means that it requires four strokes of the piston to complete one cycle.

Each time the piston moves from the top of the cylinder to the bottom of the cylinder it completes one stroke. Similarly, each time the piston moves from the bottom of the cylinder to the top of the cylinder it completes one stroke.

The term “cycle” means completion of four movements or strokes of the piston before it repeats a stroke.

To complete one stroke either from bottom dead center (BDC) to top dead center (TDC) or from TDC to BDC involves moving the crankshaft one-half revolution, or 180° . Since four strokes are required to complete one cycle, it can be seen that the crankshaft completes two revolutions or 720° of rotation during one cycle.

In one cycle the intake valve opens one time and the exhaust valve opens one time. This means that the camshaft, which causes the valves to open, completes but one revolution per cycle.

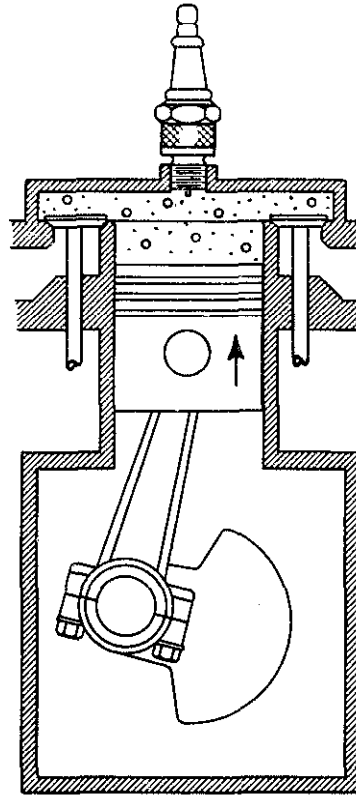
INTAKE STROKE

During the intake stroke the piston is moved from TDC to BDC. This causes a partial vacuum or suction inside the cylinder. Atmospheric pressure (outside air) rushes toward the partial vacuum in the cylinder. It moves through the air cleaner where dirt is filtered out. From the air cleaner it rushes through the carburetor where it “picks up” some gasoline. This air-fuel mixture then enters the cylinder through the open intake valve.

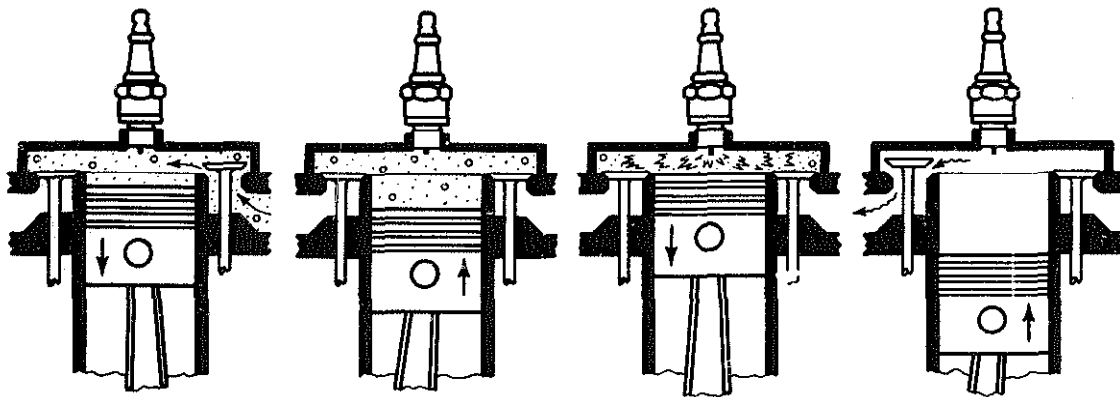
Near the end of the intake stroke the intake valve closes. When the valve is tightly closed, the air-fuel mixture is trapped in the cylinder. At this point the intake stroke is completed and the piston is at BDC (bottom dead center).

Chart 5

COMPRESSION STROKE



COMPRESSION STROKE



INTAKE

COMPRESSION

POWER

EXHAUST

Chart 5

COMPRESSION STROKE

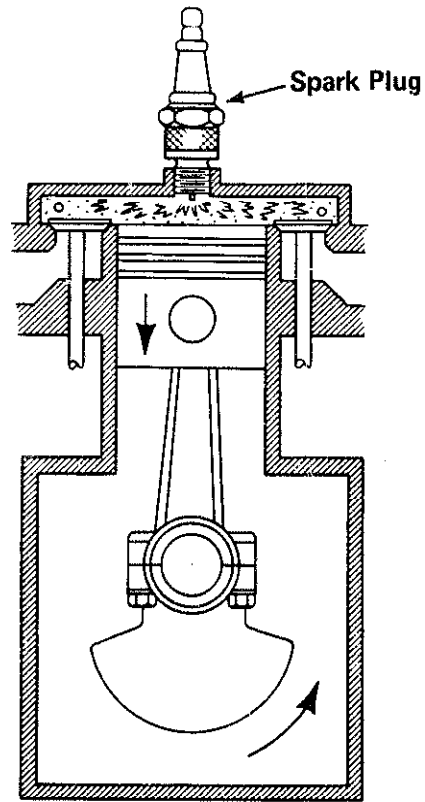
During the intake stroke an air-fuel mixture was “drawn” into the cylinder by the piston moving from TDC to BDC.

The second stroke in the cycle is the compression stroke. The piston is moved from BDC to TDC by the rotating crankshaft. Note that both valves remain closed during this stroke. This means that there is no way that the air-fuel mixture can escape—it is trapped in the cylinder. As the piston moves toward TDC, the air-fuel mixture is compressed. This compression takes place because as the piston moves toward TDC the volume of the cylinder decreases.

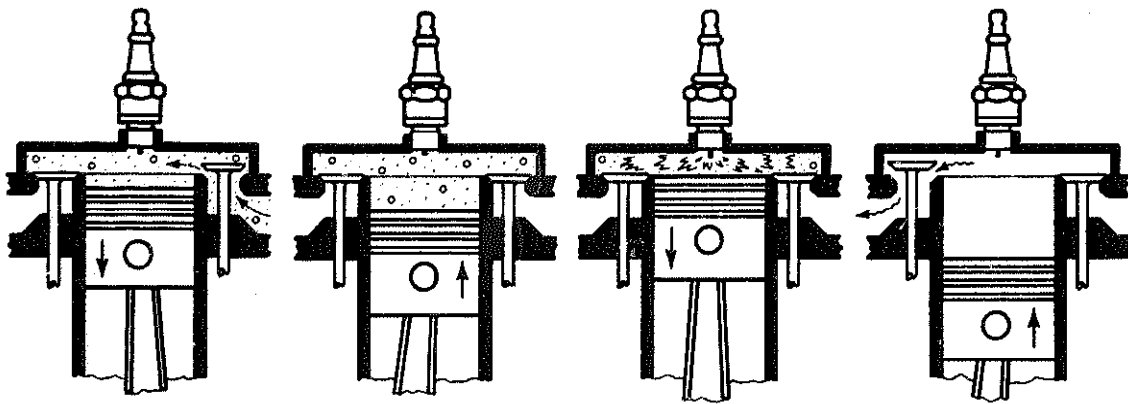
By compressing the air-fuel mixture, more pressure is created when it is burned.

Chart 6

POWER STROKE



POWER STROKE



INTAKE

COMPRESSION

POWER

EXHAUST

Chart 6

POWER STROKE

The air-fuel mixture was compressed as the piston moved from BDC to TDC during the compression stroke.

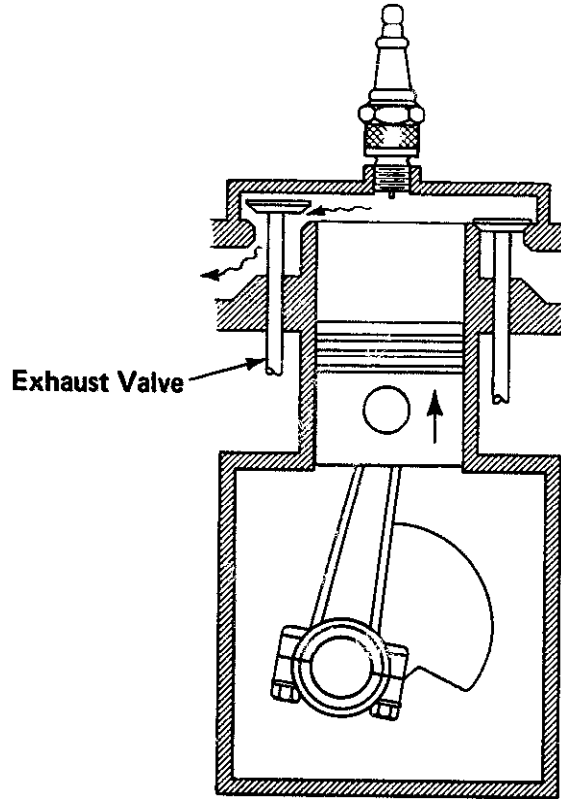
Just before the piston reached TDC on the compression stroke, the ignition system created enough voltage to jump the spark plug gap. When the spark jumped the gap of the spark plug, the power stroke began.

The spark ignites the air-fuel mixture. As the mixture burns the gases expand. The expansion of the gases increases the pressure inside the cylinder. Since both valves are closed, there is no means whereby the pressure can leak out. The increasing pressure is exerted on all parts of the inside of the cylinder. The piston is the only part which can move. The pressure forces the piston to move toward BDC. As the piston moves, the force is transmitted to the crankshaft by the connecting rod.

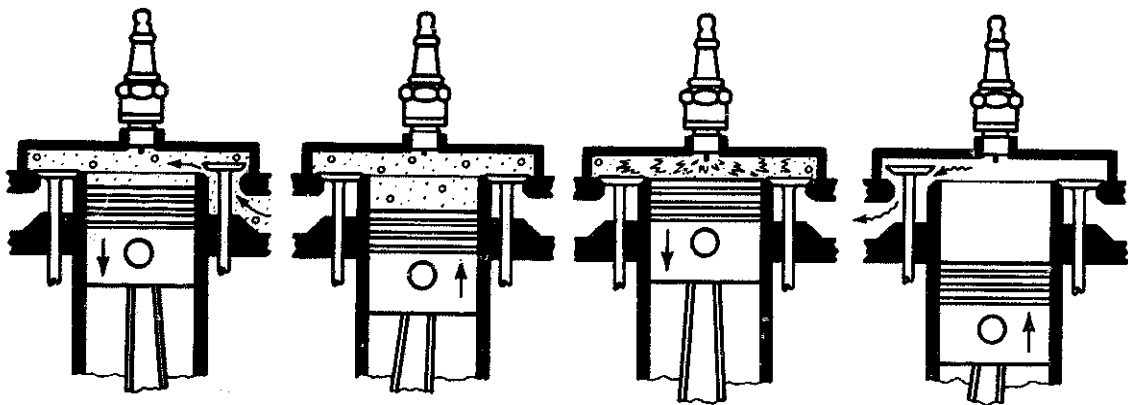
The power stroke is the only stroke in the cycle which produces usable energy. The power stroke causes the crankshaft to revolve which makes the engine "run."

Chart 7

EXHAUST STROKE



EXHAUST STROKE



INTAKE

COMPRESSION

POWER

EXHAUST

Chart 7

EXHAUST STROKE

The power stroke moved the piston from TDC to BDC. Near BDC the expansion of gases stopped, which ended the power stroke.

Near BDC of the power stroke the camshaft and valve train cause the exhaust valve to open. As the piston moves from BDC toward TDC, the burned gases are forced out through the open exhaust valve and muffler. This is the exhaust stroke. Near the end of the exhaust stroke the exhaust valve closes and the intake valve opens. This action signals the beginning of another cycle.

The sequence of strokes—intake, compression, power, and exhaust—continues to repeat so long as the engine is running.

The important points of the four-stroke cycle operation are as follows:

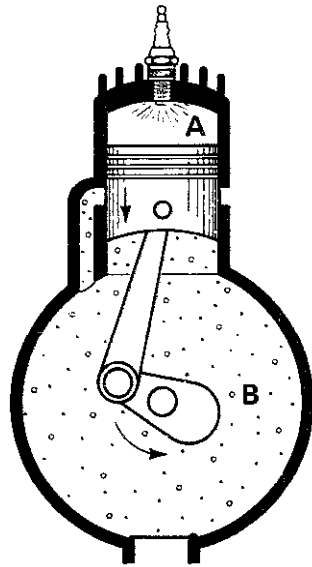
1. Each time the piston moves from one end of the cylinder to the other end a stroke is completed.
2. Four strokes—intake, compression, power, and exhaust—are required to complete one cycle of a piston.
3. To complete one cycle the crankshaft must make *two* complete revolutions and the camshaft must make *one* revolution.
4. The engine receives power to the crankshaft *only* on the power stroke. The crankshaft “coasts” through the intake, compression, and exhaust strokes.

The fact that the engine crankshaft must “coast” through three strokes requires a flywheel. Once in motion, the flywheel tends to continue to turn. The heavier the flywheel, the greater its tendency to continue to turn after the power causing it to turn is eliminated.

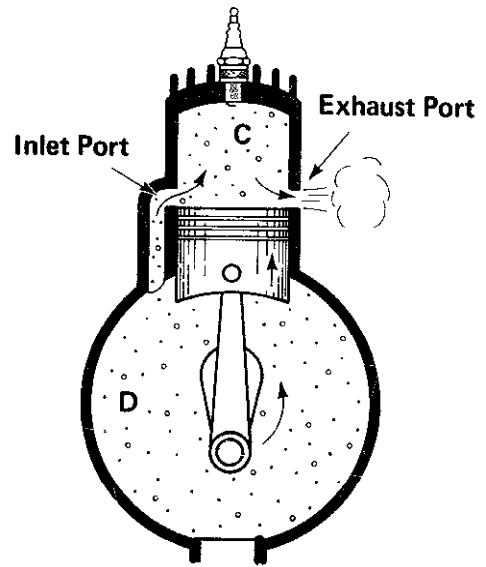
The flywheel on the small single-cylinder engine is relatively heavy because there is *only* one piston delivering power to the crankshaft. On many rotary-type lawnmowers the blade of the mower also helps the flywheel to maintain rotation of the crankshaft. Many of these types of engines run roughly if the mower blade is not bolted to the crankshaft.

Chart 8

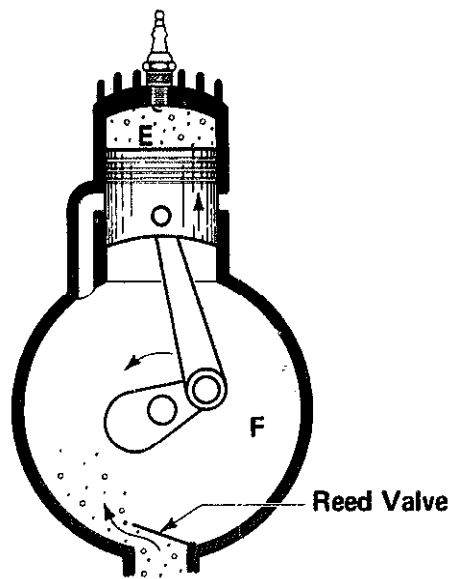
TWO-STROKE CYCLE THEORY



A. DOWN STROKE
(POWER)



B. END OF DOWN STROKE
BEGINNING OF UP STROKE



C. UP STROKE (COMPRESSION)

Chart 8

TWO-STROKE CYCLE THEORY

Two-stroke cycle means that two strokes of the piston complete one cycle. In other words, the piston must move from TDC to BDC and then back to TDC in order to complete a cycle. The two-stroke cycle engine completes a cycle each time the crankshaft completes one complete revolution.

Figure A in the chart shows the piston moving down from TDC. The air-fuel mixture has been compressed (or squeezed) above the piston, and the ignition system has created a spark at the spark plug. The spark has jumped the gap at the spark plug igniting the air-fuel mixture.

As the gases burn (A), they expand, thereby pushing the piston. As the piston moves down, the air-fuel mixture (B) (below the piston) in the crankcase is compressed.

At the end of the down stroke (Figure B) the compressed gases in the crankcase (D) flow up to the cylinder through the intake port. The exhaust gases are released from the cylinder at the end of the power stroke when the piston has passed the exhaust port (uncovering the port) which allows them to escape. The incoming intake gases help clean the remaining exhaust gases from the cylinder (C). Note that at BDC both ports are open.

When the piston begins the up stroke, it covers both the intake and exhaust ports, thereby sealing the cylinder and trapping the intake gases. As the piston continues to move upward, the intake gases are compressed.

Figure C shows that while the gases on top of the piston are being compressed (E), a partial vacuum is being created below the piston (F). The crankcase of the two-cycle engine is small so that this partial vacuum can be created. Air rushes in through the carburetor, picks up fuel, and enters the crankcase through the reed valve.

The reed valve is a one-way valve—it allows air-fuel mixtures to enter the crankcase but will not let them out once they have entered.

When the piston reaches TDC, ignition takes place and the cycle begins again.

The two-stroke cycle piston engine has activity on both the top and the bottom of the piston. Gases are compressed on both sides; however, those compressed in the crankcase do not burn. Instead, they move through the inlet port to the top side of the piston.

Most two-stroke cycle engines have no reservoir of oil in the crankcase. Lubricating oil is mixed with the fuel. When the air-fuel mixture enters the crankcase, the fuel and air form a vapor while the oil remains in droplets which cling to the components inside the crankcase. These droplets of oil maintain an oil film on the inside of the crankcase and all the moving parts. This film provides the necessary lubrication for the engine.

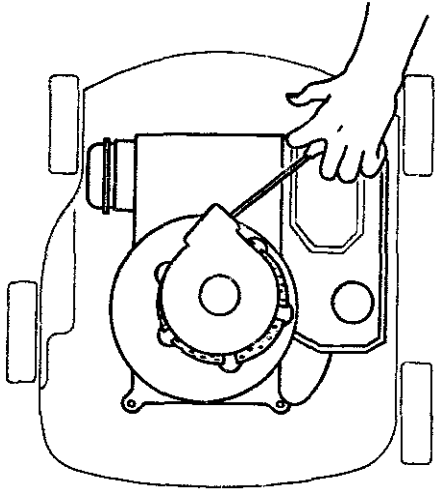
Questions for Section I

- T F** 1. For proper combustion, fuel must explode in the cylinder. (Chart 2)
- T F** 2. Large drops of fuel are required in the cylinder to produce power. (Chart 2)
- T F** 3. The crankshaft receives power during only one of the four strokes of the four-stroke cycle engine. (Chart 4)
- T F** 4. By compressing the air-fuel mixture, more pressure is created when it is burned. (Chart 5)
- T F** 5. During the power stroke, one valve is open. (Chart 6)
- T F** 6. Lawnmower engines may tend to run roughly when operated without a blade. (Chart 7)
- T F** 7. A flywheel is needed only to help cool the engine. (Chart 7)
- T F** 8. In a two-stroke cycle engine, the air-fuel mixture is compressed first in the crankcase. (Chart 8)
- T F** 9. On a two-stroke cycle engine, the air-fuel mixture is admitted to the crankcase through reed valves. (Chart 8)
10. List the five basic systems of the small gas engine. (Chart 1)
11. Describe how excess heat is removed from the small gas engine. (Chart 1)
12. What is the job of the ignition system? (Chart 1)
13. List the four things you need to know about the engine when referring to specifications or ordering parts. (Chart 3)
14. List the four strokes of the four-stroke cycle in their correct order. (Chart 4)
15. What is a stroke? (Chart 4)
16. What is meant by TDC and BDC? (Chart 4)
17. How many times does the crankshaft turn to complete the four-stroke cycle? (Chart 4)
18. Explain how the two-stroke cycle engine is lubricated. (Chart 8)

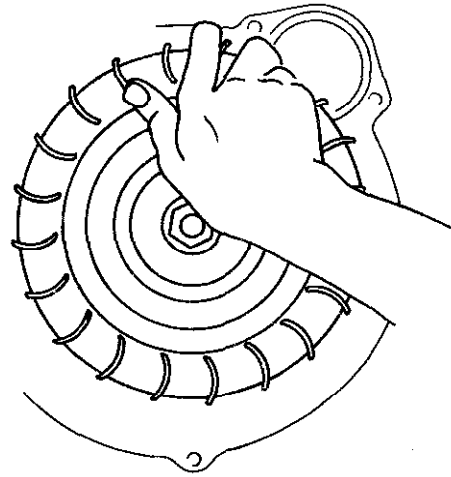
Section II
BASIC
ENGINE
TESTING

Chart 9

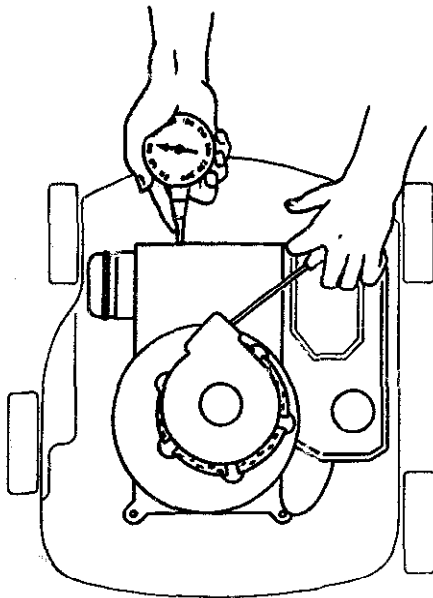
COMPRESSION TESTING



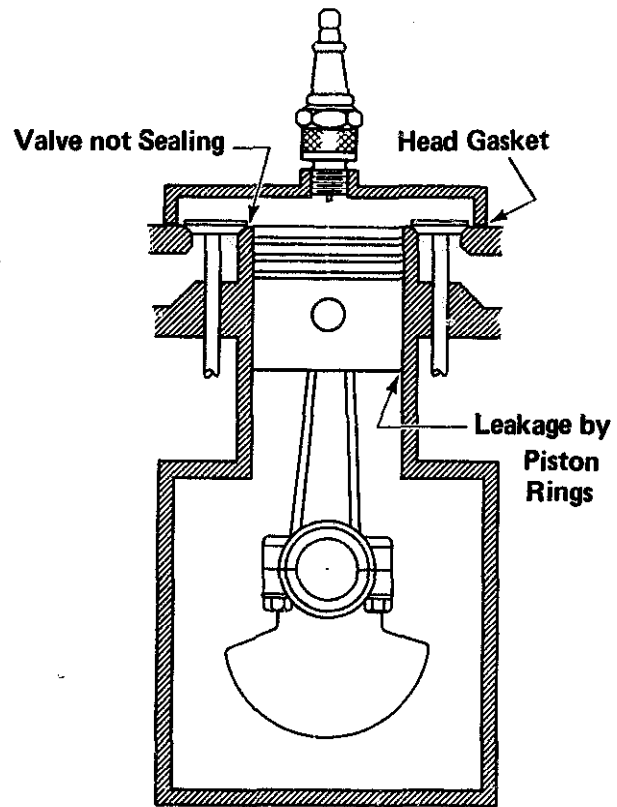
CHECKING COMPRESSION BY NOTING RESISTANCE WHEN PULLING STARTER ROPE



CHECKING COMPRESSION BY ROTATING FLYWHEEL IN DIRECTION OPPOSITE NORMAL ROTATION



CHECKING COMPRESSION WITH A COMPRESSION GAUGE



PLACES WHERE COMPRESSION AND POWER CAN LEAK

Chart 9

COMPRESSION TESTING

For an internal-combustion engine to run, three conditions must be met. The engine must have the following:

- Compression
- Air-fuel mixture
- Ignition

These three "musts" have to be working together or timed if satisfactory engine operation is to be achieved.

Test I. "Ground" the spark plug wire by connecting it to the engine. Check the compression by pulling on the starter rope. As the rope is being pulled, one should be able to feel the resistance as the piston comes upon compression. NOTE: Some engines have a built-in compression release which will release compression until the engine attains a proper speed. Usually the speed at which the release disengages occurs at the "end of the pull" of the rope when pulled at a normal starting rate. On engines with a compression release or one which fails the test, test the compression as outlined in Test II or III.

Test II. If compression cannot be felt in Test I, make certain that the spark plug wire is grounded and spin the flywheel by hand in a direction opposite its normal rotation. This can be done by removing the air shroud. When rotated in the opposite direction, the flywheel should rebound as the piston comes upon compression. If the rebound is quick, compression is good.

Test III. A third method of testing compression involves using a compression gauge. The spark plug is removed and the gauge is held tightly in the spark plug hole. The engine is cranked normally and the gauge reading is observed. The normal pressure reading varies with the size of the engine. For the lowest compression engines, the reading should not be below 25 psi (pounds per square inch). Most three-horsepower engines will give a 60–75 psi reading. Refer to the manufacturer's manual for the normal compression pressure of a given engine.

Low compression can result from several different faults. If there is a hissing sound while the compression is being checked there may be a leaking head gasket.

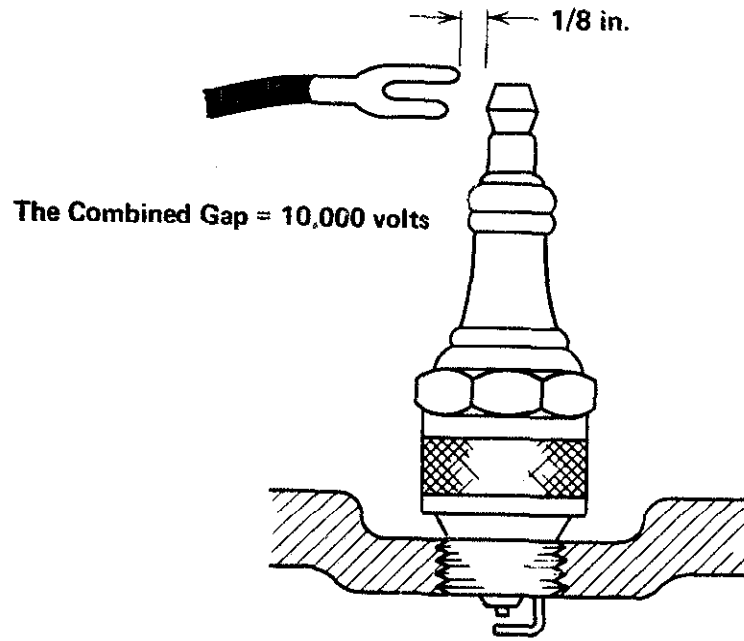
Worn or burned valves or valve seats will cause low compression readings.

Worn or improperly seated piston rings will cause compression loss into the crankcase. In extreme cases the engine will "belch" oil and smoke from the crankcase breather while it is running.

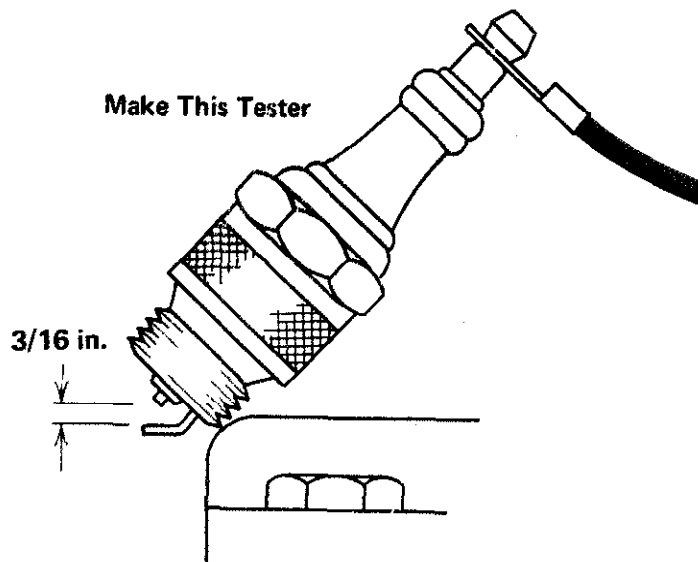
Low compression will usually necessitate engine disassembly. In some cases a partial disassembly (head gasket and burned valves) will be all that is necessary. In other cases it will be necessary to overhaul the engine. Major engine service is covered in the Overhaul section of this book.

Chart 10

SPARK TESTING



QUICK CHECK METHOD



SPARK TESTER METHOD

Chart 10

SPARK TESTING

To consistently fire the plug, approximately 6,000 volts is needed at idle and up to 10,000 volts at high speed or when under load. All of the magneto components must be in good condition in order to deliver this high-voltage spark.

The flywheel magneto ignition consists of the spark plug, high-tension wire, coil, breaker points, and condenser. A magnet attached to the flywheel supplies the energy to the coil. Failure of any of these components can affect the spark. Some of the components may be checked separately, for example, the coil, spark plug, and the flywheel magnet.

If all the components are functioning properly, the magneto should be able to produce a three-sixteenth inch spark when cranked rapidly. Either of the following methods may be used to check the spark; the first method is a little quicker to perform and the second method is a little more precise.

QUICK CHECK METHOD

1. Carefully remove the spark plug wire from the spark plug. Pull the boot (rubber cover) back so that the metal connector is exposed.
2. Grasp the spark plug wire by the insulation and hold the spark plug wire connector one-eighth inch from the spark plug terminal. Fold a hand towel and place it between your hand and the engine head so that your hand can rest firmly against the engine to hold the wire steady. The cloth towel will help prevent accidental shock.
3. Crank the engine vigorously. **CAUTION: THE ENGINE COULD START—BE PREPARED!** The spark should jump the combined gap easily and steadily. It should jump the one-eighth inch gap you are creating outside the engine and the gap of the spark plug. Failure to pass this test could be the fault of the spark plug. If the spark will not jump the one-eighth inch gap or is unsteady, perform the next test.

SPARK TESTER METHOD

A number of spark testers are available but a very satisfactory one can be made by using a new spark plug. Be sure to select a spark plug which is not the resistor or booster gap type. Adjust the tester electrodes to make a three-sixteenth inch gap.

Connect the spark plug wire to the tester and hold the tester firmly against the engine. Make sure that the tester is making contact with the bare metal of the engine because paint may insulate the tester from the engine.

Spin the engine rapidly. A steady spark across the gap indicates that the ignition system is functioning satisfactorily. In this method the spark is jumping only one gap and the results are more reliable. Also, the engine will spin much easier and there is no chance of the engine's starting with the plug removed. If the plug is removed, see the section on Spark Plug Service.

Chart 11

BASIC CARBURETOR ADJUSTMENTS

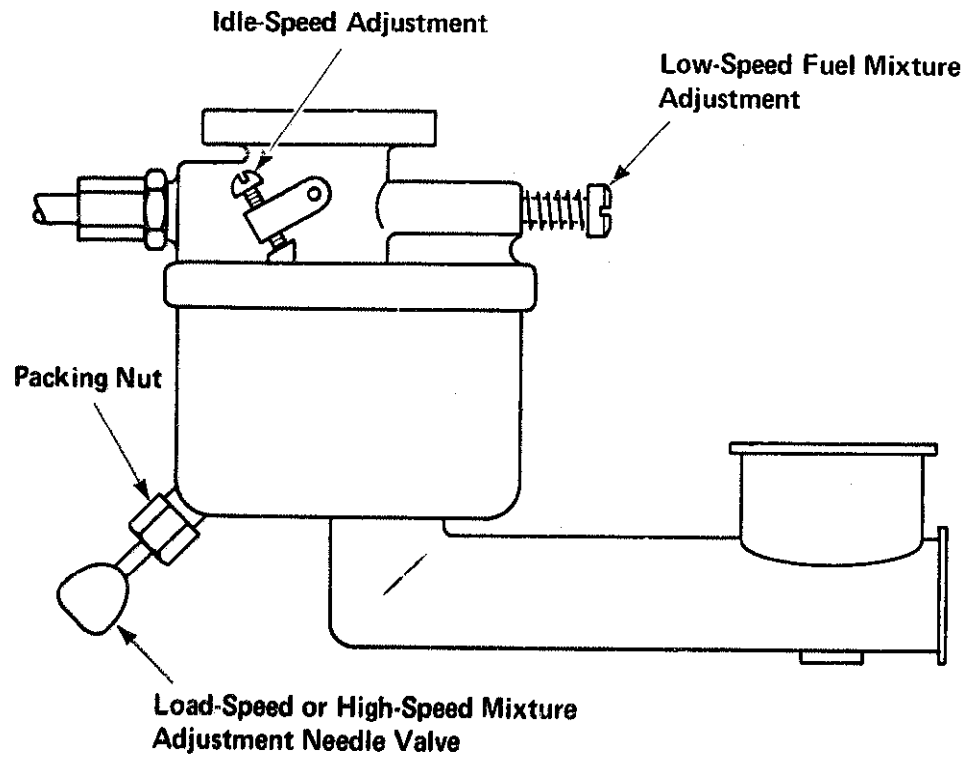


Chart 11

BASIC CARBURETOR ADJUSTMENTS

Three basic adjustments are necessary on most carburetors. These adjustments are made in the order listed below. The needle valve seats are made of soft brass and can be easily damaged. When turning the needle valve in, take care not to damage the soft brass seat. Loosening the packing nut will allow the screw to turn easier. If the fuel leaks around the adjusting screw, tighten the packing nut (see illustration).

THE LOAD-SPEED AIR-FUEL MIXTURE

Start the engine and allow it to run at least three minutes to warm up before adjusting. If the engine will not start, carefully turn the load-speed needle valve *in* (clockwise) until it closes. *Do not force it!* Back the screw out approximately one and one-half turns. This is not a correct adjustment, but it is rich enough to start most engines.

If the engine surges or runs roughly and emits black smoke from the exhaust pipe during warm up, the mixture is too rich. Turn the needle valve *in* (clockwise) slowly until the engine smooths out. If the engine surges and runs roughly without emitting black smoke, turn the mixture screw *out* (counterclockwise) to smooth out engine performance. Ignore blue smoke coming from the engine exhaust pipe at this time. It is the result of oil burning in the engine and has no effect on the carburetor adjustment unless it is excessive.

After the engine is warmed up, bring the engine to normal load-speed—near wide open throttle. *Caution:* Do not operate the engine at full throttle when it is not under normal load because the excessive speed will damage the engine. Turn the needle valve *in* until the engine begins to surge or run unevenly. This is now a lean adjustment. Turn the needle valve *out* until maximum smoothness and top speed are reached. Turn the needle valve slowly back and forth to find top speed without moving the throttle. If the engine will be pulling a heavy load, for example, a tiller, turn the needle counterclockwise up to one-eighth turn to slightly enrich the mixture for maximum power.

THE IDLE-SPEED AIR-FUEL MIXTURE

If the engine has an idle-fuel mixture adjustment, it should be adjusted after the load-speed mixture has been set and with the engine at near correct idle speed (fast idle). Again, turn this mixture screw *in* (clockwise) until the engine begins to run roughly and then back out to maximum speed. Move the adjustment screw back and forth slowly until maximum speed and smoothest operation are obtained.

THE IDLE-SPEED ADJUSTMENT

The idle-speed adjustment is a stop screw on the throttle shaft which prevents the throttle from closing farther. Single cylinder, air-cooled engines idle much faster than multicylinder engines. Normal idle speed for engines of less than ten horsepower is 1750 to 1800. If the engine will not accelerate properly from idle after the idle speed is set as described above, the idle speed may be too slow. An engine that idles too slowly will overheat because the air flow through the cooling fins will not be sufficient to cool the engine.

Questions for Section II

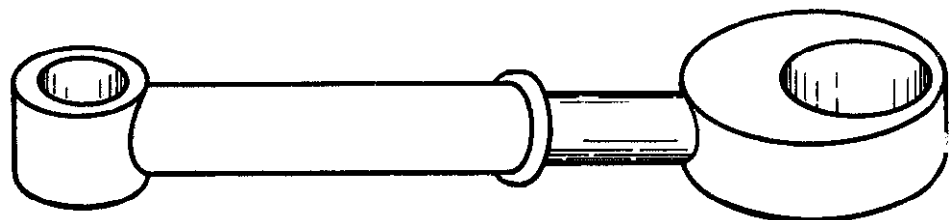
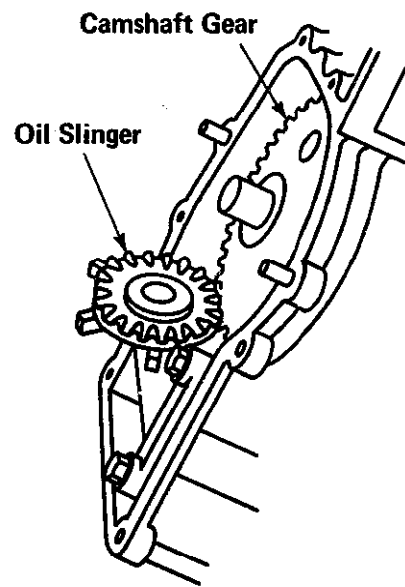
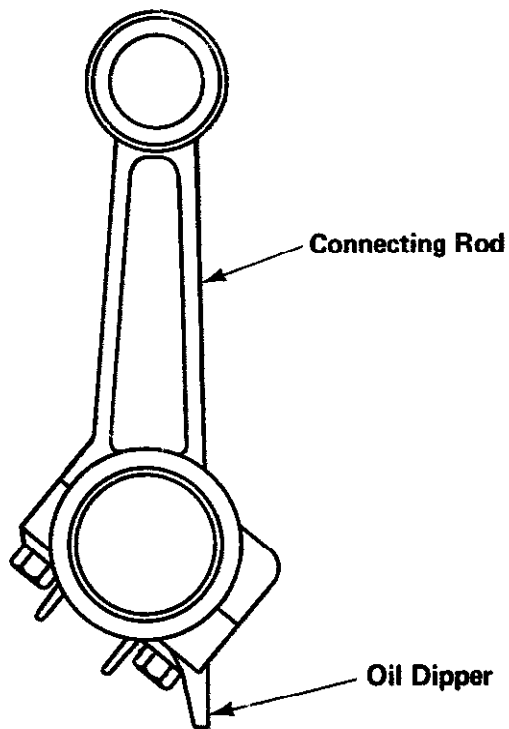
- T F** 1. The spark plug should be grounded to the engine when testing compression. (Chart 9)
- T F** 2. A magneto should be able to produce a spark across a three-quarter inch gap. (Chart 10)
- T F** 3. A leaking head gasket can cause low compression. (Chart 9)
- T F** 4. A worn connecting rod bearing can cause low compression. (Chart 9)
- T F** 5. A spark tester can be made using a new spark plug with a wide gap. (Chart 10)
- T F** 6. The order in which carburetor adjustments are made is not important. (Chart 11)
- T F** 7. Carburetor adjustments must be made only after the engine is warmed up. (Chart 11)
- T F** 8. Blue smoke is a result of an incorrect fuel mixture. (Chart 11)
- T F** 9. Auto engines must idle faster than small gasoline engines. (Chart 11)
- T F** 10. Needle valve seats are very hard. (Chart 11)
11. Why is it best to turn the engine backward for compression testing? (Chart 9)
12. List three possible causes of low compression. (Chart 9)
13. In this section, we checked the three essential elements for combustion. List the three elements. (Charts 9, 10, 11)
14. Using a compression gauge, you would expect a three-horsepower engine to give a reading of about psi. (Chart 9)
15. What is indicated by low compression accompanied by blue smoke escaping from the crankcase breather when the engine is running? (Chart 9)
16. What is the voltage required to fire the spark plug at idle speed? (Chart 10)
17. List the parts of the flywheel magneto ignition. (Chart 10)
18. List the three basic adjustments which can be made on most small gas engine carburetors. (Chart 11)
19. Most small gas engines will start if the adjustment screws are opened about turns. (Chart 11)
20. If the engine runs roughly and emits black smoke, the fuel mixture is probably too and the needle valve should be turned (Chart 11)

Section III

**PERIODIC MAINTENANCE,
ENGINE TUNE-UP PROCEDURES
AND STORAGE**

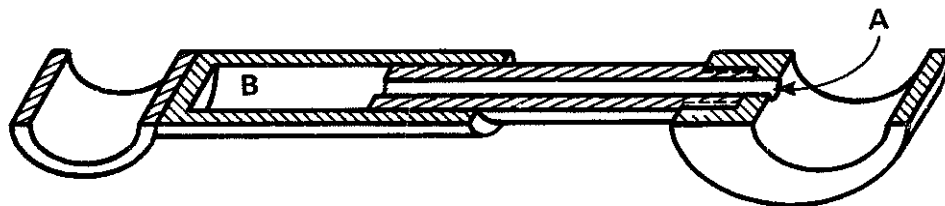
Chart 12

LUBRICATION



BARREL TYPE OIL PUMP

This End Attaches to Eccentric on Camshaft



OIL ENTERS AND LEAVES THE PUMP AT POINT A. THE OIL FLOW IS GOVERNED BY OIL PASSAGES IN THE ECCENTRIC. AS THE PUMP EXTENDS, OIL FLOWS INTO CHAMBER B. WHEN THE PUMP PLUNGER IS FORCED IN, THE OIL IS PUSHED OUT OF CHAMBER B, THROUGH PASSAGE A, AND IS DIRECTED THROUGH THE CAMSHAFT.

Chart 12

LUBRICATION

The oil in the crankcase serves five functions:

1. It helps cool the engine by removing heat from the cylinder and moving parts.
2. It cleans by rinsing particles from the cylinder and moving parts.
3. It seals the rings to the cylinder wall.
4. It reduces friction by serving as a slippery film between all moving parts.
5. It protects the machined parts from rust and corrosion.

The oil is circulated in the engine by several methods. Some engines use a dipper attached to the connecting rod which dips into the oil as the connecting rod moves. The oil is splashed so that all points within the block are constantly sprayed with oil.

The oil slinger used on some engines is driven by the camshaft. As the slinger rotates, "ears" on the slinger throw oil throughout the inside of the engine.

Various styles of oil pumps have been used in the lubrication systems of small engines. The pumps normally are submersed in oil and direct oil to the connecting rod and main bearings by tubes or orifices in the discharge tube. The other parts of the engine are lubricated by the oil which is "thrown off" the connecting rod and crankshaft.

When an engine that employs an oil pump is being overhauled, the pump should be checked carefully for wear. If the pump shows wear, replace the main components or the complete pump assembly.

OIL AND OIL CHANGE

The oil level should be checked before starting the engine and after every 5 or 6 hours of operation. The oil level should be maintained to the full mark as recommended by the engine manufacturer. When checking or adding oil, care should be taken to prevent any dust or dirt from entering the oil filler. The engine oil should be changed when it is warm so that all the oil will drain from the engine. Change the oil at least after every 25 hours of engine operation.

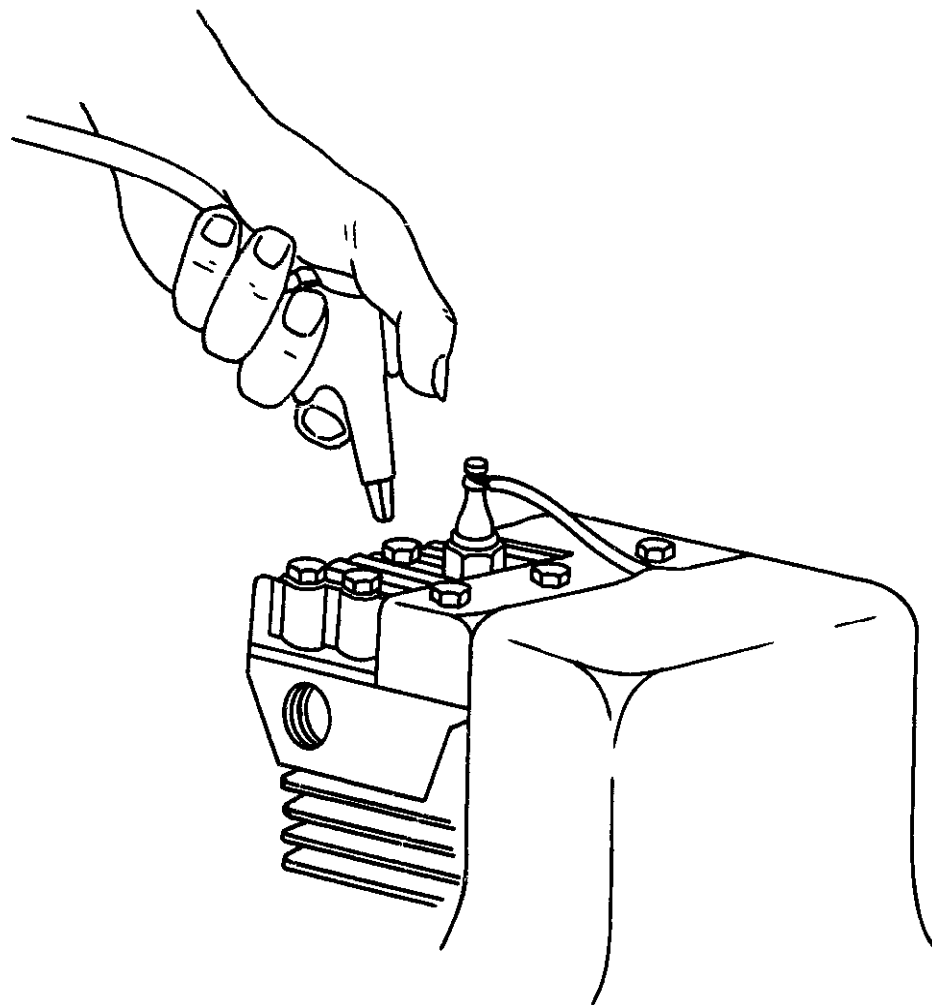
Use the weight and grade oil recommended by the manufacturer. The use of additives is not necessary unless specified by the manufacturer.

If manufacturer data are not available, use the following guide in selecting oil:

Service rating	SC, SD, or SE
Type	Detergent
Summer	SAE 30 or 10W-30
Winter	SAE 5W-20 or 10W-30

Chart 13

COOLING SYSTEM



COOLING SYSTEM

Chart 13

COOLING SYSTEM

Excess heat from the small engine is removed by air circulated over the engine. Air is drawn in through the screen in the shroud which covers the flywheel. The spinning flywheel throws the air outward and the shroud directs it across the engine.

It is very important that the air intake screen and the fins on the engine be kept clean. If dust and grass are permitted to build up over these areas, the air flow is restricted. Such restriction of the air flow can cause the engine to run "hot."

Blockage of just one passage can create a "hot spot" which can cause scratched piston rings, a scored cylinder wall, and scoring of the piston.

The engine shrouding should always be in place when the engine is operated. Without the shrouding, the air is not directed over the engine and the engine will overheat.

The screen over the air inlet area should be brushed frequently with a stiff-bristled brush to remove accumulated grass and dust.

The shroud should be periodically removed from the engine and the accumulated dust and chaff should be removed by blowing around the fins with compressed air.

When the engine is being serviced, care must be taken to prevent breakage of the cooling fins on the engine block and cylinder head. These fins provide necessary "extra" surface area to remove the excess heat from the engine.

Broken flywheel fins or blades reduce the amount of air circulated over the engine and cause the flywheel to be out of balance. If any flywheel fins are broken or missing, the flywheel should be replaced.

The fuel system and ignition timing can also affect engine cooling. If the fuel mixture is lean, the engine will tend to run hot. Late ignition timing will also increase the operating temperature of the engine.

Chart 14

SPARK PLUG SERVICE

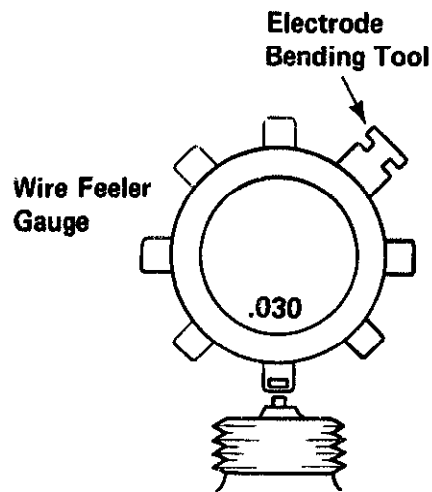
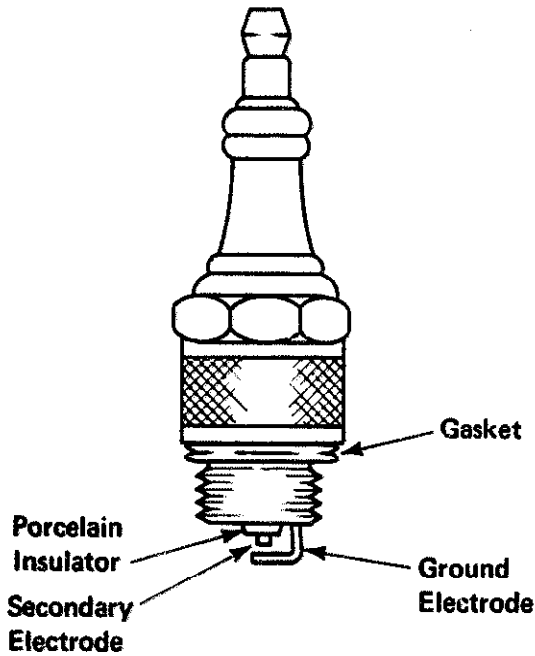


Chart 14

SPARK PLUG SERVICE

First remove the spark plug wire and attach it to a good engine ground. Use a deep well spark plug socket or box end wrench to loosen the plug. Use care not to damage the plug. Loosen the plug about one turn. Spin the engine four to five revolutions to blow out the carbon that may have been knocked loose when the plug was loosened. Blow away any trash, dirt, and caked oil from the area around the plug on the outside of the engine. Remove the spark plug from the engine.

INSPECT THE PLUG

The condition of the plug gives some clues to the condition and operation of the engine.

Normal. If the plug has only slightly worn electrodes and a very light coating of tan or gray deposits, it may be cleaned, regapped, and reinstalled.

Carbon Fouled. Fluffy, black deposits are a result of over-rich carburetion or excessive idling. If electrode wear is only slight, the plug may be cleaned and reinstalled. Be sure to correct the condition that caused the carbon fouling. **BE SURE THAT IT IS THE CORRECT PLUG FOR THE ENGINE.**

Oil Fouled. Wet, black, oily deposits indicate that oil is leaking past the rings or valve stems. Unless the engine condition allowing oil to enter the combustion chamber is corrected, a new plug will soon become fouled too. An engine overhaul may be necessary to obtain satisfactory service.

Blistered Insulator. A burnt or blistered insulator is the result of overheating. Using the wrong spark plug, low-octane fuel, incorrect timing, bad valves, and cooling system obstructions are common causes of overheating. Correct the cause of overheating and replace with a new spark plug.

DO NOT CLEAN SPARK PLUGS WITH ABRASIVE CLEANERS

Blasting the plug with abrasives quickly erodes the insulator nose which changes the heat range of the plug. Any deposits that are not readily removed with a wire brush may be scraped away lightly with a pen knife. If excessive deposits are present or if any question exists as to whether or not the plug should be replaced, replace it. A spark plug is a minor expense for the major role it plays in engine performance.

GAP THE NEW SPARK PLUG

New spark plugs are not preset. Check the engine manufacturer's specifications for the correct setting. The correct setting is .025-.030 for most small gas engines. Use a wire spark plug feeler gauge because a flat feeler gauge can give erroneous readings as shown on the opposite page.

REPLACE SPARK PLUG

If the new plug does not screw in easily by hand, clean the threads so that the plug does screw in easily. Then tighten with a torque wrench, if available, to the manufacturer's specifications. If a torque wrench is not available, tighten down finger tight against the new gasket and then turn another one-third turn. This should partially collapse the gasket but not completely smash it. Do not overtighten. Remember that the spark plug has steel threads and the engine head is most likely aluminum or cast iron.

Chart 15

THE IGNITION CIRCUIT

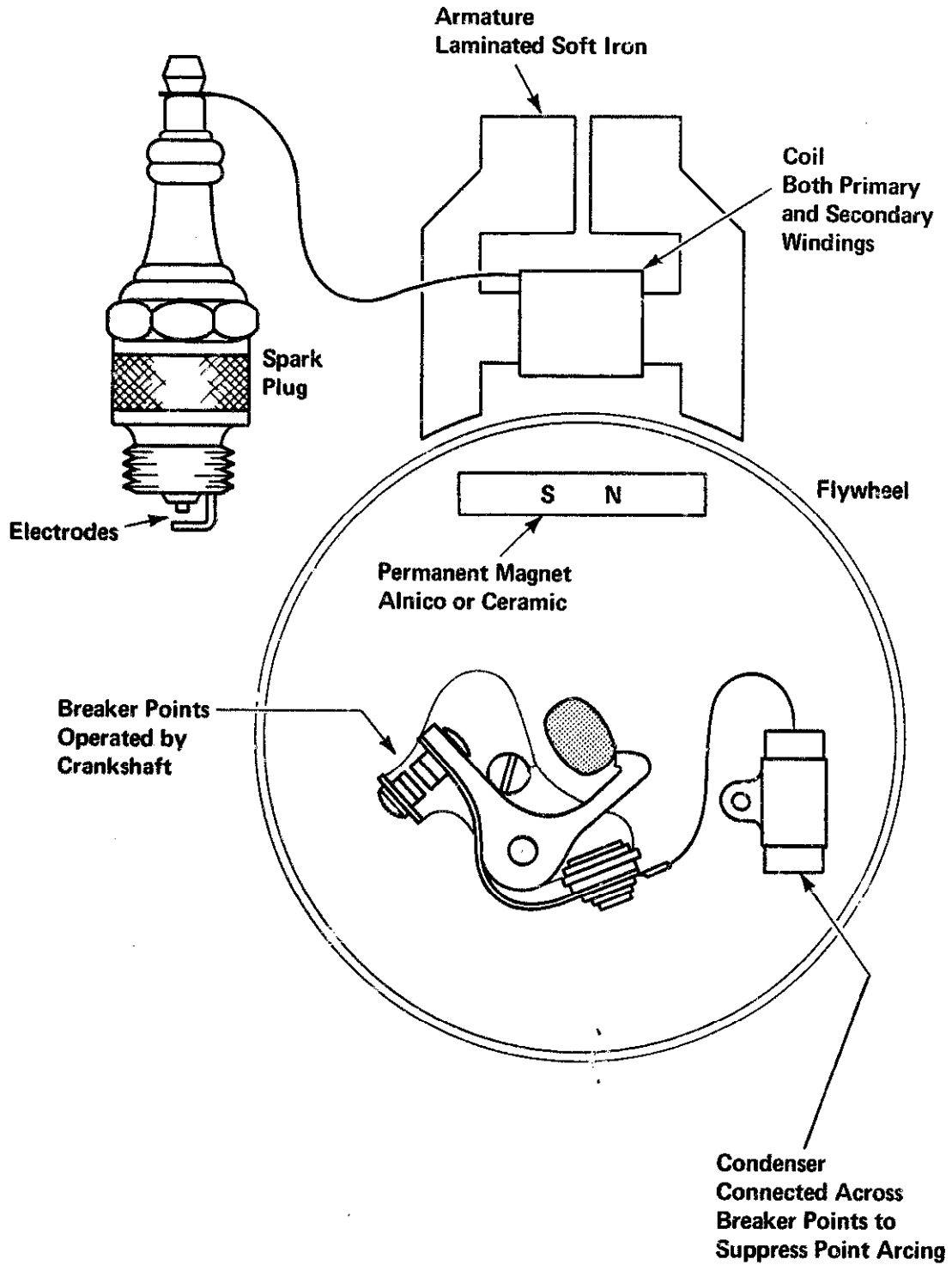


Chart 15

THE IGNITION CIRCUIT

The purpose of the ignition circuit is to create a spark to ignite the compressed air-fuel mixture at exactly the right time. In order to do this, a very high voltage is needed to cause an electric current to jump the gap between the spark plug electrodes. The duration or intensity of this small lightning bolt is not important because the compressed air-fuel mixture is highly volatile and will be readily ignited if the conditions are correct.

The ignition system consists of the following components:

- Permanent magnet (in the flywheel)
- Armature-coil assembly
- Breaker points
- Condenser
- Spark plug

As the magnet in the flywheel passes the coil armature, the moving magnet sets up a current flow in the primary winding of the coil. This current is also traveling through the breaker points. As the breaker points open, interrupting the current flow, the electrical power is transferred magnetically to the coil's secondary winding at a very high voltage. This voltage travels to the spark plug where it jumps the spark plug electrodes igniting the air-fuel mixture. As the points open, a small spark occurs across the points. Since the points open several thousand times each minute, they would soon burn up. The condenser helps absorb this spark and thus acts to increase point life.

PARTS OF THE IGNITION SYSTEM

The **FLYWHEEL MAGNET** moves rapidly past the coil assembly causing current flow in the coil primary winding.

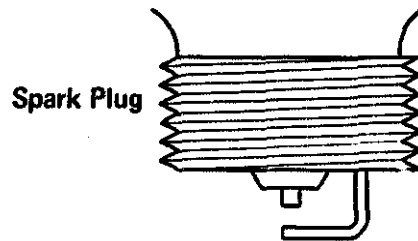
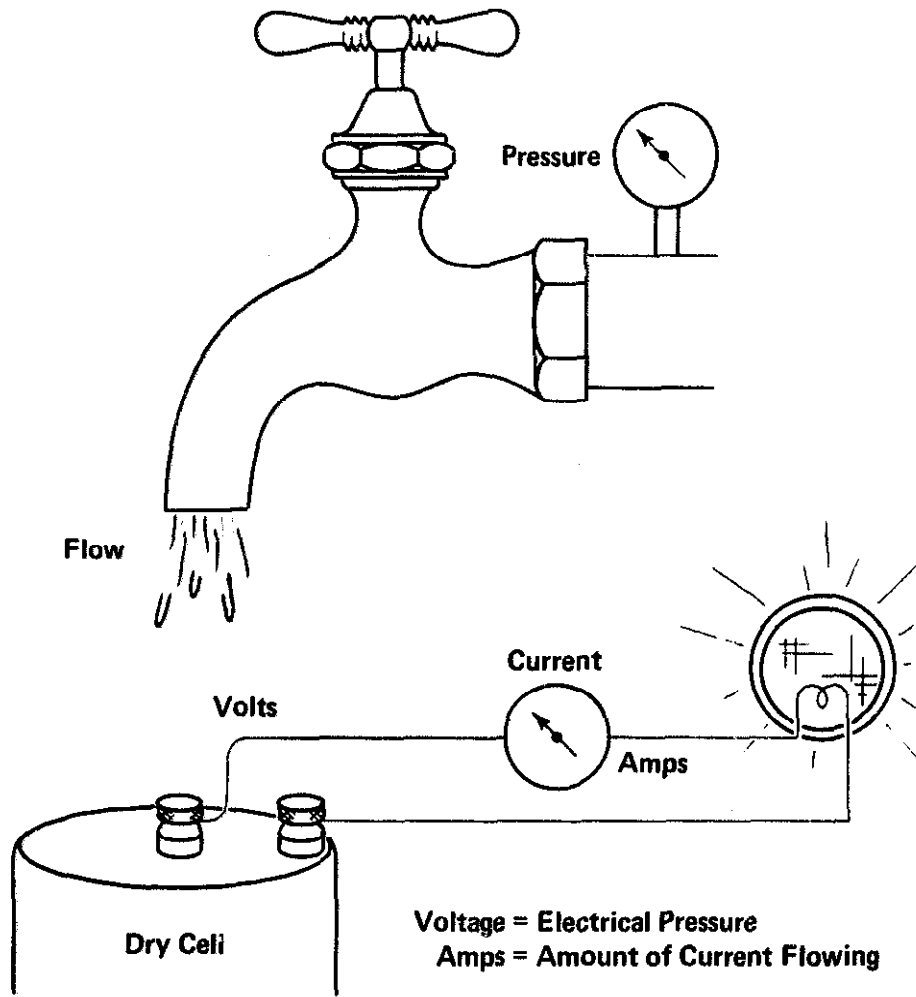
The **ARMATURE-COIL ASSEMBLY** consists of the laminated steel armature and the primary and secondary winding.

The **BREAKER POINTS** are operated by the crankshaft. They close just before the flywheel magnet passes the coil completing the primary winding circuit. The points open just as current flow in the primary is at maximum causing the power to be transferred magnetically (induced) in the secondary at a much higher voltage to fire the plug.

The **CONDENSER** is connected across (in parallel with) the points to help reduce arcing of the points which increases point life.

Chart 16

ELECTRICAL TERMS



**6,000 Volts Needed to
Fire the Plug at Idle—More
at Higher Speeds and
Greater Loads**

Chart 16

ELECTRICAL TERMS

VOLTAGE (volts) is the pressure which causes current to flow. In this sense, it is no different from the pressure that pushes water through a pipe. If you increase the pressure in a water system, more water will flow. If you increase the voltage in an electrical circuit, more current will flow.

CURRENT is the moving of electrons in a wire. This is electricity. Just as water moves in a pipe, electrons flow in a wire. This flow of electrons is called current. The amount of current that is flowing is called amperes (amps) and is measured with an ammeter.

If a faucet has 40 pounds of pressure, the amount of water flowing depends on how much the faucet is opened and on the length of the hose that is connected to the faucet. When a 1-1/2 volt battery is used, the amount of current that flows depends on what is connected to the battery. The wire used must be large enough to easily carry that amount of current. Both the headlights and the dash lights on a car operate from 12 volts. Obviously, the headlights allow more current flow and require larger wire. When the voltage is fixed, as when using a battery, the load determines the amount of current that must flow to get the work done. Opening a faucet wider allows more water to flow and does a better job of blasting off dirt. More work is being done. A larger light bulb allows more current to flow and produces more light.

A spark plug simply creates a gap in the electrical circuit. Current flows easily along the wire to the plug but cannot easily jump the gap. A lot of push (voltage) is needed to cause the current to jump. Usually the voltage required to fire the plug at idle speed is about 6,000 volts and may require as high as 10,000 volts on a small engine under load. High-compression auto engines may require in excess of 16,000 volts under load.

ELECTRICAL FUNDAMENTALS

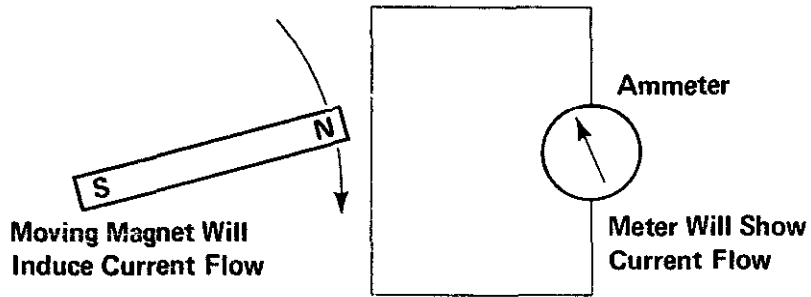


FIGURE A

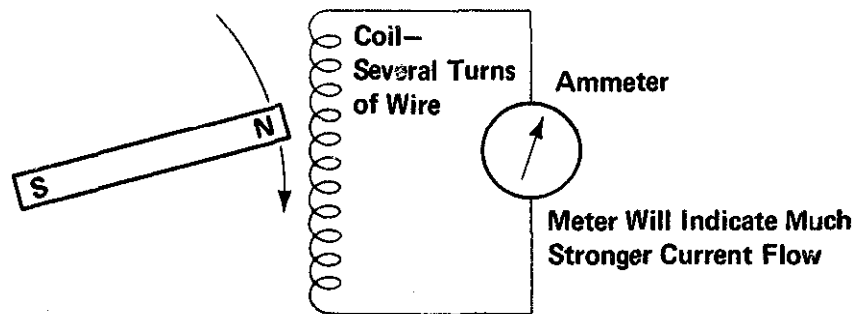


FIGURE B

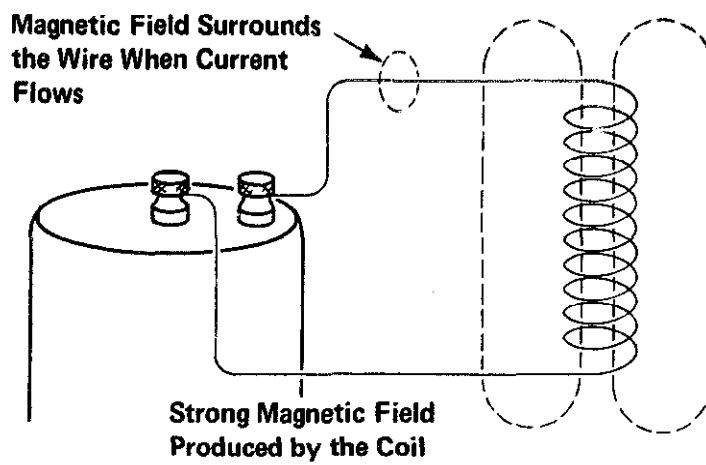


FIGURE C

Chart 17

ELECTRICAL FUNDAMENTALS

The following are basic rules that one must comprehend if the basic magnetism is to be understood. Study them carefully.

1. Moving a magnet past a wire causes an electrical current to flow in the wire if it is part of a complete circuit.
2. Moving a magnet past a coil made up of several turns of wire will produce a much stronger current flow because the current induced in each turn of wire will add to the total output.
3. Current flowing in a wire causes a magnetic field to surround the wire. The strength of this field depends directly on the amount of current flowing through it.
4. If the wire is wrapped to make a coil, the strength of the magnetic field of each turn of wire adds to the field next to it, producing a stronger magnet. Adding more turns of wire adds to the strength of the magnetic field.

Figure A shows a current meter (ammeter) connected to a loop of wire. Moving the magnet rapidly causes a very small current to flow in the wire which causes the needle to deflect. Wrapping several turns of wire on a coil makes the current flow much stronger. The current flow induced in each turn of the coil adds to the current flow induced in all of the other turns on the coil to produce a strong current flow.

If a battery is connected to a complete circuit, the current flowing will cause a magnetic field to surround the wire. The more current that is flowing, the stronger the magnetic field. By passing the current through a coil made up of several turns of wire, the magnetic strength of each loop of wire adds to the others making a stronger magnetic field (Figure C).

Chart 18

IGNITION PRIMARY CIRCUIT

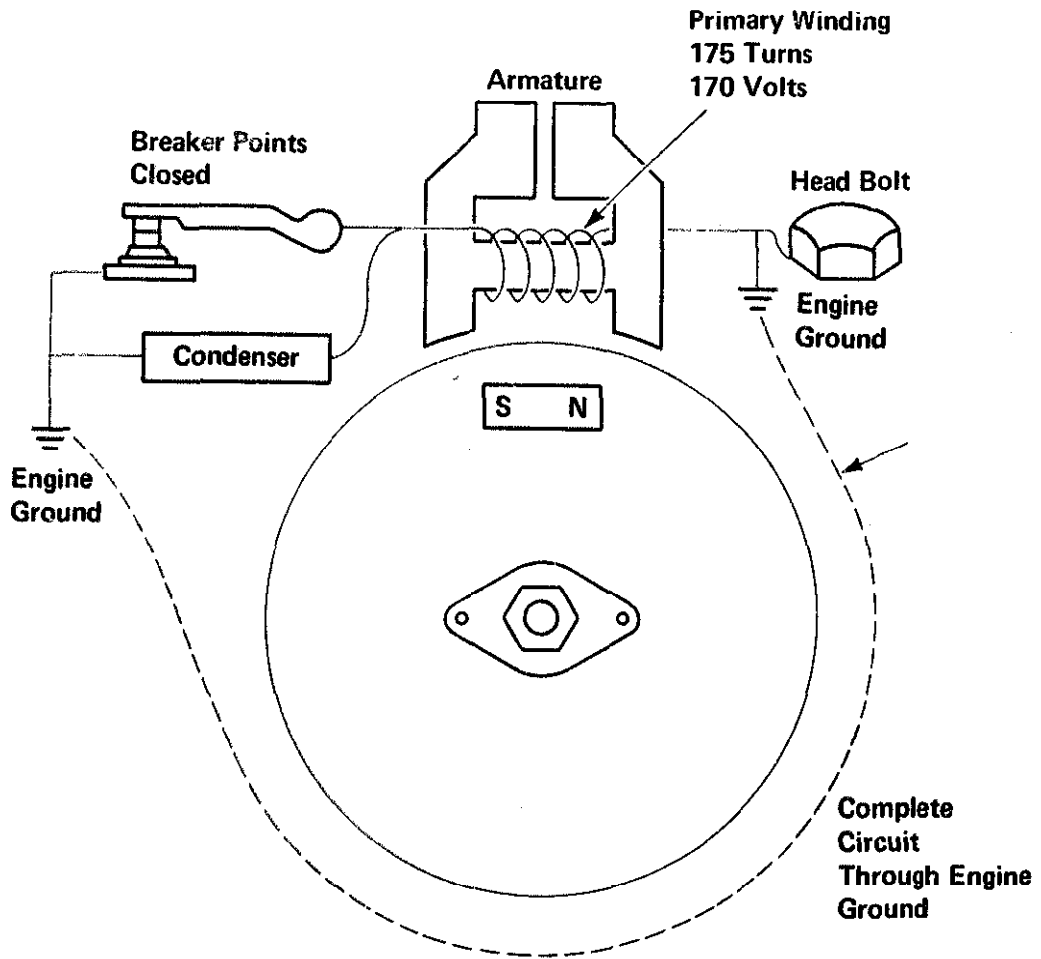


Chart 18

IGNITION PRIMARY CIRCUIT

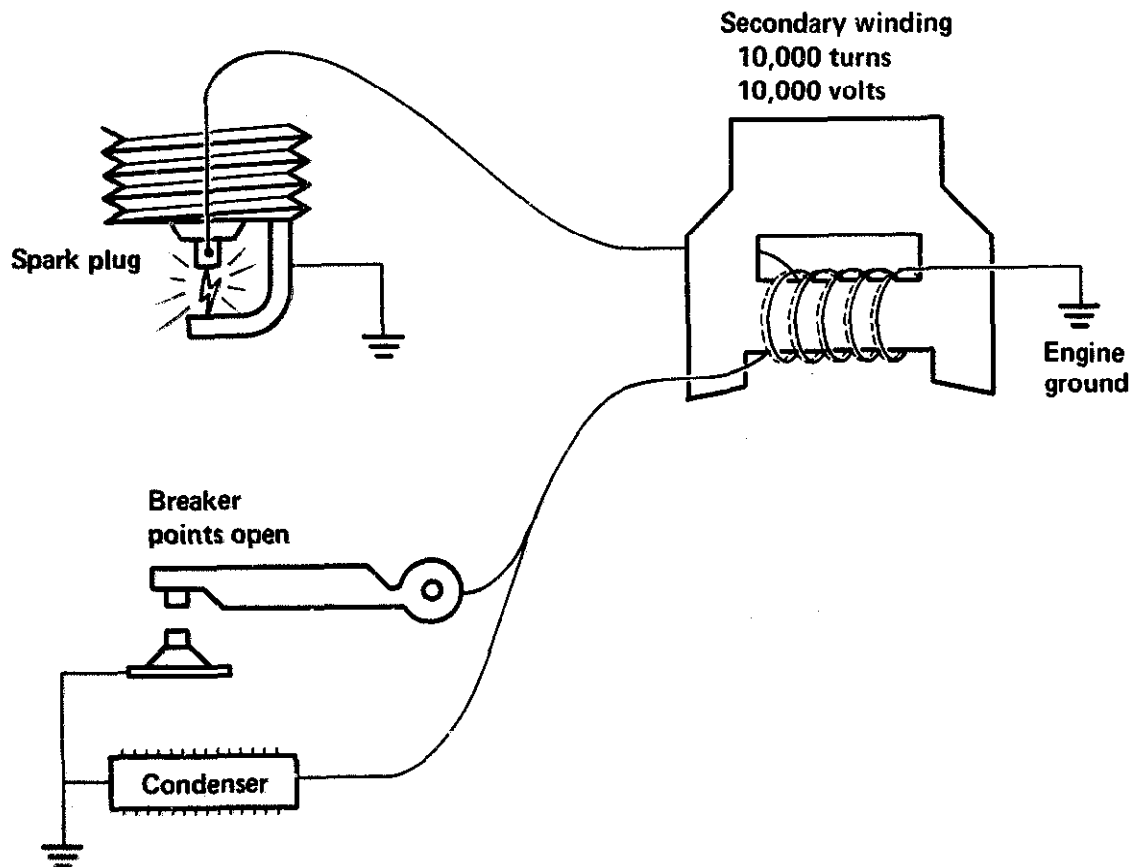
The primary or low-voltage circuit consists of the flywheel magnet, breaker points, condenser, and the coil primary winding. The primary winding usually consists of less than 200 turns of coated copper wire wound on the laminated armature. Note that one lead is connected to the armature on one of the mounting bolts which connects it to the engine ground. The other lead from the primary winding goes to the breaker points. The condenser is connected across or in parallel with the breaker points. Its only purpose is to prevent arcing of the points, thus increasing point life.

Notice that when the breaker points are closed, there is a complete circuit from the engine ground through the coil primary winding, through the breaker points, to the engine ground. Since both ends of the coil primary are now connected to the engine ground, a complete circuit now exists. Current will flow through the ground as if the two ends of the primary winding were connected directly together.

As the piston is nearing TDC on the compression stroke, the breaker points close making a complete primary circuit. The flywheel magnet passes rapidly bringing primary current to maximum. Since the current flow in the primary winding is at maximum, a strong, concentrated magnetic field will surround the primary winding. Just before the piston reaches TDC (the manufacturer determines the exact number of degrees before TDC) the breaker points open to stop all current flow in the primary circuit. This causes the magnetic field to suddenly collapse. The condenser absorbs a small amount of the current flow in order to prevent point arcing as the points open.

Chart 19

PRODUCING SECONDARY VOLTAGE



FIRING SEQUENCE

1. The points close, making the primary a complete circuit.
2. The flywheel magnet passes, creating current flow in the primary winding.
3. The current flow in the primary winding produces a strong, concentrated magnetic field which surrounds both the primary and secondary windings.
4. The points open, collapsing the magnetic field across the secondary winding.
5. The collapsing magnetic field induces several thousand volts in the secondary winding to fire the spark plug.

Chart 19

PRODUCING SECONDARY VOLTAGE

The coil's secondary winding is wrapped around the primary winding. One end of the secondary winding is connected to the ground, usually along with the lead from the primary winding which goes to the ground. The other secondary lead goes to the spark plug. The secondary winding consists of approximately 10,000 turns of very fine wire, usually about 60 times more turns than on the primary winding. The wire need not be large since we are concerned in the secondary with creating a very high voltage to push current across the spark plug gap. A very small amount of current is needed.

Since the secondary winding is wound around the primary winding, the magnetic field surrounding the primary winding is also surrounding and saturating the secondary winding. When the points open, the primary magnetic field collapses rapidly. The field collapses across the secondary winding. The collapsing magnetic field is a rapidly moving magnet moving past the secondary winding. This collapsing magnet tries to induce current flow in the secondary winding but because of the spark plug gap, a complete circuit does not exist. Since current cannot flow, voltage builds up. The voltage builds up until it is great enough to jump the spark plug gap, that is, if the coil can build up enough voltage! This is why the secondary winding is made up of several thousand turns of wire. A small voltage push is created in each turn of wire by the collapsing magnetic field. The voltage of all the turns is added together to create from 10,000 to 12,000 volts to jump the spark plug gap. The spark occurs at the plug when the points open, collapsing the primary magnetic field across the secondary winding which produces the voltage to push current across the spark plug gap.

Chart 20

FLYWHEEL REMOVAL

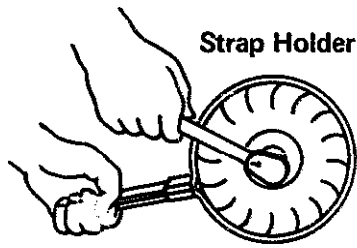


FIGURE A

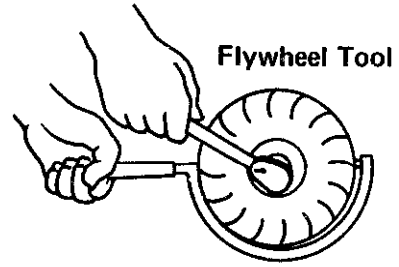


FIGURE B

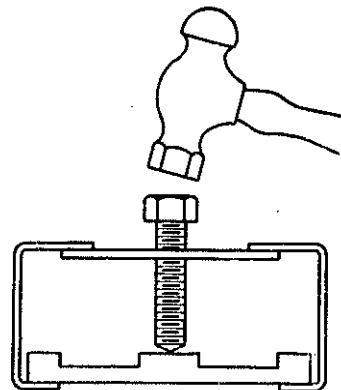
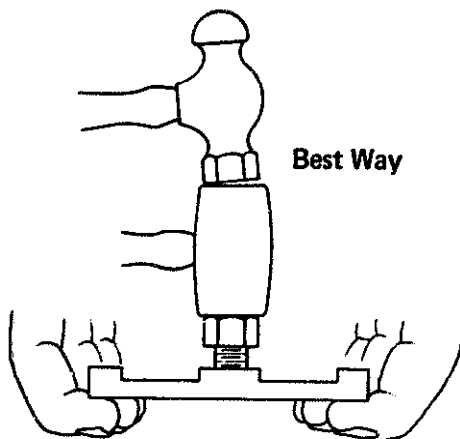
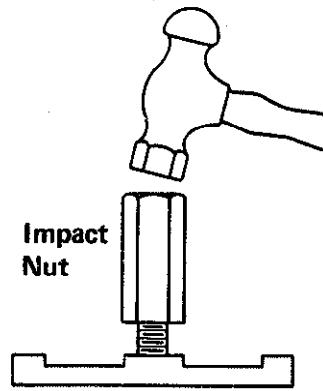
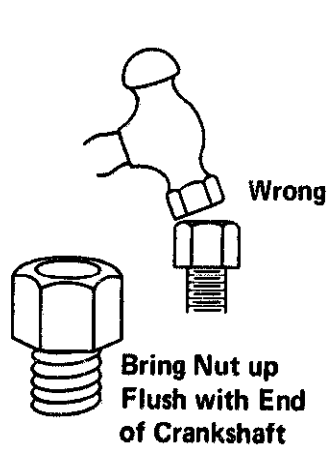
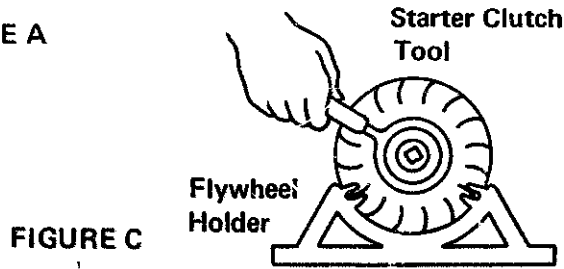


FIGURE D

Chart 20

FLYWHEEL REMOVAL

In order to service the points on most models, the flywheel must be removed. Flywheels are usually made of aluminum or cast iron and can be easily warped or cracked. The utmost care must be used in removing the flywheel. Since the flywheel magnet must travel very close to the armature, a warped or cracked flywheel will cause a weak spark or no spark at all.

The flywheel is fitted on the tapered crankshaft with a key. The flywheel is pressed onto the crankshaft taper and held there by a nut or a threaded starter clutch. The first job is to remove the nut or starter clutch. Use a belt type starter holder as shown in Figure A or a flywheel tool as shown in Figure B or C to hold the flywheel to remove the nut. **DO NOT** hold the flywheel with a screwdriver through the cooling fins. If the cooling fins are broken off, serious loss of cooling capacity will occur and the flywheel will become unbalanced and cause vibration and bearing damage. **DO NOT** try to hold the crankshaft on the power take-off end with a pipe wrench, vise grip, or similar tool because damage to the crankshaft could occur.

Use a socket to remove the nut as shown in Figure A. If necessary to remove the starter clutch, use a special starter clutch tool. **DO NOT** use a hammer on the ears of the starter clutch. If the special tool is not available, make a tool that will engage at least two of the ears on the starter clutch. On some engines, the flywheel nut has left-hand threads. Check threads carefully if there is any doubt about which way to turn the nut. After the nut is removed, the next job is to free the flywheel from the crankshaft taper. Pulling or prying will result in a damaged flywheel. The shock of a sharp blow from a steel hammer is the best way to loosen the taper fit.

NEVER STRIKE THE CRANKSHAFT WITH A HAMMER

Hitting the crankshaft directly with a hammer will result in damaged threads, a broken crankshaft, or a swollen starter clutch shaft. Also, when shock is used to remove the flywheel, care should be taken that the impact is not placed on the engine's main bearings. The best method is for one person to hold the engine approximately one-fourth inch above the workbench. The engine should be held by gripping the flywheel firmly as shown in Figure D. A second person places a first hammer on the crankshaft end squarely using the nut flush with the end of the crankshaft in order to protect the threads. Strike the first hammer with a second hammer to deliver the shock to the crankshaft end. Strike the second hammer with a strong, solid blow. One good blow will do what several light taps cannot do. **HIT IT!**

WEAR SAFETY GLASSES OR FACE SHIELD

Fragments from either the hammers or the crankshaft are extremely dangerous.

Chart 21

INSPECT FLYWHEEL AND KEY

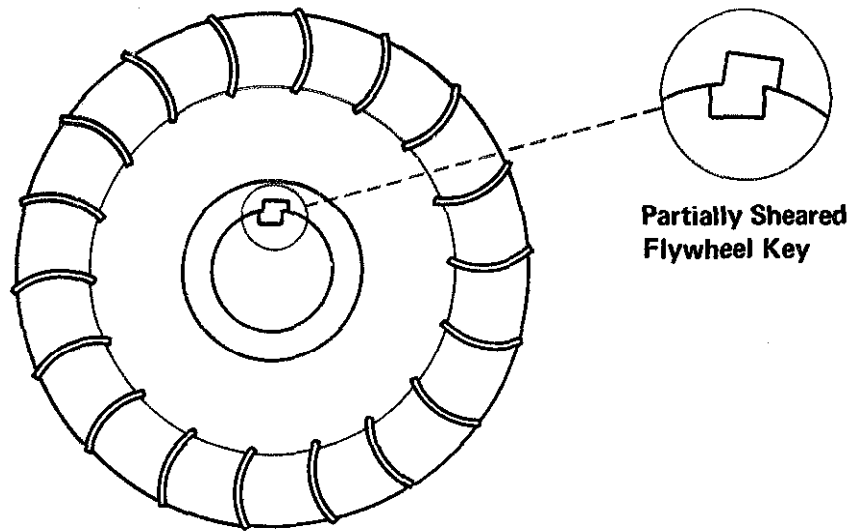
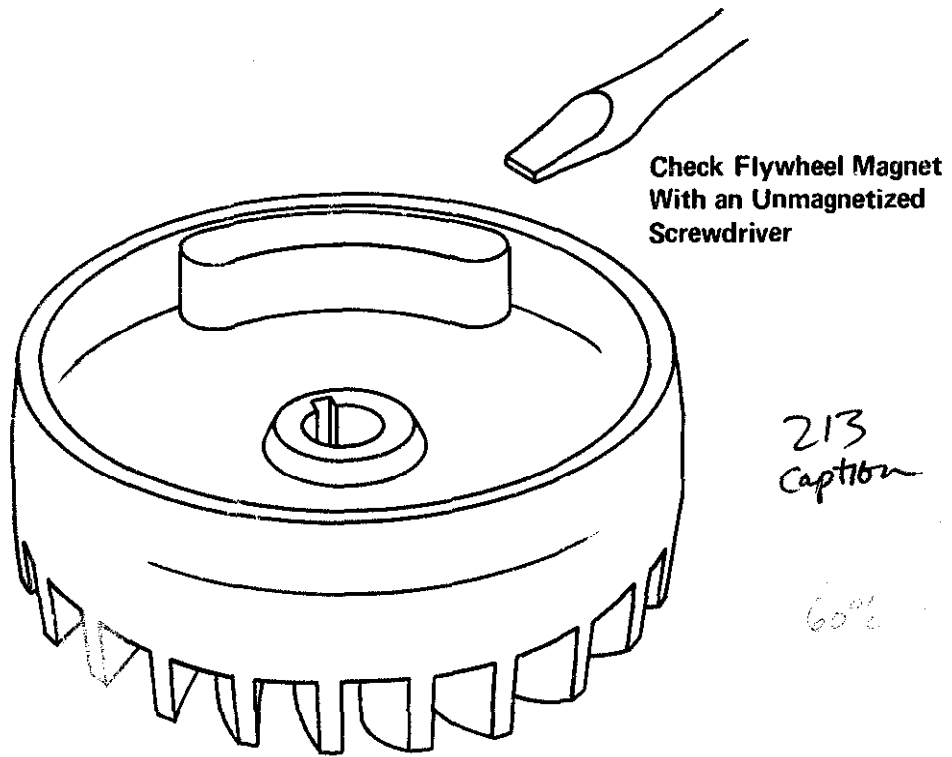


Chart 21

INSPECT FLYWHEEL AND KEY

Handle the flywheel carefully! Do not drop it or lay it near large motors or electromagnets such as a generator armature growler. Be sure to locate the key which keyed the flywheel to the crankshaft and store it where it will not be lost.

CHECK THE FLYWHEEL FOR CRACKS

Check the surface of the flywheel for cracks. Check for cracks inside the hub near the keyway. If the flywheel is cracked or if the keyway is worn excessively, the flywheel should be replaced.

CHECK THE FLYWHEEL MAGNET

Since the flywheel magnet is the source of power for the flywheel magneto ignition system, it must have full strength. An unmagnetized screwdriver should be strongly attracted to the flywheel magnet. If possible, compare with a new flywheel or other good flywheel magnet. Some flywheel magnets are replaceable, but on others the whole flywheel must be replaced. Newer flywheel magnets seldom lose their magnetism unless dropped, heated, or exposed to strong AC magnetic fields.

CHECK THE FLYWHEEL KEY

Some engines, especially lawn mower engines, use an aluminum key to keep the flywheel properly secured to the crankshaft. This is to help absorb the flywheel momentum in case the blade strikes an unmovable object. With such a sudden stop, the momentum of the flywheel would tend to snap the crankshaft. Sometimes the key will shear or partially shear as shown at left. Replace the key with a new aluminum key. **DO NOT** replace an aluminum key with a steel key.

Chart 22

BREAKER POINTS

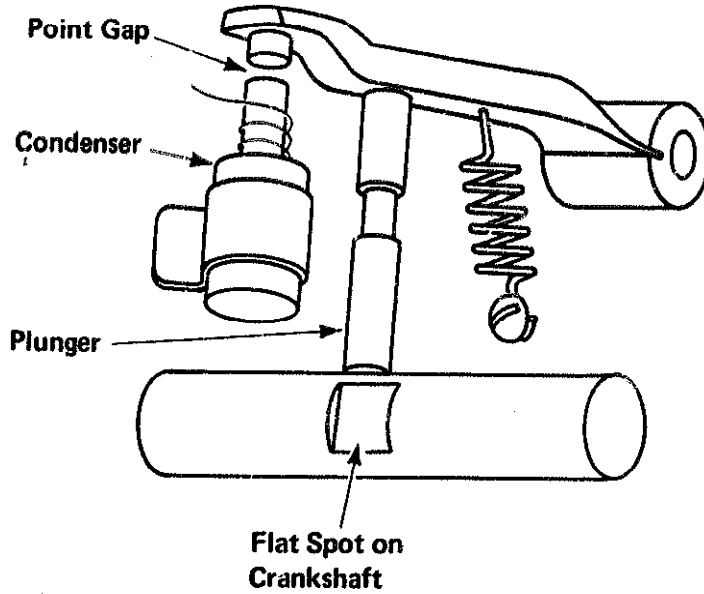
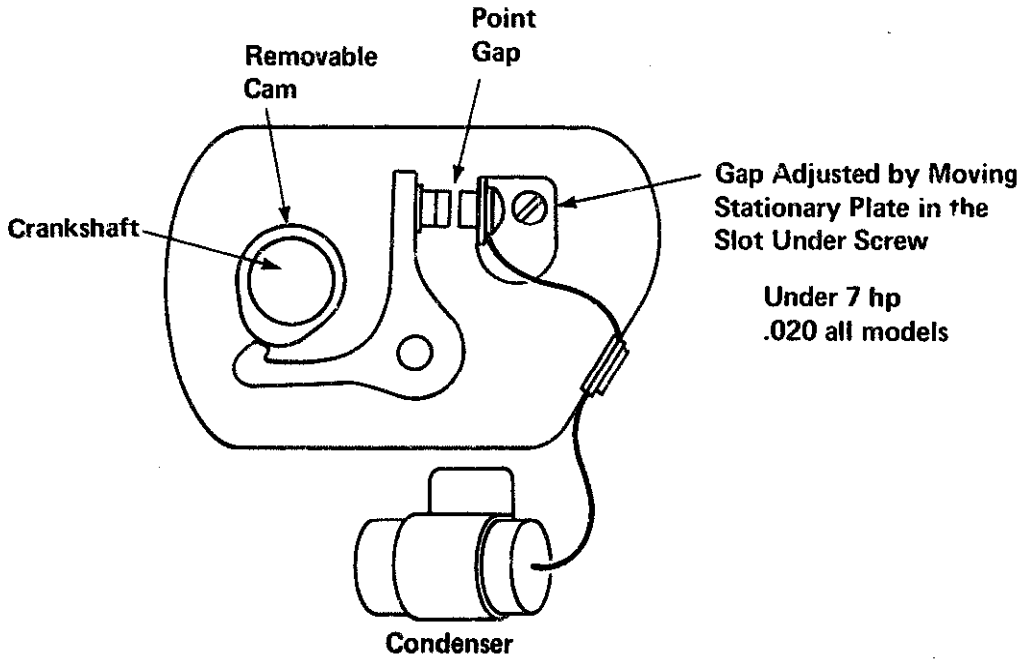


Chart 22

BREAKER POINTS

Breaker points are relatively inexpensive and easy to change. Considerable care must be used in this task in order to do the job properly. Loss of spark, weak spark, and incorrect spark timing can result from improper point installation. Remember that the spark occurs at the plug when the points open the primary circuit. Setting the breaker points incorrectly will result in improperly set ignition timing.

First, identify the type breaker point and condenser set used. It will probably be one of the two types shown at the left. Note that on one type the condenser is mounted outside the breaker point box. On the other type the condenser acts as the stationary contact point.

When ordering the new contact points, be sure to have the engine brand, model number, type number, and serial number.

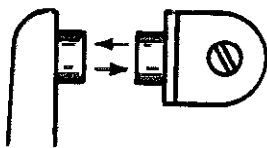
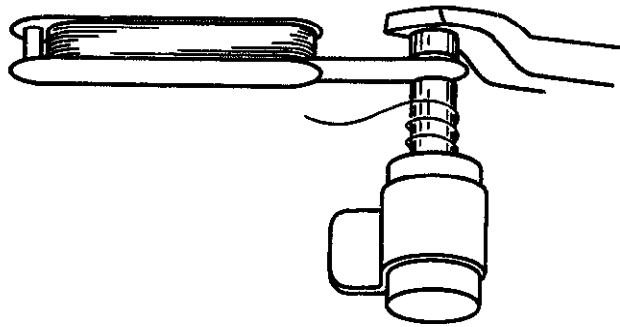
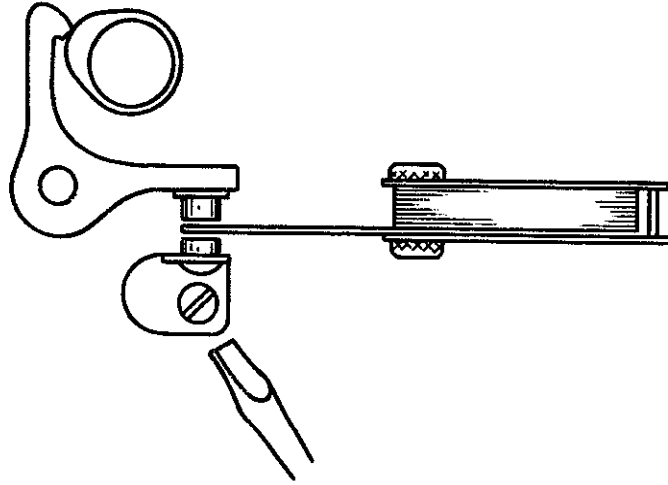
Sometimes it is recommended that breaker points be cleaned and readjusted. However, since new points and condenser are relatively inexpensive and since a number of problems can be introduced during the cleaning operation, new points are recommended whenever the engine is dismantled to this point unless, of course, the points have been changed recently.

Sanding or filing will introduce foreign matter to the breaker point area and could prevent the points from making contact or prevent them from opening properly. Many new contact point sets are plated and the cleaning process merely removes the plating. Point life will be very short once the plating is removed.

Note that on the type illustrated above on the opposite page the movable point is opened by a removable cam on the crankshaft. If this cam is removed, as it would be to remove the crankshaft from the engine, note which way the cam came off. If the cam falls off or if you cannot remember which way it came off, consult the manufacturer's manual before replacing the cam because the flywheel, when tightened, may crack if the cam is replaced backward. Also, the points could be badly out of time if the cam is reversed.

Chart 23

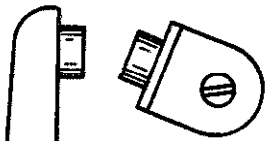
REPLACE BREAKER POINTS



Points Hitting
Squarely



Points Offset.
Poor Contact



Wrong

Points Hitting at
an Angle.
Poor Contact



Points Hitting
Squarely

Chart 23

REPLACE BREAKER POINTS

1. Secure new breaker points and condenser. Be sure to obtain the following information:

Engine brand _____
Model number _____
Type number _____
Serial number _____

2. Remove the breaker point box cover. Make a sketch of the breaker points and condenser. Use the illustration on the opposite page as a sample. Carefully indicate the number of wires and the connection point of each wire.

3. Determine the correct setting of the breaker point gap. Refer to manufacturer's specifications. For engines under 7 hp this is usually .020 inches. The correct gap for this engine is _____.

4. Check the condition of the old points.

5. Check the gap of the old points. The old points were set at _____.

6. Remove and replace the points and condenser. Place a tiny amount of lubricant on the breaker cam.

7. Align the new breaker points so that they come together squarely and without overhang. Usually the stationary contact can be adjusted. If necessary, use pliers to bend to the correct alignment. Turn the crankshaft several times to make sure that the alignment is correct.

8. Adjust the gap. Turn the crankshaft until the points are open maximum. Use the correct feeler gauge as shown at left and move the stationary contact until only a light drag is felt as the feeler gauge is moved through the contact area. Remove the feeler gauge and recheck to make sure that the points are not being pushed open as the feeler gauge enters the contact area.

Check point _____

9. Clean the new contacts. Open the points and insert a small piece of hard, white, lint free paper. Move the paper back and forth through the contact area to remove any dust or oil film from the contact area. Be sure to open the points before removing the paper so that no fragments of the paper will be torn off in the contact area.

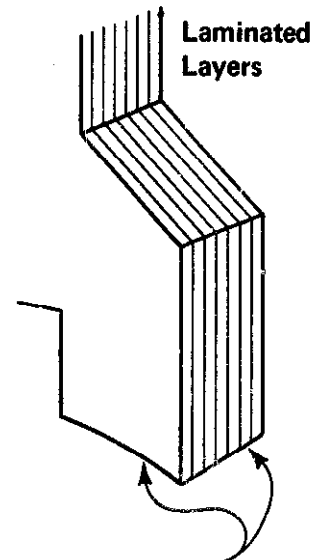
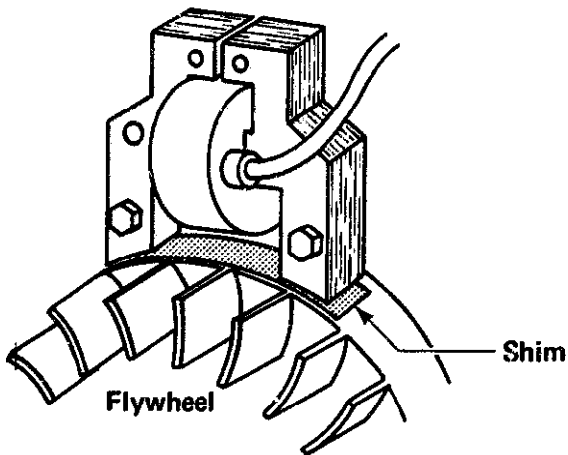
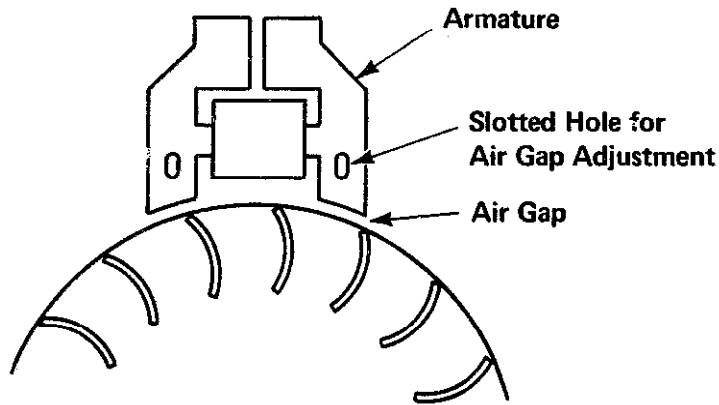
10. Recheck wiring.

Check point _____

11. Replace the breaker point box cover. Use a small amount of sealer such as Permatex to seal around wires and where the cover seats. The life of the points depends on a clean atmosphere.

Chart 24

ADJUST ARMATURE AIR GAP



Remove Rust Buildup on Laminated Layers with Sandpaper or Emery paper.

Chart 24

ADJUST ARMATURE AIR GAP

On an engine whose armature is mounted outside the flywheel as shown on the opposite page, the air gap between the armature and the flywheel must be adjusted properly.

REMOVE THE ARMATURE FROM THE ENGINE

Remove the screws holding the armature-coil assembly to the engine. Use the correct size ignition wrench or nut driver to remove the screws. Do not use pliers because the screw heads may be damaged.

CLEAN THE COOLING FINS BEHIND THE ARMATURE

If the engine is not going to be dismantled further, clean the cooling fins on the engine block behind the armature before replacing the armature.

CLEAN THE ARMATURE

Use a piece of sandpaper or emery paper to clean the armature laminations. Rust will bridge the gap between the laminations and reduce the coil efficiency. Sand all of the exposed lamination area. Coat the sanded area with a plastic protection spray or light film of grease.

REPLACE AND ADJUST THE ARMATURE

Mount the armature on the engine block. Raise the armature as high as possible and tighten one screw to hold it. Secure a piece of shim stock of the correct thickness. Check the manufacturer's specifications for the correct air gap. Usually this gap will be set approximately .010 inch. Hard paper such as magazine covers may be used. Add layers to get the correct thickness. See the section on measuring devices for micrometer operation to measure the thickness of the shim. Do not use a feeler gauge to set the armature air gap. Loosen the screw holding the armature and lower the armature against the shim. Tighten all screws and remove the shim.

On most smaller models, engines having the armature mounted outside the flywheel do not require timing. The only adjustment for timing is at the breaker points. Make sure that the breaker points are set correctly on this type engine.

Chart 25

IGNITION TIMING

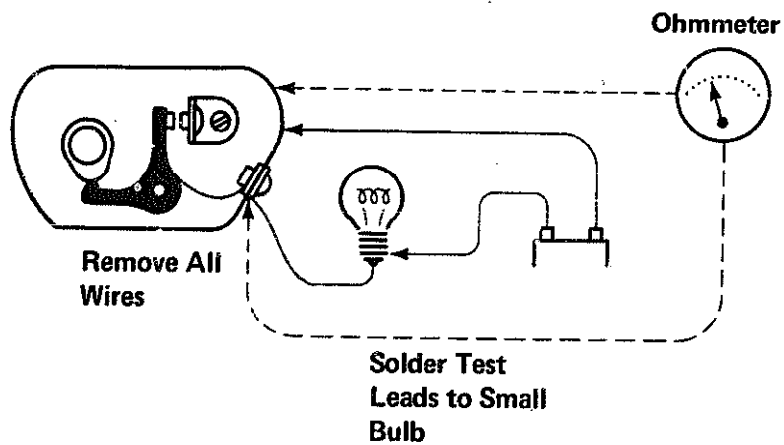
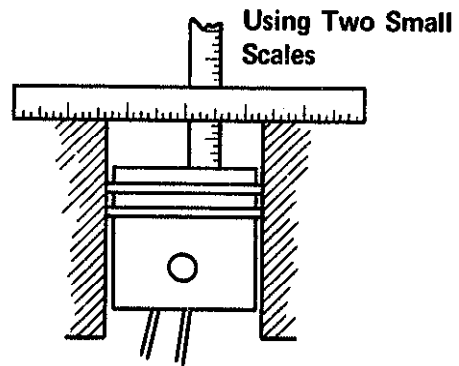
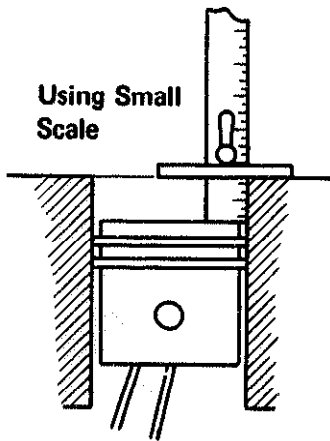
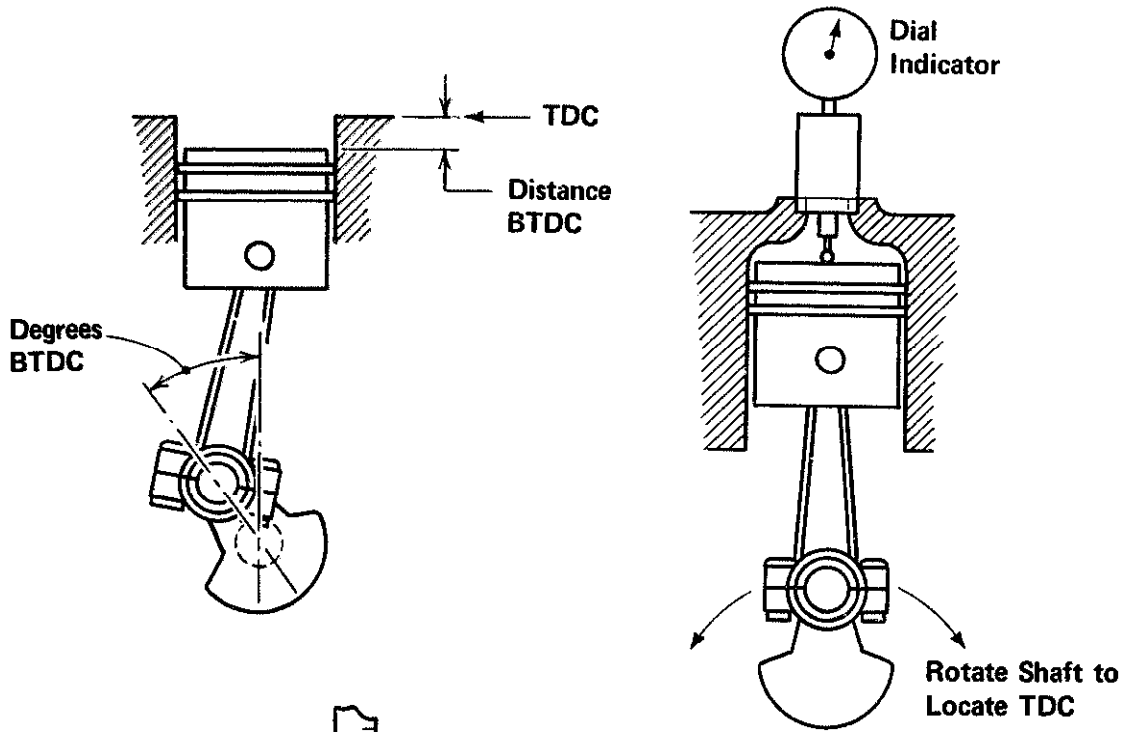


Chart 25

IGNITION TIMING

Engines having the armature-coil assembly mounted under the flywheel usually must have the ignition timing adjusted. The various manufacturers prescribe different techniques for the exact timing. Some types have timing marks on the armature and on the engine block. If these are used, it is a simple matter to align the marks and tighten the armature down. On this type, as with the externally mounted armature, the timing accuracy depends on the correct breaker point setting to fire the spark plug at exactly the right time. Adjust the breaker points carefully.

Other engines rely upon finding top dead center (TDC) of piston travel and then moving the piston a specified distance before top dead center (BTDC) to locate the exact point in piston travel that the points should open.

FIND TDC

To find TDC, find the point at which the piston stops moving up and starts moving down. Study the upper illustration on the opposite page. Note that as the crankshaft passed TDC, there is a short distance of crankshaft travel which results in no piston movement. On most engines this point can be found by removing the spark plug and inserting a dial indicator or small machinist's rule. If the cylinder head is removed, the machinist's rule may be used from the top of the block. TDC is halfway between the point the piston stops moving up and begins moving downward.

CONSULT MANUFACTURER'S SPECIFICATIONS

Some manufacturers give a distance before top dead center in terms of piston travel. This distance is usually given in thousandths of an inch, such as .060 BTDC. Turn the crankshaft backward until the piston moves the specified distance.

Check point _____

Other manufacturers give a number of crankshaft degrees before top dead center. After TDC is located, the crankshaft must be turned backward the specified number of degrees. A protractor or degree indicating wheel may be used to determine the number of degrees. If the flywheel fins are evenly spaced, as they are on some engines, count the number of cooling fins and divide into 360° to determine the number of degrees between each cooling fin. Replace the flywheel carefully and turn the crankshaft backward the specified number of degrees and remove the flywheel. Be *very* careful not to move the crankshaft while removing the flywheel.

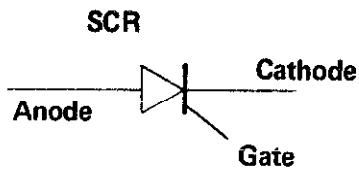
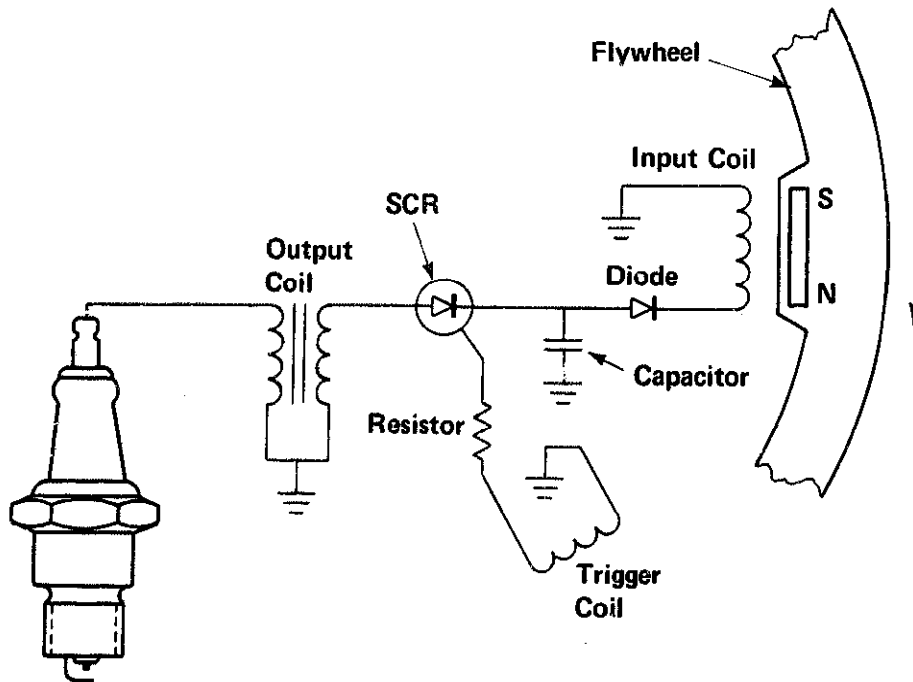
DETERMINE WHEN THE POINTS OPEN

After the crankshaft has been brought to the correct number of degrees BTDC or thousandths of an inch BTDC, the armature-breaker point assembly is adjusted until the points are just opening. Exactly when the points break electrical contact can be determined by using an ohmmeter as shown on the opposite page. All wires must be disconnected for this test. A test lamp and battery may be used instead of the ohmmeter.

Chart 26

PARTS OF

THE ELECTRONIC IGNITION



AN ELECTRONIC SWITCH
TURNED ON BY THE OUTPUT
OF THE TRIGGER COIL

Chart 26

PARTS OF THE ELECTRONIC IGNITION

The INPUT COIL is similar to the primary winding in the conventional armature. As the flywheel magnet passes the input coil, current flow is induced in the coil windings. The current will charge the capacitor.

The CAPACITOR is a device that will absorb and store electrical energy for a short time. When the flywheel magnet passes the input coil, the capacitor will become charged.

A DIODE is an electrical check valve. It allows current to flow in only one direction. In this circuit it allows current to flow to the capacitor, charging the capacitor. The electrical energy is then trapped in the capacitor because the diode will not allow it to go back through the coil.

The SILICON CONTROLLED RECTIFIER (SCR) is an electronic switch. It has no moving parts but normally acts as an open switch to electrical current. The switch (SCR) is turned ON by a small voltage applied to the *gate* connection.

The TRIGGER COIL provides the gate voltage to turn ON the SCR. After the magnet passes the input coil which charges the capacitor, it then passes the trigger coil which turns on the SCR allowing the capacitor to discharge through the transformer primary winding. The trigger coil is the timing device since the signal (voltage) to fire (turn on) the SCR is provided by the trigger coil.

The PULSE TRANSFORMER is similar to the coil in that it has a primary winding which will build up a strong, concentrated magnetic field when current passes through it and a secondary winding made up of several thousand turns of wire which will create the high voltage needed to fire the spark plug. The pulse transformer primary gets its current flow from the capacitor rather than directly from the flywheel magnet as in the flywheel magneto.

Chart 27

ELECTRONIC IGNITION

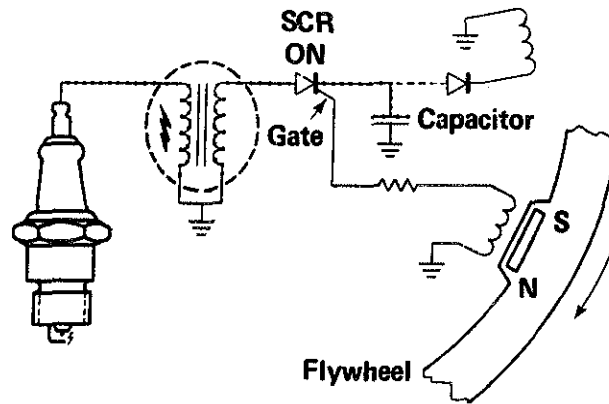
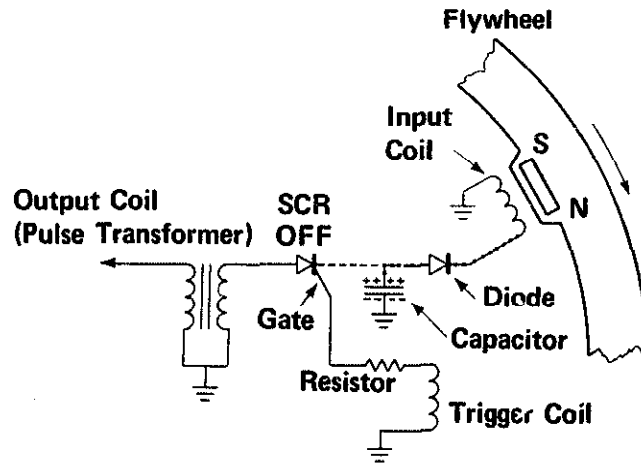


Chart 27

ELECTRONIC IGNITION

The solid-state electronic ignition is available on small gas engines. A battery is not necessary to operate the solid-state ignition because it is self-energized by the flywheel magnet as is the conventional magneto ignition system. The breaker points have been replaced with an electronic switch (SCR) which is triggered by a small coil. With this system, the only moving part is the flywheel magnet which does not actually make moving contact with other parts.

CHARGING THE CAPACITOR

As the flywheel magnet passes the input coil alternating current is induced in the coil. The diode, which is a one-way electrical check valve, allows the current to flow in only one direction. The flow charges the capacitor as the SCR is still turned OFF. The charge placed on the capacitor is trapped there by the diode since it is a one-way device and will not allow the current to flow back to the input coil.

TURNING THE SCR ON

After the flywheel magnet passes the input coil charging the capacitor, it then passes a small trigger coil which produces enough voltage to trigger (turn on) the SCR. A resistor is necessary to prevent excessive current flow which would damage the SCR.

DISCHARGING THE CAPACITOR

When the trigger coil turns on the SCR, it opens a path for the capacitor, which was left holding a charge, to discharge through the primary of the pulse transformer to the engine ground. This sudden burst or pulse of current through the primary winding of the pulse transformer sets up a magnetic field which induces a very high voltage in the secondary winding to fire the spark plug. The action of the primary and secondary winding in the pulse transformer is similar to that of the conventional coil. Spark timing is determined by the placement of the trigger coil.

Chart 27 (continued)

ELECTRONIC IGNITION

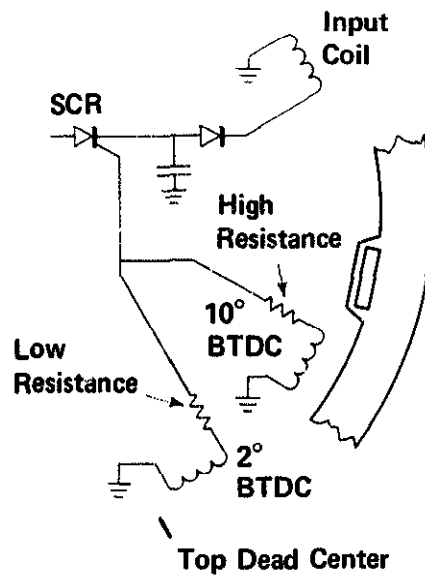


Chart 27 (continued)

ELECTRONIC IGNITION

TIMING ADVANCE

Two trigger coils could be used to trigger the SCR. The first trigger coil would be connected to the SCR through a high value resistor which would allow this coil to fire the SCR only at high speed. The other trigger coil placed after the first would fire the SCR at low speed.

With this arrangement, the SCR would not be fired until near TDC at low speed. When the engine speed increases to the point at which the first trigger coil produces enough voltage to overcome the higher resistance in its circuit, the SCR would be fired earlier causing earlier firing of the spark plug

WHY ADVANCE TIMING

From the instant the spark plug fires until the burning gas mixture expands to create maximum push against the piston takes time. The time needed to "build the fire and get it going" is nearly the same at all engine speeds.

At idle speed only a few degrees of crankshaft rotation are needed to provide this time. As the crankshaft turns faster, the spark plug must fire earlier in order to provide the same amount of time to get the fuel mixture burning. This is called timing advance.

Chart 28

CARBURETION

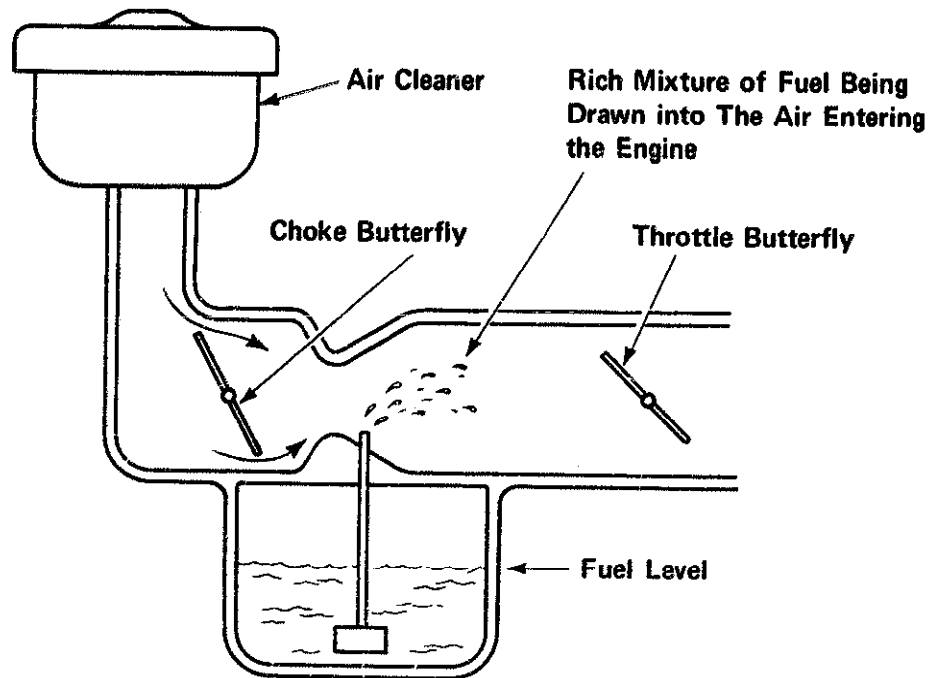
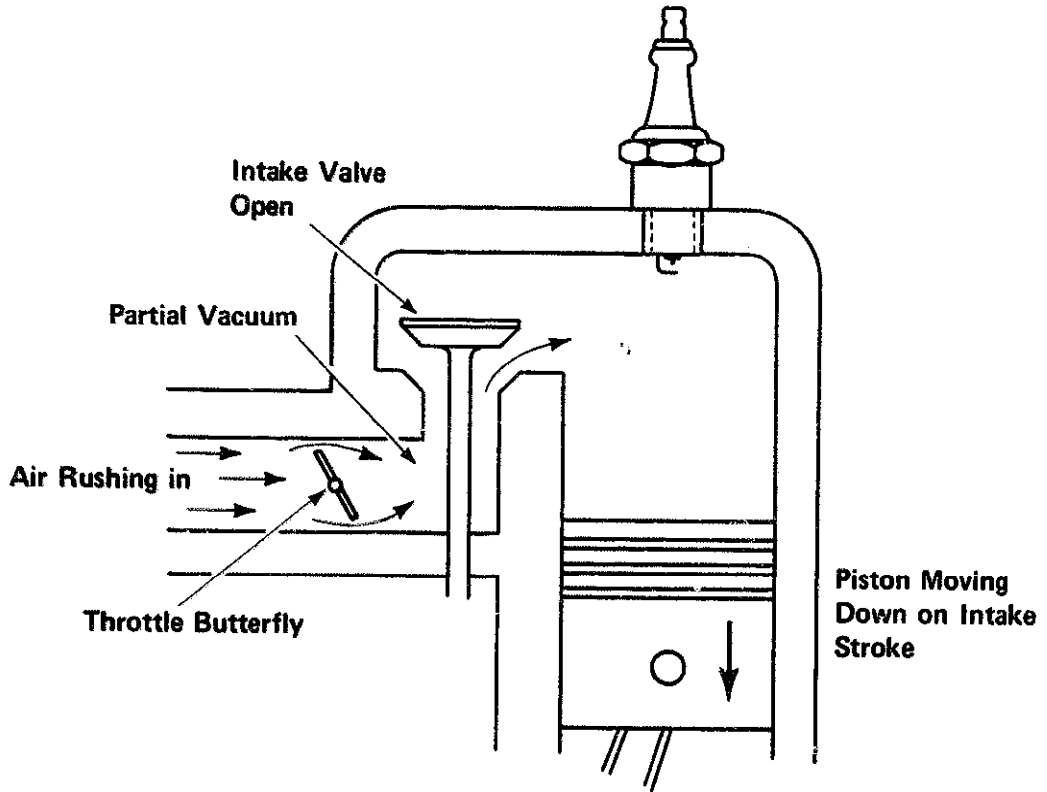


Chart 28

CARBURETION

The carburetor controls the engine speed and provides it with a correct air-fuel mixture. The problem of providing a correct air-fuel mixture is complicated by the fact that the carburetor must provide this mixture through a wide range of engine speeds, varying loads, and varying temperatures. A carburetor which can do all of these things is complicated and expensive. On small gas engines, carburetors are designed to do as many of these things as possible while keeping the carburetor simple and inexpensive.

On four-stroke cycle engines, when the piston moves downward on the intake stroke, the intake valve is held open. Air rushes through the carburetor to fill the space being created by the moving piston. The moving piston is creating a partial vacuum above it. In this sense the engine is an air pump that pumps in large amounts of air on the intake stroke and emits large amounts of hot air and exhaust gas during the exhaust stroke.

SPEED CONTROL

The engine speed is controlled by a flat disc called the throttle butterfly which restricts the flow of air through the carburetor and controls the air-fuel mixture to the engine. Note that unless the throttle butterfly is wide open the engine cannot get all the air it wants. This restriction by the throttle causes a partial vacuum to be created behind it. This is referred to as the intake vacuum. When the engine is running smoothly at low speed and under no load, the intake vacuum will be quite high for the throttle is restricting air flow to the engine. Opening the throttle will allow more of the air-fuel mixture to the engine and the speed will increase. An engine which is pulling hard will have the throttle open wide in proportion to the engine speed and the intake vacuum will be low. When an engine is under a light load, the intake vacuum will be high for the throttle will be limiting the air flow to the engine and the engine speed will be controlled.

THE CHOKE

The choke is a restriction in the outer end of the carburetor to provide an extra rich air-fuel mixture for starting. When the engine is cold, the fuel will not vaporize properly and an additional amount of fuel is needed to start the engine. The choke may be either a sliding tube or butterfly. It creates a restriction that cuts down the air flow to the engine and causes additional fuel to be drawn into the air stream. Some engines utilize a small primer pump instead of a choke. The primer pump injects a small amount of extra fuel into the air stream to create the rich mixture needed for starting.

CAUTION

Do not attempt to choke engines by putting the hand over the carburetor inlet. A misfire (backfire) could cause serious burns. Never look directly into the carburetor while the engine is being cranked.

Chart 29

AIR-FUEL MIXTURE

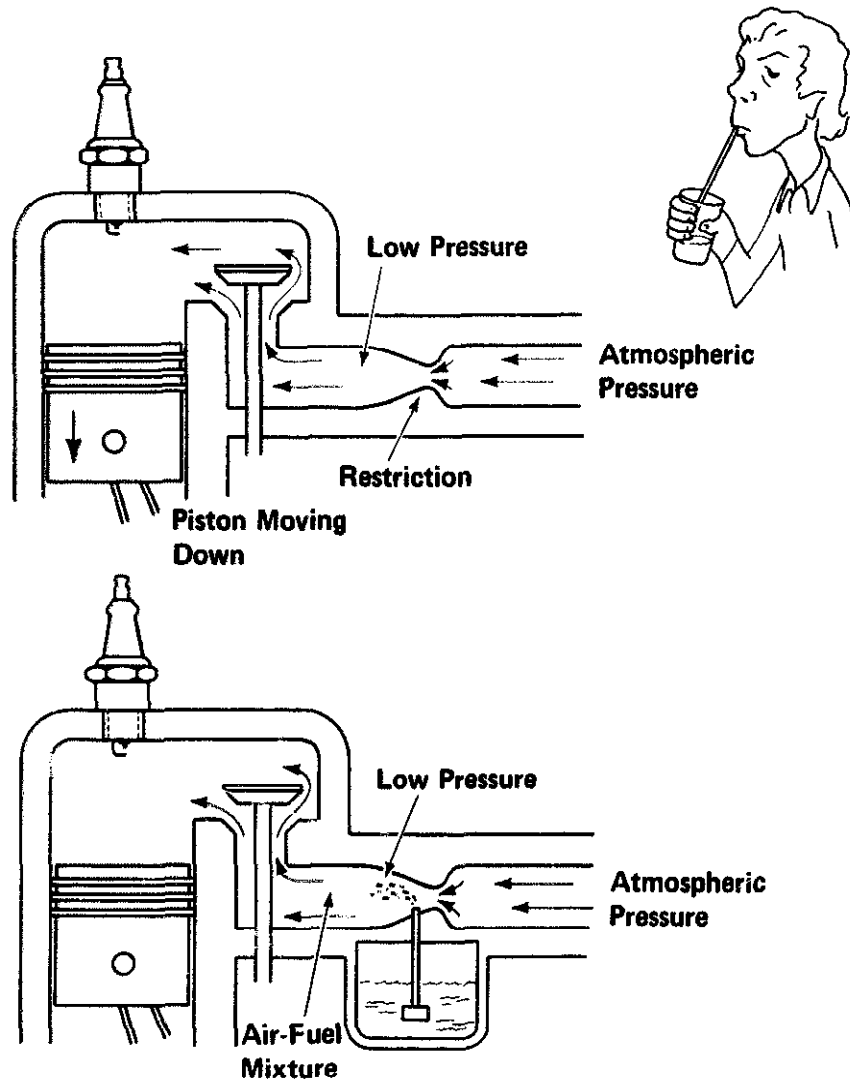


Chart 29

AIR-FUEL MIXTURE

Good combustion requires a correct air-fuel mixture. A correct air-fuel mixture is one that has enough air to completely burn all the fuel. A mixture that has too much fuel is called a rich mixture. An engine running on a rich mixture will have reduced power and will emit black smoke from the exhaust pipe. Running an engine with a rich air-fuel mixture will result in rapid build up of carbon on the piston, valves, and head. A mixture that does not have enough fuel for the air entering the engine is called a lean mixture. A lean mixture results in severe loss of power and a tendency for the engine to "surge" (speed up and slow down constantly). If the engine is operated on a lean fuel mixture under load, overheating will result which can lead to a breakdown of the lubrication on the cylinder walls and allows the rings to scrape the cylinder walls and may cause them to seize (freeze up).

THE VENTURI

As air rushes through a restriction, it must speed up. The increased speed of the air through the restriction causes a low-pressure area in the restriction. A restriction is placed in the carburetor air horn to cause a low-pressure area. This restriction is called the VENTURI. A tube is connected from the fuel bowl into the venturi so that as air passes through the venturi, fuel is drawn into the air stream by the low pressure just as Coke is drawn through a straw. Creating a low pressure in your mouth causes the Coke to be drawn into your mouth. When the throttle is opened wider, the air flow will increase and the pressure in the venturi will become even lower, increasing the fuel flow into the airstream. The amount of fuel drawn out of the fuel bowl is determined by the amount of air flowing through the venturi. The mixture is consistent over a wide range of speeds. Opening the throttle wider will allow more air through the carburetor. This additional air will cause more vacuum in the venturi which will draw additional fuel into the airstream. The proportion of air to fuel will be the same, providing enough air to properly burn the fuel allowed into the cylinder. Also, mixing fuel with the air in the venturi helps to turn the fuel into a vapor mist rather than drops of fuel. Fuel that reaches the cylinder in drop-let form will not burn properly. Only fuel that is changed into a vapor will burn properly in the engine. A rich fuel mixture allows drops of fuel into the engine. Instead of burning quickly like the vapor, the fuel drops tend to "wash" the oil film from the cylinder wall and cause undue wear on the rings and cylinder wall.

Chart 30

THE HIGH-SPEED AND INTERMEDIATE-SPEED CIRCUIT

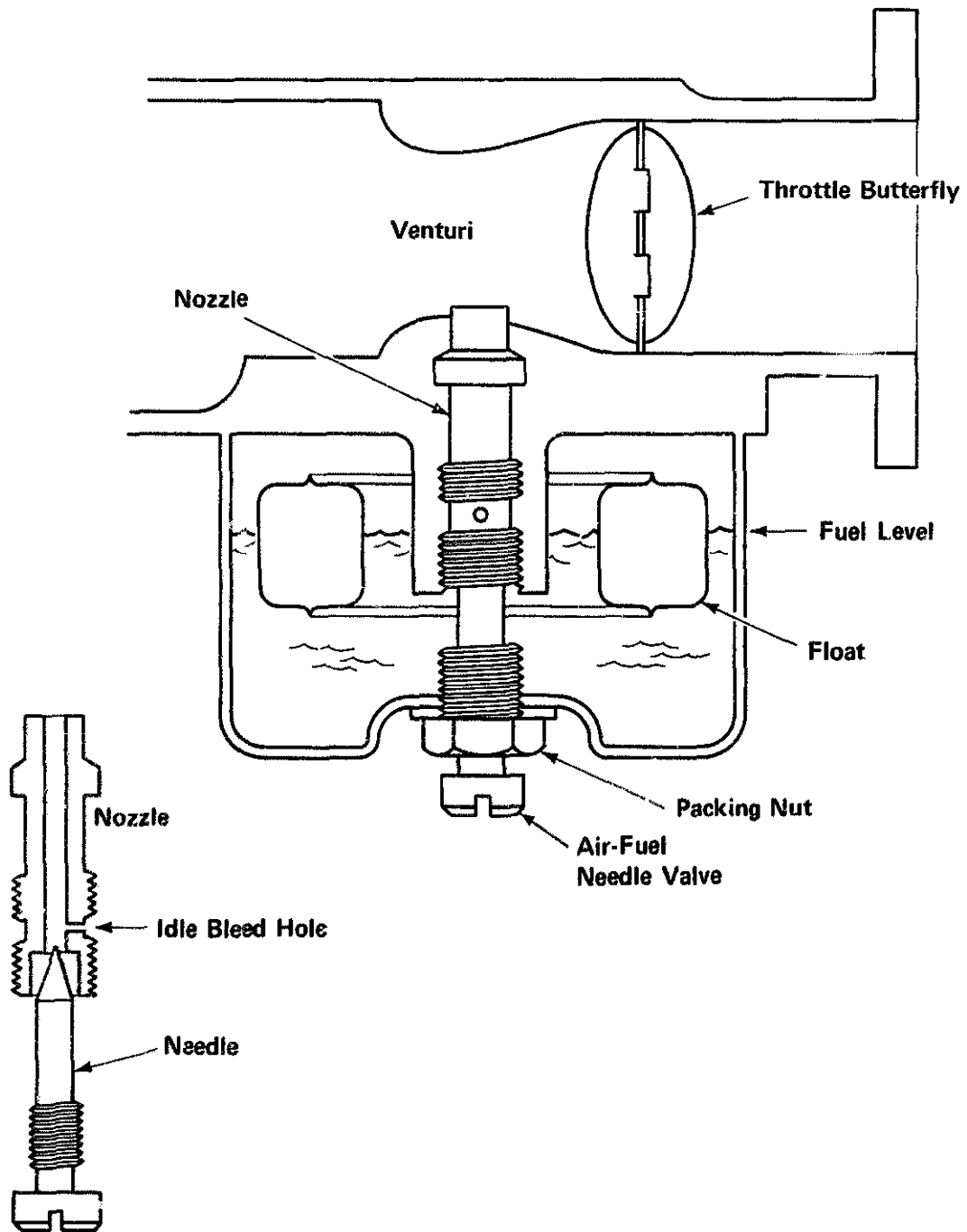


Chart 30

THE HIGH-SPEED AND INTERMEDIATE-SPEED CIRCUIT

The high-speed or load circuit is the real heart of the carburetor for fuel economy, engine power, engine temperature, and engine life are all dependent on the correct mixture during normal speed and load operation. The illustration at the left shows the major components of the circuit during normal operating conditions. The throttle butterfly is regulating the air flow into the engine. The venturi is creating a low-pressure area to draw the fuel from the fuel bowl. The carburetor shown here utilizes a float to maintain a constant fuel level. Some carburetors use other methods to maintain a constant fuel level. The fuel level is very important. An increase of as little as one-sixteenth inch in the fuel level will make the fuel easier to pull into the airstream in the venturi and will cause a rich mixture. A low level will cause a lean air-fuel mixture.

The nozzle is a precision tube which usually is removable. It provides the seat for the needle valve and extends into the venturi as shown here. The nozzle is made of brass or other soft material and is subject to wear and damage from abuse.

The fuel metering adjustment needle valve adjusts the flow of fuel into the nozzle. It limits the amount of fuel that will be drawn into the airstream flowing through the venturi. This adjustment is made with the engine warm and running at least at half speed. Never operate engines at high speed when the engine is not under load! The engine may reach a speed at which mechanical failure can occur in the connecting rod or other fast-moving parts.

Notice the idle bleed hole located in a flat ring turned in the threaded portion of the nozzle. This allows fuel to enter the idle circuit (see idle circuit) on this type carburetor. On some older models this area of the threads was not turned flat but was threaded all the way up. On these models the old nozzle cannot be replaced in the carburetor because the idle bleed hole will not align with the matching hole in the carburetor. If these holes do not align, there will be a loss of the idle circuit and the engine will die when the throttle is returned to the low speed position. Once the nozzle has been moved for any reason, it should be completely removed. If it does not have a flat area completely around the nozzle in the thread area, it must be replaced with a new nozzle.

Chart 31

THE IDLE CIRCUIT

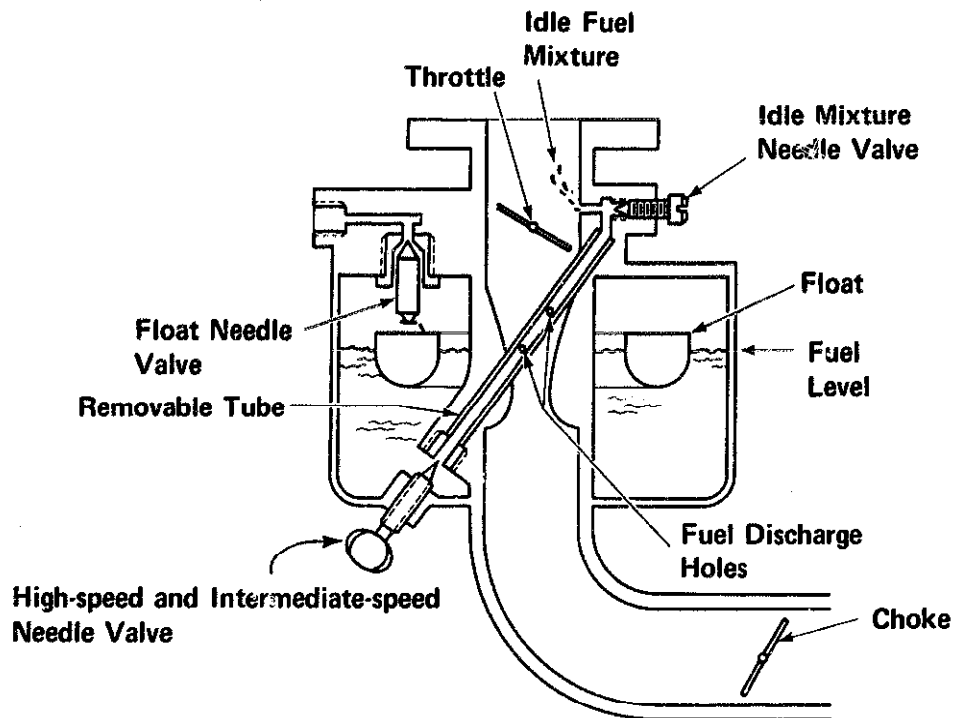
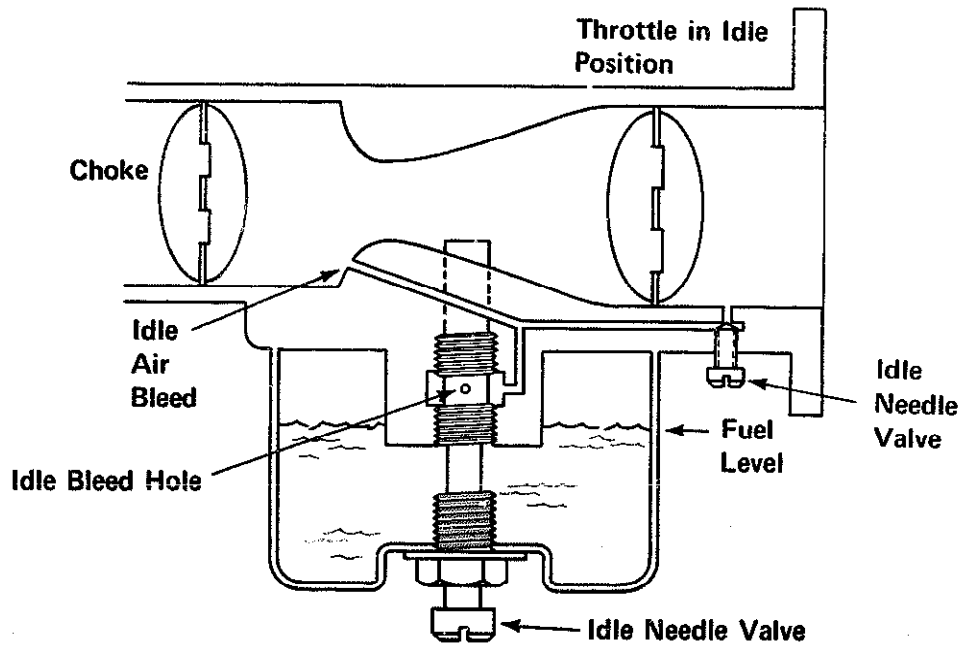


Chart 31

THE IDLE CIRCUIT

The idle circuit is necessary to supply a correct air-fuel mixture to the engine when the engine is at idle and low speeds. Air flow through the venturi at low speeds is too slow to create the low-pressure area needed to draw the fuel into the venturi. A low-pressure area (vacuum) exists behind the throttle butterfly during idle since the throttle is restricting the air flow into the engine. A separate idle circuit connected behind the throttle comes into operation when a high vacuum exists behind the throttle.

Gas is drawn by the low pressure behind the throttle butterfly from the fuel bowl past the idle mixture screw. Air is also drawn into the idle circuit through the air bleed in the air horn near the venturi. Some air is also entering the engine around the throttle butterfly. This air has no fuel since it passed through the venturi too slowly to draw fuel from the fuel bowl. This air entering around the throttle and the air carrying a rich mixture of fuel is entering through the idle mixture needle valve. Adjusting the idle mixture screw limits the amount of air fuel entering from the idle circuit which mixes with the air entering around the throttle butterfly. This adjustment is made only with the engine at operating temperature and at the correct idle speed (see Basic Carburetor Adjustments).

Some carburetors utilize the fuel discharge holes in the venturi for air bleed during idle (see the illustration at the bottom of the opposite page). During high-speed operation the low pressure in the venturi draws fuel through the high-speed fuel needle valve and through the fuel discharge holes in the tube extending through the venturi. When the throttle is closed and the vacuum is greater behind the throttle butterfly than in the venturi, air enters through the fuel discharge holes on its way through the idle circuit. Note that during idle the fuel also comes through the high-speed needle valve. The adjustment of high-speed needle valve can also affect the idle mixture. Always adjust the high-speed mixture first and remember that anytime the high-speed mixture is changed, the idle mixture should be readjusted.

Chart 32

CARBURETOR FUEL SUPPLY

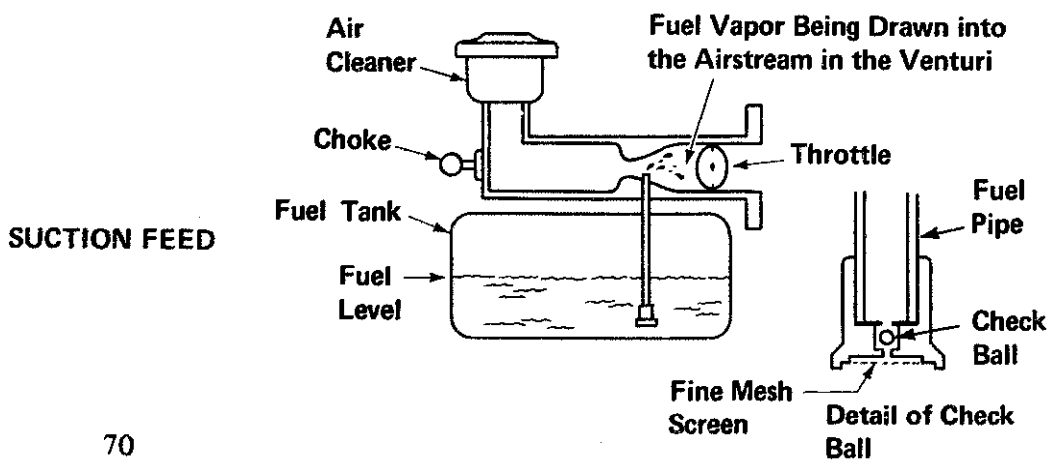
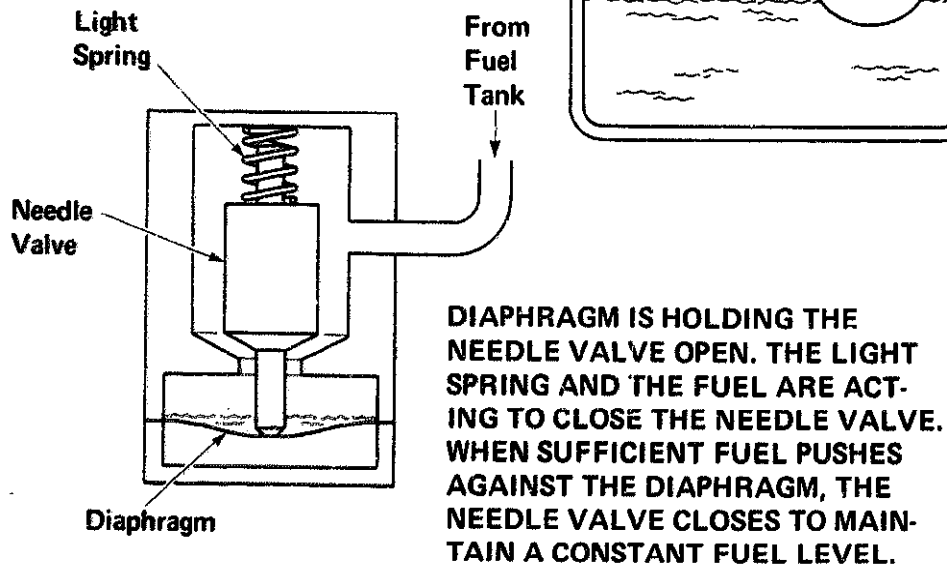
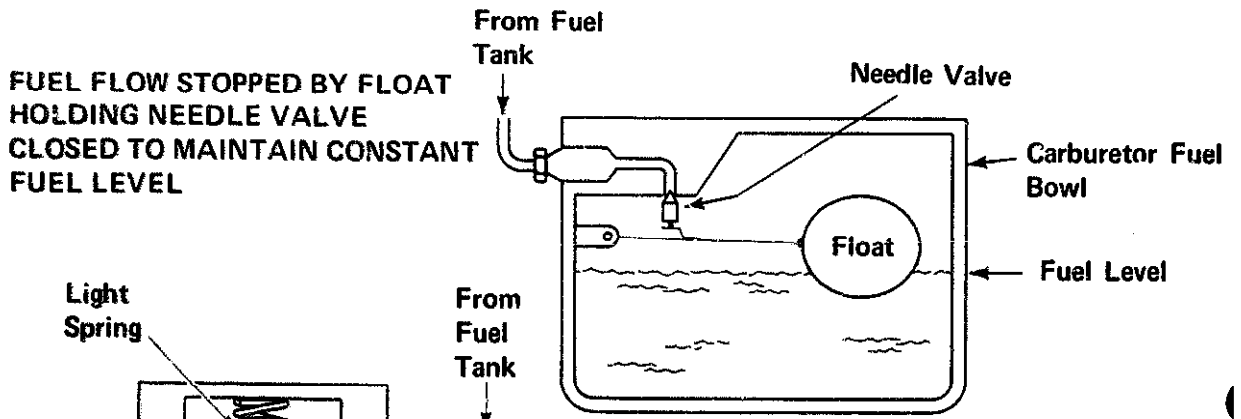
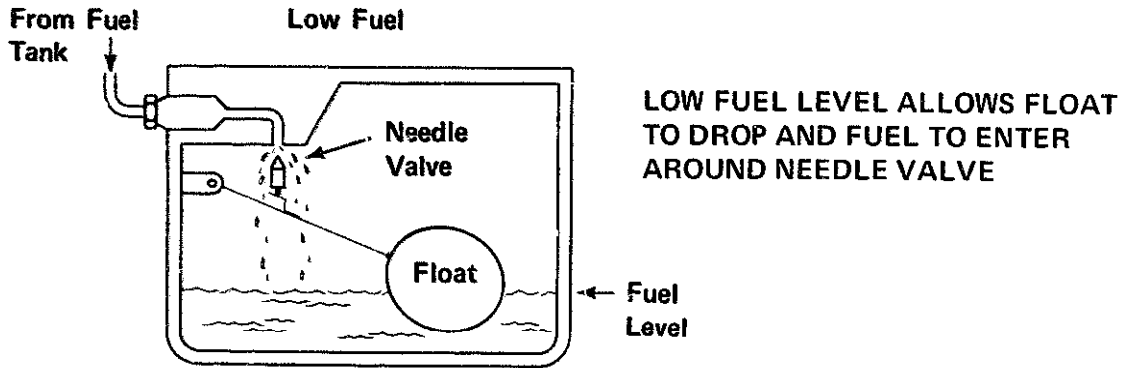


Chart 32

CARBURETOR FUEL SUPPLY

A constant fuel level below the venturi is necessary to maintain a stable air-fuel mixture. Slight differences in the fuel level in the carburetor float bowl will affect engine power and performance. The fuel level can be controlled in a number of ways. A few of the more common techniques will be discussed here.

THE FLOAT

A common method of controlling the fuel level is by using a float and needle valve. With no fuel in the float bowl of the carburetor, the float is lowered leaving the needle valve open. The fuel will flow from the tank into the float bowl and will raise the float. When the fuel reaches the level determined by the float setting, the needle valve closes against the seat and stops the fuel flow. As fuel is drawn out of the fuel bowl, the float drops slightly, allowing the needle valve to admit more fuel. The fuel level is very accurately maintained by this method. Float type carburetors are limited to near level operation. They are more expensive to build and repair, and they require very precise adjustment.

THE DIAPHRAGM CARBURETOR

This carburetor uses a light flexible diaphragm to open the needle valve to admit fuel. The diaphragm holds the needle valve open to admit fuel. The fuel enters the bowl and pushes against the diaphragm allowing the light spring to close the valve. Thus, a constant amount of fuel is maintained by the diaphragm. This carburetor can be used on engines that must be tilted during operation, for example, outboards and chain saws. Sometimes engine vacuum is utilized in aiding the control of the diaphragm.

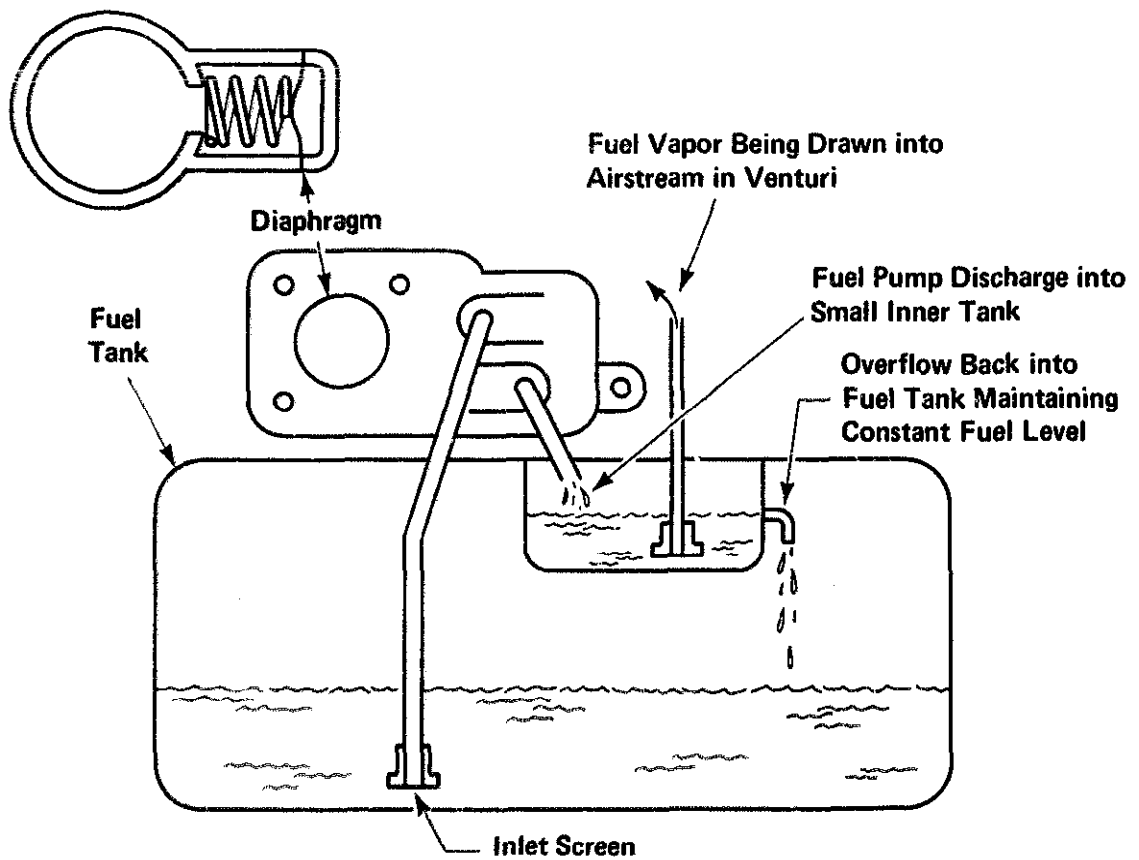
SUCTION FEED

The suction feed carburetor uses a shallow fuel tank mounted directly below the venturi section of the carburetor. The shallow fuel tank replaces the float bowl. Since the tank is shallow, the difference between the fuel level in a full tank and a near empty tank will not create excessive differences in the fuel mixture. It does tend to provide a rich mixture when the fuel tank is full and a lean mixture when the tank is nearly empty. It is therefore necessary to have the tank half-full when adjusting the carburetor. This carburetor may not have an idle mixture adjusting screw. The idle mixture will be dependent on the high-speed mixture. This carburetor is simple and maintenance free. It requires a clean air cleaner, clean fuel, and a tight connection to the engine.

The fuel pipe has a fine mesh inlet screen and may have a check ball. If fuel has been allowed to remain in the engine during storage or if dirt has gotten into the tank, the screen and check ball may become clogged. Remove and clean thoroughly. If the fuel tube is brass, it is a press fit in the carburetor body. To remove a brass fuel tube, clamp the tube lightly in a vise and pull the carburetor off. If the tube is nylon, it is threaded into the carburetor body and is removed with a socket wrench.

Chart 33

BUILT-IN FUEL PUMP



VACUUM OPERATED INTEGRAL FUEL PUMP

Chart 33

BUILT-IN FUEL PUMP

A fuel pump built into the carburetor may be utilized to maintain a constant fuel level which eliminates the need for the float. On single cylinder, four-stroke cycle engines there is a partial vacuum just behind the throttle plate on the intake stroke since the piston is moving downward and the throttle is restricting the air flow. During the other three strokes the intake area is at normal pressure. This creates a pulsing vacuum in the intake area between the intake valve and the throttle. A flexible diaphragm placed in this area is pulled in by the intake vacuum during the intake stroke and is released during the compression, power, and exhaust strokes. The flexible diaphragm will be moving back and forth. The other side of this pulsating diaphragm can then be used as a fuel pump to draw gas from a large fuel tank up into a small inner tank. Flapper type check valves cut into the diaphragm direct the fuel through the pump into the inner tank. The fuel pump can pump fuel faster than the engine can use it. The excess fuel is allowed to overflow back into the large fuel tank, thus maintaining a constant fuel level in the small inner tank without using a float.

The air flow through the venturi causes a partial vacuum which draws the fuel from the inner tank just as it does from the float bowl on the float type carburetor.

Many of these models also have the magneto stop switch on the carburetor speed control. When removing or servicing this carburetor, care should be taken to note the location of the wire coming from the magneto. If this wire comes in contact with the engine ground, the magneto will be disabled.

Diaphragm failure may be the cause of hard starting or may lead to an excessively rich fuel mixture if the diaphragm ruptures. A hole in the diaphragm would allow fuel to be pulled from the fuel pump directly into the intake manifold. Diaphragm replacement is simple, but care must be taken to get the diaphragm placed correctly in the fuel pump.

Chart 34

ENGINE SPEED CONTROLS

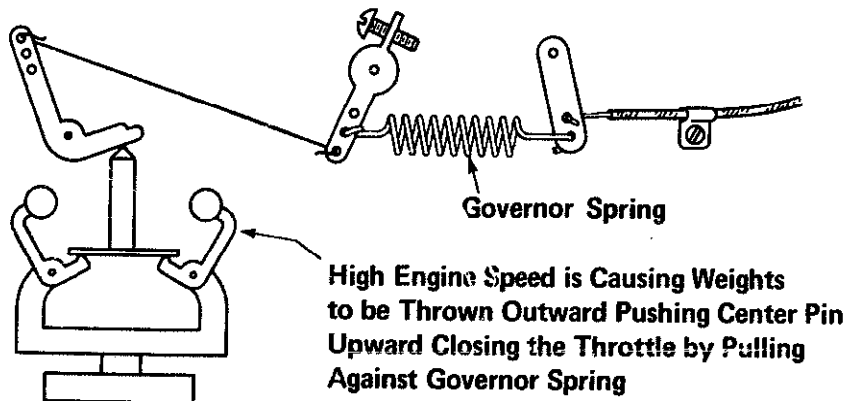
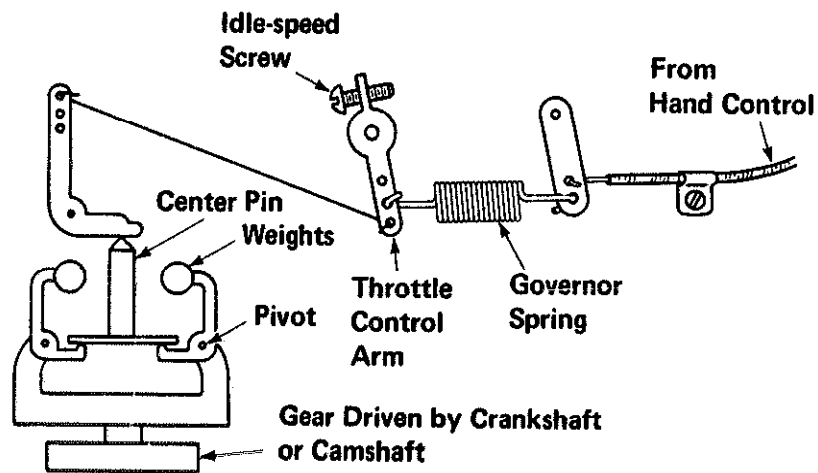
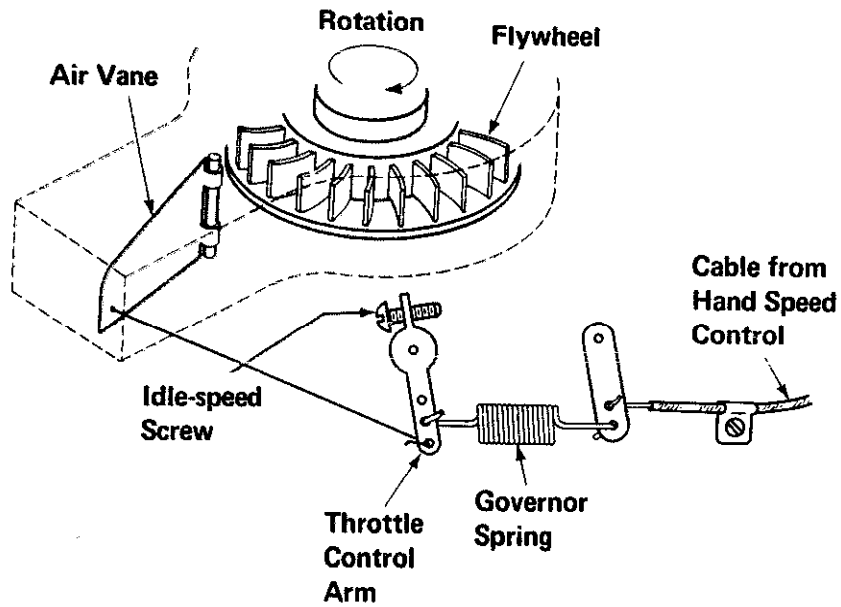


Chart 34

ENGINE SPEED CONTROLS

Engine speed is controlled by the operator's manual speed control and the governor. Most small gasoline engines which are used to power a constant load such as a mower or tiller must employ a governor to maintain a nearly constant speed as the load changes. Changing or removing the linkages on lawn mowers usually results in the loss of the governor as a speed control. The engine speed is then nearly uncontrollable. The engine will act as though it has almost no power and it will slow down excessively upon encountering a load. The operator must then increase the engine speed with the manual speed control lever. Once the load is reduced, the engine will overspeed. A normally functioning governor is essential for satisfactory operation on machines such as mowers, tillers, and generators.

AIR VANE GOVERNORS

The air vane governor is a simple and inexpensive device for controlling engine speed. An air vane located under the shrouding near the flywheel senses the engine speed by the amount of wind created by the fins of the spinning flywheel. As the engine speed increases, the increased force of the air flow created by the flywheel will push against the air vane. The air vane is connected by a wire linkage to the throttle control arm. It pulls against the governor spring to close the throttle thereby reducing the engine speed. The speed of the engine is determined by a balance between the pull created by the air vane and the pull on the governor spring from the hand control.

If the operator moves the hand control to increase the engine speed, the governor spring will pull harder on the throttle control arm opening the throttle wider. The engine speed will increase until the air flow from the flywheel against the air vane increases to equal the pull of the governor spring.

If the engine encounters an increase in load, the engine speed begins to decrease and the air flow against the air vane will decrease allowing the governor spring to pull the throttle open wider to retain the engine speed. The governor will maintain constant speed as conditions vary.

MECHANICAL GOVERNORS

Mechanical governors are considered to be somewhat more precise and dependable than air vane governors. They are more expensive and add weight to the engine. The mechanical governor senses the engine speed by the amount of centrifugal force exerted on rotating weights located inside the crankcase. The type shown in the illustration has weights mounted on a pivot so that as the weights are thrown outward by centrifugal force the center pin is lifted upward. As the engine speed increases, the weights are spinning faster and the force exerted by the weights to the center pin is increased. This acts to slow the engine down. Again, as with the air vane governor, the engine speed is determined by the balance of force created on the governor spring by the hand speed control and the force produced by the spinning weights. If a load causes a reduction in the engine speed, the centrifugal force acting on the spinning weights will be reduced allowing the governor spring to open the throttle to increase the engine speed. As the engine speed recovers, the governor will again exert pull against the governor spring to maintain the engine speed.

Chart 35

FUEL SYSTEM SERVICE

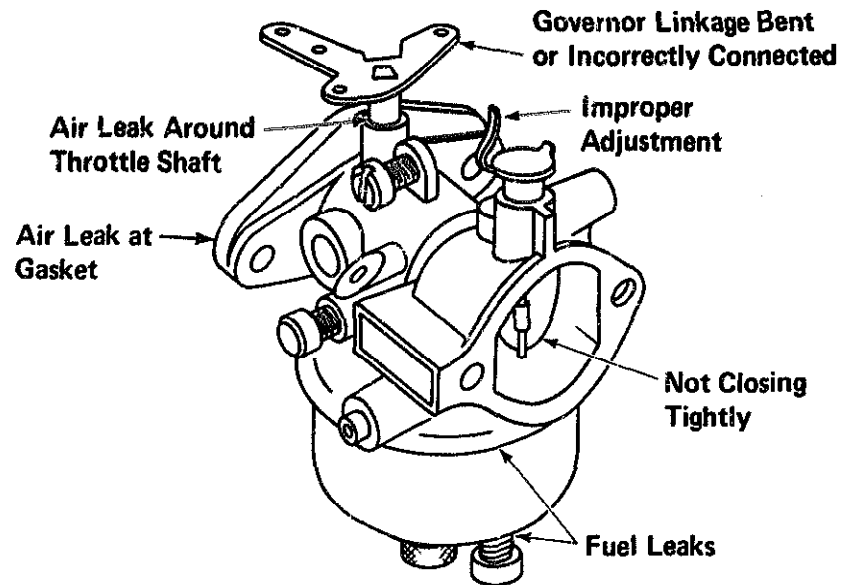
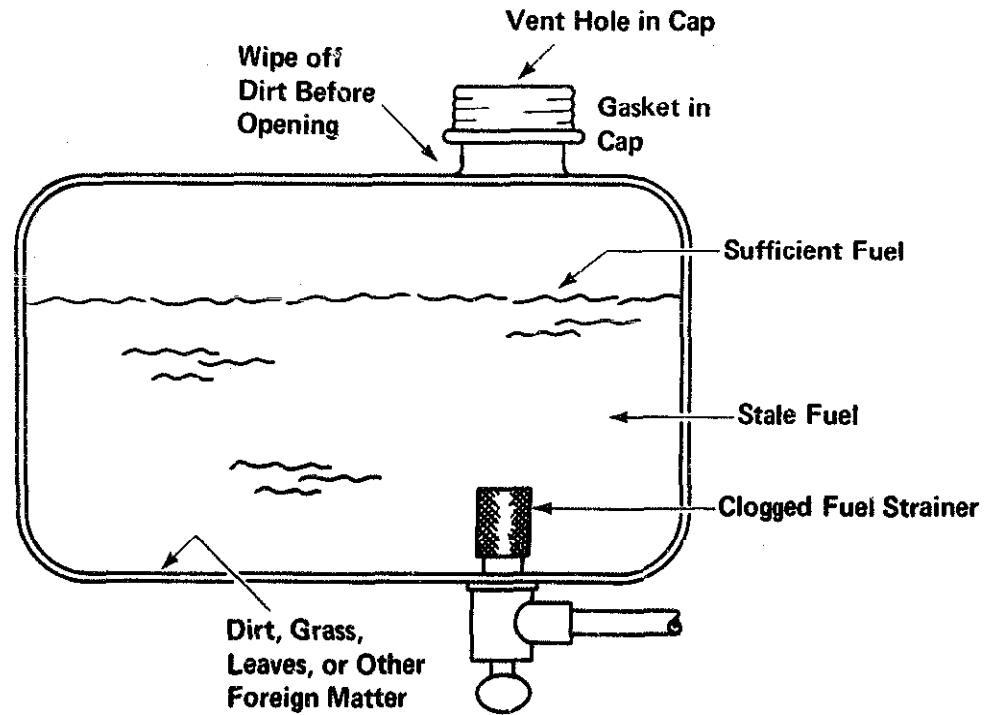


Chart 35

FUEL SYSTEM SERVICE

Many of the problems commonly associated with the fuel system may actually be electrical problems such as a bad spark plug or a weak spark caused by a bad condenser or breaker points. Even a rusted magneto armature may cause symptoms similar to fuel problems. Check the condition of the spark plug (see Chart 14, Spark Plug Service) and the quality of the spark before blaming the fuel system for failure to start or for poor performance. If the spark plug condition is good and if a strong spark is present, the following suggestions may help find the problem.

ENGINE FAILS TO START

Check Fuel Tank. Make certain that there is sufficient fuel. Make certain that the fuel is fresh. Stale gasoline can cause hard starting and poor performance. Check the fuel tank for dirt or grass, etc. Mowers and tillers tend to collect foreign matter in the fuel tank. Remove the tank and clean it completely if foreign matter is present. It is good practice to wipe off the top of the fuel tank before removing the filler cap.

Check the Choke. On many small gasoline engines the choke is operated automatically by the hand speed control lever. Improper adjustment of the speed control cable may be causing the choke to close completely. If necessary, remove the air cleaner to determine if the choke is closing completely.

Remove the Spark Plug. After cranking the engine several times with the choke fully closed, remove the spark plug and observe the condition of the plug (see Chart 14, Spark Plug Service).

ENGINE STARTS BUT SURGES INSTEAD OF RUNNING SMOOTHLY

Incorrect Fuel Mixture. Adjust the carburetor (see Carburetor Adjustment Section). Surging usually indicates a lean fuel mixture unless accompanied by black smoke from the exhaust pipe.

Incorrect Governor Operation. Incorrect connection of governor linkages, bent or broken linkages, incorrect linkages, or binding or rubbing of the linkages can cause incorrect governor operation. Check these linkages for free operation. On mechanical governors, check for correct adjustment.

Air Leaks. Air leaks into the carburetor can occur at the gasket where the carburetor attaches to the engine. Most carburetors are held on by two capscrews which are readily loosened by vibrations allowing air to enter past the gasket. Do not overtighten these capscrews for they are easily stripped in the aluminum engine block. Also check the throttle shaft for air leaks. If the throttle shaft is loose in its bushings, air will enter around the throttle shaft and will cause the fuel mixture and the engine speed to change as the throttle shaft moves around in the bushing. This condition usually calls for replacement of the carburetor body.

Chart 36

CARBURETOR SERVICE

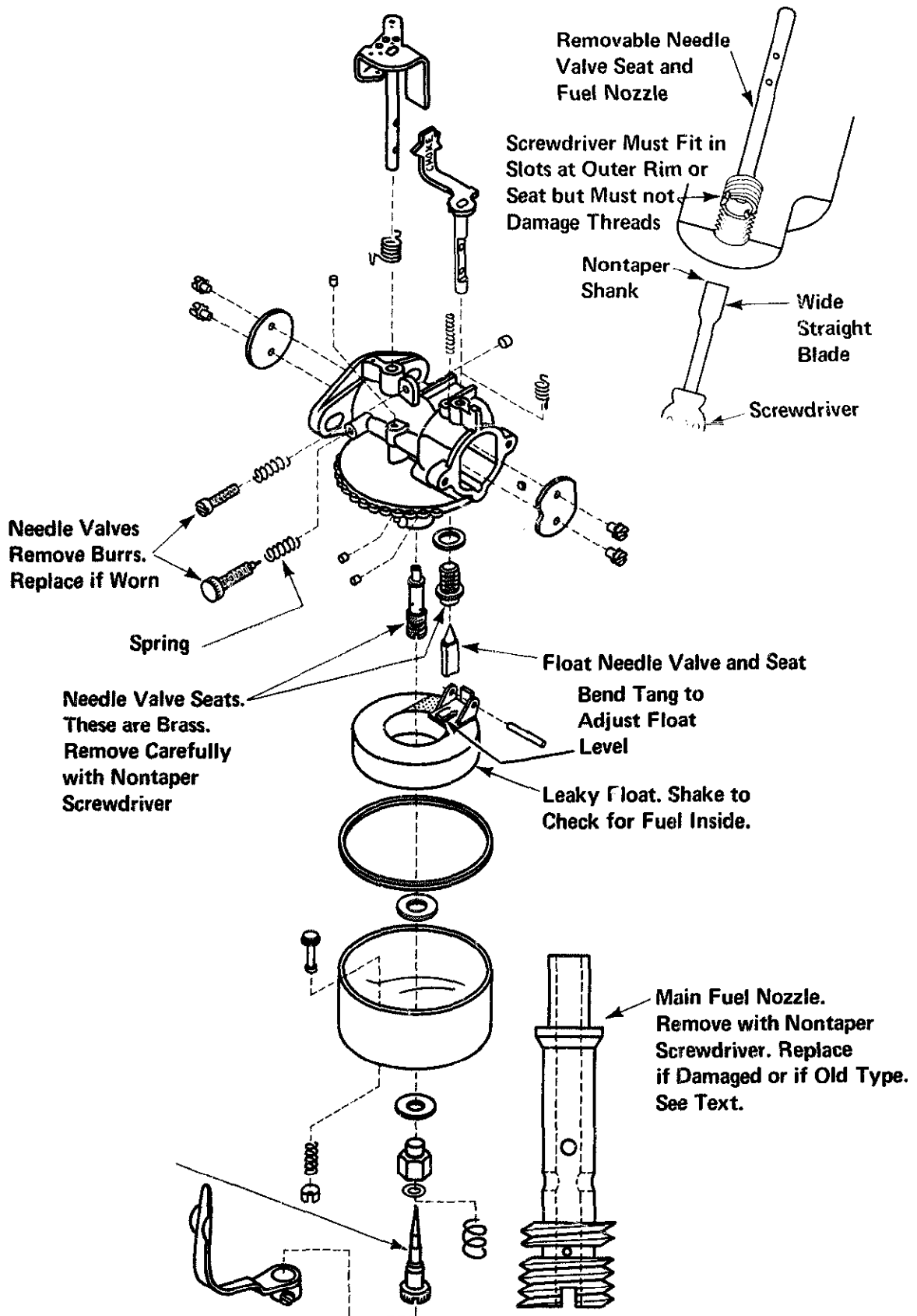


Chart 36

CARBURETOR SERVICE

In most cases it will be necessary to remove the carburetor if disassembly is required. The first step is to draw a diagram of the speed control linkages and springs because the proper operation depends on the correct connection of these linkages. If these linkages are already disconnected or missing, it will be necessary to consult the manufacturer's literature or find a similar engine to determine the correct connection. Do not bend the linkages when removing them from the carburetor. Bending the linkages will change the length and affect governor operation. Remove the bolts that hold the carburetor to the engine and twist the carburetor assembly to disconnect the linkage. Needle nose pliers are helpful in removing springs. Be very careful not to stretch the springs.

An assortment of good screwdrivers, pliers, and a clean, well-lighted work area can be very helpful for carburetor disassembly, cleaning, and reassembly. Clean the exterior of the carburetor with a stiff brush and cleaning solution before disassembly. If the carburetor is to be disassembled, it is usually worthwhile to rebuild the carburetor. A kit of necessary parts can be purchased that contains the parts that normally wear and cause trouble, for example, gaskets, needle valves, and seats. Check the kit to determine the parts which are provided before disassembly to determine which parts should be removed.

After disassembly, the carburetor should be soaked for a few minutes in carburetor cleaner to remove the gum and varnish residue. *Caution:* Carburetor cleaner is extremely painful if it is brought in contact with the eyes or skin. Avoid contact with the cleaner. Wash the parts in water thoroughly after cleaning them with carburetor cleaner. Do not attempt to brush or blow out the carburetor passages until they are thoroughly washed out with water. Remove all gaskets and plastic parts. Do not place them in the carburetor cleaner for some of them will be dissolved by the cleaner.

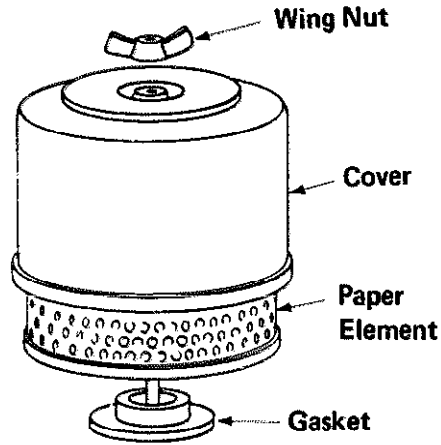
Remove and replace needle valves and seats very carefully. They are made of soft material and can be very easily damaged. Use only screwdrivers that are flat across the tip and are the correct width for the screw. Use wrenches instead of pliers to remove fuel lines and hexagon head capscrews. When removing needle valve seats that are recessed, use a screwdriver that is wide enough to make good contact with the seat but not so wide that it will damage the threads on the sides. Usually a nontaper screwdriver is required.

Check the float for leaks. If a hollow brass float is used, leaks will allow fuel to fill the float. Shake the float near your ear to determine if there is fuel in the float.

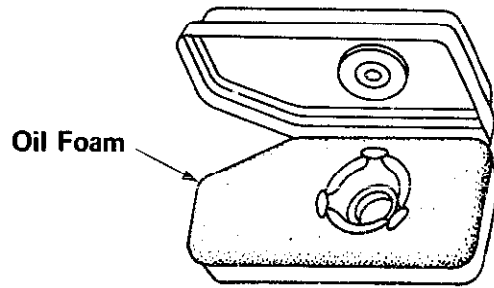
Before replacing the needle valve seats and the needle valves, visually inspect the fuel passages to make sure that they are clean. Reassemble the carburetor with care. Remember to reconnect the linkages and magneto stop wire (if so equipped) before attaching the carburetor.

Chart 37

AIR CLEANER SERVICE



DRY PAPER TYPE FILTER



POLYURETHENE FOAM TYPE FILTER

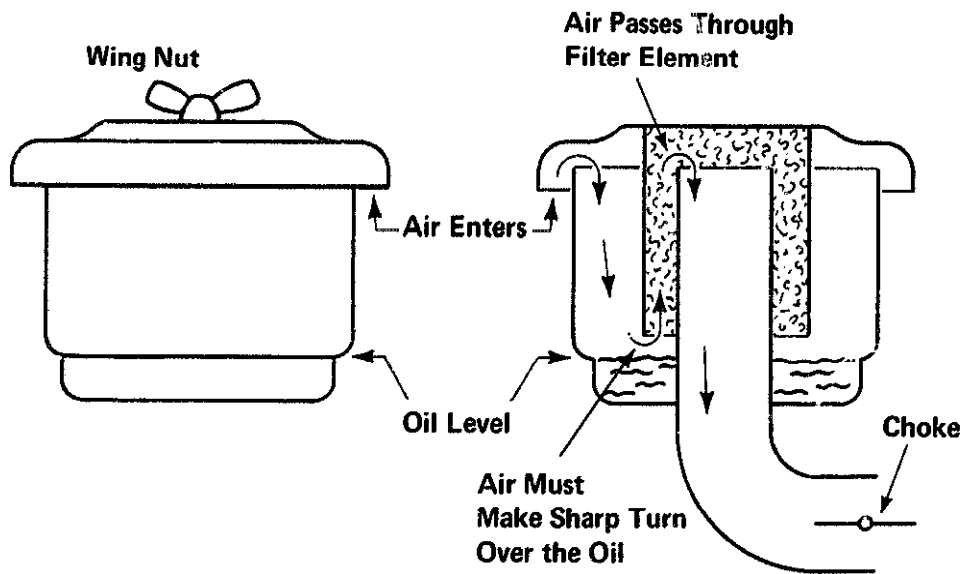


Chart 37

AIR CLEANER SERVICE

Small gasoline engines are often exposed to very dirty working conditions. A good, clean air filter is essential to efficient operation and long life. Remember that the engine is really quite an efficient air pump. An engine with a displacement of eight cubic inches will try to draw in eight cubic inches of air on *each* intake stroke. You can readily see that an engine running at full throttle will consume a great deal of air. An air cleaner must be kept in good condition to admit that much air without allowing dirt into the engine. If the air filter starts to become clogged with dirt, grass, or other matter, it will restrict the flow of air through the carburetor. This is exactly what the choke does. A dirty air cleaner will choke the engine, causing it to run on a rich air-fuel mixture which will cause loss of power, spark plug fouling, and carbon buildup. The excess gas will tend to "wash down" the oil film from the cylinder walls causing improper ring lubrication and will lead to excessive wear or possibly engine lock up. Also, the excess fuel in the mixture will get past the rings into the crankcase, diluting the oil.

DRY PAPER TYPE FILTER

This type of air filter utilizes porous paper to allow air flow and collect dirt and foreign matter. Tap the filter element to jar the dirt loose. Blow dirt away by blowing from inside out with low pressure air. A vacuum cleaner is effective for cleaning this filter. If the filter still appears clogged, replacement is necessary. Do not attempt to soak or wash the dry paper element.

POLYURETHENE ELEMENTS

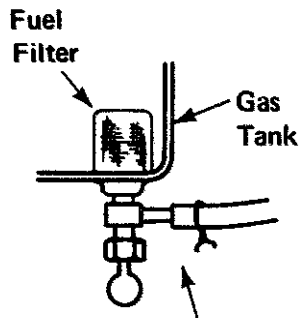
Air filters of this type can usually be cleaned several times. Clean the filter thoroughly with soap and warm water. Squeeze out and add a few drops of light oil before replacing. Make sure that the filter fits back into the metal holder and is retained so that it cannot be drawn into the engine.

OIL BATH AIR CLEANERS

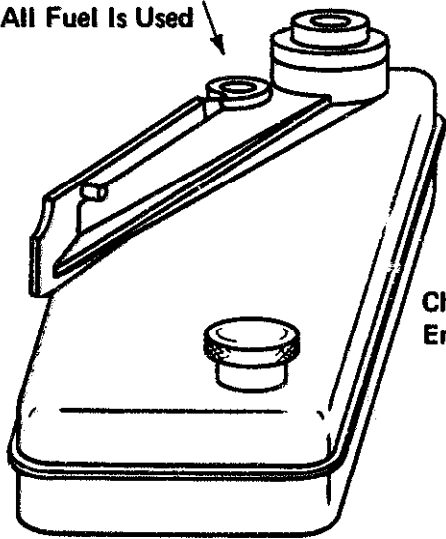
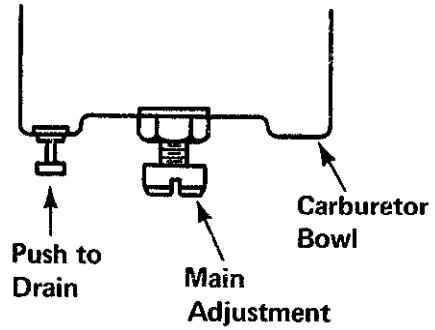
Oil bath air cleaners are usually used on engines that are used regularly in dirty conditions. This air cleaner is capable of collecting larger amounts of dirt and is easily serviced. The incoming air travels downward toward the oil at a high rate of speed. The air is forced to make a sharp turn just above the oil. Dirt and foreign matter tend to travel straight into the oil and stick there. Most of the dust and dirt entering the air cleaner will collect in the oil. The air then travels upward through a filter element before entering the engine. Check this element and wash it out if necessary. If the oil is changed regularly, the air cleaner will do a very efficient job of protecting the engine from dirt. The interval for oil change is determined by the amount of use and the operating conditions. Usually, instructions are labeled on the air cleaner.

Chart 38

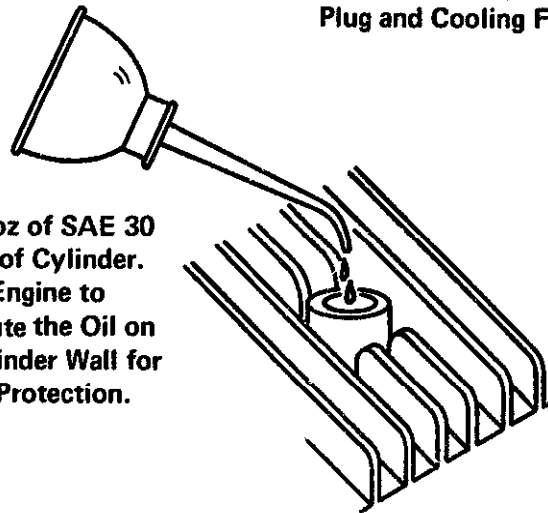
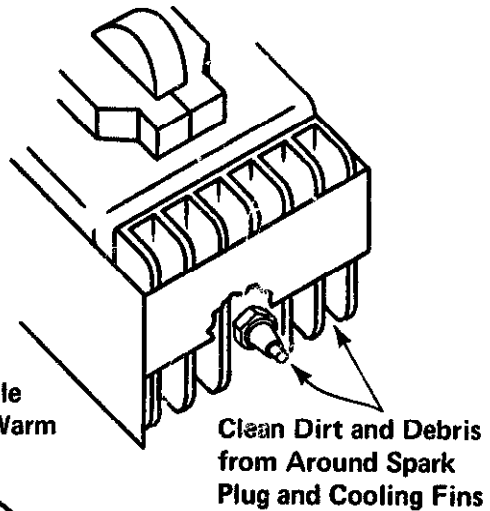
SMALL GAS ENGINE STORAGE



Drain Fuel from Tank and Clean Filter or
Run Engine Until All Fuel Is Used



Change Oil While Engine is Still Warm



Add 1 oz of SAE 30 to Top of Cylinder. Crank Engine to Distribute the Oil on the Cylinder Wall for Winter Protection.

Chart 38

SMALL GAS ENGINE STORAGE

The successful operation of a small gas engine depends on the care given it. A few precautions taken before storing an engine can prevent several problems which can occur during storage.

REMOVE ALL FUEL

Fuel that evaporates from an engine leaves gummy deposits that can cause serious problems. Drain the fuel tank and clean the filter screen. Drain the carburetor. On some models this can be done by pushing the small drain on the bottom of the carburetor fuel bowl. An excellent way to drain the fuel system is to run the engine until the fuel is used up. This also warms up the engine so that the oil change will remove most of the dirt accumulated in the crankcase.

CLEAN THE ENGINE

If necessary, remove air shrouds to clean around the cooling fins, governor linkage, and spark plug. Always replace the air shrouds for they are an essential part of the cooling system.

LUBRICATE THE CYLINDER WALL

Remove the spark plug (see Spark Plug Service). Add approximately one ounce of SAE 30 motor oil to the cylinder. Make sure that the piston is near top dead center before adding oil, especially on two-stroke cycle engines. Crank the engine several times to distribute the oil all over the cylinder wall area, valves, and valve guides. Replace the spark plug with a new plug (see Spark Plug Service).

REMOVE THE BATTERY

If a unit is battery equipped, the battery should be removed during storage. Care should be taken to record the battery's position and cable connections. If the battery cables are connected backward, the alternator diodes will be blown instantly.

Place the battery in a cool, dry place where it will not freeze. The battery should be fully charged when it is placed in storage and it should be recharged occasionally to maintain full charge (see Battery Section). Do not store battery on concrete. Place a small board under the battery during storage to keep it off the concrete.

RESTARTING AFTER STORAGE

1. Check oil level.
2. Clean air filter.
3. Check battery electrolyte level (see Battery Service).
4. Add clean, *fresh* fuel.
5. Adjust carburetor.

Questions for Section III

- T F 1. Engine oil should be changed when the engine is still warm. (Chart 12)
- T F 2. Oil additives are necessary to fortify the oil used in the crankcase of small gas engines. (Chart 12)
- T F 3. The light metal shrouding around the engine is for appearance only and should be removed for best performance. (Chart 13)
- T F 4. Fuel adjustments and engine timing can affect engine temperatures. (Chart 13)
- T F 5. Any old spark plug which will fit can be cleaned and regapped for small engine service. (Chart 14)
- T F 6. New spark plugs are properly set at the factory. (Chart 14)
- T F 7. Voltage is necessary to cause current to jump the spark plug gap. (Chart 17)
- T F 8. Spark voltage is created in the primary windings of the coil. (Charts 18 and 19)
- T F 9. One lead from the coil primary winding is connected to ground at all times. (Chart 18)
- T F 10. Current flows in the primary circuit while the breaker points are closed. (Chart 18)
- T F 11. Current flows in the secondary circuit when the breaker points open. (Chart 18)
- T F 12. The spark jumps the gap just after the piston reaches the top of its stroke. (Chart 18)
- T F 13. The flywheel may be pried off with a screwdriver. (Chart 20)
- T F 14. A small amount of lubricant should be placed on the cam when installing new breaker points. (Chart 23)
- T F 15. Armature laminations should be cleaned with sandpaper to remove rust which would bridge the laminations and reduce coil efficiency. (Chart 24)
- T F 16. It is not good practice to use pliers to remove the small armature screws. (Chart 24)
- T F 17. A small test lamp and battery can be used instead of an ohmmeter for determining when the breaker points open. (Chart 25)
- T F 18. A diode is like an electrical check valve. (Chart 26)
- T F 19. Breaker points are not needed on the electronic ignition. (Chart 26)
- T F 20. An incorrectly adjusted carburetor will cause an engine to surge. (Chart 29)
- T F 21. A rich fuel mixture will cause an engine to wear rapidly. (Chart 29)
- T F 22. A high or low float level can affect fuel mixture. (Chart 30)
- T F 23. Most small engine carburetors have one adjustment for air and one for fuel. (Chart 30)
- T F 24. The throttle must be wide open and the engine under no load to adjust the high speed circuit. (Chart 30)
- T F 25. Stale gasoline can cause hard starting. (Chart 35)
- T F 26. Choke linkage adjustment is a common cause of hard starting. (Chart 35)
- T F 27. The capscrews which hold the carburetor to the engine block should be tightened very tightly. (Chart 35)
- T F 28. A dirty air cleaner will have the effect of choking the engine. (Chart 37)

29. List the five functions oil must perform in the engine. (Chart 12)
30. List the different methods used to circulate oil through the engine. (Chart 12)
31. Describe the procedure for removing a spark plug. (Chart 14)
32. Describe how the small engine is cooled. (Chart 13)
33. Why are wire feeler gauges better for gapping spark plugs than the flat type? (Chart 14)
34. What is the purpose of the ignition system? (Chart 15)
35. What is the source of power used to create spark on the magneto ignition? (Chart 15)
36. What component determines the exact instant the spark will occur? (Charts 15 and 18)
37. The amount of current flowing in a circuit is called (Chart 16)
38. Pressure in an electrical circuit is called (Chart 16)
39. Wrapping several turns of wire on a coil would make the magnetic field (Chart 19)
40. Describe the sequence of events in the magneto ignition required to produce a spark. (Chart 19)
41. The voltage produced by the magneto may be as high as volts. (Chart 19)
42. Describe how the flywheel is attached to the crankshaft. (Chart 20)
43. Why should you never strike the crankshaft end directly with a hammer? (Chart 20)
44. Flywheel magnets seldom lose their magnetic strength. List some conditions which might cause the magnet to be destroyed. (Chart 20)
45. Why do some small engines use soft flywheel keys? (Chart 21)
46. Explain why an incorrect setting of the breaker points would affect engine timing. (Chart 21)
47. What information will you need to order new breaker points? (Charts 22 and 23)
48. Describe why new breaker points should be cleaned and how this is performed. (Chart 23)
49. Describe how you can get a piston at exactly top dead center. (Chart 25)
50. How can a protractor be used to set timing? (Chart 25)
51. On the electronic ignition, the pulse transformer replaces the (Chart 26)
52. The SCR replaces the on the magneto ignition system. (Chart 26)
53. Why is timing advance used on an engine? (Chart 27)
54. What is a typical idle speed for lawn mower engines? (Chart 27)
55. The carburetor controls engine speed and provides it with (Chart 28)
56. Engine speed is controlled by a flat disc called the (Charts 28 and 30)
57. Describe intake vacuum at idle speed. (Chart 28)

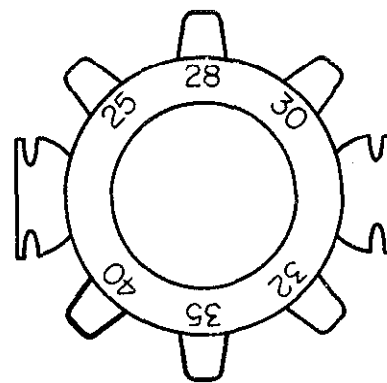
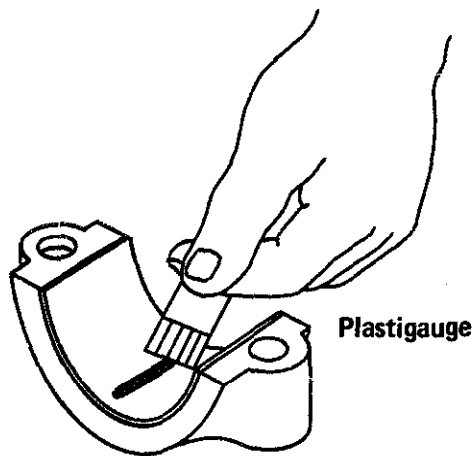
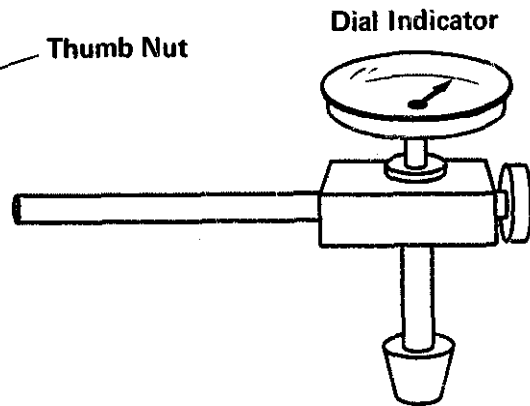
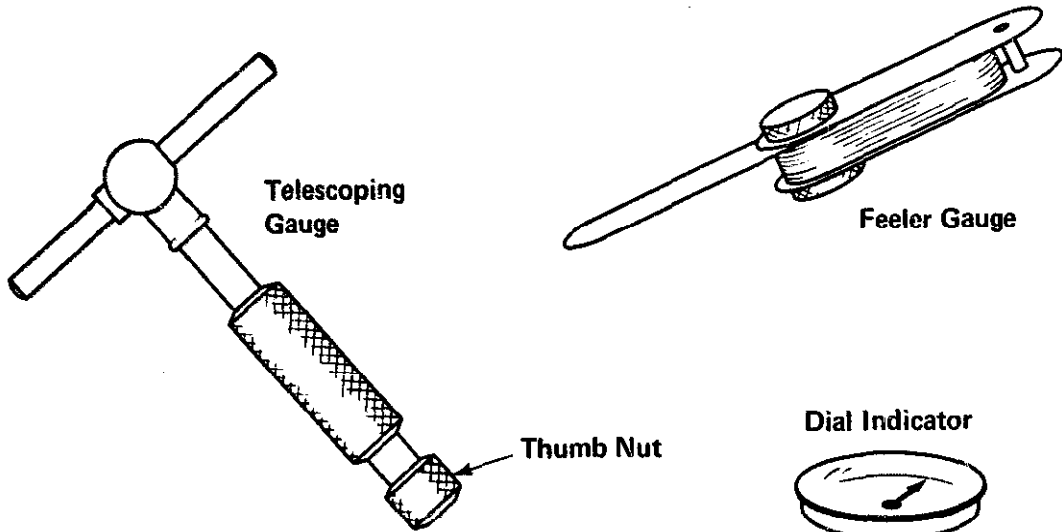
58. Describe intake vacuum under heavy load. (Chart 28)
59. Why is it dangerous to use your hand to choke the engine? (Chart 28)
60. Excessive carbon will build up inside an engine operated with a fuel mixture. (Chart 29)
61. Describe the action in the venturi. (Chart 29)
62. Why is a special circuit necessary for idle speeds? (Chart 31)
63. Why is the idle mixture adjusted after the high speed circuit? (Chart 31)
64. What conditions are necessary when adjusting the suction feed carburetor? (Chart 32)
65. What moves the flexible diaphragm on the carburetor fuel pump? (Chart 33)
66. What determines the fuel level on carburetors with a built-in fuel pump? (Chart 33)
67. Some engines have an electrical wire connected to the throttle speed control. What is the purpose of this wire? (Chart 33)
68. What is the purpose of the governor on a small gas engine? (Chart 34)
69. Describe an air vane governor. (Chart 34)
70. List the steps recommended before storing a small gas engine. (Chart 38)

Section IV

**FOUR-STROKE CYCLE ENGINE
SERVICE AND OVERHAUL**

Chart 39

MEASURING DEVICES



Spark Plug Gapping Gauge

Chart 39

MEASURING DEVICES

TELESCOPING GAUGE

The telescoping gauge gets its name from the way the "legs" of the device slide together. To use the telescoping gauge, first loosen the thumb nut and slide the legs together. When the legs are together, tighten the thumb nut. The gauge is then placed inside the hole or space to be measured. The thumb nut is then released. This permits the legs to spring outward against the sides of the hole. With the handle parallel to the sides of the hole, tighten the thumb nut. The gauge is then removed and the distance across the legs is measured with an outside micrometer.

FEELER GAUGE

The feeler or thickness gauges are used to measure small distances or clearances. These tools measure in thousandths of an inch. The flat feeler gauge contains blades (thin strips of metal) of different thicknesses. The thickness is stamped on each blade. By placing different blades together many different measurements can be made.

SPARK PLUG GAPPING GAUGE

The spark plug gapping gauge normally is made from small wires. The diameter of each wire (thickness) is marked on the gauge. The hook on this gauge is used to bend (adjust) the ground electrode of the spark plug.

DIAL INDICATOR

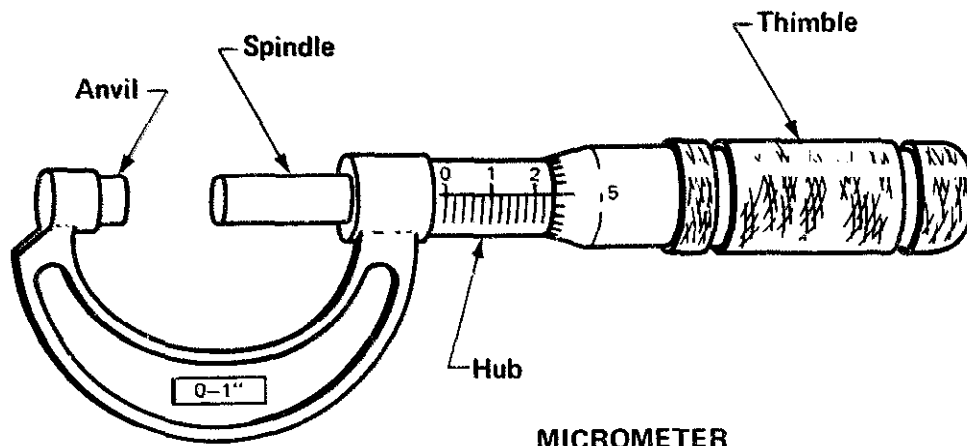
The dial indicator measures distances in thousandths of an inch. This device is fastened securely in place by special holders and clamps. The pad is pressed against the shaft or unit being tested for movement such that the needle gives a reading. The outer ring of the gauge is rotated until the needle is on 0. The shaft is then moved or turned. The movement of the needle indicates the variation in thousandths of an inch.

PLASTIGAUGE

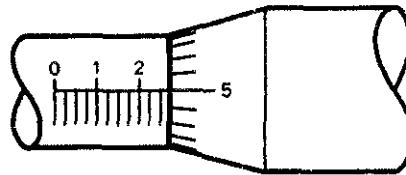
Plastigauge is used to measure the clearance between a plain bearing and the journal. The clearance is determined by placing a piece of the Plastigauge (string-like plastic) across the bearing and then assembling the bearing cap. The cap is tightened to specifications. *Without* moving the shaft, the cap retaining nuts or bolts are loosened and the cap is removed. The flattened Plastigauge will be on the shaft or the bearing. The width of the flattened Plastigauge is compared to the scale on the Plastigauge package to determine the bearing clearance. Plastigauge is available in several different sizes. Clearances up to nine thousandths can be measured by this method.

Chart 40

THE MICROMETER

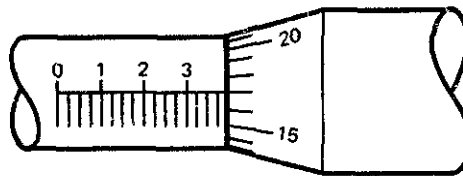


MICROMETER



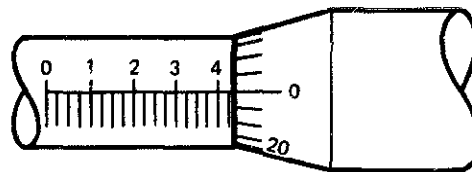
Example A

0-1" Mike



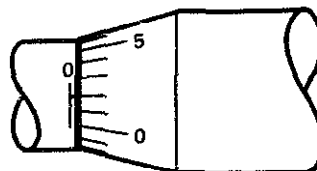
Example B

2-3" Mike



Example C

3-4" Mike



Example D

0-1" Mike

Chart 40

THE MICROMETER

The micrometer is used to measure distances in thousandths of an inch. Micrometers come in different sizes. For example, a 0-1" "mike" will measure from 0 to 1 inches in thousandths of an inch; a 2-3" mike will measure from 2 to 3 inches in thousandths of an inch.

One complete turn of the thimble changes the distance between the anvil and the spindle 25 thousandths (.025). Each number on the hub is read hundred thousandths. Each mark on the thimble is one thousandth.

To read a mike first note the size of the micrometer—1", 2", etc. Second, read the longest numbered line that is visible. Third, count .025 for each of the short marks on the hub to the right of the numbered line. Fourth, to these readings add the reading on the thimble.

Example A.

1. 0.000 (0-1" mike)
2. .200 largest numbered line
3. .050 two short marks beyond numbered line
4. .005 5 on the thimble

.255 = distance between anvil and spindle

Example B.

1. 2.000 (2-3" mike)
2. .300 largest numbered line
3. .075 three short marks beyond numbered line
4. .017 17 on the thimble

2.392 = distance between anvil and spindle

Example C.

1. 4.000
2. .400
3. .025
4. .000

4.425 = distance between anvil and spindle

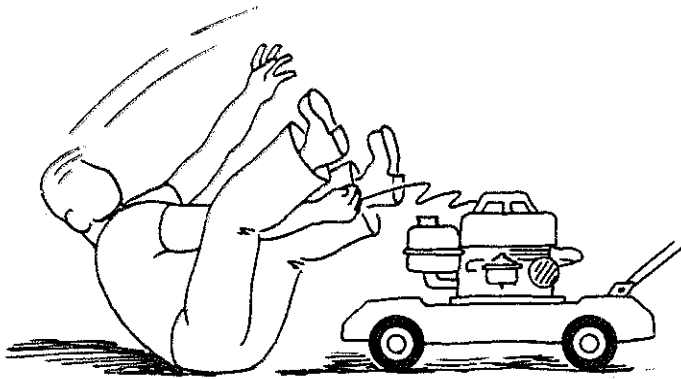
Example D.

1. .000
2. .000
3. .000
4. .002

.002 = distance between anvil and spindle

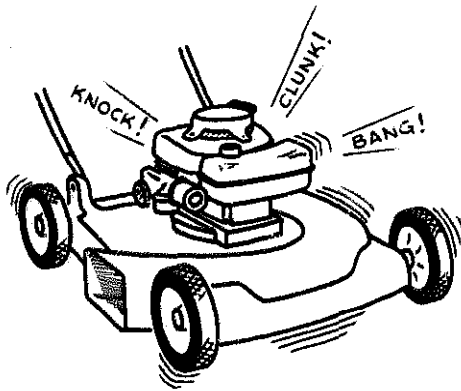
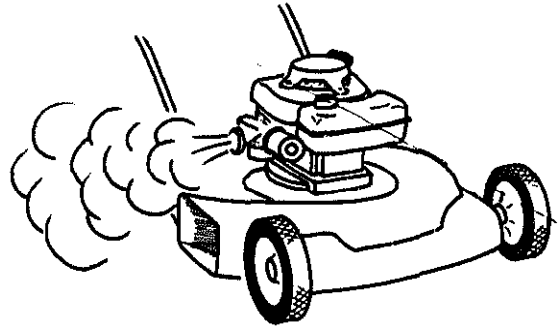
Chart 41

DISASSEMBLE AND REASSEMBLE INSTRUCTIONS AND PRECAUTIONS



POOR COMPRESSION

HIGH OIL CONSUMPTION



ENGINE KNOCKS

ENGINE "LOCKED"

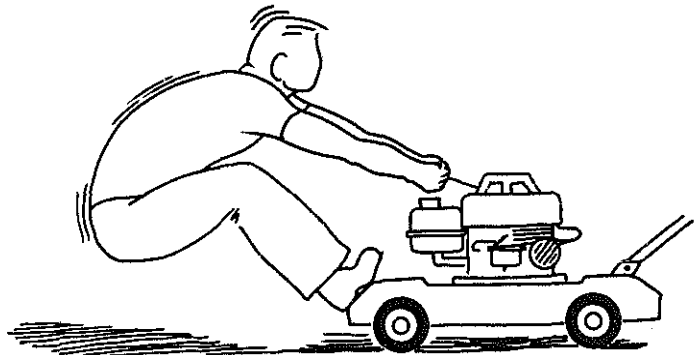


Chart 41

DISASSEMBLE AND REASSEMBLE INSTRUCTIONS AND PRECAUTIONS

The engine should be dismantled *ONLY* if there is good reason. Thorough testing can determine whether or not complete teardown is necessary. (See the Compression Testing section.)

REASONS FOR DISASSEMBLY

1. Poor compression because of internal wear or leak at head gasket.
2. High oil consumption because of poor rings.
3. Excessive noise or knocks coming from inside the crankcase.
4. Crankshaft won't turn because of internal problem.
5. Excessive oil leaks around the crankshaft seals or crankcase gasket.
6. Failure of lubrication system.

PRECAUTIONS

Take your time. Do not be in a hurry when disassembling the engine. Observe how the unit is assembled before taking any component apart. If it is a first-time experience, it is wise to make notes and sketches of how parts go together.

Work in a clean work area. Lay parts in order on the work bench as they come apart. Place small parts and bolts in a container. In some instances it may be helpful to thread bolts into their respective engine parts rather than place them in a container.

NEEDED TOOLS

Disassembly of a small engine does not require extensive special tools and equipment. The following common hand tools are recommended:

- 3/8" square drive socket set with reversible ratchet and extensions (sizes 1/4" through 7/8" by sixteenths)
- 3/8" square drive torque wrench (150 inch-pound capacity)
- Combination wrench set (5/16" through 3/4" by sixteenths)
- Ball peen hammer (12 oz)
- Combination slip joint pliers
- Needle nose pliers
- Assorted flat blade screwdrivers (3)
- Phillips screwdriver
- Carbon scraper or putty knife
- Flat feeler gauge

Chart 42

BASIC COMPONENTS

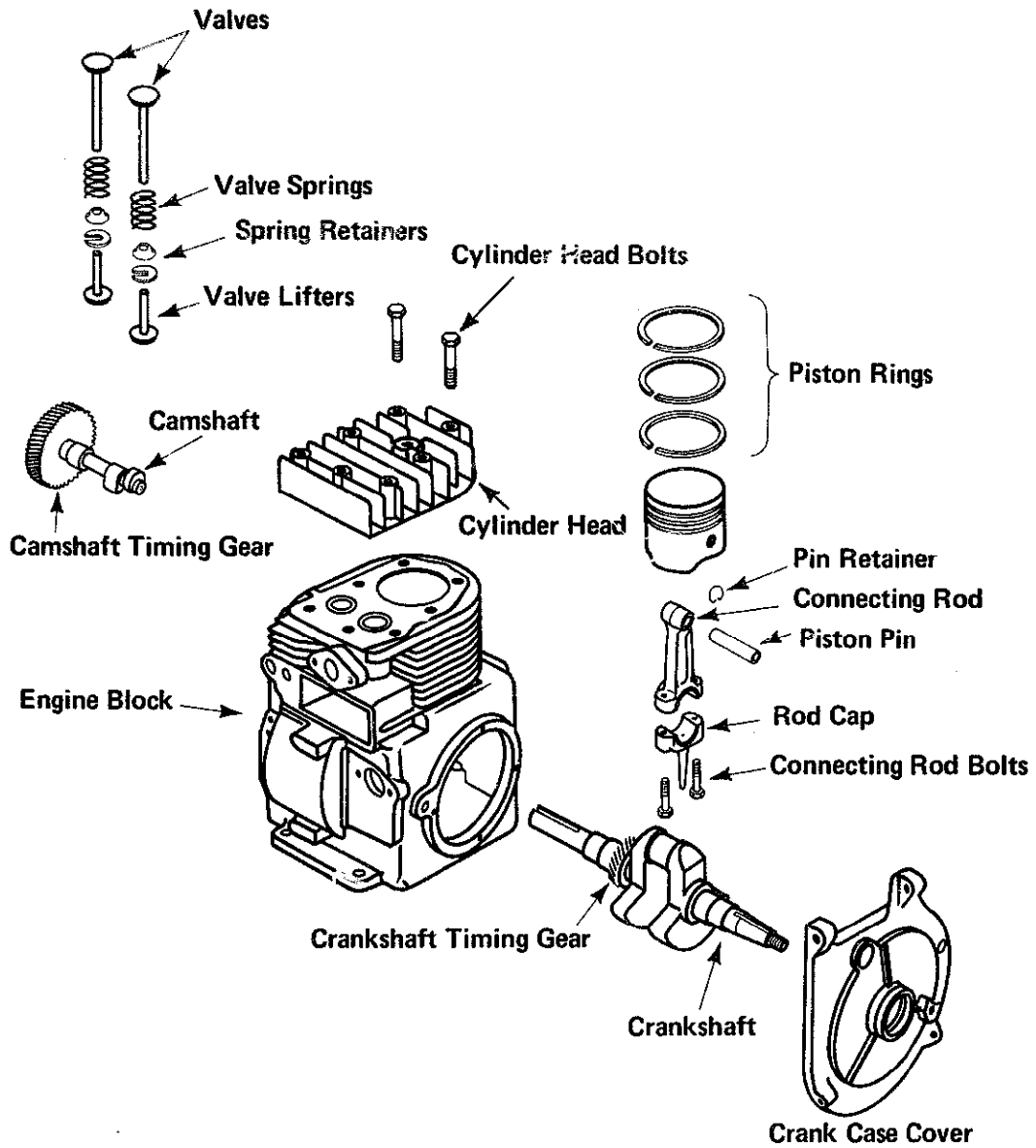


Chart 42

BASIC COMPONENTS

ENGINE BLOCK

Most all internal-combustion engines have similar basic components. The engine block is the major component of all engines. This unit contains all the moving parts which are necessary to convert heat energy (burning gases) to mechanical energy (rotating crankshaft). All engines have a smooth, round cylinder which permits the piston to move up and down. The crankshaft turns on main bearings, which are also located in the engine block.

In most piston-type engines the piston is connected to the connecting rod by a piston pin. The other end of the connecting rod is connected to the crankshaft at the connecting rod journal.

Piston rings are fitted on the piston to prevent the loss of compression and power. In addition to sealing the cylinder, the rings also clean the cylinder wall of excess oil and exhaust deposits and transfer some of the heat from the cylinder wall to the oil.

All the moving parts inside the engine must fit properly to their mating parts or the engine will not perform properly.

FOUR-STROKE CYCLE ENGINE

Four-stroke engines require components which permit operation of poppet valves to control the movement of intake and exhaust gases. The camshaft is driven by a gear on the crankshaft at one-half the crankshaft speed. This gear ratio enables each camshaft lobe to move its lifter and thereby open its valve one time while the crankshaft completes two revolutions. The valve spring maintains constant tension on the valve. When the valve is opened, it is moved against the spring tension. The spring causes the valve to return to its seat. The valve will seal as long as the sealing surfaces of the valve and seat are in good condition.

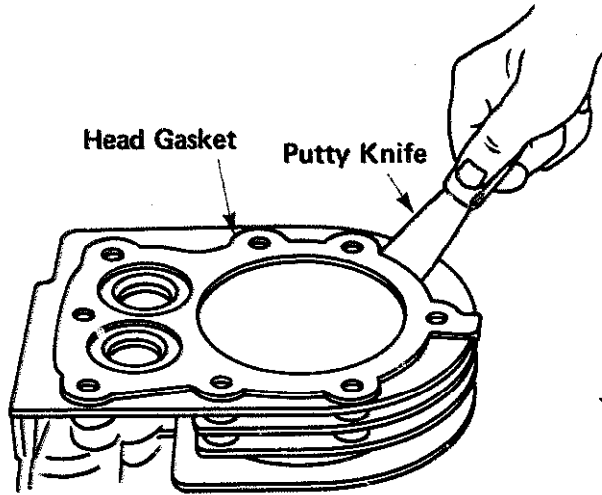
A constant supply of oil is delivered to the points of friction by a pump and splash system on some engines and entirely by a splash system on others. Seals on the crankshaft and gaskets on the bolt on components prevent leakage of the oil. Gaskets and seals should not be reused. Always install new gaskets and seals when assembling an engine.

Power of the four-stroke engine is wasted when wear occurs on the internal parts. Most wear occurs on the piston rings, piston, cylinder, and valves. Improper maintenance greatly increases wear. If the engine is run low on oil, it wears very rapidly and can be ruined in a short time.

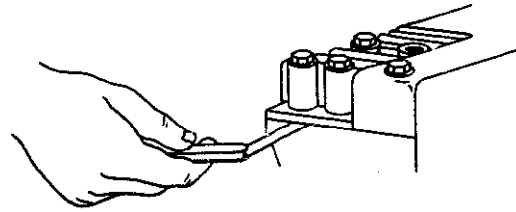
Low compression and knocking inside the engine usually are signals that an overhaul is needed. When overhauling the engine, check the clearances and either replace or recondition worn components. Piston rings should *always* be replaced if the piston is removed.

Chart 43

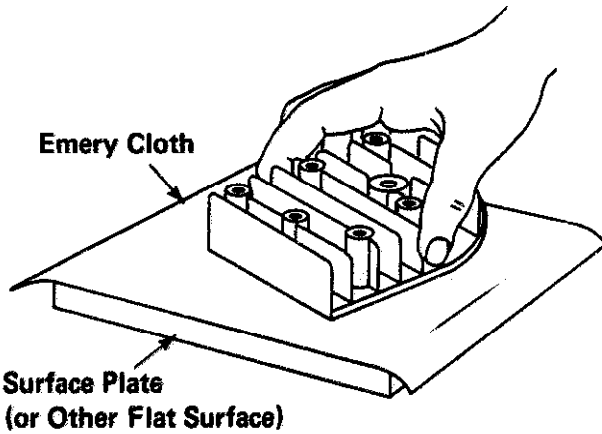
HEAD GASKET REPLACEMENT



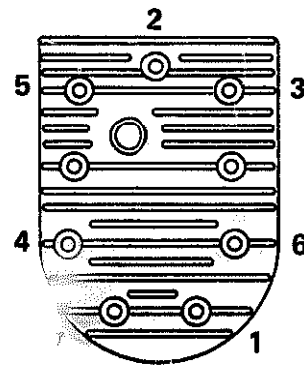
CLEANING GASKET FROM ENGINE



CHECKING FOR WARPAGE



RESURFACING HEAD



SAMPLE OF HEAD BOLT TIGHTENING SEQUENCE

TIGHTEN CYLINDER HEAD BOLTS WITH A TORQUE WRENCH

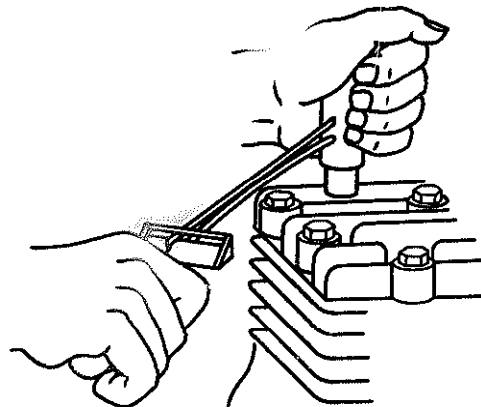


Chart 43

HEAD GASKET REPLACEMENT

1. Remove the air shroud and the parts that cover the cylinder head. Be sure to mark any wires which are disconnected. If the fuel tank is to be removed, shut off the fuel at the tank or plug the line. Clean dust from fins on the block and cylinder head.

2. Remove the spark plug.

3. Remove the bolts that secure the head to the engine. *Caution:* Some engines have bolts of different lengths. Note the location of the longer bolts.

4. Remove the old head gasket and clean the carbon from the cylinder head.

5. With a putty knife or carbon scraper, remove all carbon from the piston head and block surfaces.

Check point _____

6. Check for warpage of the block and/or head by placing the head on the engine without using a gasket. With a feeler gauge check the maximum space between the head and the block. If the gap is more than .015 inch, the head should be checked on a surface plate. If the warpage is in the head, the head should be resurfaced or replaced. If the warpage is in the block, the block should be resurfaced. To resurface the head or the block, place a sheet of medium grit emery cloth over a surface plate or other flat steel surface. (The table of a power saw will work.) Move the head or block over the emery cloth until it shows a true gasket surface. The head gasket will permit a slight amount of variation between the cylinder head and the block mating surfaces.

7. Make certain that the block and head are clean and place a new head gasket on the block. *Carefully* check the gasket to be sure that it aligns properly with the bolt holes and the block surface. Place a small amount of graphite grease on the threads of the head bolts and install the head on the engine. (If graphite grease is not available, scrape a soft lead pencil over the threaded portion of the bolts.) Make certain that all bolts are installed in the proper locations. (If the bolts were accidentally mixed, check with a small rod or nail to determine where the longer bolts are needed to ensure that the bolts adequately thread into the engine.)

8. Snug all head bolts by hand. Torque the bolts to one-third torque specifications following the tightening sequence shown for your bolt arrangement. Refer to the manufacturer's manual for the torque specifications and tightening sequence. If these data are not available, use a criss-cross pattern as shown in the head bolt tightening sequence. Retighten all bolts to two-thirds torque specifications. Tighten to the torque specifications and go over them one more time to be sure that all are at the proper torque.

9. Clean, gap, and replace the spark plug. (It is best to install a new gasket under the spark plug.) Torque the plug to 20 foot-pounds. If a torque wrench is not available, thread the spark plug in until it is snug against the new plug gasket. Tighten the plug one-third turn, and it will be at the approximate torque recommendation.

10. Replace the air shroud and other components that were removed or disconnected.

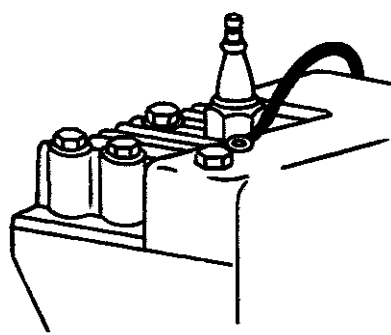
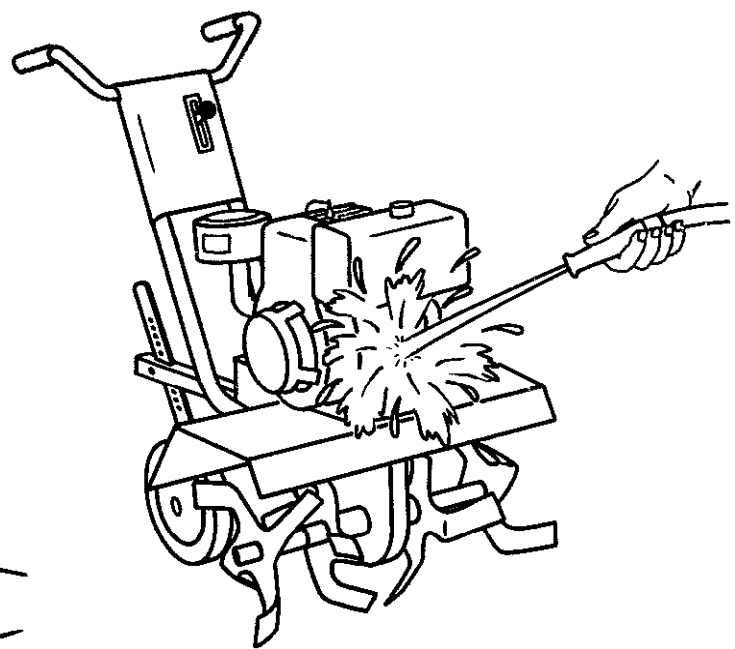
Check point _____

Chart 44

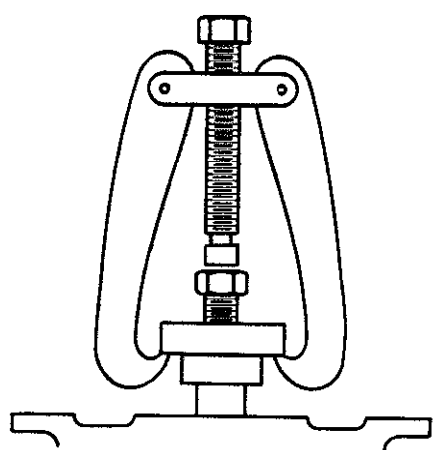
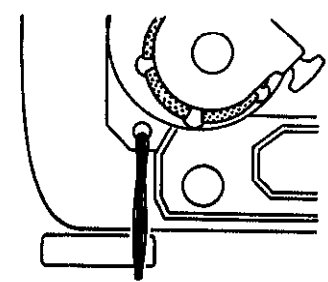
ENGINE OVERHAUL

PRELIMINARY STEPS

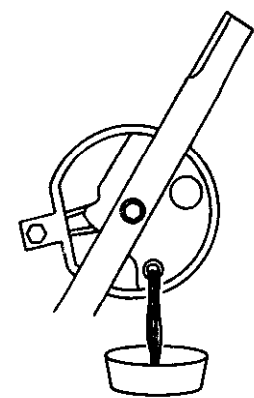
CLEAN WITH HOT
SOAPY WATER AND
RINSE WITH HOSE



ALWAYS GROUND
SPARK PLUG WIRE



REMOVE BLADE
AND ADAPTER



DRAINING ENGINE OIL

Chart 44

ENGINE OVERHAUL PRELIMINARY STEPS

The engine should be overhauled if there is poor compression because of worn cylinder components which reduce compression or cause high oil consumption. Complete disassembly also will be necessary to correct problems such as a "locked engine" or one which "knocks." Diagnosing these problems is explained in the Compression Testing section.

On most engines it is best to do a complete overhaul even though the diagnosis shows only problems with the valves.

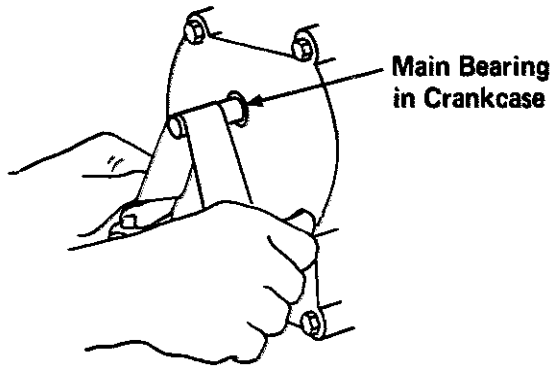
1. *Cleanliness.* Clean the engine before starting disassembly. Clean all parts so that they can be inspected and accurately measured. Keep the work area clean and orderly.
2. *Ordered Procedure.* Keep track of how the engine comes apart—where each unit attaches and the mating of moving components. Draw sketches and make notes on the wiring connections and carburetor linkage.
3. *Working to Specifications.* All components must be checked carefully for wear and failure. During reassembly all parts must fit properly and all bolts must be tightened to the proper tension.
4. *Lubrication.* When any engine is reassembled, all internal parts must be well oiled or the engine will be damaged the instant that it is started.

The following special tools are needed when completing an overhaul:

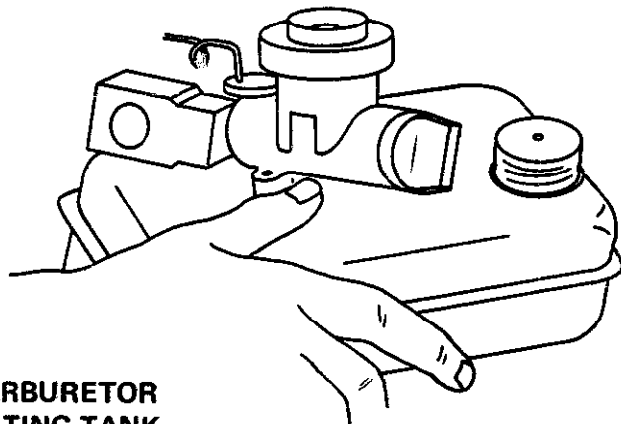
Dial indicator
0–1" micrometer
1–2" micrometer
2–3" micrometer
Telescoping gauges
(0–1", 1–2", 2–3")
Ring ridge remover
Piston ring compressor
Valve spring compressor
Valve reseating tool

Chart 45

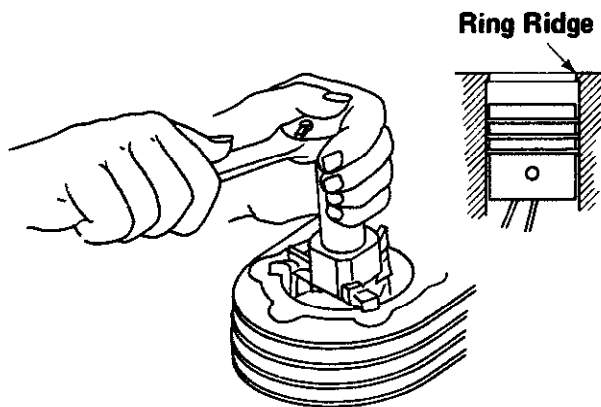
**RING RIDGE REMOVAL AND
BASIC DISASSEMBLY**



**CLEAN RUST AND DIRT
FROM CRANKSHAFT**



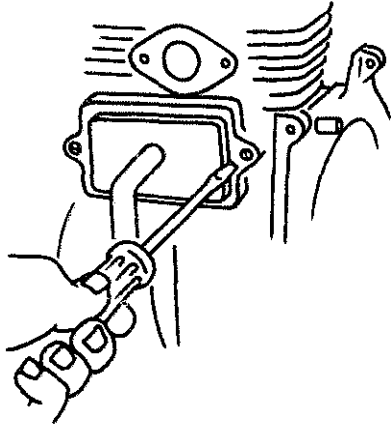
**DISCONNECT CARBURETOR
LINKAGE BY TILTING TANK**



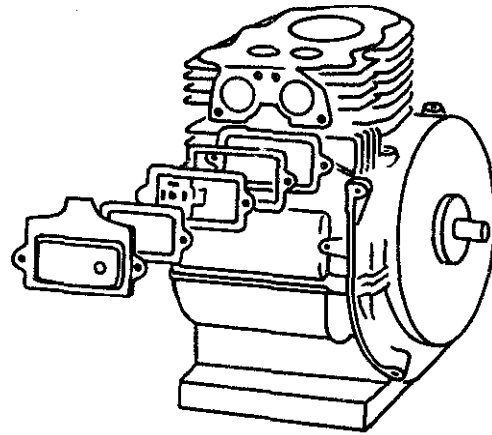
**REMOVING PISTON
RING RIDGE**

Chart 46

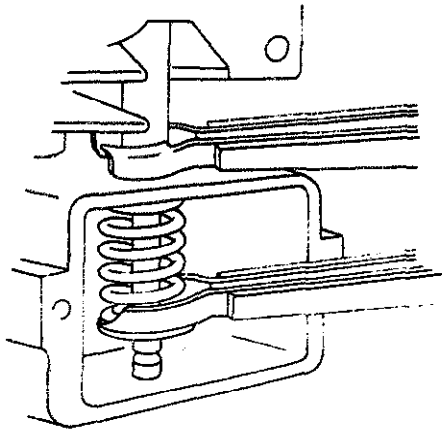
**EXTERNAL CRANKSHAFT CHECKS
AND VALVE REMOVAL**



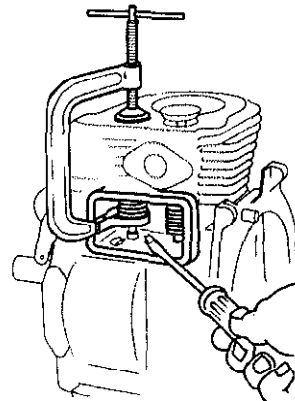
REMOVING VALVE COVER



KEEP BREATHER COMPONENTS IN ORDER



VALVE REMOVAL



VALVE REMOVAL

Chart 46

EXTERNAL CRANKSHAFT CHECKS AND VALVE REMOVAL

11. Remove the ring ridge from the top of the cylinder. If a ring ridge remover is not available, carefully remove the ridge by hand with medium grit emery cloth. Failure to remove the ridge may damage the piston when it is reassembled with new piston rings. The sharp corner on the new rings will catch on the ridge and break the piston ring land beneath the first ring groove.

Check Point

12. Remove the valve cover. Some covers contain a filter unit and serve as a crankcase breather. Be careful to observe the assembly order of units which contain filter and breather valve components.

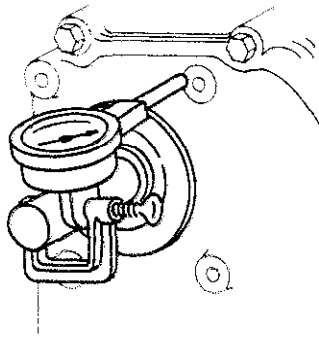
13. Remove the valves by compressing the valve spring and removing the retainer with pliers. If a valve spring compressor is not available, two screwdrivers can be used to compress the springs.

Keep the valve springs with their respective valves. On some engines the exhaust valve has a spring which is heavier than the intake valve spring.

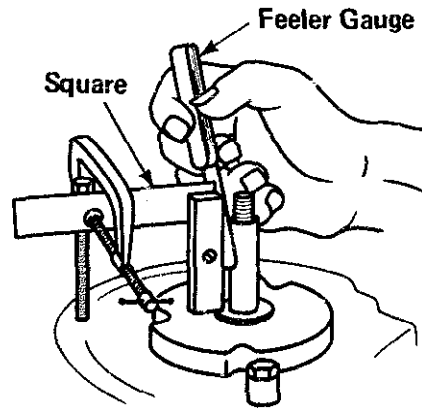
14. Check the end play of the crankshaft by clamping a dial indicator to the crankshaft with the pad resting against the crankcase. Move the crankshaft in and out. The indicator will show the end play in thousandths of an inch.

Chart 46 (continued)

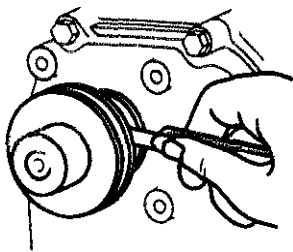
EXTERNAL CRANKSHAFT CHECKS AND VALVE REMOVAL



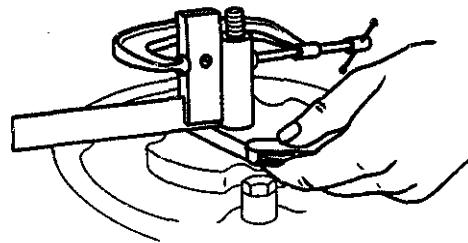
**CHECKING CRANKSHAFT END PLAY
WITH DIAL INDICATOR**



**CHECKING FOR BENT CRANKSHAFT
WITH SQUARE AND FEELER GAUGE**



**CHECKING CRANKSHAFT END PLAY
WITH FEELER GAUGE**



**CHECKING CRANKSHAFT END PLAY
WITH A SQUARE AND FEELER GAUGE**

Chart 46 (continued)

EXTERNAL CRANKSHAFT CHECKS AND VALVE REMOVAL

If a dial indicator is not available, the end play can be checked with a feeler gauge. On some engines the feeler gauge can be placed between the drive pulley and the crankcase. Measure the gap when the crankshaft is pulled "out" and then measure the gap when it is pushed "in." The difference between the two measurements is the crankshaft end play.

Another method of checking the end play is to clamp a square on the crankshaft with a C-clamp. Take a measurement with the feeler gauge when the crankshaft is pulled "out" and another measurement when it is pushed "in." The difference between the measurements is the crankshaft end play.

Record the crankshaft end play in the Data Block below. If the end play is not correct, it can be adjusted when the engine is being reassembled.

If the engine is from a rotary lawnmower, check for a bent crankshaft. To make this check, mount a dial indicator on the engine with the pad against the crankshaft. Slowly rotate the crankshaft and observe the movement of the indicator needle.

An alternate method is to clamp a bar or square on the engine so that it is very close to the end of the crankshaft. Rotate the crankshaft and measure the difference in the gap between the bar and the crankshaft with a feeler gauge. A difference in the gap indicates a bent crankshaft.

A crankshaft with more than .005 run out should be replaced.

Check Point _____

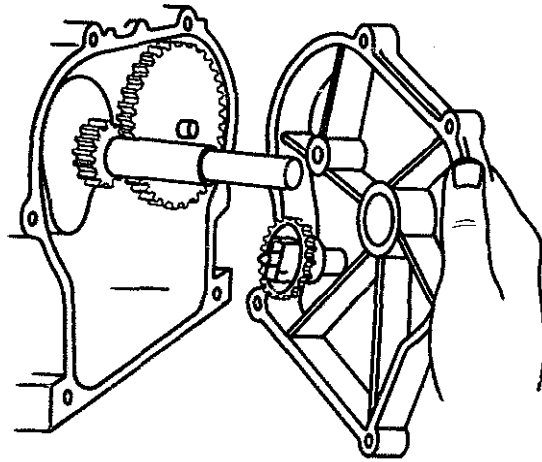
Data Block

	<i>Actual</i>	<i>Specifications</i>
Crankshaft end play	_____	_____
Crankshaft runout	_____	<u>.005 Maximum</u>

NOTES: _____

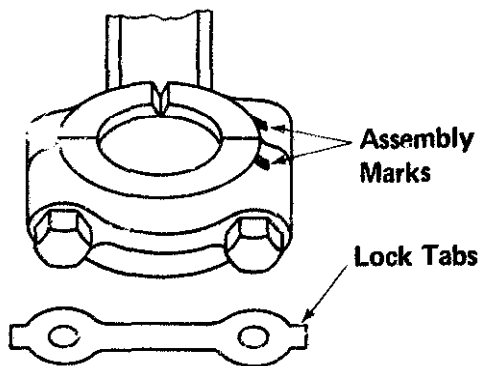
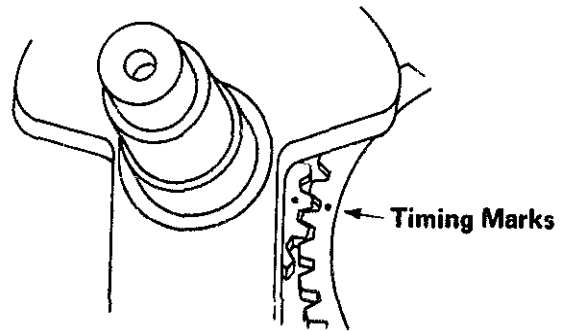
Chart 47

**OPENING THE CRANKCASE
AND PISTON REMOVAL**



REMOVING CRANKCASE BASE

**MARKS ON CRANKSHAFT
AND CAMSHAFT TIMING GEARS**



**CONNECTING ROD AND
CAP REFERENCE MARKS**

Chart 47

OPENING THE CRANKCASE AND PISTON REMOVAL

15. Position the engine so that it is easy to remove the removable crankcase side or base.

16. Remove the bolts which attach the crankcase side or base cover. Carefully remove the cover. If a gasket sealer was used, it will be necessary to tap the cover with a hammer to "break it loose."

Don't discard the old crankcase side cover gasket because it must be measured when selecting the gasket to be used in reassembly.

On engines that have a side cover, check for timing marks on the camshaft and crankshaft gears. Some engines have a mark on the camshaft gear which aligns with a mark on the crankshaft counterweight. Other engines have a mark on the camshaft gear which is aligned with the crankshaft gear key or a mark on the crankshaft gear.

Rotate the crankshaft until the two timing marks align. If no marks are visible, wipe the oil from the matching teeth on the two gears and paint a mark on each gear.

Check Point

17. Remove the camshaft oil distributor or slinger if one is used.

Carefully remove the camshaft and valve lifters. Mark the lifters with masking tape so that they can be reinstalled in the same location.

Note: The above step can be omitted on an engine that has a removable base.

18. Study the connecting rod and cap to identify marks or reference tabs. If no locator marks or tabs are visible, make a small punch mark on the rod and the rod cap on the camshaft side of the engine. Note these data at the end of this chart.

With a punch and hammer or pliers straighten the sheet metal locks on the connecting rod nuts. (Some engines use self-locking nuts instead of a sheet metal lock.)

Remove the connecting rod nuts or bolts with a socket wrench or box-end wrench. Carefully push the piston-rod assembly out the top of the cylinder.

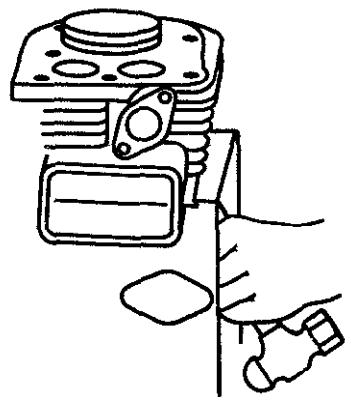
Caution: DO NOT permit the rod bolts to "bang" against the crankshaft.

DO NOT place any tools against the bearing portion of the connecting rod.

19. Once the piston assembly is removed from the engine, reinstall the connecting rod cap on the connecting rod. Remove the crankshaft from the engine block. Make certain that the bearing surfaces of the crankshaft aren't nicked by careless handling. The main bearing retainer or side of the block must be unbolted on an engine that has a removable base.

Chart 47 (continued)

OPENING THE CRANKCASE AND PISTON REMOVAL



REMOVING PISTON ASSEMBLY

**THE MARKING ON THE PISTON INDICATES
THAT THE BLOCK HAS BEEN MACHINED
0.020 OVER STANDARD**

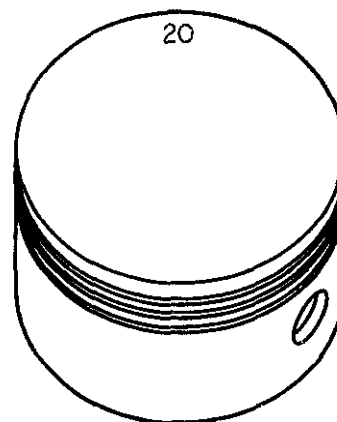


Chart 47 (continued)

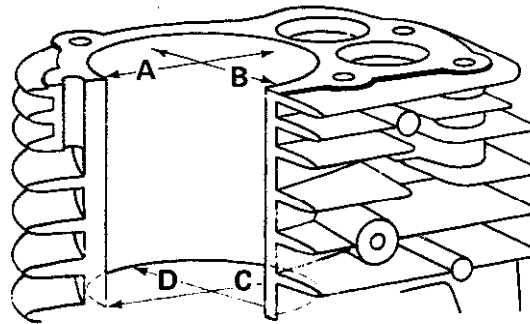
OPENING THE CRANKCASE AND PISTON REMOVAL

20. Clean all parts, including the inside of the block, in parts cleaning solvent or in kerosene. **DO NOT** use gasoline to clean parts because gasoline leaves a chalky deposit when it evaporates and it is a fire hazard.

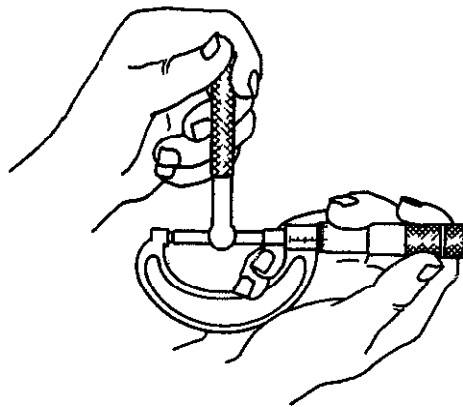
21. Inspect the head of the piston for its size. If the engine cylinder has not been resized (bored), the top of the piston will have no marking or **STD** stamped upon it. **STD** means that the cylinder is standard sized. A cylinder that has been resized will have the amount of diameter-over-standard stamped on the top. Oversizes are usually .010, .020, or .030 greater than the manufacturer's standard bore for the engine.

Chart 48

**CYLINDER MEASUREMENTS
AND CHECKS**



PLACE WHERE CYLINDER MUST BE MEASURED



**CHECKING CYLINDER WEAR WITH A TELESCOPING
GAUGE AND A MICROMETER**

Chart 48

CYLINDER MEASUREMENTS AND CHECKS

CYLINDER CHECKS

22. The cylinder must be checked for wear and scores or scratches. There are three different kinds of wear which can occur in the cylinder—oversize, out-of-round, and taper.

The three types of wear are checked by taking precision measurements at two locations in the cylinder—three-quarters of an inch from the top and three-quarters of an inch from the bottom.

The measurements can best be taken with a telescoping gauge and outside micrometer, an inside micrometer, or a cylinder dial gauge.

First, take two measurements three-quarters of an inch from the top of the cylinder and at 90° to each other (measurements A and B in the first illustration). The difference between the smaller of the two measurements and the original bore of the engine (2 inches, 2-1/4 inches, 2-5/16 inches, etc.) represents cylinder wear. Record the cylinder wear in the Data Block.

The difference between the two measurements taken three-quarters of an inch from the top of the cylinder (measurements A and B in the first illustration) represents the out-of-round of the cylinder at the top. Record the out-of-round in the Data Block.

The difference between the measurements taken at right angles to the crankshaft (measurements A and C in the first illustration) is the cylinder taper. Record the cylinder taper in the Data Block.

If precision measuring instruments are not available, the cylinder taper can be measured with a new or used piston ring and a feeler gauge (third illustration). To measure taper in this manner, carefully remove a piston ring from the piston and place it in the cylinder. With the head or skirt of the piston push the ring down until it is three-quarters of an inch from the top of the block. Make sure that the ring is square with the cylinder.

Measure the gap between the ends of the ring with a feeler gauge.

Move the ring to three-quarters of an inch from the bottom of the cylinder and measure the gap between the ends of the ring with the feeler gauge. Subtract the reading taken at the bottom from the reading taken at the top and then divide by 3. This will give the taper in thousandths of an inch.

Compare the cylinder wear, out-of-round, and taper to the manufacturer's specifications. If any wear exceeds the maximum recommended by the manufacturer, the cylinder should be resized by a machine shop.

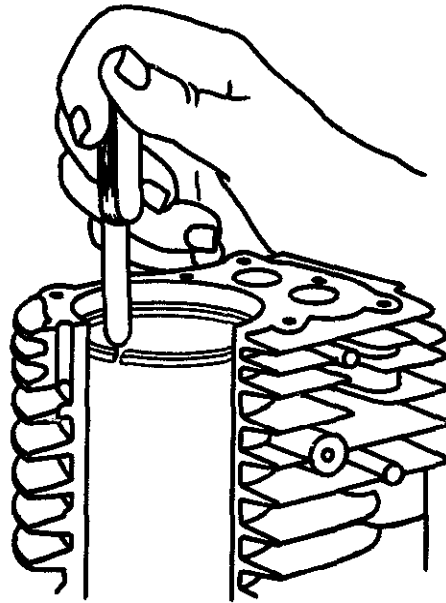
Cylinders are usually resized to .010, .020, or .030 over the standard bore.

If manufacturer's data are not available, the following data can be used as a guide to determine whether or not the cylinder should be resized:

Maximum oversize diameter	.003
Maximum out-of-round	.005
Maximum taper	.004

Chart 48 (continued)

CYLINDER MEASUREMENTS AND CHECKS



**CHECKING CYLINDER WEAR WITH A PISTON
RING AND A FEELER GAUGE**

Chart 48 (continued)

CYLINDER MEASUREMENTS AND CHECKS

Inspect the cylinder for deep scores or scratches. A deep scratch will cause compression loss and oil burning even though the cylinder wear is not excessive.

A badly scored or scratched cylinder should be resized.

Resizing is accomplished by increasing the cylinder size with special cylinder hones, a boring bar, or a metal cutting lathe. Resizing procedures recommended by the resizing equipment manufacturer should be followed carefully.

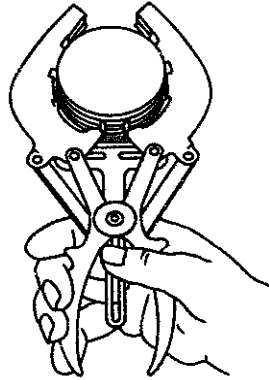
Data Block

Cylinder wear	_____
Cylinder out-of-round	_____
Cylinder taper	_____

Check Point _____

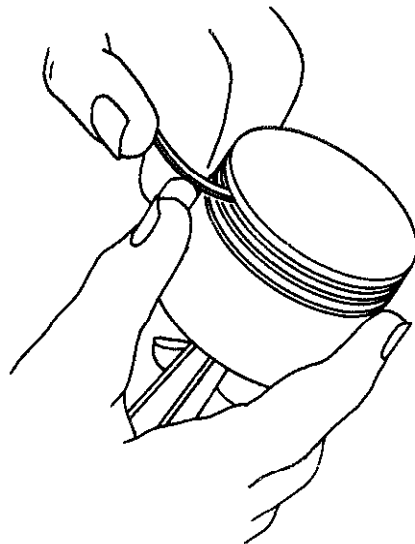
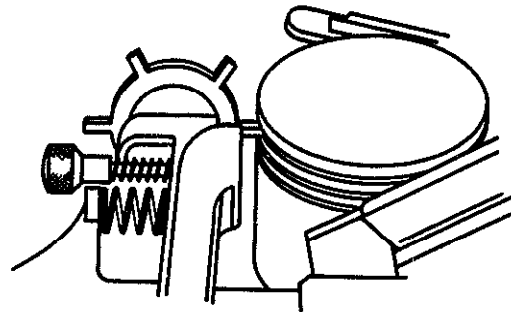
Chart 49

PISTON CHECKS



REMOVING PISTON RINGS

**CLEANING RING GROOVES
WITH RING GROOVE CLEANER**



**CLEANING RING GROOVE
WITH BROKEN RING**

Chart 49

PISTON CHECKS

23. If the cylinder is resized (rebored), a new piston must be installed.

If the engine is not to be rebored and the piston is to be reused, the old rings must be removed. To remove the rings, use a ring expander as shown in the chart. If a ring expander is not available, carefully expand the ring by hand and move it up over the top of the piston. **AVOID SCRATCHING** the ring lands with the ends of the ring. Remove the other rings in the same manner.

Clean the carbon from the top of the piston with a carbon scraper or putty knife. **DO NOT** use a wire brush to clean the piston because it will wear away part of the ring lands. Stuck piston rings, broken rings, severe piston burning, and top groove wear can be the result of improper combustion or detonation. Careful service of the ignition system and the use of proper fuel will prevent such problems from occurring.

A ring groove cleaning tool is used to remove carbon from the bottom of each ring groove. Adjust the cutter head so that the proper sized cutter will be in line with the ring groove when the tool is placed on the piston. Place the cutter in the groove to be cleaned and adjust the tool so that spring tension keeps the tool under tension. Rotate the tool by hand until all the carbon is removed from the groove. This procedure is followed for each ring groove.

If a ring groove cleaning tool is not available, a broken piston ring can be used to scrape the carbon from the ring grooves. If a broken ring is to be used, the scraping end should be square so that it scrapes evenly along the bottom of the groove. If the carbon is not cleaned from the grooves, it can cause the new rings to bind in the cylinder when the engine is reassembled.

Wash the piston in solvent and carefully inspect it for burned areas on the piston lands or deep scores, scratches, or cracks on the skirt.

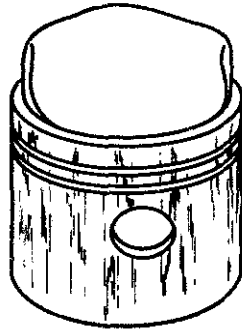
If the piston has any of the above defects, it should be replaced. Scoring or scuffing usually results from inadequate lubrication or a dirty cooling system. If scores are present, carefully examine the cooling fins and passages on the block. Dirt-clogged passages can cause the engine to overheat. Poor lubrication can also cause cylinder scoring. Inspect the lubrication system for broken or damaged components.

Check the ring groove for wear by placing a new ring in the groove and checking the remaining space with a feeler gauge. If a .007 or larger feeler gauge can be inserted between the ring and the piston, the piston should be replaced. Excessive wear in the ring groove can cause the rings to "pump" oil to the combustion chamber. Such wear can also cause the piston rings to break.

Check Point _____

Chart 49 (continued)

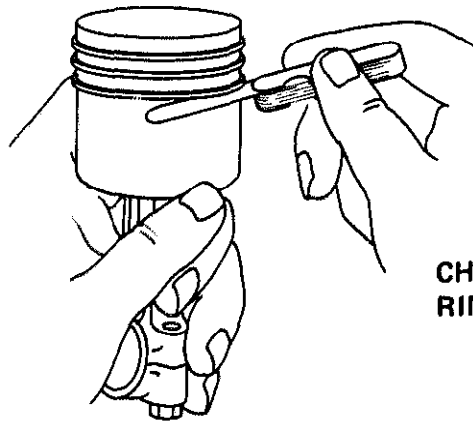
PISTON CHECKS



SCORED PISTON



BURNED PISTON



CHECKING PISTON
RING GROOVE WEAR



SCRATCHED RING

Chart 49 (continued)

PISTON CHECKS

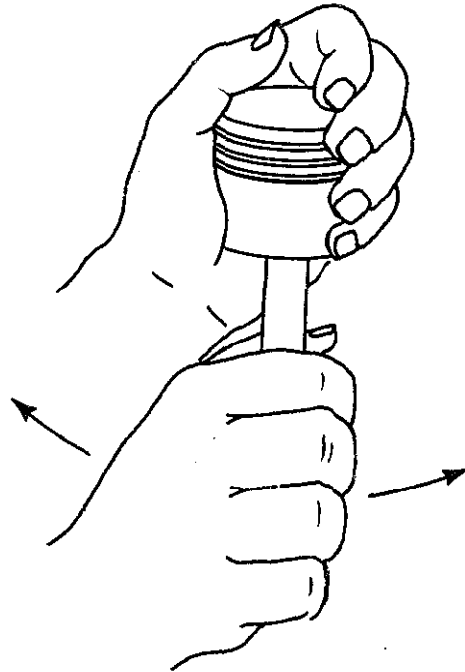
24. Inspect the old piston rings. Careful inspection may indicate the causes of wear or damage.

Fine vertical scratches on the ring faces show that dirt has entered the engine along with the intake air. Failure to correct the problem will cause the new rings to wear out quickly. The usual source of such dirt is the air cleaner. The air cleaner must be serviced periodically. (See Air Cleaner Service section.) It must be connected tightly to the carburetor to prevent entry of dirt.

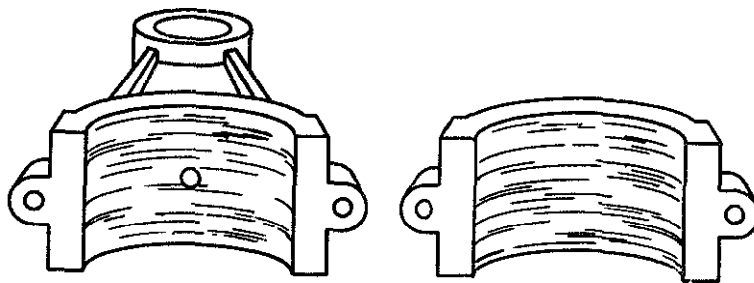
Deep scratches or scoring on the rings are normally the result of an engine which has overheated. Overheating can be caused by insufficient cylinder lubrication, clogged cooling fins, or air passages on the block, incorrect combustion, or insufficient ring or piston clearance.

Chart 50

PISTON PIN AND CONNECTING ROD CHECKS



CHECKING PISTON PIN WEAR



SCORED ROD BEARING

Chart 50

PISTON PIN AND CONNECTING ROD CHECKS

PISTON PIN CHECKS

25. Piston pin wear can be checked by holding the piston firmly in one hand while attempting to rock the rod with the other hand. The rod must be rocked in line with the piston pin. It is normal for the rod to slide freely across the piston pin. Don't confuse this with piston pin wear.

If looseness is detected, the piston pin should be removed. Before removing the pin, note identifying marks or mark the piston and rod with a punch mark so that the two can be reassembled properly. Remove the piston pin retainer with small nose pliers and remove the piston pin. Measure the piston pin with a micrometer. Compare the measurement with the standard size recommended by the manufacturer. If the pin is worn over .0005 out-of-round or below the minimum specified by the manufacturer, the pin should be replaced.

Check Point _____

Check the pin bore in the piston for wear with a telescoping gauge and a micrometer. If the bore is over .0005 out-of-round or oversize, the bore should be machined for an oversize pin or the piston should be replaced.

Oversize piston pins are available for some engines. To install an oversize pin, the piston and connecting rod bore must be reamed to fit the new pin. This machining operation should be performed by a machine shop equipped to complete the precision reaming required.

Some manufacturers include new piston pins with new pistons. The fit between the rod and the new pin should be checked. If the rod is loose on the new pin, the rod should be replaced.

CONNECTING ROD CHECKS

26. Inspect the connecting rod for wear. If there was looseness when the piston-rod assembly was checked for wear, the pin bore in the rod should be measured with a telescoping gauge and micrometer. If the pin bore in the rod is over .0007 out-of-round or is scored, the rod should be replaced.

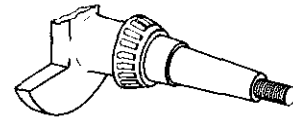
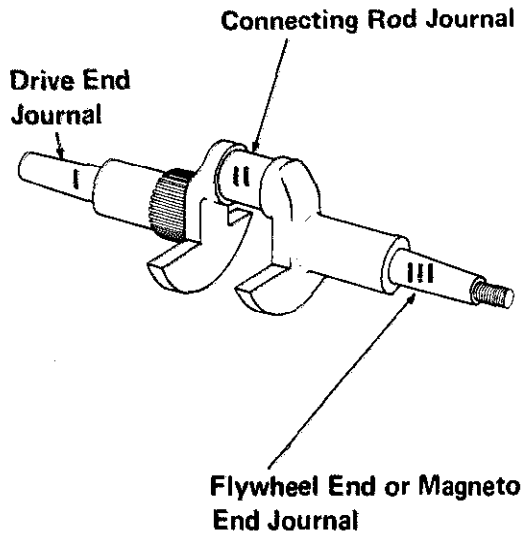
The crankpin bearing in the connecting rod should be inspected carefully for pits and scratches. If the bearing surface is pitted or scored, the connecting rod should be replaced. If there are wear spots on diagonally opposite points of the rod and the rod cap, the connecting rod is bent and should be replaced. It is NOT recommended that the connecting rod cap be filed to compensate for wear in the rod bearing or crankpin journal.

If the connecting rod was "loose" on the crankshaft when the engine was disassembled, the crankpin bearing in the connecting rod should be measured carefully with a telescoping gauge and micrometer. The bore should not be over .0005 out-of-round. If the bore is over .0005 over the manufacturer's standard size, the rod should be replaced.

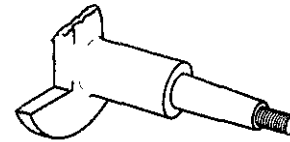
Check Point _____

Chart 51

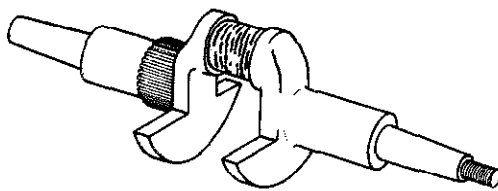
CRANKSHAFT CHECKS



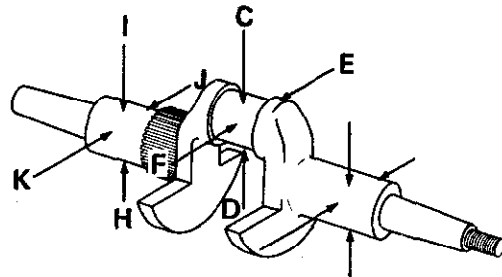
ANTI-FRICTION TYPE BEARING



PLAIN TYPE BEARING



SCORED CONNECTING ROD JOURNAL



POINTS OF MEASUREMENT FOR CHECKING JOURNAL OUT-OF-ROUND

Chart 51

CRANKSHAFT CHECKS

27. The crankshaft of the single cylinder engine incorporates three bearing surfaces. Each surface is referred to as a journal. On some engines the surface of the journal serves as the bearing surface. This bearing is referred to as a plain bearing. On some engines an anti-friction bearing (taper roller or ball type) is pressed on to the crankshaft.

If the engine has plain type bearings on the "mains" and the rod, each bearing surface must be checked carefully. Each surface should be inspected for roughness and scoring. If any of the journals is very rough, the crankshaft should be replaced. In a few cases the shaft can be polished with emery cloth and reused.

Each bearing journal should be measured carefully with a micrometer. The measurements should be taken as illustrated in the chart.

The drive-end main journal should be checked for out-of-round by comparing the measurement H-I to measurement J-K. The difference between the measurement is out-of-round. Record the out-of-round measurement in the Data Block. If the manufacturer's data are not available, the out-of-round normally should not exceed .001.

The flywheel or magneto main bearing journal should be checked for out-of-roundness in the same manner. Record the out-of-round measurements in the Data Block. Check the connecting rod journal for out-of-round by comparing measurement C-D to measurement E-F. Record the out-of-round in the Data Block.

The taper of the bearing journals can also be checked. The taper on any plain bearing journal is measured by taking measurements at each end of the journal as shown in the chart. The taper on journals of small engine crankshafts normally should not exceed .001. If the journal is not scored and is not out-of-round, it seldom will have "taper."

Crankshafts that exceed the wear limits or ones that are badly scored should be replaced. Some manufacturers have replacement main bearings and rods for use on undersized crankshafts. If these are available, the crankshaft can be reconditioned by a machine shop. Be certain that undersized bearings are available before having the crankshaft reground.

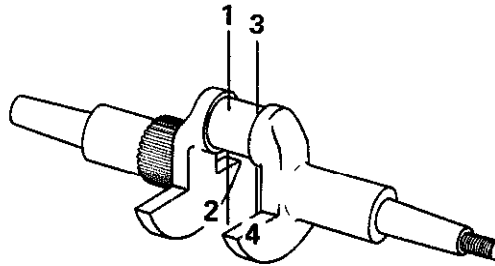
On engines with anti-friction (taper roller or ball type) main bearings, the bearings should be carefully inspected for nicks on the rollers or balls and races. Defective bearings can also be identified by rotating the bearing by hand. Roughness in the bearing can be felt as the bearing is turned slowly. *Note:* The bearing must be clean when it is checked for roughness.

If roughness or wear is detected, the bearing should be replaced. Some of these bearings are a press fit on the crankshaft. To remove these, an arbor press or special bearing puller is required.

Replacement procedures for this type of bearing vary. The manufacturer's recommendations should be followed when installing the new bearing. *Note:* When installing these bearings NEVER use a torch to heat the bearing.

Chart 51 (continued)

CRANKSHAFT CHECKS



**POINTS OF MEASUREMENT FOR
CHECKING JOURNAL TAPER**

Chart 51 (continued)

CRANKSHAFT CHECKS

As explained earlier in the text, most manufacturers recommend that a bent crankshaft be replaced. Straightening a bent crankshaft weakens the shaft. Such a shaft could break later while in operation.

Inspect the timing gear on the crankshaft for wear and damaged teeth. Normally these gears will last the life of the engine. If there is much wear or if there are damaged gear teeth, the gear should be replaced. On a smaller engine the timing gear is made as a part of the crankshaft. It will be necessary to replace the crankshaft if the timing gear is faulty.

Data Block

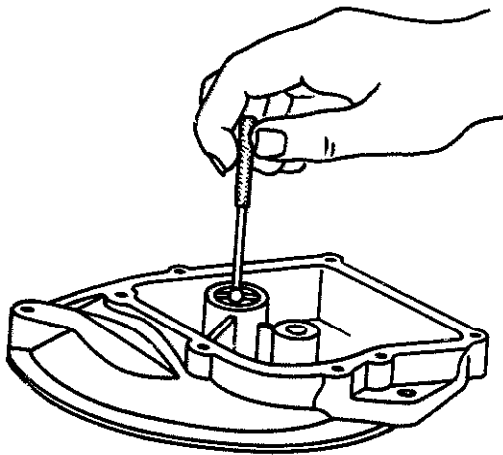
	<i>Actual</i>	<i>Specifications</i>
Drive-end main journal out-of-round	_____	_____
Magneto-end main journal out-of-round	_____	_____
Connecting rod journal out-of-round	_____	_____
Drive-end main journal taper	_____	_____
Magneto-end main journal taper	_____	_____
Connecting rod journal taper	_____	_____

NOTES: _____

Check Point _____

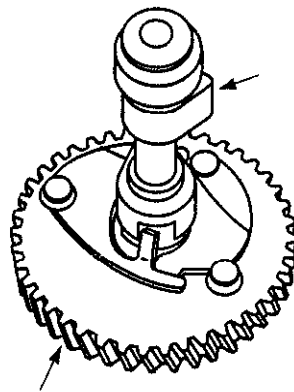
Chart 52

**MAIN BEARING AND
CAMSHAFT CHECKS**



MEASURING MAIN BEARING BORE

**COMPRESSION
RELEASE
MECHANISM**



CHECK FOR WEAR

**ENGINE WITH REMOVABLE BASE AND
CAMSHAFT HELD IN THE BLOCK BY A
PIVOT SHAFT**

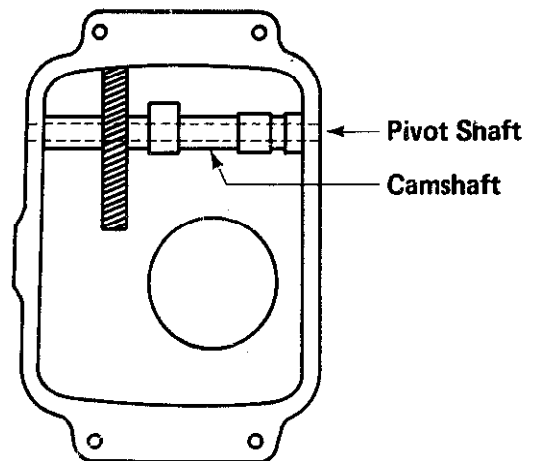


Chart 52

MAIN BEARING AND CAMSHAFT CHECKS

MAIN BEARING CHECKS

28. On engines that have plain type main bearings it is important to check the bearing bores for wear.

Carefully check each bearing (one on the block and one in the crankcase cover) for scoring. If there is much scoring or pitting, the bearing should be replaced. Wear of the main bearing can be checked further with a telescoping gauge and micrometer. On some engines the bearing bore can be reamed with a reamer, and a replacement sleeve can be installed. Such sleeves are *not* available from some manufacturers. If the bearing is not serviceable and a replacement sleeve is not available, the bearing can be reamed out and a sleeve can be custom-made by a machine shop. In such cases the costs of the repair must be weighed against the costs of replacing the engine or short block.

A short block includes the block, crankshaft, rod and piston assembly, valve train, and side cover. Installing a short block involves relatively little work and provides a literally new engine.

CAMSHAFT CHECKS

29. The camshaft opens the valves by operating valve lifters which push the valves off their seats. The camshaft will normally last the life of the engine if the engine oil is properly maintained.

On some engines the camshaft is easily removed once the crankcase side or base is removed. On other engines the camshaft is on a pivot shaft which runs completely across the block. To remove this camshaft requires that the pivot shaft be forced out of the block. It is not normally necessary that the camshaft be removed as a part of the overhaul.

Check the camshaft for wear by carefully inspecting each lobe for a scored or scratched surface. If there is no scoring, normally the camshaft is satisfactory. The lobes can be checked further by comparing the lobe measurements with the manufacturer's specifications.

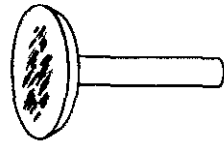
The camshaft gear or assembly should be replaced if the gear teeth are worn, broken, or chipped. Camshaft bearing wear can be checked by comparing the shaft measurements with the standards recommended by the manufacturer.

On engines in which the camshaft is held in the block on a pivot shaft, bearing wear can be checked by feeling for looseness. To make this check, grasp the camshaft and attempt to move it toward the valve area of the engine. Then try to move it in the opposite direction. If there is much movement of the camshaft on its bearings, the camshaft should be removed and further checks made with a micrometer.

On engines that have governor units fitted to the camshaft, the governor should be checked for wear. Refer to the manufacturer's manual for data on a particular governor. Some manufacturers mount a centrifugal mechanism on the camshaft to provide compression release. On these units check for binding of the weights and free operation of the springs.

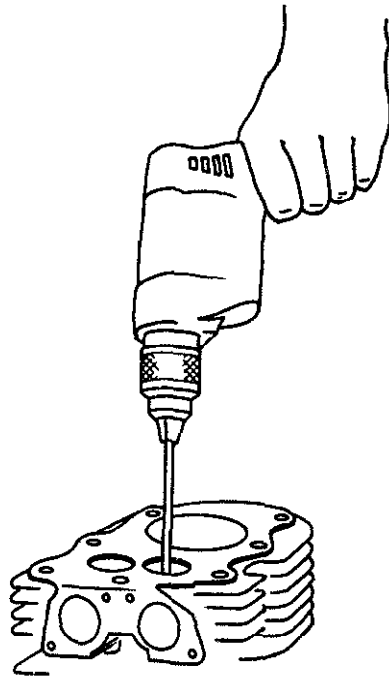
Chart 53

**VALVE LIFTER AND
VALVE GUIDE CHECKS**



WORN LIFTER FACE

CLEANING VALVE GUIDE



**CHECKING VALVE GUIDE
WEAR WITH DIAL INDICATOR**

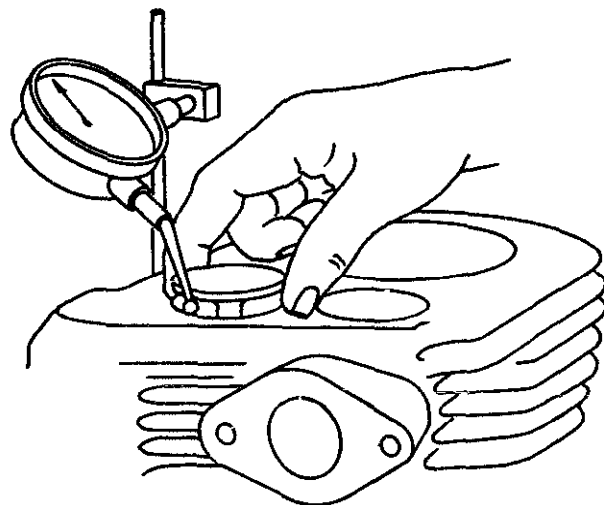


Chart 53

VALVE LIFTER AND VALVE GUIDE CHECKS

30. Examine the valve lifters for wear or scoring on the lifter face which rides on the cam lobes. If the face is worn or scored, the lifter should be replaced. The face should not be remachined or ground because this will remove the hardened surface of the lifter. Without the hardened face surface, the lifter will wear very rapidly.

Before valve guides can be checked for wear, clean carbon from the guide with a valve guide brush. Check for valve guide wear by placing a new valve (a used valve will work providing the stem is not worn over .001) in the guide and measuring the side play with a dial indicator. The maximum allowable clearances are listed below:

<i>Valve Head Diameter</i>	<i>Maximum Side Play</i>	
Up to 1-1/4"	Intake	.005
	Exhaust	.007
Over 1-1/4"	Intake	.006
	Exhaust	.008

Another means of checking valve guide wear is to measure the valve guide with a small hole gauge and micrometer. Compare the guide diameter one-quarter inch from the top of the guide to the specifications listed by the manufacturer.

If valve guide wear exceeds the manufacturer's recommendations, the guide should be replaced or reconditioned.

The guide can be resized by a knurling process that can be done by most automotive machine shops.

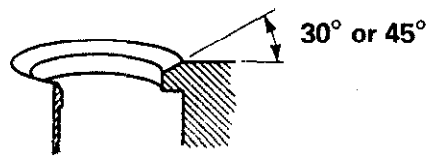
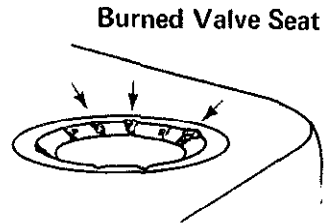
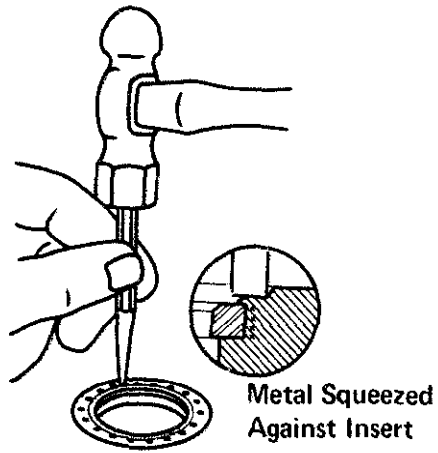
Some manufacturers have valves with oversized stems that can be installed in guides that have been reamed to the proper oversize.

Replacement guides are available for many small engines. Follow the manufacturer's recommendations when replacing the valve guide.

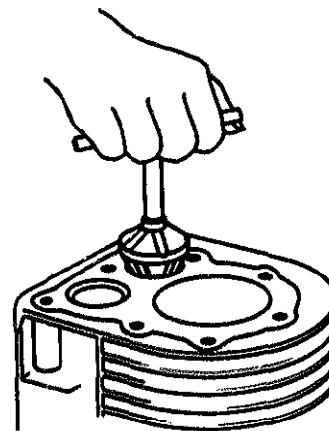
Check Point _____

Chart 54

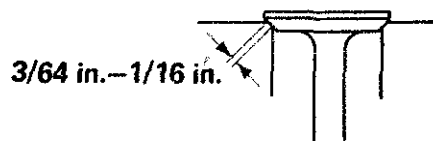
VALVE SEAT SERVICE



VALVE SEAT ANGLE



RECONDITIONING THE VALVE SEAT



VALVE PROPERLY SEATED IN BLOCK

Chart 54

VALVE SEAT SERVICE

31. Clean the carbon from the valve ports and valve seat area.

To ensure a good seal between the valve and the valve face requires that the valve seat be in good condition. If the valve seat is loose in the block, it can be tightened by staking the block adjacent to the seat with a punch and hammer.

Badly burned valve seats should be replaced. Follow the recommendations of the engine manufacturer when replacing valve seats.

Valve seats that are not badly burned can be reconditioned by machining or grinding a new sealing surface. One type of seat reconditioner uses a hand-operated cutter. To use this tool, first place the proper-sized pilot in the *clean* valve guide. The proper-angled cutter (usually 45° or 30°) is then placed over the pilot. The cutter is turned in a clockwise rotation by the special T-wrench that comes with the reconditioning tool set.

Pressure is exerted on the tool as the cutter is turned. The cutting action is continued until a clean seating surface appears completely around the seat.

Caution: The seat should be machined as little as possible. The width of the finished seating area should be from 3/64 inch to 1/16 inch.

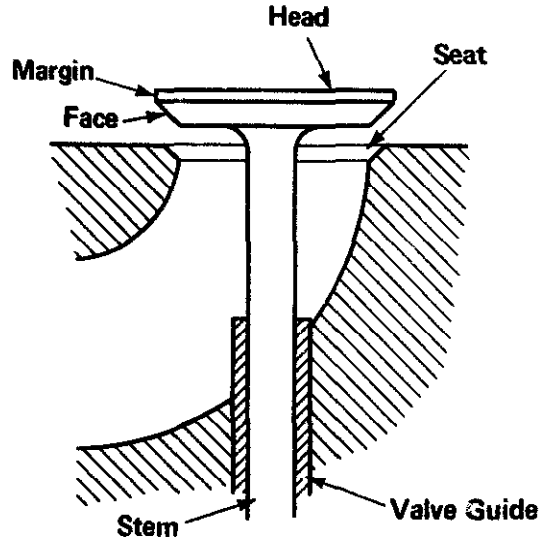
If the seating area exceeds 1/16 inch in width, it should be narrowed by removing stock from the top of the machined area. The narrowing operation is performed with a cutter which is of a lesser angle than the valve seat. (A 30° cutter can be used to narrow 45° seats.)

If much narrowing of the seat is required, be sure to check the height of the valve head when it is seated. The lower edge of the valve margin should be above the top of the valve seat (see illustration). If the valve rides too low in the seat, check to be certain that the valve margin is sufficient. If the margin is satisfactory, the problem probably is caused by the seat being too large.

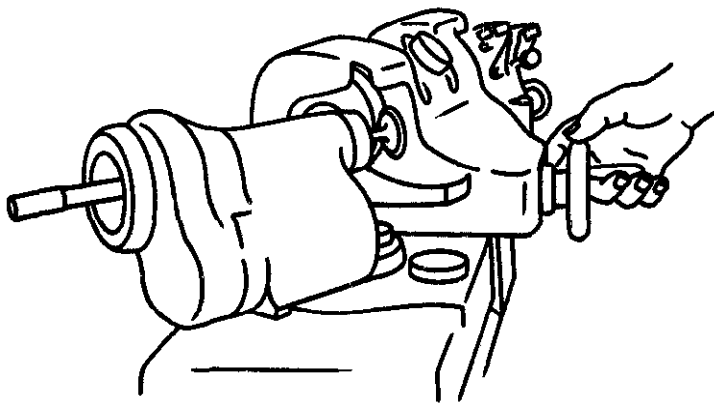
Before condemning the valve seat, however, place a new valve in the engine to see if it will correct the problem. If it rides properly in the seat, there is no need to install a new seat. If the new valve rides too low, a new valve seat should be installed. Refer to the manufacturer's data for valve seat replacement on a particular engine.

Chart 55

VALVE SERVICE



VALVE PARTS



REFACING VALVE



HAND LAPPING A VALVE

Chart 55

VALVE SERVICE

32. Clean the intake and exhaust valves with a wire brush. Examine each valve for burned faces. If the faces are pitted or badly grooved, the valve should be replaced.

Measure the margin on each valve. If the margin is $1/64$ inch or less, the valve should be replaced.

Check the valve stems for scoring and wear. Check for wear by measuring the valve (with a micrometer) one inch above the retainer groove or hole and one-quarter of an inch below the upper point of contact with the valve guide. If these measurements differ by .001 or more, the valve should be replaced.

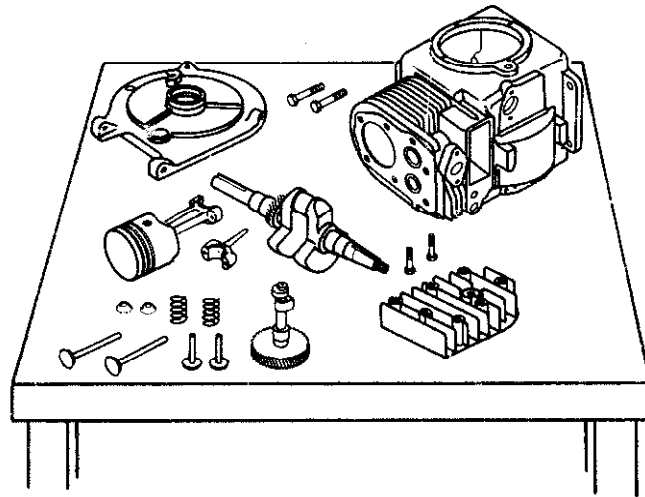
If the valves are to be reused, the faces should be reconditioned by grinding on a valve refacer. Follow the recommended procedures for the valve refacer in the refacing operation. Be certain that the machine is set for the proper face angle before starting the refacing operation. Some engines use different angles for the intake and exhaust valves. If a valve refacer is not available, the operation can be performed by most automotive machine shops.

An alternate method of reconditioning the valve and the valve seat is known as lapping. If the valve seat and valve face are in relatively good condition, the seating surfaces can be reconditioned by the lapping process. To do this, first place the valve in its guide in the engine. Put a small amount of lapping compound between the valve face and the valve seat. (Be sure that none of the lapping compound gets on the valve stem!) Place the suction cap of the lapping tool over the head of the valve. Rotate the valve back and forth against the seat. Frequently raise the valve off the seat to allow the compound to flow to the point of friction. Continue the lapping operation until a good sealing surface is obtained. Clean all the lapping compound from the valve and valve seat.

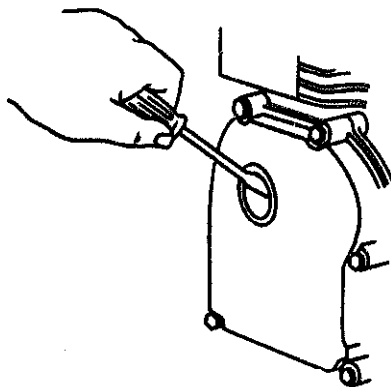
The final process on the valve (adjusting the clearance) can only be completed later when reassembling the engine. This operation will be explained as a part of the Reassembly Procedure.

Chart 56

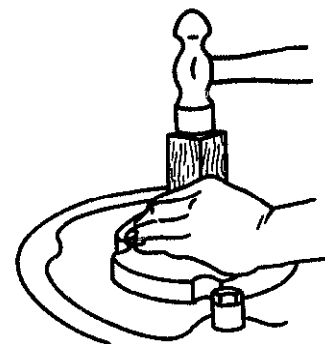
REASSEMBLY PROCEDURE



ALL COMPONENTS OF THE ENGINE SHOULD BE CLEANED AND PLACED ON A CLEAN WORK SURFACE BEFORE BEGINNING THE REASSEMBLY



REMOVING CRANKSHAFT SEAL



INSTALLING CRANKSHAFT SEAL

Chart 56

REASSEMBLY PROCEDURE

When reassembling the engine, it is very important that everything—parts, work area, your hands, and tools—be clean. Surgical cleanliness is a must if the engine overhaul is to be successful.

1. Rinse all engine parts in solvent and dry them with compressed air. As each part is cleaned, place it on the clean surface of the workbench. Avoid drying parts with rags because lint will collect in the small crevices. If your work on the engine is interrupted for any length of time, cover the engine components with a clean, lint-free cloth.

2. Install new crankshaft seals in the engine block and the cover housing. The old seals can be pried out with a large screwdriver or they can be driven out with a punch and hammer.

When new seals are being installed, be certain that the sharp edge or lip of the seal is toward the inside of the engine. Some manufacturers recommend that a film of sealer (Permatex #2) be applied to the outer part of the seal (between the seal and the casting) to prevent oil leakage between the seal and the housing. Seat the seal in the housing with a seal driver (or block of wood) and a hammer.

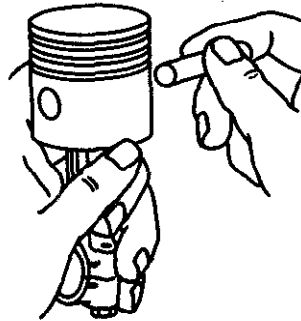
3. If the piston, piston pin, or connecting rod is being replaced, proceed with installation of the piston on the connecting rod. First, match the old components that you marked prior to disassembly. Position the new replacement components adjacent to the old parts. Assemble the piston and rod so that it is just like the old parts were prior to disassembly.

Check Point

4. If the camshaft was removed and was the kind held in the engine block on a pivot shaft, proceed with its replacement. First, clean the block lifter holes and camshaft bearings. Lubricate these surfaces with motor oil (SAE 20 or 30, SE classification). Install the lifters in their respective bores and place the camshaft in the block. Install the camshaft pivot shaft and expansion plugs in the block.

Chart 56 (continued)

REASSEMBLY PROCEDURE



INSTALLING PISTON ON ROD

Chart 56 (continued)

REASSEMBLY PROCEDURE

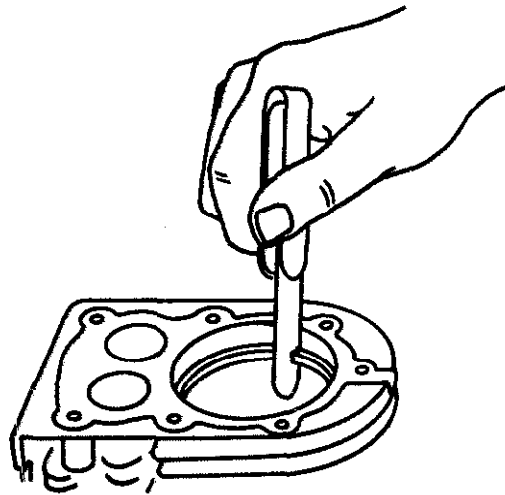
5. Wipe the main bearing surfaces in the engine block and lubricate them with motor oil.

Wipe the main bearing journals on the crankshaft, apply a film of oil, and install the crankshaft in the engine. *Carefully* guide the crankshaft through the seal on the magneto or flywheel side of the engine. *Note:* The following procedure is only for an engine whose camshaft is held in the engine on a pivot shaft. If your engine has a removable side crankcase cover or base containing a main bearing, disregard the remainder of this step. Align the timing marks on the crankshaft and the camshaft gears. Refer to the Data Block in the disassembly procedure for the crankshaft end play recorded prior to disassembly of the engine. Compare this end play measurement to the manufacturer's data. If the end play is within specifications, select a new bearing retainer cover gasket of the same thickness as the one that was removed from the engine during disassembly. Install the gasket and bearing retainer. If the end play of the crankshaft was more than recommended by the manufacturer, select a thinner gasket and install the retainer.

Using the dial indicator, check the crankshaft end play with the new gasket in place. If the end play is not within specifications, remove the retainer and select a gasket that will provide the proper end play. If a dial indicator is not available, check the end play with a feeler gauge as shown in the disassembly procedure. If manufacturer's data are not available, adjust the end play between .004 and .012.

Chart 57

INSTALLING PISTON RINGS



CHECKING END GAP OF NEW PISTON RING

Compression



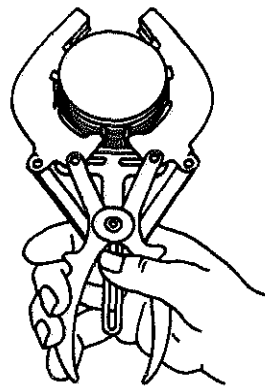
Scraper



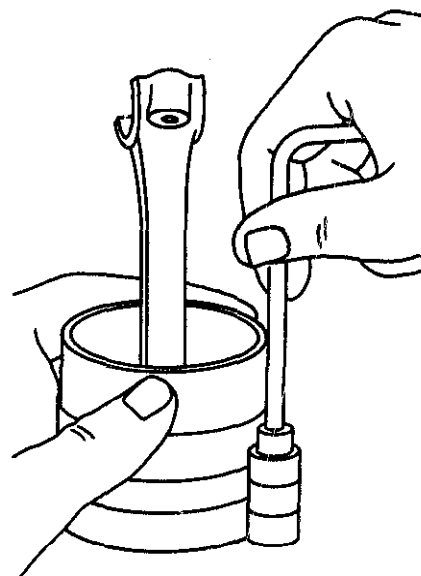
Oil



EXAMPLES OF PISTON RINGS



INSTALLING RINGS ON PISTON



INSTALLING PISTON RING COMPRESSOR

Chart 57

INSTALLING PISTON RINGS

6. Place one of the new piston rings in the cylinder and push it down to approximately one-half inch from the bottom of the cylinder with the piston. Check the gap between the ends of the ring with a feeler gauge. Compare this end gap clearance with the minimum ring end gap clearance recommended by the manufacturer. The end gap must *not* be less than the minimum clearance specified or the rings will tend to seize in the cylinder. (If the manufacturer's data are not available, allow .003 end gap clearance for each inch of cylinder diameter.)

If the end gap clearance is less than recommended, carefully file the end of the ring to obtain the necessary clearance. If it is necessary to file the end of one ring, it will also probably be necessary to file the other rings.

Check Point

7. Install the new piston rings on the piston. *ALWAYS* install new piston rings in an engine that has been disassembled. Used rings cannot seat in properly and will cause oil consumption and compression loss.

When installing the piston rings, carefully follow the instructions included with the new piston rings. Lubricate the ring grooves on the piston before installing the rings. Use a piston ring expander when installing the new rings. The rings can be "stretched" if they are installed by hand springing them over the piston.

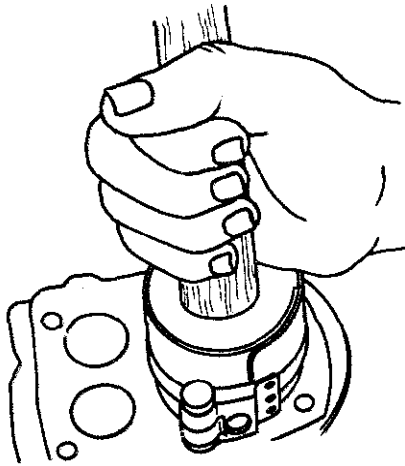
The widest ring is the oil ring that fits in the bottom groove of the piston. Some manufacturers use a thin metal expander behind this ring. The middle ring is referred to as the scraper ring or the center compression ring. It normally has a groove on its outside edge. This groove must be down when the ring is assembled on the piston. The top ring or compression ring normally has a bevel on its inside edge. This bevel must be up when the ring is installed on the piston.

Check Point

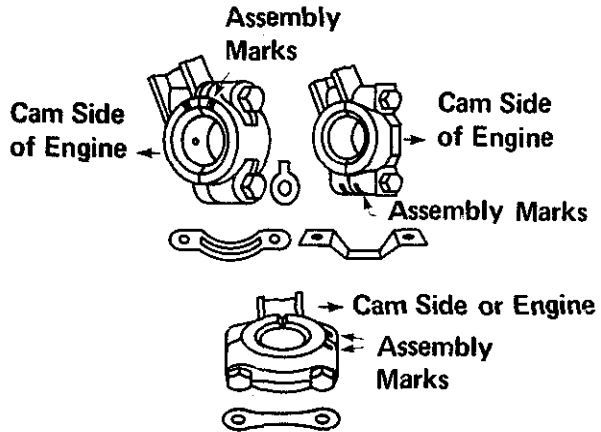
8. Lubricate the piston and rings thoroughly with motor oil. Rotate the piston rings so that the end gaps of the rings are not in line. Install the piston ring compressor over the piston and tighten. Continue to tighten the compressor until the bottom edge of the compressor is against the piston.

Chart 58

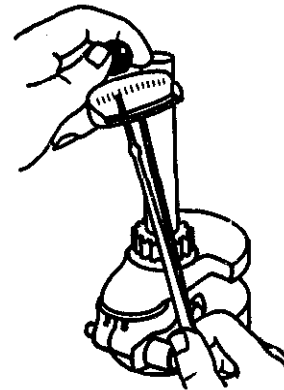
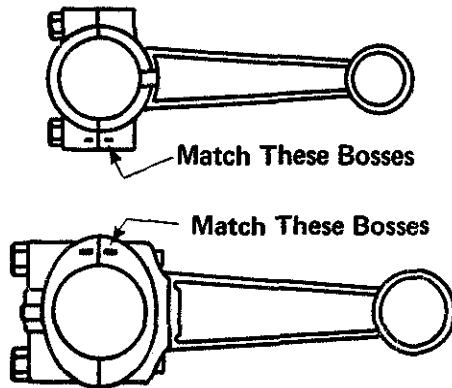
INSTALLING THE PISTON ASSEMBLY



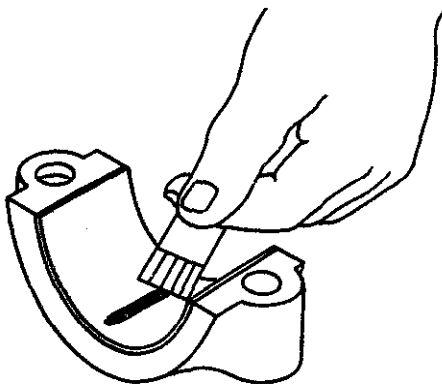
INSTALLING PISTON ASSEMBLY



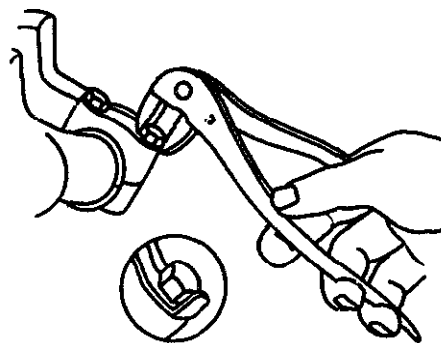
EXAMPLES OF MATCH MARKS AND ROD BOLT LOCKS



TIGHTEN ROD BOLTS TO SPECIFIED TORQUE



CHECK CONNECTING ROD BEARING CLEARANCE WITH PLASTIGAUGE



LOCKING ROD BOLTS

Chart 58

INSTALLING THE PISTON ASSEMBLY

9. Wipe the cylinder with a clean cloth. Lubricate the cylinder with motor oil and rotate the crankshaft to place the rod journal opposite the cylinder. Place the piston assembly in the bore. *Make certain* that the marks on the connecting rod are positioned properly in the engine.

Position a hammer handle against the head of the piston. With one hand exert pressure on the handle while bumping the end of the hammer with the other hand. Carefully guide the connecting rod so that it does not catch on the crankshaft.

10. If desired, the clearance between the connecting rod and the crankshaft can be checked at this point.

Wipe the crankshaft and connecting rod bearing surfaces. Position the rod over the crankshaft journal. Lay a piece of Plastigauge on the crankshaft and install the connecting rod cap. Carefully tighten the rod bolts to the specified torque with a torque wrench. **DO NOT TURN THE CRANKSHAFT.** Remove the rod cap and compare the width of the flattened Plastigauge to the scale on the Plastigauge package. The clearance should be within the specifications recommended by the manufacturer.

If the clearance is less than the minimum, check to make certain that the rod cap was installed properly on the rod and that there is no dirt or foreign material between the connecting rod and the crankshaft. If both items check out, the connecting rod is probably the incorrect rod for the engine.

If the clearance exceeds the maximum, check for dirt or foreign material between the rod and the cap at the point of connection. If no foreign material is present, remeasure the crankpin with a micrometer and compare it with the manufacturer's data. If the crankpin size is correct, either the rod is worn or else it is the incorrect rod for the engine.

If the manufacturer's rod clearance data are not available, the following specifications can be used as a guide:

.001 minimum clearance between rod and crankpin

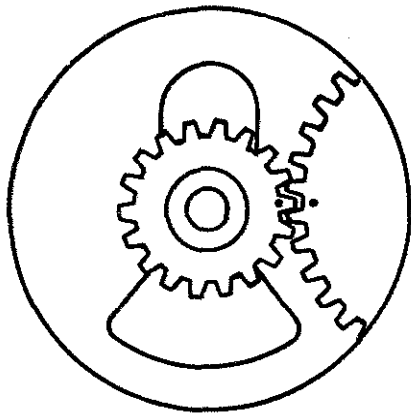
.0035 maximum clearance between rod and crankpin

11. Thoroughly lubricate the crankpin, rod bearing, and cap bearing. Install the rod cap (oil dipper, if used), lock plate, and rod bolts or nuts. Tighten the rod bolts evenly to the manufacturer's torque specifications and bend the lock plate tabs to secure the rod bolts or nuts.

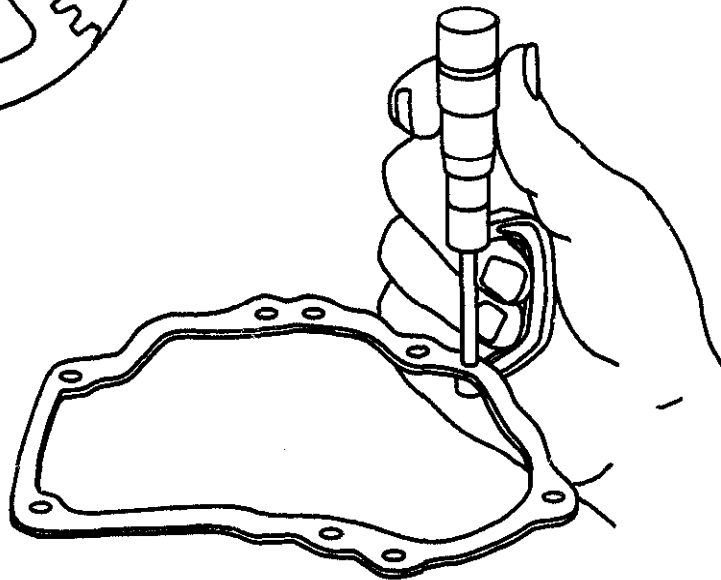
Rotate the crankshaft to ensure that there will be no binding of the rod bearing.

Chart 59

**CAMSHAFT AND CRANKCASE
COVER INSTALLATION**



PROPERLY ALIGN TIMING MARKS



SELECT THE RIGHT COVER GASKET

**WRAP CRANKSHAFT WITH
WAX PAPER TO PREVENT
DAMAGE TO THE SEAL**

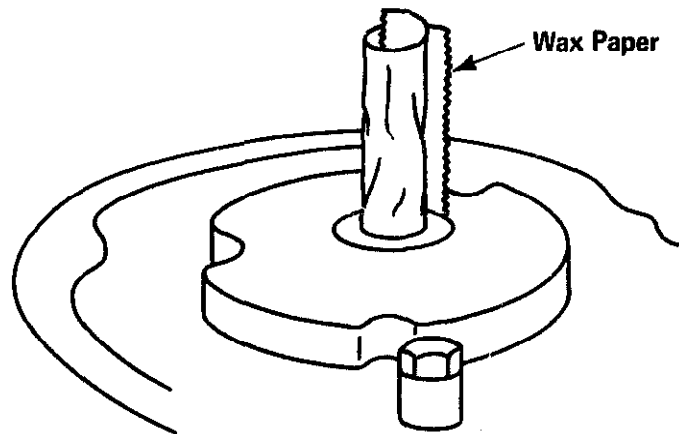


Chart 59

CAMSHAFT AND CRANKCASE COVER INSTALLATION

12. On an engine that does not have the camshaft held in the block on a pivot shaft, lubricate the valve lifter bores and install the lifters. Lubricate the camshaft bearings and install the camshaft. **MAKE CERTAIN** that the timing mark on the camshaft gear and the crankshaft are matched properly.

13. Refer to the Data Block in the disassembly procedure for the crankshaft end play recorded prior to disassembly of the engine. Compare this end play measurement to the manufacturer's data. If the end play is within specifications, select a new crankcase cover gasket of the same thickness as the one that was removed from the engine during disassembly.

If the end play of the crankshaft was more than that recommended by the manufacturer, select a thinner gasket.

For an engine with extreme wear, some manufacturers supply a thin washer which is placed between the crankshaft timing gear and the side cover.

14. If the engine has the governor built in to the crankcase, position the governor components so that the crankcase cover can be installed.

15. On an engine that has an oil pump, check the pump for wear. Replace worn components and install the pump in the engine. With a pump oil can, apply a liberal amount of oil to the piston pin, crankshaft bearings, and camshaft.

16. Lubricate the camshaft and crankshaft bearings in the crankcase cover.

17. Install the oil slinger or oil pump.

Check Point _____

18. Carefully install the cover gaskets and cover. Be sure to work the crankshaft seal into position as the cover is installed. *Note:* It is not necessary to use a sealer on the side cover gasket. To prevent damage to the crankshaft seal use a special installing cone or wrap wax paper around the crankshaft to guide the seal over the bearing shoulder.

19. Tighten the cover retaining bolts to the specified torque.

20. Check the crankshaft end play with a dial indicator. Compare the end play of the engine to the manufacturer's data. If the end play is not sufficient, remove the cover and install a thicker gasket.

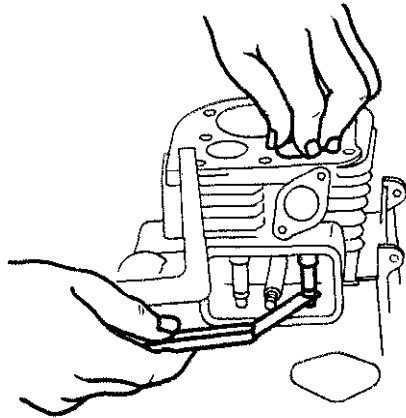
If the end play is excessive, remove the cover and install a thinner gasket.

Always use at least one gasket between the cover and the engine even though the end play slightly exceeds the maximum recommended.

If the manufacturer's data are not available, adjust the crankshaft end play between .004 and .012.

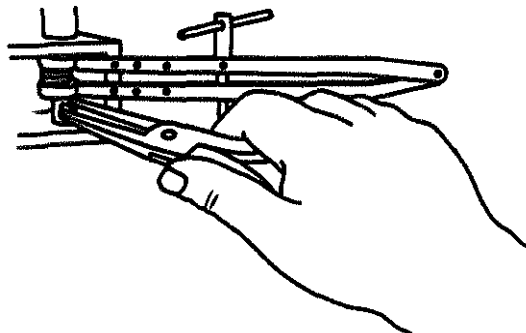
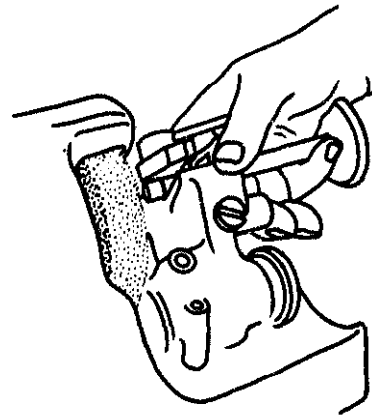
Chart 60

**VALVE ADJUSTMENT
AND INSTALLATION**



CHECKING VALVE OPERATING CLEARANCE

**GRINDING END OF VALVE STEM TO
ATTAIN PROPER VALVE CLEARANCE**



VALVE INSTALLATION

**IF VALVE SPRING COMPRESSOR IS NOT
AVAILABLE, COMPRESS SPRING IN A BENCH
VISE AND SECURE WITH WIRES AS SHOWN.
REMOVE WIRES AFTER VALVE IS INSTALLED.**

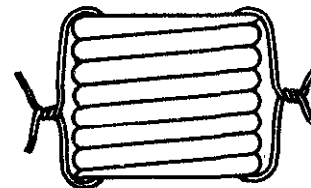


Chart 60

VALVE ADJUSTMENT AND INSTALLATION

21. On an engine that has a removable crankcase base, place a new gasket on the engine block and replace the base. Tighten the bolts that secure the base. **BE CERTAIN** to tighten the oil drain plug.

22. Place the intake valve in its valve guide and turn the crankshaft until the valve opens. **TURN** the crankshaft an additional half turn. This should position the intake valve in the closed position. Hold the valve tightly closed with your thumb and check the clearance between the end of the valve stem and the valve lifter with a feeler gauge.

Check the manufacturer's specifications for the proper valve operating clearance for your engine and compare the clearance to the measured clearance of the engine. Since the valve seating surfaces have been machined, it will probably be necessary to remove some material from the end of the valve stem to achieve the right clearance.

The valve stem can be "shortened" by grinding material from the stem on a valve reconditioning machine or on a bench grinder with a V block. Grind a small amount; then recheck the clearance. If too much material is ground off, the valve will have to be replaced.

Once the intake valve operating clearance is properly adjusted, place the exhaust valve in the engine. Rotate the crankshaft until the exhaust valve opens; then rotate the crankshaft an additional half turn. Check the clearance specification of the exhaust valve and adjust it in the same manner as the intake valve.

Check Point

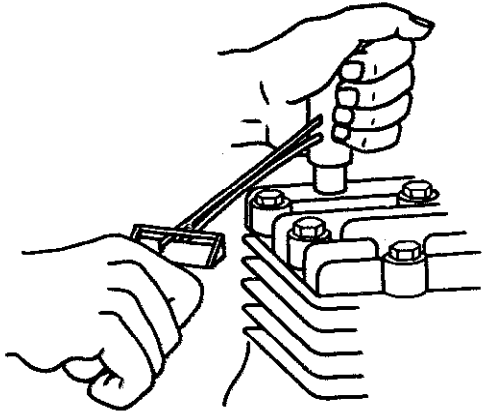
23. Thoroughly lubricate the valve stem and guide. Compress the intake valve spring (the lighter spring) and install the spring and retainer on the intake valve.

In similar manner install the exhaust valve spring (the heavier spring) and retainer. If a valve spring compressor is not available, the springs can be compressed in the bench vise and held with wire. Once the retainers are in position, cut the wire from the spring and remove it from the valve chamber.

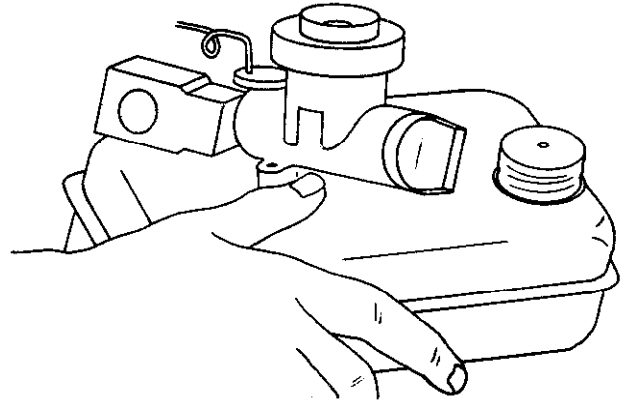
Replace the valve cover using a new gasket. If the cover contains a crankcase breather, be certain to reassemble the unit in the proper sequence.

Chart 61

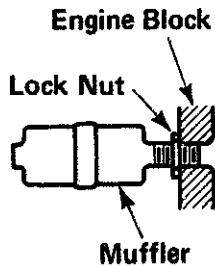
**HEAD REPLACEMENT AND
FINAL REASSEMBLY**



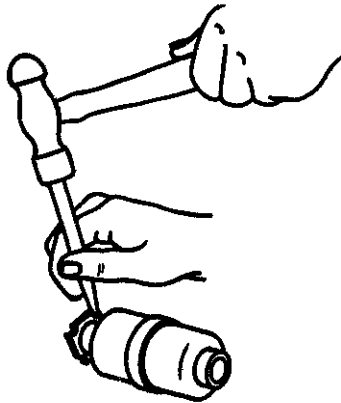
**TIGHTEN HEAD BOLTS WITH
A TORQUE WRENCH**



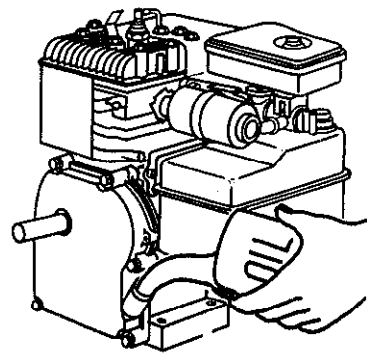
**TILT THE FUEL TANK ASSEMBLY
TO CONNECT THE CARBURETOR
LINKAGE**



**THREAD MUFFLER
1/2" INTO BLOCK
AND SECURE WITH
LOCKNUT**



**TIGHTEN MUFFLER
LOCK NUT WITH
HAMMER AND PUNCH**



**FILL THE CRANKCASE
WITH SAE 30-SE OIL**

Chart 61

HEAD REPLACEMENT AND FINAL REASSEMBLY

24. Make certain that the block and head are clean and place a new head gasket on the block. *Carefully* check the gasket to be sure that it aligns properly with the bolt holes and the block surface. Place a small amount of graphite grease on the threads of the head bolts and install the head on the engine. Make certain that all bolts are installed in the proper locations. If the bolts were mixed accidentally, check with a small rod or nail to determine where the longer bolts are needed to ensure that the bolts adequately thread into the engine.

25. Snug all head bolts by hand. Torque the bolts to one-third torque specifications following the tightening sequence shown for your bolt arrangement. Refer to the manufacturer's specifications for the torque value. Retighten all bolts to two-thirds torque specifications. Tighten to the torque specifications and go over them one more time to be certain that all bolts are at the proper torque.

26. Adjust the gap and install a new spark plug. Torque the plug to the specified torque. If specifications are not available, torque the plug to 20 foot-pounds.

27. Replace the intake manifold and carburetor assembly. Connect the governor linkage before bolting the carburetor to the engine. (DO NOT BEND THE LINKAGE WIRE.)

28. Replace the ignition system and flywheel as outlined in the Ignition section.

29. Replace the muffler. *Caution:* On a model that has a muffler which threads into the engine block, DO NOT thread the muffler all the way into the block. Thread the muffler into the block approximately one-half inch and tighten the locking nut. If the muffler is threaded into the engine too far, it may "pinch" the exhaust valve guide or the tapered threads may distort the engine block.

30. Replace the air shroud and other components which were removed or disconnected.

31. Fill the crankcase with SAE 30, SE classification, motor oil.

Note: Do not overfill the crankcase. Fill only to the full mark or level of the engine. After 5 hours of operation change the engine oil. During break in of a newly overhauled engine the oil becomes contaminated quickly as the new parts "wear in"

32. Replace the engine on the tiller, lawnmower, etc., and connect all controls.

33. Reconnect the drive train or blade.

34. Fill the fuel tank with clean fuel.

35. Start the engine and maintain a fast idle for the first few minutes of running.

36. Adjust the carburetor as outlined in the Carburetor section.

Questions for Section IV

- T F** 1. Piston rings are fitted to the piston to keep the piston centered in the cylinder. (Chart 42)
- T F** 2. The crankshaft drives the camshaft at one half crankshaft speed. (Chart 42)
- T F** 3. Gaskets and seals should not be reused when servicing the engine. (Chart 42)
- T F** 4. The part inside the engine that wears the most is the connecting rod bearing. (Chart 42)
- T F** 5. Failure to remove the rust from the drive end of the crankshaft can cause damage to the main bearing when the crankcase is removed. (Chart 45)
- T F** 6. Any cylinder head which is warped must be replaced. (Chart 43)
- T F** 7. Some small engine valve covers contain filter units for the crankcase breather. (Chart 46)
- T F** 8. Gasoline should *not* be used to clean the engine. (Chart 44)
- T F** 9. Cylinder head bolts used on small engines are all the same length. (Chart 43)
- T F** 10. Removing the carburetor requires bending the governor linkage. (Chart 45)
- T F** 11. The spark plug wire should be grounded before beginning work on the blade or drive unit. (Chart 44)
- T F** 12. Improper combustion can cause the piston rings to break or become "locked" in the ring groove. (Chart 49)
- T F** 13. On some engines the exhaust valve spring is heavier than the intake valve spring. (Chart 46)
- T F** 14. Identification marks should be painted on timing gears if there are no manufacturer marks. (Chart 47)
- T F** 15. All internal parts of the engine should be cleaned with soapy water when performing an overhaul. (Chart 47)
- T F** 16. A broken piston ring should never be used to clean the ring grooves of the piston. (Chart 49)
- T F** 17. If the cylinder of an engine is .015 out of round, the engine should be junked. (Chart 48)
- T F** 18. Cylinder taper can be measured with a piston ring and feeler gauge. (Chart 48)
- T F** 19. A new piston should be installed in a cylinder which has been rebored. (Chart 49)
- T F** 20. Before removing the connecting rod from the piston, the rod and piston should be marked with a punch to aid in reassembly. (Chart 50)
- T F** 21. If the crankpin bearing surface of the connecting rod is scored, the connecting rod should be replaced. (Chart 50)
- T F** 22. The connecting rod cap should be filed down to achieve a proper fit on the crankshaft. (Chart 50)
- T F** 23. Most manufacturers recommend that bent crankshafts be straightened in a heavy press. (Chart 51)
- T F** 24. Wear on the camshaft is a common problem found in small engines. (Chart 52)
- T F** 25. On many small engines the crankshaft timing gear is made as a part of the crankshaft. (Chart 51)
- T F** 26. Crankshaft and camshaft timing gears wear quickly and must be replaced. (Chart 51)

- T F 27.** If the face of a valve lifter is badly scored, it should be refaced on a valve refacing machine. (Chart 53)
- T F 28.** A valve seat which is loose in the block should be welded in place with an arc welder. (Chart 54)
- T F 29.** The seating area of a valve seat should not be over 1/8" wide. (Chart 54)
- T F 30.** Valve margin should be at least 1/64". (Chart 55)
- T F 31.** When installing crankshaft seals, the sharp edge or lip should be towards the inside of the engine. (Chart 56)
- T F 32.** Piston ring end gap can be increased by filing the end of the ring. (Chart 57)
- T F 33.** The bevel on the inside edge of a piston ring should be towards the top of the piston. (Chart 57)
- T F 34.** A ring expander is used to hold the rings in place as the piston is installed in the cylinder. (Chart 58)
- T F 35.** The piston assembly should be hammered into the cylinder with a ball peen hammer. (Chart 57)
- T F 36.** Connecting rod bolts should be tightened with an open end wrench. (Chart 58)
- T F 37.** If the valve operating clearance is too much, the valve will have to be replaced unless the margin will allow additional refacing. (Chart 60)
- T F 38.** The engine oil should be changed after 5 hours of operation on a newly-overhauled engine. (Chart 61)
39. Describe how the piston is attached to the connecting rod. (Chart 42)
40. How is the crankshaft supported in the engine block? (Chart 42)
41. List the functions of the piston rings. (Chart 42)
42. The connecting rod is attached to the _____ of the crankshaft. (Chart 42)
43. Identify the components and describe the operation of the valve train. (Chart 42)
44. Name two symptoms which would indicate that an engine should be overhauled. (Chart 42)
45. What procedure should be followed in tightening cylinder head bolts? (Chart 43)
46. What four key points should be observed or practiced when overhauling an engine? (Chart 44)
47. Why must the ring ridge be removed from the cylinder as part of overhaul procedure? (Chart 45)
48. Describe how crankshaft end play can be measured. (Chart 46)
49. The crankshaft run-out or wobble should not exceed _____. (Chart 46)
50. What tool should be used to remove connecting rod bolts or nuts? (Chart 47)
51. What does "10" mean when it is stamped on the top of the piston? (Chart 47)
52. Explain how carbon should be removed from the piston. (Chart 49)
53. What is cylinder taper? (Chart 48)
Cylinder taper should not exceed _____. (Chart 48)
54. List the three different types of cylinder wear which must be checked. (Chart 48)
55. Cylinder wear can be measured with a telescoping gauge and a _____. (Chart 48)

56. If ring groove wear exceeds _____, the piston should be replaced. (Chart 49)
57. Describe what can cause deep scores or scratches on the piston rings. (Chart 49)
58. How can piston pin wear be checked? (Chart 50)
59. Explain the difference between a plain-type bearing and an anti-friction type bearing. (Chart 51)
60. How can a worn valve guide be corrected or repaired? (Chart 53)
61. What parts are included in a new short block assembly? (Chart 52)
62. Identify the checks which should be made on anti-friction bearings. (Chart 51)
63. Describe the measurements and checks which should be made on crankshaft journals. (Chart 51)
64. Explain the procedure for machining the valve seats in the engine block. (Chart 54)
65. Describe the procedure for replacing a crankshaft seal. (Chart 55)
66. Why is cleanliness important when reassembling an engine? (Chart 56)
67. Sketch an engine valve and label the main parts. (Chart 55)
68. Explain how crankshaft end play can be measured. (Chart 56)
69. Describe the procedure for checking piston ring end gap. (Chart 57)
70. Why should used piston rings *not* be reused in an overhauled engine? (Chart 57)
71. Identify by name the different rings used on the piston and the function of each. (Chart 57)
72. What precautions should be observed when installing piston rings on the piston? (Chart 57)
73. List the steps of procedure for checking and adjusting valve operating clearance. (Chart 60)
74. Explain how plastiguage is used to check bearing clearance. (Chart 58)
75. What could cause excessive clearance between the connecting rod and the crankshaft? (Chart 58)
76. How can the crankcase cover be installed without damaging the crankshaft seal? (Chart 59)

Section V

**TWO-STROKE
CYCLE ENGINE
SERVICE AND OVERHAUL**

Chart 62

BASIC COMPONENTS

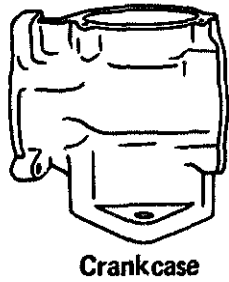
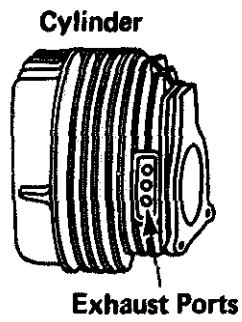
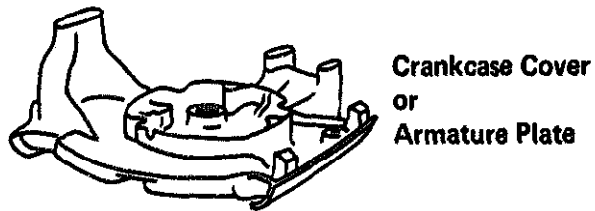
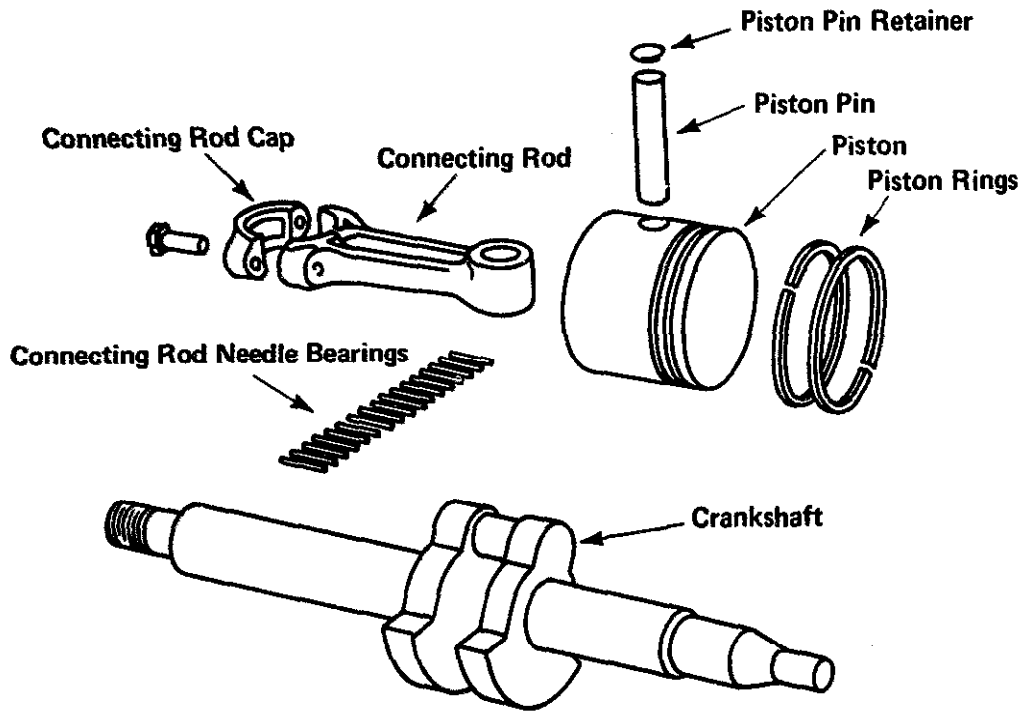


Chart 62

BASIC COMPONENTS

The two-stroke cycle engine delivers one power impulse each time the crankshaft completes one revolution. Intake and exhaust gases move in and out of the cylinder through ports (holes) in the sides of the lower part of the cylinder. This arrangement takes the place of the valve train found on four-stroke cycle engines.

Oil is mixed with the fuel for the two-stroke cycle engine. Therefore, there is no need for a volume of oil in the crankcase. The oil suspended in the fuel vapor sticks to the surfaces of all the moving parts. This keeps all the parts coated with a film of oil, regardless of how much the engine is tilted.

Reed valves (thin strips of metal) are located in the side of the crankcase. The reed valves permit the intake gases to enter the crankcase. The gases are transferred to the cylinder through the intake port in the lower part of the cylinder.

There is no exhaust valve used with the typical two-stroke cycle engine. The exhaust gases leave the cylinder through the exhaust port when the piston nears the end of the downward stroke.

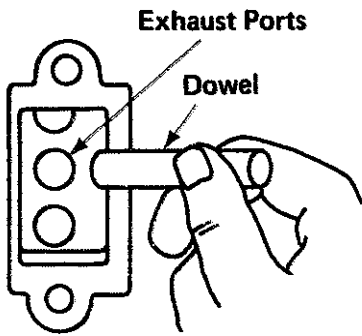
The exhaust port tends to build up with carbon as a result of burning some of the oil in the fuel mixture. The port must be kept clean and free of this carbon.

The engine has main bearings and rod bearings which are similar to the four-stroke cycle engine. On some two-stroke engines anti-friction (roller) bearings are used. When servicing an engine with anti-friction bearings, it is important that the rollers (needles) are not lost. Extreme care must be taken when disassembling the engine to make certain that all the bearing rollers are kept together.

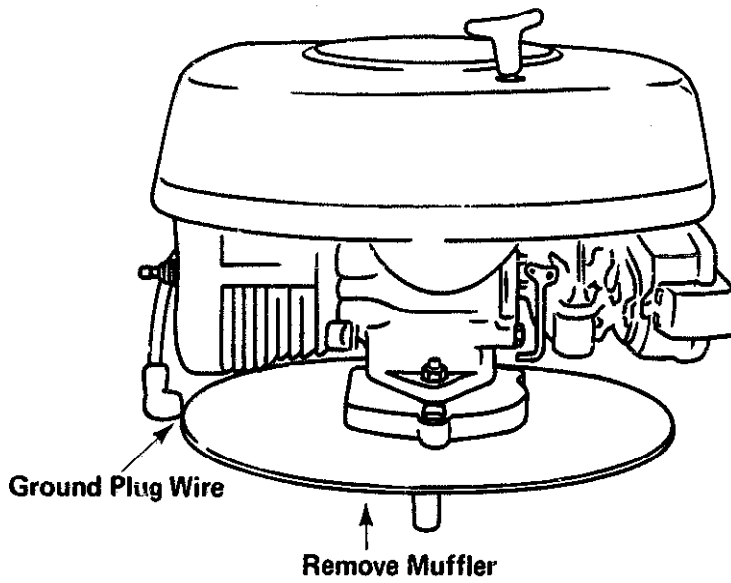
The crankcase gaskets and crankshaft seals on the two-stroke cycle engine must be in good condition. Leakage past the seals or gaskets can prevent the engine from running properly. If the crankcase is not sealed completely, the intake gases will be diluted by the air leaked to the crankcase.

Chart 63

MINOR ENGINE SERVICE



CLEANING CARBON FROM THE EXHAUST PORTS



CHECKING FOR AIR LEAKS
AT CRANKCASE GASKET

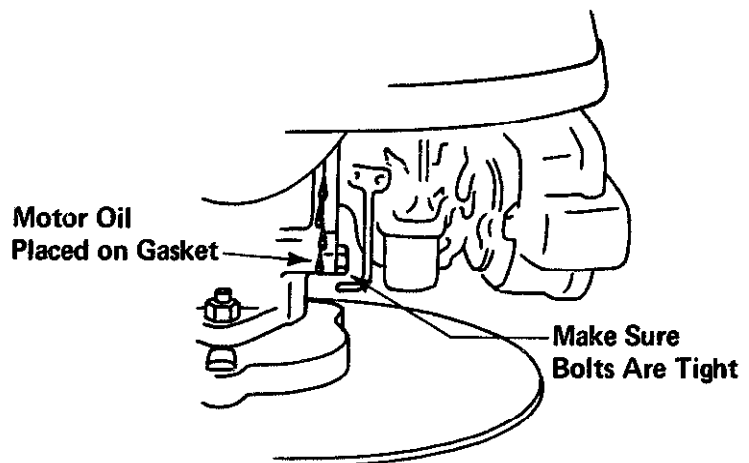


Chart 63

MINOR ENGINE SERVICE

Two-stroke cycle engines require some basic services quite different from the four-stroke cycle engine. There is a tendency for carbon to build up around the ports of this engine because of the oil in the air-fuel mixture. If the carbon buildup is excessive, the engine will lose power.

EXHAUST PORT CLEANING

1. Remove the shields and other components necessary to loosen the muffler or exhaust passage bolts.
2. Remove the muffler (or exhaust system).
3. Remove the spark plug and rotate the crankshaft until the piston blocks the exhaust port. **Check Point** _____
4. Use a wooden dowel rod to scrape carbon from the ports. Be very careful that the cylinder walls and piston are not damaged.
5. **WITH THE SPARK PLUG WIRE DISCONNECTED** and connected to ground, crank the engine over to blow any carbon particles from the piston head and port area.
6. Clean the muffler and cover plate. **Check Point** _____
7. Scrape the threads of the muffler bolts with a lead pencil. This will prevent the threads from seizing in the block casting.
8. Reassemble the muffler and shields.
9. Check the spark plug gap and replace the spark plug and spark plug wire.

CRANKCASE AIR LEAKS

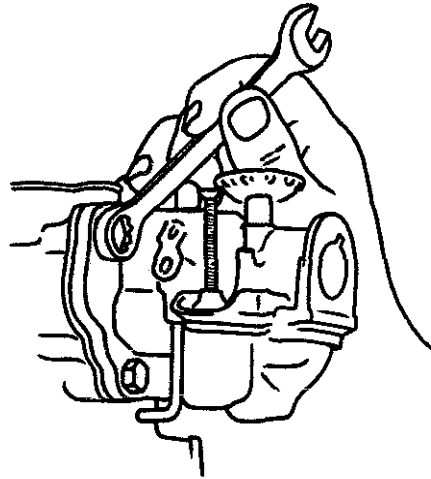
The two-cycle engine depends on a sealed crankcase for efficient intake of gases into the crankcase and movement of the air-fuel mixture to the cylinder. Any defect that permits air to enter the crankcase on intake will also permit loss of the compressed air-fuel mixture in the crankcase at the time it is moved to the cylinder.

CHECKING FOR CRANKCASE AIR LEAKS

1. Check for loose screws and bolts which would allow crankcase leaks.
2. Tighten any loose components.
3. Apply a film of motor oil on the gasket sealing area of any portions that were loose.
4. Crank the engine and observe whether or not the oil is drawn into the crankcase through a defect in the gasket. Start the engine and continue to check suspicious areas for leaks. If any leakage is observed, the gasket should be replaced. **Check Point** _____

Chart 64

REED VALVE INSPECTION AND SERVICE

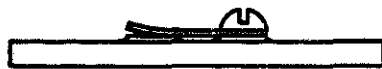


**REMOVING CARBURETOR
AND REED VALVE ASSEMBLY**

**INSTALL REED WITH
SMOOTH EDGE TOWARD
REED PLATE**



Warped or Bent Reed

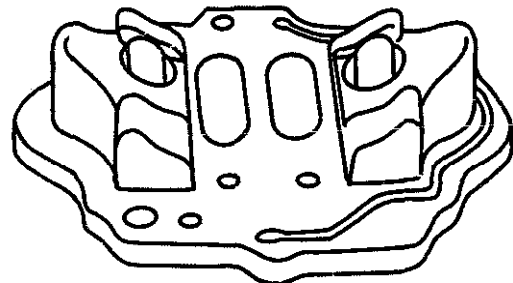


Bent Convex



Bent Concave

Reed Plate



**CAREFULLY INSPECT
REED VALVES FOR
THE PROBLEMS
SHOWN ABOVE**

**CHECK REED CLEARANCE
WITH A FEELER GAUGE
(REFER TO MANUFACTURER'S
SPECIFICATIONS)**

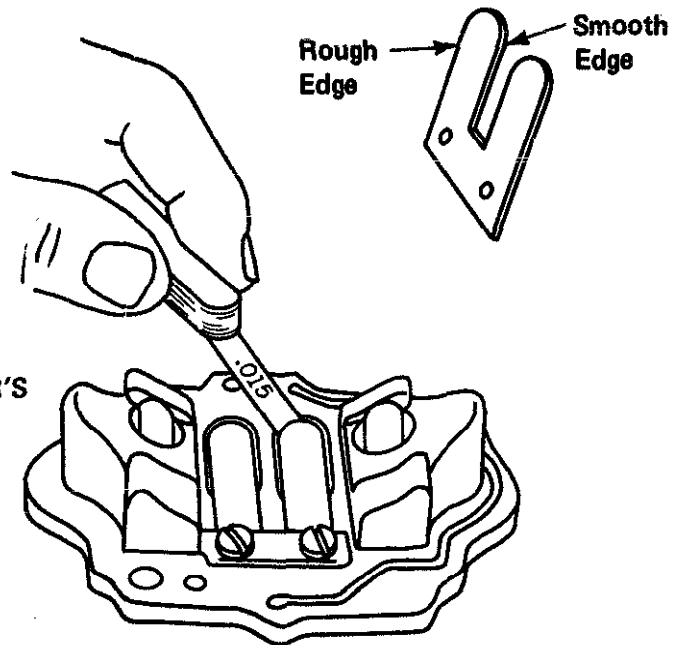


Chart 64

REED VALVE INSPECTION AND SERVICE

The reed valve(s) employed in the air-fuel intake system must function properly or else the two-stroke cycle engine will not run. A speck of dirt or a piece of grass in the reed valve will cause improper pressure buildup in the crankcase of the engine.

SERVICE PROCEDURE

1. Remove the carburetor assembly from the engine.
2. Carefully remove the reed valve assembly.
3. Inspect the unit for foreign material between the reed and its seat. Also inspect the reeds for warpage or other damage.
4. Remove the reed and rinse the valve components in clean solvent. **AVOID USING COMPRESSED AIR** because the blast of air can distort or bend the reeds. If the reeds are damaged or badly worn, replace them with new reeds.
5. Carefully reassemble the reed valve assembly. Check the clearance between the reed valve with a feeler gauge. Compare the clearance to specifications. If the clearance is improper, check to see that the unit is assembled properly.

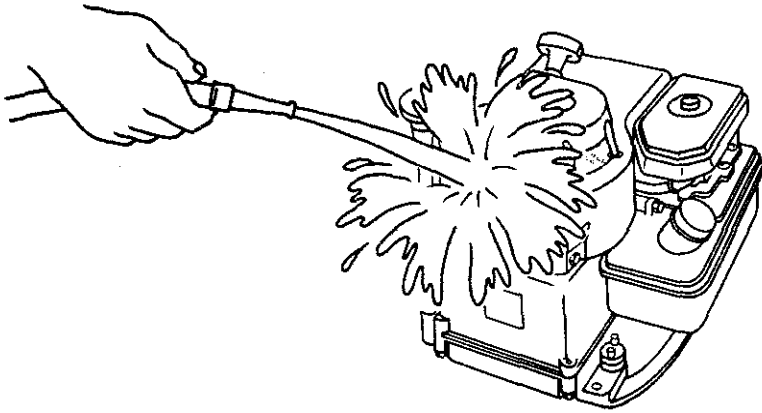
Note: Used reeds may appear to be good but not give the proper clearance. In such cases the reed should be replaced.

Check Point _____

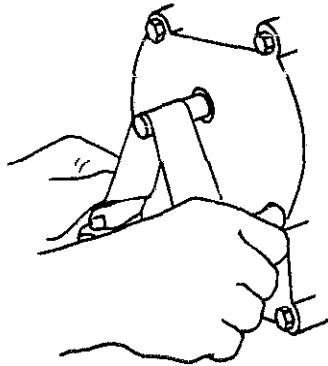
6. Using new gaskets, replace the reed valve assembly and carburetor on the engine.

Chart 65

**ENGINE OVERHAUL
(TWO-STROKE CYCLE ENGINE)**



CLEAN THE ENGINE BEFORE STARTING DISASSEMBLY



**POLISH DRIVE END OF
THE CRANKSHAFT TO
REMOVE RUST**

**REMOVING ARMATURE PLATE
FROM THE CRANKCASE**

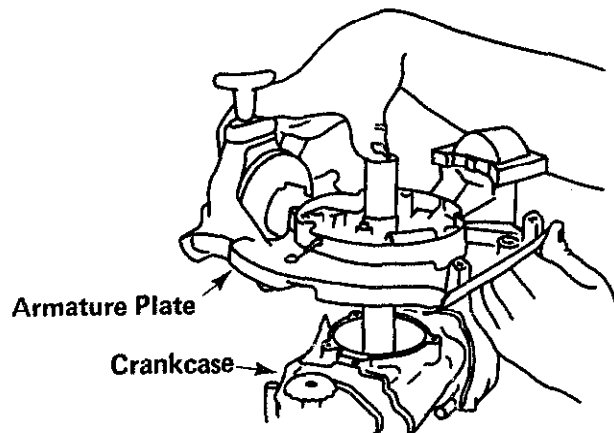


Chart 65

ENGINE OVERHAUL (TWO-STROKE CYCLE ENGINE)

The engine should be disassembled completely for overhaul *only* if there is good reason. Thorough testing can determine whether or not an overhaul is necessary.

REASONS FOR OVERHAUL

1. Poor compression because of internal wear (compression testing is explained in the Compression Testing section of this text).
2. Excessive noise or knocks coming from inside the engine.
3. Crankshaft will not turn because of internal problem.

OVERHAUL PROCEDURE

1. Remove or disconnect the control cables and linkage. Disconnect the spark plug wire and attach it to the engine ground.

2. Disconnect the power drive belt, blade, or other power mechanisms. On shaft-driven, self-propelled units, mark the gears so that they can be re-assembled in the same relative position. **Check Point** _____

3. Remove the engine from the lawnmower, generator, or equipment.

4. Clean the outside of the engine. Hot, soapy water can be used to scrub the engine. Rinse with water.

On engines which are very dirty and greasy, apply engine cleaning solvent and rinse with water. **DO NOT USE GASOLINE TO CLEAN THE ENGINE.**

5. Dry the engine with cloths or compressed air.

6. Remove the shroud and the fuel tank. Note the types of screws used to mount these components. They should be replaced in the same positions.

7. Clean all rust and dirt from the drive end of the crankshaft as shown in the illustration. Any rust or roughness on the shaft will damage the drive-end main bearing when the crankshaft is removed from the crankcase.

Check Point _____

8. Check for a bent crankshaft. (See the Crankshaft area of the Four-Stroke Cycle Engine section for methods of checking the crankshaft.)

9. Remove the flywheel. On some models a filter screen must be removed to gain access to the flywheel nut. (See the Ignition section for the details on flywheel removal.)

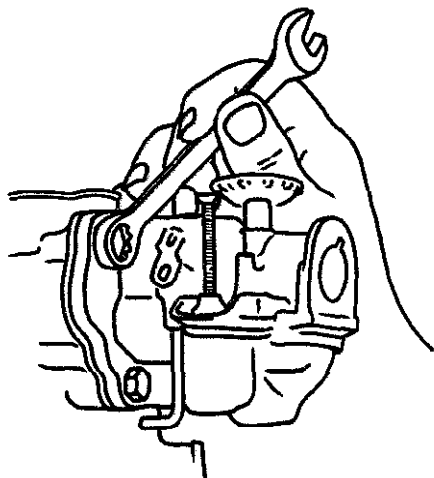
10. Remove the governor assembly and the armature plate. The armature plate contains a main bearing. On some engines the bearing is a loose-needle type. Be careful that none of the needles is lost.

11. Remove the carburetor and the reed plate.

12. Loosen the connecting rod bolts or nuts but **DO NOT** remove them from the rod.

Chart 65 (continued)

ENGINE OVERHAUL (TWO-STROKE CYCLE ENGINE)



REMOVING CARBURETOR
AND REED VALVE ASSEMBLY

LOOSENING CONNECTING
ROD BOLTS

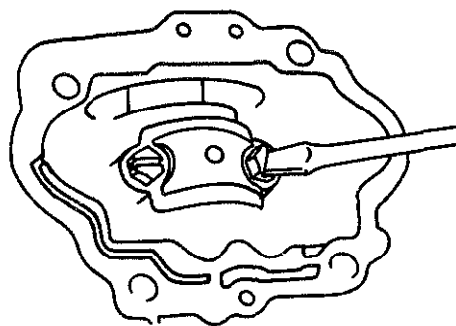


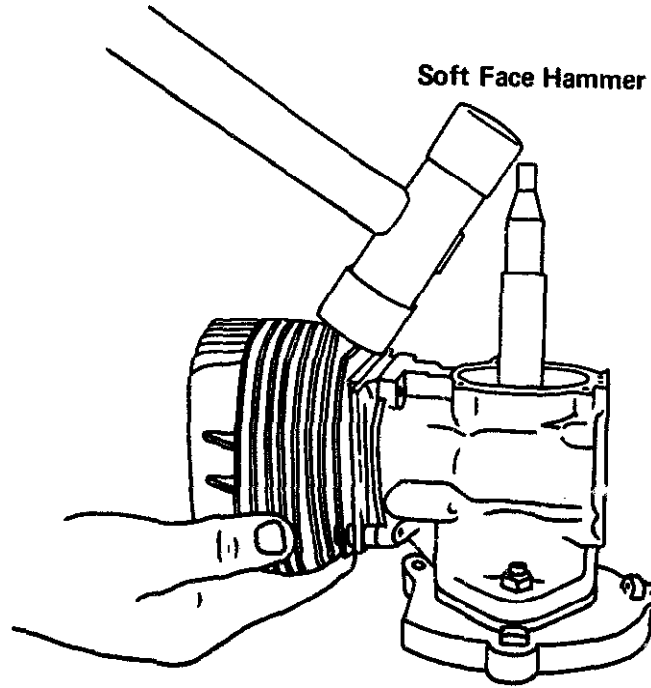
Chart 65 (continued)

ENGINE OVERHAUL (TWO-STROKE CYCLE ENGINE)

NOTES: _____

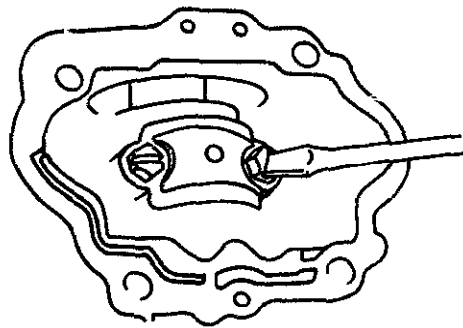
Chart 66

CYLINDER, PISTON, AND CRANKSHAFT REMOVAL



REMOVING CYLINDER (JUG) FROM THE CRANKCASE

REMOVING THE CRANKSHAFT



REMOVING CONNECTING ROD CAP

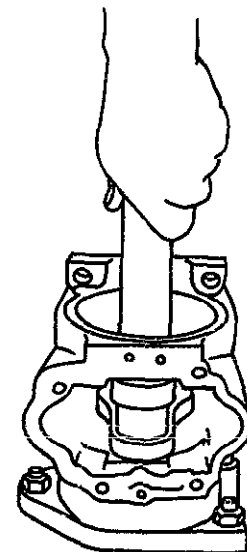


Chart 66

CYLINDER, PISTON, AND CRANKSHAFT REMOVAL

13. Remove the bolts or screws which attach the cylinder (jug) or the cylinder head. *Note:* There is no provision for removing the cylinder head or cylinder on some two-cycle engines. On these engines the piston is removed through the bottom of the cylinder.

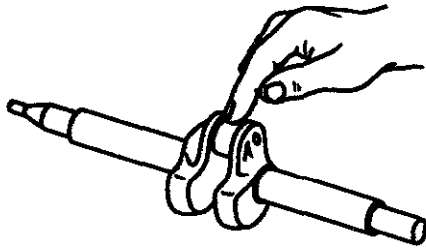
14. Tap the cylinder with a soft hammer to break it loose from the crankcase.

15. Remove the cylinder by pulling it away from the piston quickly. Note the match marks on the connecting rod and the connecting rod cap. Remove the connecting rod bolts or nuts and remove the piston assembly from the engine. Be careful to retain all the loose-needle bearings of the connecting rod bearing. *Note:* On some two-cycle engines the rod *cannot* be removed from the crankshaft. On such engines check carefully for roughness by revolving the connecting rod on the crankshaft. If there is roughness or if the side play is excessive, the crankshaft-rod assembly should be replaced.

16. Remove the crankshaft from the crankcase.

Chart 67

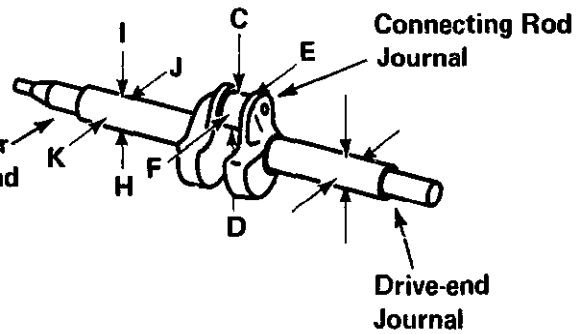
CHECKING WEAR OF ENGINE COMPONENTS



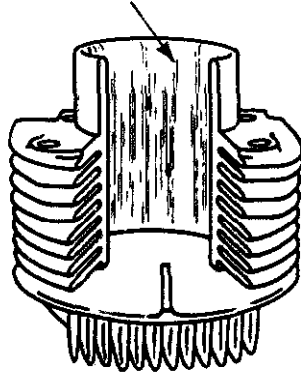
FEEL FOR WAVINESS ON THE BEARING JOURNAL ON ENGINES WHICH HAVE ROLLER BEARINGS

POINTS OF MEASUREMENT FOR CHECKING JOURNAL OUT-OF-ROUND

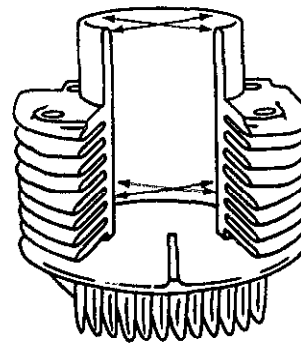
Flywheel or Magneto-end Journal



Scored Cylinder



EXAMINE THE CYLINDER FOR SCORING



MEASUREMENT POINTS FOR CHECKING CYLINDER WEAR

Check Point _____

NOTES: _____

Chart 67

CHECKING WEAR OF ENGINE COMPONENTS

17. Wipe crankshaft bearing journals with a clean cloth. Carefully inspect the journals which employ needle-type bearings. Wear can be noted by feeling the journal. Slight roughness or waviness indicates wear and the crankshaft should be replaced.

Check Point

When the crankshaft journal is a plain bearing, it should be measured with a micrometer. Refer to the Crankshaft Measurement section in Four-Stroke Cycle Overhaul for information on measuring crankshaft journals. Compare the measurements to the manufacturer's specifications. If they exceed the maximum acceptable wear, the crankshaft should be replaced. If the manufacturer's data are not available, .001 can be considered the maximum out-of-round which is acceptable. Record the crankshaft out-of-round and taper in the Data Block.

18. Inspect the cylinder for wear and scoring. Some two-cycle engines utilize a chrome-plated cylinder. If the chrome has "worn through," the cylinder should be replaced. If the cylinder is scored, it should be replaced.

Check the cylinder for wear and taper by taking measurements with a telescoping gauge and micrometer. For additional information on cylinder measurements, refer to the Cylinder Measurement section in Four-Stroke Cycle Overhaul. Compare the measurements to determine out-of-round and taper. Check the manufacturer's specifications for the maximum allowable taper and wear. Record the information in the Data Block.

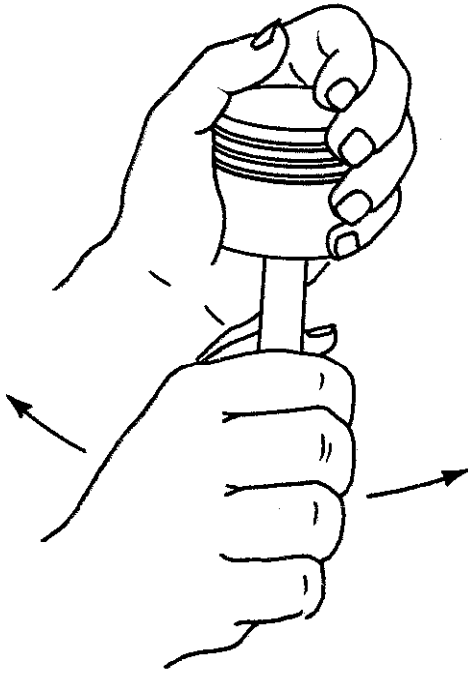
If the wear or taper exceeds the maximum, the cylinder should be bored or honed oversize. The cylinder resizing should be done by a machine shop equipped to perform this machining. Check the availability of an oversize piston and rings before reconditioning the cylinder. In some instances it may be more economical to replace the cylinder rather than have it reconditioned.

Data Block

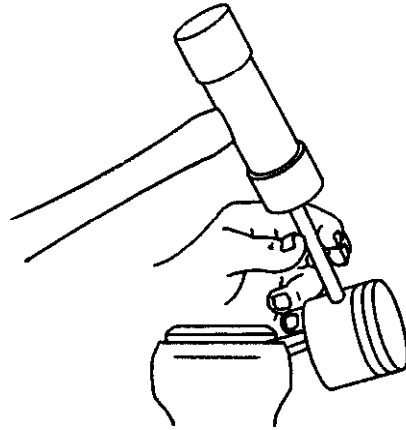
	<i>Actual</i>	<i>Specifications</i>
Drive-end main journal out-of-round	_____	_____
Magneto-end main journal out-of-round	_____	_____
Connecting rod journal out-of-round	_____	_____
Drive-end main journal taper	_____	_____
Magneto-end journal taper	_____	_____
Connecting rod taper	_____	_____
Cylinder wear	_____	_____
Cylinder out-of-round	_____	_____
Cylinder taper	_____	_____

Chart 68

**PISTON PIN AND
CONNECTING ROD CHECKS**

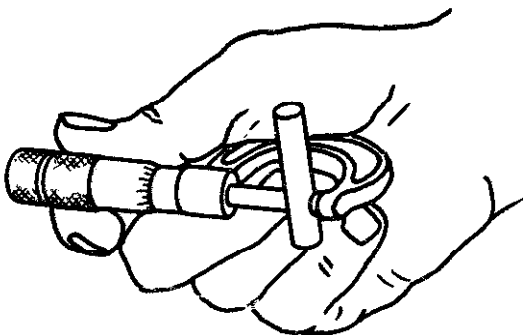
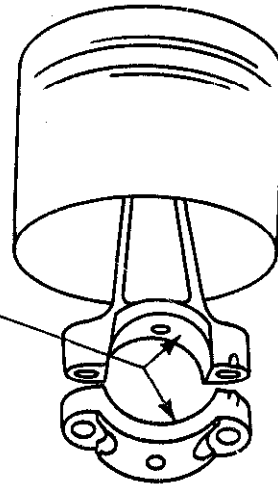


**CHECKING FOR
PISTON PIN WEAR**

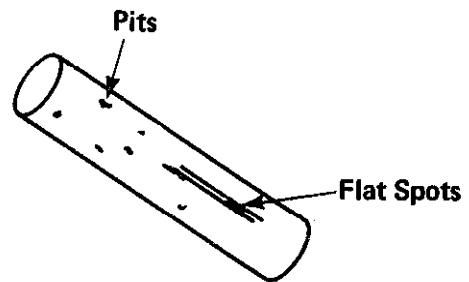


REMOVING PISTON PIN

**INSPECT BEARING SURFACES
FOR WEAR**



CHECKING PISTON PIN WEAR



**CAREFULLY EXAMINE
BEARING ROLLERS**

Chart 68

PISTON PIN AND CONNECTING ROD CHECKS

19. Piston pin wear can be checked by holding the piston firmly in one hand while attempting to “rock” the rod with the other hand. The rod must be “rocked” in line with the piston pin. It is normal for the rod to slide freely across the piston pin. Do not confuse this with piston pin wear.

If looseness is detected, the piston pin should be removed. Before removing the pin, note identifying marks or mark the piston and rod with a punch mark so that they can be reassembled properly. Remove the piston pin retainer with small nose pliers and remove the piston pin. Be careful that none of the rollers is lost on units which utilize a needle-type bearing.

Examine the piston pin and connecting rod pin bore for scoring or roughness. Any component that is scored should be replaced.

Measure the piston pin and the connecting rod bore with a micrometer.

On a model that utilizes a plain-type bearing at the pin, the clearance between the piston pin and the connecting rod pin bore should not exceed .002 on most engines.

Oversize pins are available from some manufacturers. When an oversize pin is being installed, the rod and piston must be reamed or honed to achieve the proper fit.

Check Point _____

20. Inspect the connecting rod bearing for scoring and wear. The bore can be measured with a telescoping gauge and micrometer to find its size. Compare the measurement to the manufacturer’s specification to determine wear. If over .0005 wear is present, the rod should be replaced.

On a model that utilizes a needle bearing in the rod, carefully examine the rod or the insert for roughness. If roughness is present, replace the component. Inspect the rod bearing needles for pits and flat spots. If either is present, the complete set of needles should be replaced.

Check Point _____

PISTON PIN AND CONNECTING ROD CHECKS

19. Piston pin wear can be checked by holding the piston firmly in one hand while attempting to "rock" the rod with the other hand. The rod must be "rocked" in line with the piston pin. It is normal for the rod to slide freely across the piston pin. Do not confuse this with piston pin wear.

If looseness is detected, the piston pin should be removed. Before removing the pin, note identifying marks or mark the piston and rod with a punch mark so that they can be reassembled properly. Remove the piston pin retainer with small nose pliers and remove the piston pin. Be careful that none of the rollers is lost on units which utilize a needle-type bearing.

Examine the piston pin and connecting rod pin bore for scoring or roughness. Any component that is scored should be replaced.

Measure the piston pin and the connecting rod bore with a micrometer.

On a model that utilizes a plain-type bearing at the pin, the clearance between the piston pin and the connecting rod pin bore should not exceed .002 on most engines.

Oversize pins are available from some manufacturers. When an oversize pin is being installed, the rod and piston must be reamed or honed to achieve the proper fit.

Check Point _____

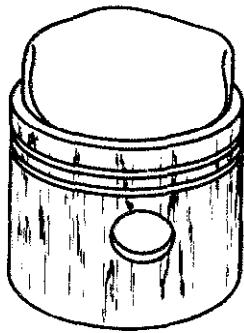
20. Inspect the connecting rod bearing for scoring and wear. The bore can be measured with a telescoping gauge and micrometer to find its size. Compare the measurement to the manufacturer's specification to determine wear. If over .0005 wear is present, the rod should be replaced.

On a model that utilizes a needle bearing in the rod, carefully examine the rod or the insert for roughness. If roughness is present, replace the component. Inspect the rod bearing needles for pits and flat spots. If either is present, the complete set of needles should be replaced.

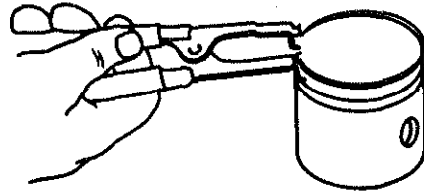
Check Point _____

Chart 69

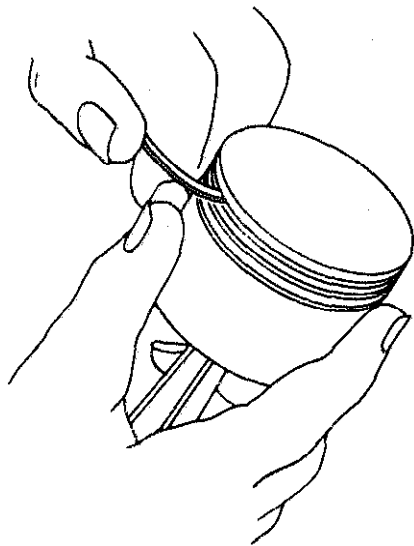
PISTON CHECKS



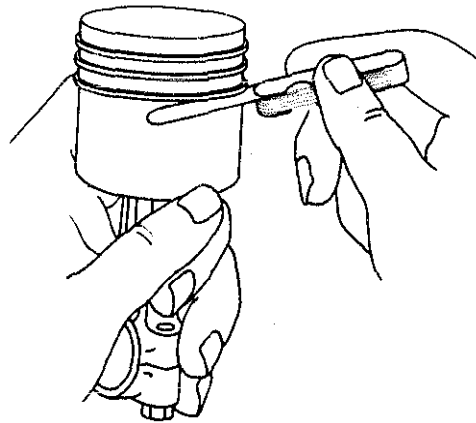
Scored Piston



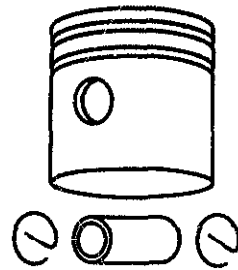
REMOVING PISTON RINGS WITH A PISTON RING EXPANDER



CLEANING CARBON FROM THE RING GROOVES WITH A BROKEN PISTON RING



CHECKING PISTON RING GROOVE WEAR



PREPARING TO INSTALL THE CONNECTING ROD ON THE PISTON



Chart 69

PISTON CHECKS

21. Carefully examine the piston for scoring and wear. If a two-cycle engine is operated on fuel with no oil added, the piston will score very quickly. If too much oil or a low-grade oil is added to the fuel, carbon will build up quickly in the exhaust port. This excessive carbon can cause scoring of the piston.

A badly scored piston should be replaced. To verify the wear of a piston, measure it with a micrometer and compare the measurements to the manufacturer's specifications.

22. If the piston is not scored or worn, it can be reused. Remove the piston rings with a piston ring expander. The piston ring grooves must be cleaned thoroughly. Many manufacturers use "pins" or wires to prevent the piston rings from turning on the piston. Either remove the pins or wires or use extreme caution when cleaning the ring grooves. Clean all carbon from the grooves with a piston ring groove cleaner or a broken piston ring. If a broken ring is used, grind the end of the ring square so that the carbon in the base of the groove can be removed.

23. Check the ring groove wear by placing a new ring in the groove and measuring the side clearance with a feeler gauge. The side clearance measurement should be checked against the manufacturer's specifications. If the manufacturer's data are not available, .006 is considered maximum side clearance on many engines. If the ring side clearance is excessive, the piston should be replaced.

Check Point _____

24. Install the piston on the connecting rod. (Match the punch or identifying marks on the rod and the piston.) Be certain that the rod and piston are assembled so that when installed in the engine the long slope of the piston is on the exhaust port side of the cylinder. When installing the piston pin retainers, make certain that the retainer ring opening is toward the top of the piston.

Chart 70

PISTON RING CHECKS AND INSTALLATION

Cleanliness is most important when reassembling an engine. Make certain that the work area, tools, component parts, and your hands are clean before beginning the reassembly of the engine.

25. Clean all engine parts in solvent. Blow the excess solvent from the parts with compressed air and lay each part on a clean work surface.

26. Check the ring end gap of the new piston rings in the cylinder. **ALWAYS INSTALL NEW PISTON RINGS.** Position the ring squarely in the cylinder and measure the gap between the ring ends with a feeler gauge. Check the manufacturer's data for acceptable end gap. If these data are not available, .005 is considered the minimum gap. If the gap is less than the minimum or .005, check to be certain that the rings are the proper ones for the engine. On some models the end gap can be filed with a file to achieve proper clearance. Generally the gap should not exceed .020.

27. Carefully install the rings on the piston. Use a piston ring expander for this operation. If no ring expander is available, carefully place the rings on the piston. Install the lower piston ring first. If the piston has pin or wire retainers, be careful to position the ring properly over the retainer. The pin retainers or wire prevent the ring from rotating to a position where the end of the ring would catch in the cylinder port.

Check Point

Chart 71

SEAL REPLACEMENT AND CRANKSHAFT INSTALLATION

28. Remove the old seals from the crankcase and/or crankcase covers with a large screwdriver.

29. Install new crankshaft seals with a seal installation tool or a block of wood. Be certain that the lip of the seal is toward the inside of the engine. *Note:* On some engines which employ needle-type main bearings, the seal is installed after the bearings are in place in the crankcase and armature plate.

30. Wipe the main bearing of the block and lubricate it with SAE 20, SE oil. Wipe the crankshaft clean, oil with clean motor oil, and install it in the crankcase. **BE CAREFUL** that the oil seal is not damaged as the shaft is installed. On models with loose-needle bearings, coat the needles with Vaseline or other low-melting temperature grease to keep the rollers in place while the crankshaft is being installed.

31. Position the piston assembly in place. Be certain that the piston is positioned identical to its position before disassembly. If a rod "liner" is used, position the liner in the connecting rod. Place one-half of the loose needles in the connecting rod. Keep the needles in place with grease and pull the rod into place on the crankshaft. Position the remaining needle bearings in the cap or on the crankshaft and install the connecting rod cap.

Make certain that the match marks on the rod and rod cap are aligned. Carefully tighten the rod bolts until they are *snug*. **DO NOT TIGHTEN THE CONNECTING ROD BOLTS AT THIS TIME.**

Note: On engines with a plain-type rod bearing, disregard the above needle bearing instructions.

Check Point _____

Chart 72

CYLINDER AND CRANKCASE REASSEMBLY

32. Place the cylinder-crankcase gasket on the crankcase. *Be certain that the port holes are properly aligned.*

33. Apply a liberal coat of oil to the piston and piston rings. Position the rings properly over the retainers on pistons so designed. On engines without pins, stagger the rings so that the end gaps are not in line with each other and are not in alignment with the cylinder ports. Install a ring compressor over the rings. Wipe the cylinder clean, apply a liberal coating of oil, and slide the cylinder (jug) over the piston.

34. Tighten the connecting rod bolts to the proper torque specifications with a torque wrench. Bend the lock tabs around the rod bolts or nuts. Rotate the crankshaft to be certain that there is no binding.

35. Install the armature plate or crankcase cover with a new gasket between the cover and the crankcase. Apply grease to the needle bearings to hold them in place if this type bearing is employed. *Be careful* that the new crankshaft seal is not damaged when sliding the cover into place. A film of wax paper can be wrapped around the crankshaft to prevent the seal from catching on the main bearing shoulder. Tighten the cover retaining bolts.

36. Install the reed valve reassembly and carburetor. Use new gaskets. Be certain that the reeds are toward the engine! Tighten the reed valve and carburetor retaining nuts or bolts.

37. Install the ignition system components and flywheel. See the Ignition Service section for details on the ignition system.

Chart 73

FINAL STEPS OF REASSEMBLY

38. Replace the flywheel shrouds. Reconnect the carburetor linkages and the fuel lines.

39. Reassemble the engine on the lawnmower or powered unit and reconnect all the control cables and mechanisms.

40. Fill the fuel tank with the proper mixture of fuel and oil.

41. Perform the basic carburetor adjustments as outlined in the Carburetor Service section.

42. Start the engine and make final carburetor adjustments.

Check Point _____

43. Operate the engine under normal conditions and readjust the carburetor as is needed.

27. Why are pins or wires used to locate the piston rings on the piston on a two-stroke cycle engine? (Chart 70)
28. List some reasons for a scratched or scored piston. (Chart 69)
29. The maximum side clearance of a piston ring is (Chart 69)
30. What tool is used to install piston rings on the piston? (Chart 70)
31. Why should new seals be installed in the crankcase when the engine is overhauled? (Chart 71)
32. Explain how the reed valve assembly should be installed on the engine. (Chart 73)
33. How can loose needle bearings be held in place when assembling the engine? (Chart 71)

Section VI

**BATTERY AND STARTER
TESTING**

THE STORAGE BATTERY

The storage battery is designed to chemically accept an electrical charge and hold it until needed. Batteries have a number of characteristics and weaknesses that are usually overlooked until it is too late. This is especially true on garden equipment in which the entire charging and starting circuits are controlled by accessories. The location of the battery is not a primary design consideration and is usually not located to the batteries best advantage.

Electrical power is stored chemically in the battery. The electrolyte of the battery must be maintained. Do not add chemicals to the electrolyte as they will only destroy the chemical balance.

Do not add refill it with clean water or acid. As the battery discharges, the chemical composition of the electrolyte solution changes. The specific gravity of the electrolyte is determined by the state of charge of the battery. Adding electrolyte with new would upset the battery's

balance and cause electrolyte loss. The loss is water. This causes the battery to operate with a low

specific gravity. Only a limited area below the plates below the plates becomes ruined.

Some explosive gas is being released from the equipment engine.

Chart 75

BATTERY TESTS

Several tests may be performed to determine the condition of the battery. Any one test will not ensure a complete analysis. Making an assumption about a cause of a problem based on only one test would be like a doctor's performing brain surgery on you because you have a headache when perhaps an aspirin would cure it. Make as many tests as possible to determine the battery condition.

SELF-DISCHARGE

A common problem is dirt and moisture buildup on top of the battery which creates a path for current flow or discharge across the top of the battery. Check for this by connecting the negative voltmeter lead to the battery by touching the positive voltmeter probe several places on the insulated portion of the battery top. Any voltage found here is a result of leakage of current. Clean the battery top. Use a baking soda solution to help remove corrosion and acid deposits. Do not allow the baking soda solution to enter the battery. Always wear safety glasses and wash your hands frequently when you work with a battery. Wash off any liquid that splashes on your face or arms.

SPECIFIC GRAVITY TEST

As the battery is charged and discharged, both chemical solution and its specific gravity (weight) are changed. The charge of each cell can be measured with a battery hydrometer. Hydrometers are calibrated to read correctly at 80° or room temperature. If the test must be made at any other temperature, a hydrometer with a temperature correction scale must be used to get an accurate reading.

Draw enough water into the hydrometer to allow the bulb to float freely and to record the reading accurately. Perform this test on each cell of the battery and compare the readings. A fully charged battery should read near 1.280. These readings indicate only the state of charge the battery currently has placed on it. A perfectly good battery will read low if the charging system is not keeping it charged or if considerable cranking or accessory load has just been placed on it.

One really important indication is that whatever the state of charge of the battery, all cells should read the same. The cells are connected in series and the charge and discharge of each cell are equal. Any variation between the readings obtained from the cells indicates bad cells and a weakened battery. If this battery is continued in use, it will place extra load on the charging circuit and will have reduced cranking power.

Chart 76

BATTERY CAPACITY TESTS

The battery must be able to maintain voltage during the cranking operation. Just taking a voltage reading from a battery not in use does not tell much. A nearly dead battery can show full voltage (12.6 volts D.C.) when no load is connected. The true test of capacity is the ability to maintain voltage while under load.

A simple battery test can be made by connecting a voltmeter across the battery while the battery is still on the equipment. The no-load reading should be 12.6 volts. Observe the voltmeter and crank the engine. Crank until the voltmeter drops to a steady hold position. *Caution:* Do not crank longer than 15 seconds! The voltmeter reading should be above 9.5 volts. If the engine cranked at a good normal speed and if the voltage remained above 9.5 volts, the battery is satisfactory. Failure to pass this test could be caused by excessive starter draw. Check the battery by using the carbon pile method.

CARBON PILE TEST

A carbon pile is a variable load device. Connect the carbon pile in series with an ammeter. The ammeter will indicate the amount of load being placed on the battery by the carbon pile. Connect a voltmeter across the battery to measure the battery voltage. Adjust the carbon pile to three times the ampere-hour rating of the battery for 15 seconds and observe the voltmeter reading. Do not leave the load on the battery for more than 15 seconds because the battery will be quickly discharged. If the battery reading does not drop below 9.5 volts, the battery will provide dependable performance. If the battery drops below 9.0 volts, it is either defective or is not fully charged. Retest with a hydrometer, and recharge the battery if necessary. If a fully charged battery does not pass the test, it is defective and must be replaced.

EQUIPMENT

The ammeter and carbon pile used for this test must be able to handle three times the ampere-hour rating of the battery being tested. Battery/Starter testers with a D.C. voltmeter, suitable ammeter, and carbon pile are available.

Chart 77

TEST RESULTS

TEST	INDICATION	SOLUTION
<i>Visual</i>	Loose hold-down clamp.	Tighten clamp or replace with new one if necessary.
	Corrosion on battery posts and clamps.	Clean with baking soda solution.
	Top of battery wet.	Possible overcharge. Check charging circuit.
	Frayed cables.	Repair or replace.
	Cracked case.	Repair or replace battery.
	Electrolyte level low.	Refill with clean water. Could be caused by overcharging. Check charging voltage.
<i>Self-discharge</i>	Readings found across top of battery.	Clean battery with baking soda solution.
<i>Hydrometer</i>	All cells show 1.280 specific gravity.	Fully charge battery.
	All cells show 1.280 except one.	Bad cell-battery. Will fail soon.
	All cells read low but equal.	Battery probably OK. Needs charging.
<i>Cranking capacity test</i>	Voltage remained above 9.5 volts during cranking—engine cranked normally.	Battery OK.
	Voltage dropped below 9.0 volts.	Battery defective or not fully charged. Check battery charge with hydrometer. Recharge and retest.
	Battery recharged, but voltage still drops below 9.0 volts during cranking.	Battery defective or starter circuit problem. Check battery with carbon pile.
	Battery stays above 9.5 volts, but starter slow or not working at all.	Check starter circuit. See page 194.
<i>Carbon pile test</i>	Battery voltage remains above 9.5 volts while ammeter reads three times battery ampere-hour rating.	Battery OK.
	Battery voltage drops below 9.0 volts.	Battery defective if fully charged. Check with hydrometer and retest.

Chart 78

REWIND STARTERS

A number of rewind starter types are used on small gas engines. Regardless of the type, they are subject to the same wear and abuse. Basically, they consist of a pull rope, recoil spring, and an engaging mechanism. The variations occur in the engaging mechanism. These mechanisms should be basically understood so that wear and mechanical failures can be determined. Since repair usually consists of just replacing the worn parts, detailed repair instructions are not necessary.

DOG TYPE

The dog type engaging mechanism consists of a notched starter cup mounted solidly to the flywheel which turns with the flywheel at all times. Inside the starter cup is the starter dog which is turned by the starter rope. A brake spring mounted under the starter dog housing causes a slight drag on the dog assembly so that when the starter rope is pulled, the dogs extend, engaging the notched starter cup. The slight drag caused by the brake spring also causes the dogs to retract out of the way of the spinning starter cup when the spring rewinds the starter.

FRICTION SHOE TYPE

The friction shoe type utilizes cam action to engage the friction shoe against a smooth starter cup. As with the dog type, a brake spring creates a slight drag on the shoe unit holding the shoes from turning until the cam under the shoes moves, pushing the shoes out against the starter cup engaging the starter rope with the flywheel.

BALL TYPE

When the engine is stopped, the balls roll down the inclined ramp to the center pawl. When the rope is pulled, the center pawl catches one of the balls and locks it against the starter cup engaging the pawl with the starter cup. As soon as the engine starts, centrifugal force carries the balls out into the recesses and they continue to turn with the engine. The pawl remains stopped with the rewind rope. This type screws onto the crankshaft and requires a special tool (see Flywheel Removal) to remove. The ears cast on the starter cup are easily broken off if a hammer is used to loosen the starter assembly. The entire assembly slides on over the extended crankshaft and is removed as an assembly. On older models the unit is held together by a large snap ring which is easily pried out. Newer units are sealed. The sealed cover may be removed by using a small chisel to pry off the retainer cover. Do not use a screwdriver because it will be necessary to strike it with a hammer to remove the cover and most screwdrivers were not intended to be struck with a hammer and they may explode.

When replacing the ball type starter unit, be sure that it slips freely over the extended crankshaft end because the crankshaft must turn inside the starter pawl. Failure of the shaft to turn freely inside the pawl will cause the starter to "catch" occasionally making a loud scratching sound. Polish the shaft as needed to remove burrs and rust so that the assembly slides freely on the shaft.

REWIND STARTERS CONTINUED

IMPULSE WINDUP TYPE

The windup starter uses one of the clutches described previously, but it allows the spring to be wound up tight while the flywheel is held locked in place by a locking pawl. A fold-up handle ratchets around the crankshaft gear while the spring is being wound up. Once the spring is securely wound, the lock is released allowing the spring to crank the engine. On older types the lock pawl tended to wear a groove in the aluminum flywheel resulting in partial "releases" of the flywheel while trying to wind the spring. Remounting the lock mechanism so that it engages the flywheel at a different point is sometimes possible or the flywheel may be replaced. The entire starter assembly and blower housing can easily and inexpensively be replaced with the conventional recoil starter. See the manufacturer's literature for spring rewinding instructions for their model starter.

VERTICAL PULL STARTER

The vertical pull starter utilizes a starter gear that engages a gear ring on the flywheel. The small starter gear is fitted on a threaded shaft. The first partial pull of the starter rope causes the starter gear to move down the threaded shaft to engage the flywheel ring gear. As the recoil spring rewinds the rope, the gear moves back down the threaded shaft disengaging it from the flywheel. When the engine starts, the flywheel spins the small starter gear in the direction that quickly disengages it from the flywheel.

STARTER CLUTCH SERVICE

Starter clutch problems usually are the result of worn parts or are caused by rust or dirt freezing up the parts. It is not usually a good idea to put grease or oil on the starter clutch parts because it may prevent good engagement and will collect gum and dirt. If the parts are clean, free of rust, and properly aligned, the clutch should engage firmly. Always inspect for wear and replace all badly worn parts. For example, replacing the notched starter cup without replacing worn, rounded starter dogs would soon cause the cup notches to wear out again. Replacement parts are usually inexpensive and ensure good operation. If several parts are badly worn, consider replacing the entire starter unit.

Chart 80

ELECTRIC STARTER – BENDIX DRIVE

The electric starter is similar to the D.C. generator in that it has a field wound on field pole shoes and a turning armature that is connected to the circuit through the commutator and brushes. Generally, the armature winding is much heavier wire to allow greater current flow and thus develop the great torque needed to turn the engine. Small gas engines do not pose the same problems as does the high-compression automotive engine. In addition to being much smaller, most small gas engines incorporate some type of compression release technique to provide for easy pull rope starting. Speed reduction and torque increase are achieved by the very small starter pinion gear meshed with the large flywheel ring gear. Reductions of up to 20-1 are achieved.

The starter is most commonly engaged to the flywheel by a Bendix type drive that utilizes a spring loaded pinion gear fitted to a threaded shaft. The sudden start of the starter motor causes the pinion gear to thread itself out on the shaft until it hits the stop washer. Then the pinion gear must turn with the starter-motor. As the pinion gear moves out on the shaft, it becomes meshed with the flywheel ring teeth. Now the starter motor is driving the flywheel through the pinion gear. When the engine starts, the spinning flywheel ring gear will "spin" the pinion gear back down the threaded shaft out of the way of the flywheel ring gear.

The starter is mounted securely to the engine by mounting flanges on either the side or end of the starter. Since the engine block may be made of cast aluminum and the size of the starter motor may be small, the mounting bolts may be a problem. If a large wrench is used, the bolts may easily be overtightened and the threads stripped. Also, because of the vibration encountered, the bolts may become loose. If the bolts become loose, the starter will not make a good electrical connection to the engine ground or may allow the pinion gear to move away from the flywheel ring gear causing improper meshing of the gear teeth.

Bendix drives may fail because of dirt, wear, or improper mounting. Dirty and worn Bendix drive units usually allow the starter motor to spin free without engaging the flywheel. The Bendix drive is easily replaced.

If the starter is not mounted firmly or not correctly aligned, the pinion gear may bind when meshing with the flywheel ring gear causing starter drag. This will cause slow starter operation or will cause the starter to be locked completely.

Chart 81

ELECTRIC STARTER TESTS

Starter circuits can be quickly checked with a D.C. voltmeter for the voltmeter can be connected without disconnecting any circuit components.

First, test the battery voltage. Connect the voltmeter as shown in Test 1. Observe the battery voltage. It should be either 6.3 volts or 12.6 volts. Record the reading below. Push the starter switch and observe the battery voltage. Record the reading.

TEST 1 Battery voltage with no load. _____
Battery voltage with starter
switch being held. _____

If the battery voltage remains the same or falls very little and the starter fails to crank the engine, either the switch, starter, or wiring is not making a complete circuit connection. Continue with voltmeter Tests 2, 3, 4, and 5.

If the battery voltage falls below 4 volts for a 6-volt battery or 8 volts for a 12-volt battery, either the battery is not up or a short exists in the starter circuit. Test the battery. (See Battery Tests.)

TEST 2 Meter reading with no load. _____
Meter reading with starter
switch being held. _____

Test 2 checks the switch and cables. Before cranking, the voltmeter will read the battery voltage, the same as Test 1. When the starter switch is engaged, the voltmeter should drop to zero or less than one-half volt. If the voltmeter does not drop down when the switch is engaged, a loss is occurring in the switch or cables.

TEST 3 Voltage across switch before contact. _____
Voltage across switch with switch
being held. _____

To check the switch only, connect the voltmeter across the switch terminals as shown in Test 3. Again, the meter will read the battery voltage until the switch is engaged. When the switch is engaged, the meter should drop to near zero volts. Failure to drop to less than one-half volt indicates a bad switch.

If Test 2 showed a loss that Test 3 did not show, the loss occurred in a cable or connection. Tests 4, 5, and 6 will show cable loss while cranking. Any reading indicates loss. Locate the loss and correct it. Corroded terminals or bad connections could cause loss. Test as shown in Tests 7 and 8. These tests are made with the starter switch engaged. Any reading indicates loss.

Chart 82

STARTER-GENERATOR

The operation of the combination starter-generator refers to the purpose of the cutout relay in the regulator unit. When the output voltage of the generator becomes less than the voltage of the battery, the current stops flowing in the direction that charges the battery and it begins to flow back through the generator armature winding. The field and the armature are both now battery powered. The magnetic fields produced by the field windings and the armature are now like magnetic poles and are therefore repelling each other causing the armature to attempt to turn to align the magnets. The generator is now acting as a *motor*. During generator operation the cutout relay opens when the generator output falls and it prevents the generator from "motoring."

A starter switch connected to bypass the cutout relay makes the generator become a starter motor when desired. The starter switch connects the armature directly to the battery plus while the other armature brush is connected directly to the engine ground (battery negative). This makes both the field windings and the armature winding full strength for maximum starting torque.

The starter-generator is usually belt driven to the engine. The engine pulley is larger to decrease the speed and increase turning torque while starting. The belt must be kept at correct tightness to crank the engine satisfactorily. Once the engine starts, the generator and regulator operate as described in the generator section.

A solenoid switch and ignition key may be used instead of the heavy starter switch. Keep in mind here that since a great deal of power is needed to crank the engine, heavy current flow is needed in the starter switch circuit. On the solenoid switch the starter switch is engaged electrically. The ignition key engages the starter switch.

Notice that the ignition key in the START position connects the solenoid coil to the battery positive for cranking. In the OFF position the key shorts the ignition primary winding to the engine ground and prevents the points from creating a spark and thus stops the engine. (See Ignition section.) *Caution:* This switch cannot be replaced with an automotive switch because an automotive switch connects the ignition terminal to the battery positive instead of to the ground. The magneto and switch would be burned out immediately.

The ammeter is also bypassed during the cranking operation and will not read the cranking current. The current needed for cranking is in excess of the capability of the meter and would cause meter damage. The charge from the regulator to the battery will show on the ammeter, as will flow from the battery to an accessory load. On some units there is an accessory terminal on the regulator.

Chart 83

STARTER-GENERATOR TESTS

Starter-generator units are tested as separate units. The charging function is tested as any generator unit. (See Generator Tests.) On these units it is usually advisable to check the starter function first since the starter and generator are the same unit. If it will crank the engine, then it should also charge and if it will crank the engine but will not charge, the problem is likely in the external wiring or the regulator unit.

A frequent cause of failure of these systems is the drive belt. Check the pulleys to make sure that a smooth vee belt has not been placed on a unit designed for a notched belt. Check the belt tightness. It should not deflect more than one-quarter of an inch with normal thumb pressure. If the belt has been slipping and has become glazed, replace it. The new belt will need retightening after a few hours of operation and certainly after each operating season. If the unit is used two seasons such as mowing in summer and snow plowing in winter, the belt tightness should be checked *each* season.

VOLTMETER BATTERY TEST

Indication of starting or charging problems may be detected by connecting a D.C. voltmeter to the battery as shown on the next page. When connected to a battery on a unit not running, the voltmeter should read 12.6 or 6.3 volts indicating a normal battery voltage. Observe the voltmeter carefully while cranking the engine. The meter should stay above 4 volts for a 6-volt battery and above 8 volts for a 12-volt battery. Once the engine is running, the voltmeter will indicate charging voltage. If the battery comes above the initial reading of 6.3 or 12.6 volts, the unit is charging. The amount of charge will be indicated on the ammeter if there is one. If there isn't an ammeter, one can be connected as shown by placing it in the battery cable at the regulator battery terminal. At half throttle, voltage readings should not exceed 7.5 volts or 15 volts.

Chart 83 (continued)

STARTER-GENERATOR TESTS

STARTER-GENERATOR TESTS

PROBLEM	CAUSE
Starter spins but does not turn engine.	Loose belt. Glazed belt. Wrong type belt.
Battery does not stay fully charged.	Loose belt. Recharge battery. If starter functions OK, fault is in wiring or regulator. See Generator Test section. Test as for any generator.
Battery stays fully charged but will not crank or cranks slowly.	Problem in the starter switch circuit. Check starter switch and wiring as described in Starter Test section.
Voltage drops below 4 volts on a 6-volt system or 8 volts on 12-volt system when cranking.	Battery defective or not fully charged. Starter shorted.
Battery voltage remains unchanged when starter switch is pushed. Charging circuit OK. Battery voltage drops too low when cranked. Voltage does not rise above battery normal after engine starts.	Defective starter switch, loose or corroded connection, defective ground on battery or starter. Battery discharged because of no charging circuit output. Check charging circuit. See Generator Tests.

Section VII

**GENERATOR AND ALTERNATOR
TESTING**

MAGNETS

There are three basic types of magnets: natural magnets, permanent magnets, and electromagnets. The magnetic fields set up by these magnets are alike, that is, they each have a north pole and a south pole. They differ only in the way in which the magnetic field is produced and retained. Since unlike magnetic poles attract, the south pole of a permanent magnet is attracted to the north pole of a D.C. electromagnet just as it would be to the north pole of another permanent magnet.

NATURAL MAGNETS

The Earth is itself a natural magnet because it has a definite north and south magnetic pole. Some ores are also natural magnets. Since they are not strong enough or durable enough for use on small gasoline engines, natural magnets will not be discussed further.

PERMANENT MAGNETS

Permanent magnets are no more or less permanent than a lady's permanent wave. Permanent magnets are man-made and can be destroyed at any time. Hardened steel can be magnetized and will retain its magnetism for a long period if it is handled properly. Special alloy magnets now available have extremely long lives.

A screwdriver is a good example. The hardened blade of a screwdriver may become magnetized and will remain magnetized for many years. Some screwdrivers are purposely magnetized to help hold screws or to pick up objects. A screwdriver so magnetized is a permanent magnet.

Good permanent magnets are usually in the form of a bar or horseshoe. Like natural magnets, they have a definite north and south magnetic pole. A strong attraction exists between the north and south magnetic poles which causes lines of force to be set up between the poles. Study the diagrams on lines of force on the opposite page.

DESTROYING THE PERMANENT MAGNET

Magnetism in a hardened steel permanent magnet is a result of molecular alignment. The molecules may be returned to their normal random arrangement and thus destroy the magnetism. Permanent magnets such as flywheel magnets may be destroyed by a sharp blow, for example, by dropping, heating, or by exposing them to alternating current magnetic fields such as large electric motors.

Chart 85

ELECTROMAGNETS

When electric current is passed through a wire, a magnetic field surrounds the wire. The illustration at the left shows how soft iron filings will be attracted in a circular pattern to a wire carrying current. A coil of wire made up of several turns wound closely and continuously will produce a strong magnetic field. The magnetic field produced by each turn of wire adds to the magnetic field produced by all the other turns of wire to form a single strong field around the coil. As with the natural magnet and the permanent magnet, the electromagnet will have a north and south pole. Reversing the battery terminals will reverse the current flow through the coil and will reverse the north and south poles.

If the coil is wound on a soft iron core, the magnetic field will become concentrated and much stronger. Most electromagnetic devices used on engines (the ignition coil, generator, and alternator) have coils of wire wound on laminated steel to improve the magnetic strength. The laminated layers of steel are insulated from each other to prevent currents through the core which would decrease the magnetic strength and produce heat. Sometimes rust will bridge across these laminations and will seriously cut the efficiency of the electromagnet.

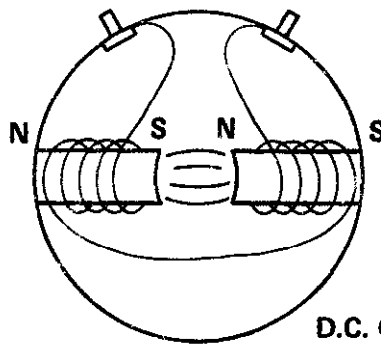
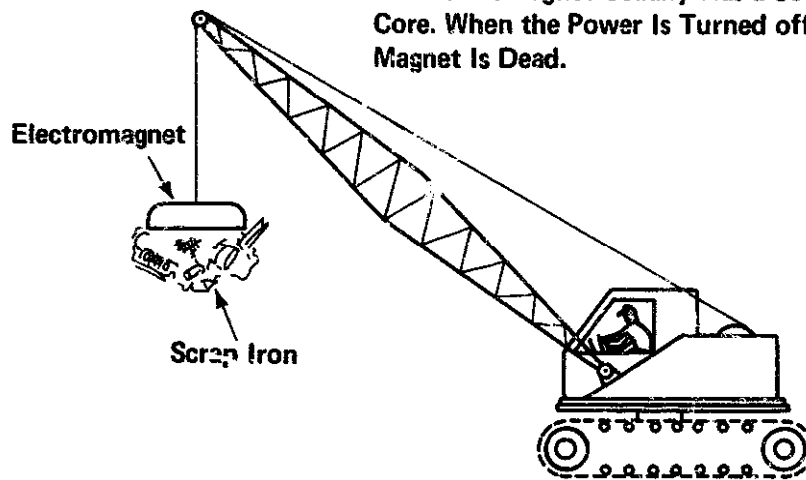
The strength of the magnetic field surrounding a wire is dependent on the amount of current flowing through it. The strength of the magnetic field around a coil of wire depends on:

1. The size of wire used. The larger the wire size, the easier it is for the current to flow. Thus, more current flow and a stronger magnet are produced.
2. The number of turns of wire. Since the magnetic field of each turn of wire adds to that of the adjacent turns, more turns of wire will produce a stronger magnet.
3. Increase of the voltage to the coil. Increasing the electrical pressure (voltage) will cause more current to flow. If the voltage is increased to the point that the current flow exceeds the wire size, the coil will heat up causing damage to the coil.

Chart 86

RESIDUAL MAGNETISM

An Electromagnet Usually Has a Soft Iron Core. When the Power is Turned off, The Magnet Is Dead.



D.C. Generators Are Designed So That Residual Magnetism Remains After the Field Coils Are Turned off. This Makes the Generator Self-exciting. It Can Start Charging Without Help from the Battery.

RESIDUAL MAGNETISM

Note that in making an electromagnet a soft iron core was used. A soft iron core will act to concentrate the magnetic fields satisfactorily, but it will lose its magnetic characteristics as soon as the current stops flowing. It is usually desirable to have an electromagnet that will shut off completely when the current flow is stopped, for example, one used to load scrap iron. If the coil is wound on a core that has been hardened, the hardened core will retain some of the magnetic strength of the electromagnet. This remaining magnetism is referred to as residual magnetism.

If the core is sufficiently hardened, it will become a permanent magnet, that is, it will retain considerable magnetic strength after the current flow in the winding has been stopped. If not destroyed, this remaining magnetism could remain for several years.

The pole shoes of a D.C. generator retain some of the magnetic strength of the field coils around them. This makes the generator self-exciting and makes it possible for the generator to generate when it is not connected to a battery. An automotive *alternator* usually does not have this characteristic. It will not charge if the battery is completely dead because it relies on the battery to supply the excitation or magnetic field. If the battery is too weak to create a magnetic field in the alternator, the alternator will not charge.

Chart 87

THE CHARGING CIRCUIT

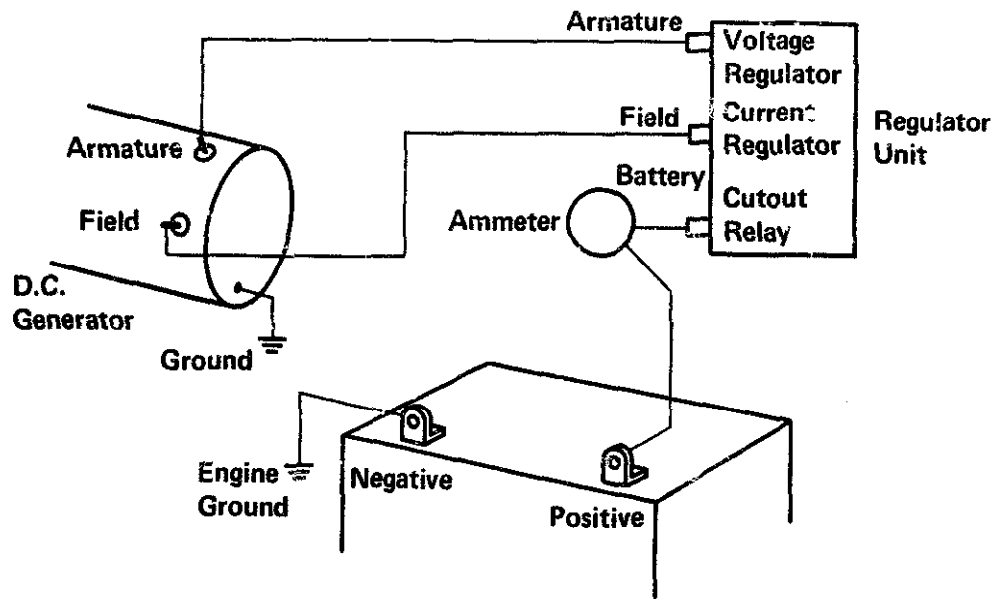


Chart 87

THE CHARGING CIRCUIT

The purpose of the charging circuit is to replace the charge used from the battery while the engine is not running and to supply current flow to electrical units while the engine is running. The battery is an electrical storage unit that supplies current when the engine is not running or if the load becomes greater than the generator output.

The **GENERATOR** is a device that changes mechanical energy (rotary motion) into electrical energy. The generator may be either a D.C. generator or an A.C. generator (alternator) which uses diodes to change the A.C. to D.C. if a battery is in the circuit. Some lawn and garden tractors and motorcycles operate the headlights directly from the A.C. output of an alternator. In this case the engine must be running before the lights will operate. D.C. generators and alternators will be discussed in detail in the following pages.

The **REGULATOR UNIT** may consist of a voltage regulator coil, current regulator coil, and a cutout relay, depending on the design of the unit.

The **VOLTAGE REGULATOR COIL** limits the voltage output of the generator. The generator must be capable of charging at less than maximum engine rpm. If the generator can create from 13 to 14 volts at 2,000 rpm, the voltage could be excessive when the engine is operated at 3,000 rpm or higher. Some charging systems require a voltage regulating unit.

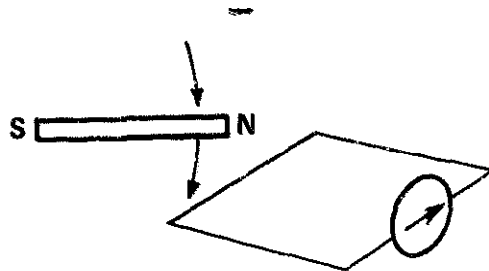
The **CURRENT REGULATING COIL** limits the amount of current flow that the generator is allowed to produce. When the battery is quite low and/or the accessory load is heavy, the D.C. generator will try to supply more current than it was designed to produce. This would result in overheating and burning out of the generator and wiring. Some charging systems have a current regulating coil in the regulator unit or some current limiting device in the circuit. The A.C. system is self-current regulating and does not need a current regulating coil in the regulator.

The **CUTOUT RELAY** is necessary on D.C. generators to prevent the battery charge from discharging back to the generator when the generator is not charging. It disconnects the battery from the charging system when the charging system is not charging.

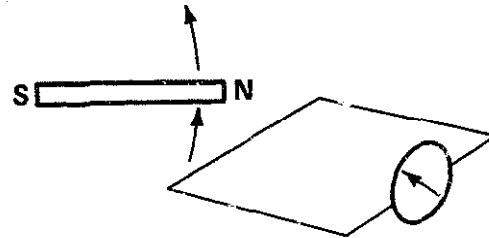
An **AMMETER** may be placed in the wire connecting the charging circuit to the battery. Since an ammeter measures the amount or current flow, the current must be made to flow through the meter. Note in the diagram on the opposite page how the ammeter is connected in the circuit so that current flow is through the meter. The meter shown is a **ZERO CENTER** type. The meter will read the D.C. current flow in either direction. If the current flow is charging the battery, the meter will indicate the current on the charge side of zero; if the battery is being discharged, the ammeter will show the rate of discharge. Normally, the ammeter will not show the starter current draw.

Chart 88

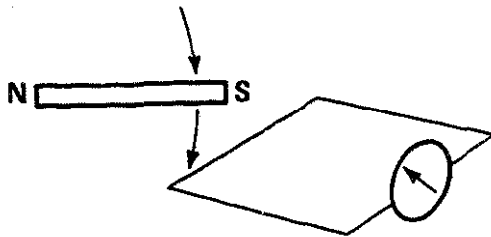
CREATING CURRENT FLOW



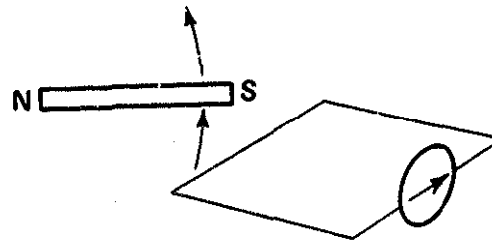
North Pole Moving Down Past Wire



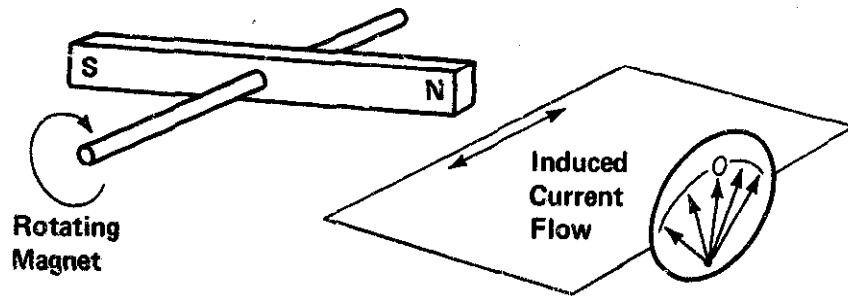
North Pole Moving Up



South Pole Moving Down Past Wire



South Pole Moving Up



Rotating Magnet

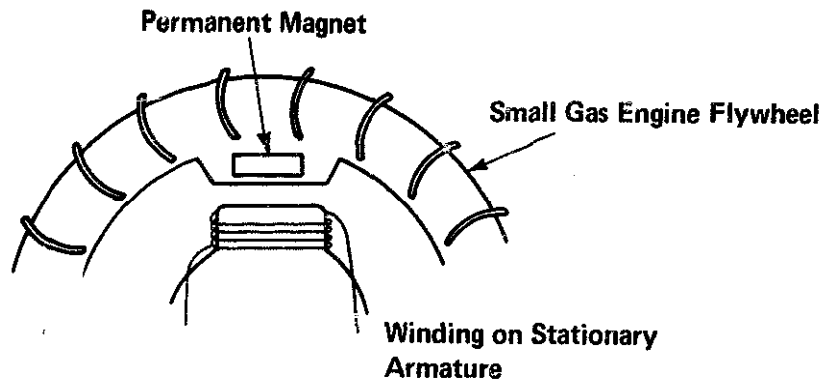


Chart 86

CREATING CURRENT FLOW

Current flow was induced in the primary winding of the ignition coil by a moving magnet. The same principle is utilized in the charging system whether it is the D.C. or A.C. type. As you recall, moving a magnet rapidly past a conductor will induce current flow. In the upper illustration on the opposite page, the magnet is moved rapidly past the conductor and the current flow will be indicated on the ammeter. If the magnet is moved back past the conductor in the opposite direction, the current will flow back the other way as indicated by the direction of deflection of the ammeter.

Moving a south pole past the wire will create current flow in one direction. Moving a north pole past the wire will cause current flow in the opposite direction.

PRODUCING ALTERNATING CURRENT

If the magnet were attached to a shaft and rotated, current flow would be induced in the wire first in one direction when the north pole moves past and would be induced in the other direction as the south pole moves past. This back and forth movement of current would cause the ammeter to deflect both directions from the center zero point. If the magnet is turned fast, the meter would not be able to deflect fast enough and would not accurately read the amount of current flow. Damage to the meter could result. This continuous back and forth movement of current is called **ALTERNATING CURRENT (A.C.)**. The current produced by a battery that is always flowing the same direction is called **DIRECT CURRENT (D.C.)**.

PRODUCING A STRONGER CURRENT

The current produced by moving the magnet past one wire would be very small. Increasing the wire area being passed by the magnet will increase the current flow. If the wire is wrapped into a coil, the current will be induced in each turn of the coil. The current induced in each turn of the wire adds to the current of all the turns producing a strong current flow. Winding the coil of wire on a laminated iron core will help the passing magnet set up the magnetic lines of force through the winding which will increase the current flow in the winding.

Typical small gas engine alternators use a series of coils (stator winding) mounted on a laminated ring (stator) under the flywheel using the flywheel magnet to induce the current flow in the stator winding. The ignition coil may or may not be integrated into the same set of coils.

Keep in mind that this is alternating current at this point and is not suitable for charging the battery because the current flow is equal in each direction and no charging of the battery would occur.

Chart 89

DIODES

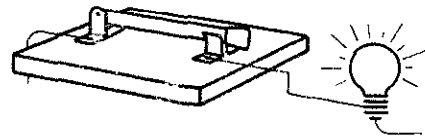
Water Flow



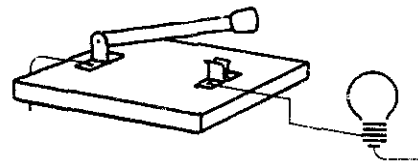
Flow in This Direction Opens Door



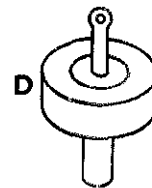
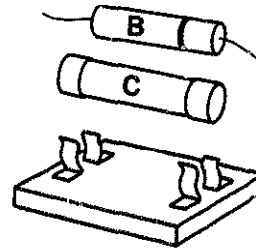
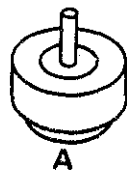
Flow in the Reverse Direction is Blocked



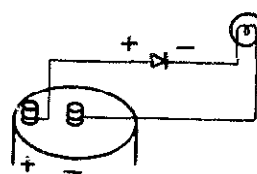
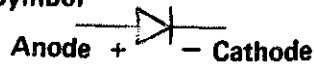
A Diode Acts as a Closed Switch and Allows Current to Flow Freely in One Direction



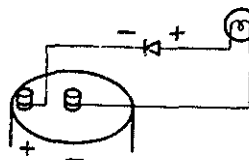
But Acts as an Open Switch and Prevents Flow in the Reverse Direction



Diode Symbol



Reverse Connection. Current Flow is Blocked by the Diode and the Bulb Will Not Light



Forward Connection. Current Will Flow Through the Diode and the Bulb

DIODES

A diode is a one-way electrical check valve. It permits the electrical current to flow easily in one direction, but it stops the current flow in the other direction. Just as a check valve will permit water to flow in one direction and will block flow in the opposite direction, a diode performs this function in an electrical circuit.

One use for the diode as seen in the electronic ignition system is to allow current to flow freely from the charging coil to the capacitor, charging the capacitor. The diode prevents the current from flowing back through the coil trapping the charge on the capacitor. This is a typical use for a diode.

The diode might also be compared to an electrical switch that is quickly closed so that the current can flow in one direction, but it is quickly opened to prevent current flow in the opposite direction.

Diodes are available in a number of shapes and sizes, depending on the job they are performing. Diodes are rated by current capacity and maximum voltage.

The CURRENT rating is the maximum amperes the diode can pass in the forward direction. Current flow in excess of this amount will blow the diode.

The VOLTAGE rating determines the maximum voltage that can be applied to the diode in the reverse direction when no current is flowing without forcing its way across or bridging the diode. Remember that voltage is electrical pressure and that high voltage is capable of jumping distance. High-voltage diodes are very different from those used in low-voltage circuits. High-voltage diodes usually look like illustration B on the opposite page.

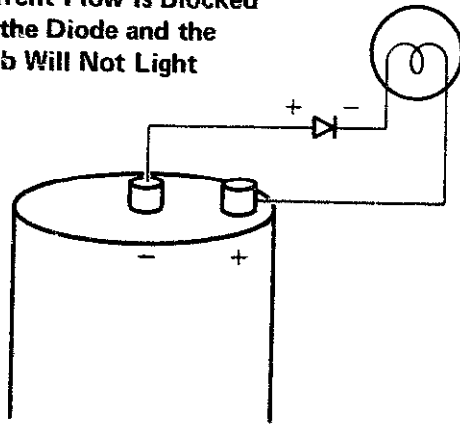
A HEAT SINK is necessary for high-current diodes such as shown in illustrations A and D on the opposite page. The type shown in A is used on larger alternators. It is pressed into the alternator frame or isolated heat sink. The type shown in D is bolted to a heat conducting surface. In both cases the heat sink becomes part of the circuit because there is only one connecting terminal on the diode.

Most diodes used with alternators on small gas engines are like C and E on the opposite page. They do not carry enough current to need a heat sink and they usually fit into a clip connection for easy removal.

Chart 89 (continued)

DIODES

**Reverse Connection.
Current Flow Is Blocked
by the Diode and the
Bulb Will Not Light**



**Forward Connection.
Current Will Flow Through
the Diode and the Bulb**

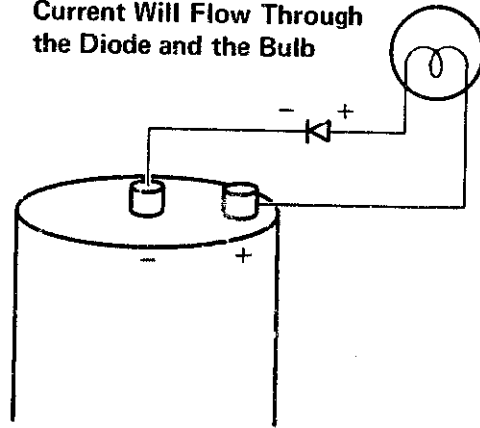


Chart 89 (continued)

DIODES

DIODE TESTING

Diodes may be tested with an ohmmeter. Connecting the lead to the diode one way should show low resistance. Connecting the lead the other way should show high resistance. If the diode shows either high or low resistance both ways, it is defective.

The circuit showing the dry cell and light bulb connector through a diode may be used as an effective diode tester. Place the diode in the circuit both ways. The bulb should light with the diode connected one direction and should not light at all if connected the other way. If the bulb lights both ways, the diode is shorted. If the bulb will not light either way but will light when connected without the diode, the diode is open. If the light glows dimly during the reverse CONNECTION, the diode is leaking and should be replaced.

Chart 90

THE BASIC ALTERNATOR

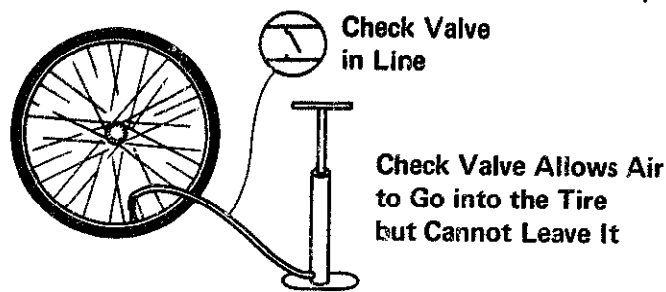
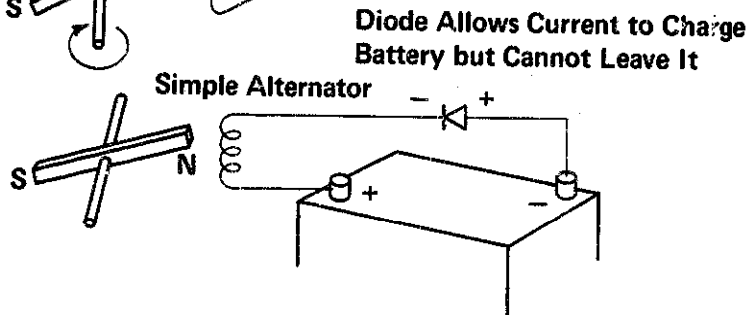
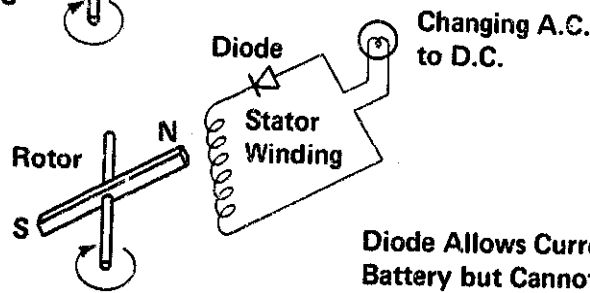
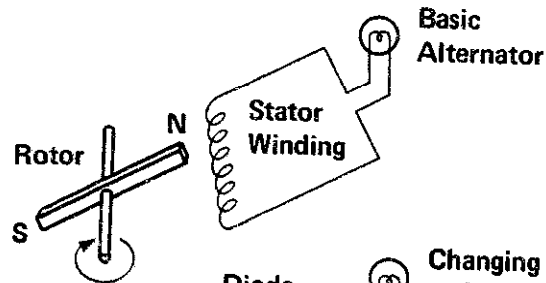


Chart 90

THE BASIC ALTERNATOR

Study the diagrams on the opposite page carefully. In the upper diagram we have the basic alternator, a stationary (stator) coil and a rotating magnet (rotor). Remember that as the rotor turns, the alternating north and south poles will cause current to flow back and forth in the circuit (alternating current). The light bulb does not care that this is alternating current (A.C.) because the A.C. will heat the filament and produce light just as will direct current (D.C.).

DIODE RECTIFIED OUTPUT

In the next diagram a diode has been placed in series with the circuit so that all current must flow through the diode. As one magnetic pole passes the stator winding, it will produce current flow in the circuit if the current flow is in the forward direction of the diode. As the other magnetic pole passes the stator, it will try to induce current flow in the reverse direction to which the diode acts as an open switch allowing no current flow. The circuit is shut off by the diode.

Now the bulb will be lighted by pulses of current all moving in the same direction. When the current flow is all in one direction, it is called direct current (D.C.). The bulb is now operated on pulses of D.C. In this circuit A.C. has been changed to pulsating D.C.; this is called rectifying. The diode is one type of rectifier that will change A.C. to D.C.

CHARGING THE BATTERY

When this circuit is connected to a battery, the pulses of D.C. can be used to charge the battery. Notice that the diode is placed in the circuit in reverse to battery polarity. The battery cannot discharge through the diode and coil. The diode is placed so that the current can flow in the direction that charges the battery but cannot flow in the direction that will discharge the battery.

Compare the illustration of the tire pump with the simple alternator above. When the pump pressure becomes greater than the tire pressure, the air moves through the check valve into the tire. As the pump moves back up, the air is prevented from coming back out of the tire by the check valve (enlarged). The back and forth movement of the pump is changed into a one-way movement of air by the check valve.

When the voltage in the stator becomes greater than the voltage of the battery, the current will flow, charging the battery. When the current tries to flow the other direction in the stator, which would discharge the battery, the diode acts as an open switch and prevents the current flow.

Chart 91

LOW CURRENT ALTERNATORS

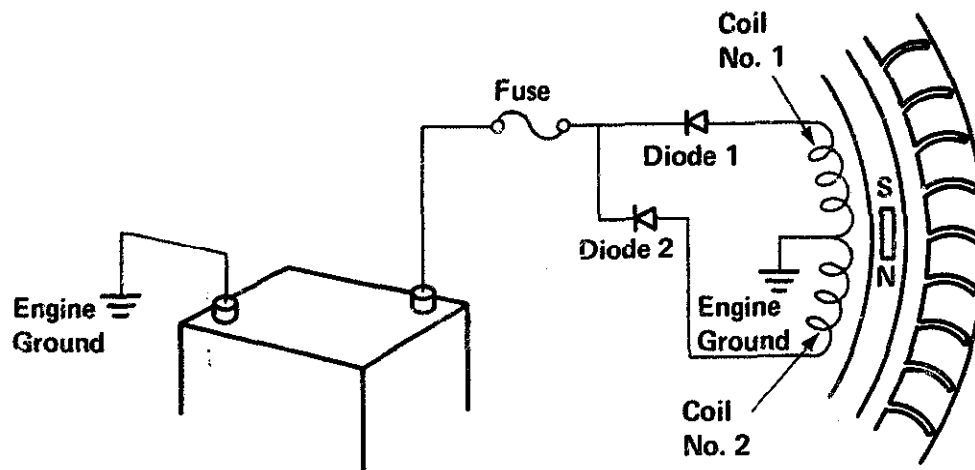
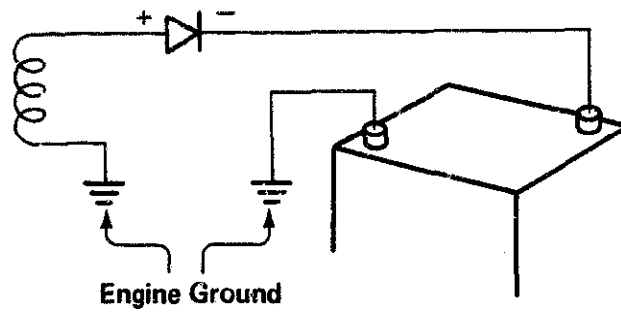
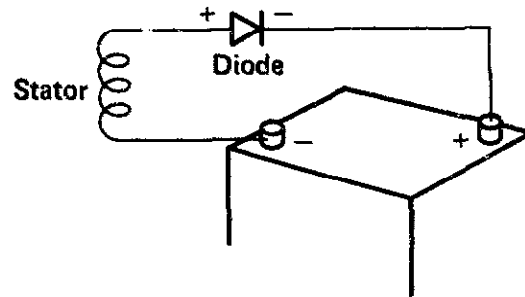


Chart 91

LOW CURRENT ALTERNATORS

Typical charging systems use the engine as one side of the electrical circuit. This is called the grounded side. Compare the two circuit diagrams. On both diagrams, a complete circuit exists from the battery negative (-) terminal to the stator coil, to the diode, and to the battery positive (+) terminal. Using the engine as one side of the circuit eliminates some of the wiring and reduces confusion for there are fewer wires to keep straight and less danger of hooking something up backward as the engine block is always the same as the battery negative terminal. On some older cars and tractors, the battery was reversed and the engine (entire chassis) became the same as the battery positive terminal. They were referred to as *positive ground* systems. It is important to check this out before removing the battery cables or attempting any tests on the circuit.

The low current alternator diagram shows two charging coils mounted under the flywheel. The flywheel magnet, or magnets, induces current flow in each of the coils as it passes. Note that each coil has one lead connected to the engine ground which in turn is connected to the battery negative terminal. The other lead from each coil is connected through its diode to a common fuse and to the battery positive terminal.

As the flywheel magnet passes charging coil No. 1, the current flow induced one direction in the coil is passed through diode No. 1 to charge the battery. The current flow induced in the opposite direction is blocked by the diode. The magnet continues on, inducing A.C. current in coil No. 2. Diode No. 2 allows current flow to charge the battery and blocks the reverse flow.

This is an alternator typically used on lawn and garden tractors. It is simple, inexpensive, and trouble free if it is not abused.

Since charging coils are quite small, they limit the output of the system. Since the output is limited, it is not likely that the battery will become overcharged during use; thus, no voltage regulator is supplied with this system. If the engine is operated for long periods of time without restarting, the battery will be overcharged by the system. The first symptoms of overcharging will usually be excessive water consumption by the battery. Removing one of the diodes will cut the charging system output and will prevent overcharging during extended engine operation. If the engine is used only for short periods calling for frequent starter use, an additional battery charge may be necessary occasionally.

Since the alternator is an A.C. current device, it is self-current regulating and no current regulating device is needed as with D.C. generators. Because the diodes prevent the return of the battery current to the alternator when the alternator is not in use, a cutout relay is not needed.

Chart 92

FLYWHEEL ALTERNATOR SYSTEM TESTING

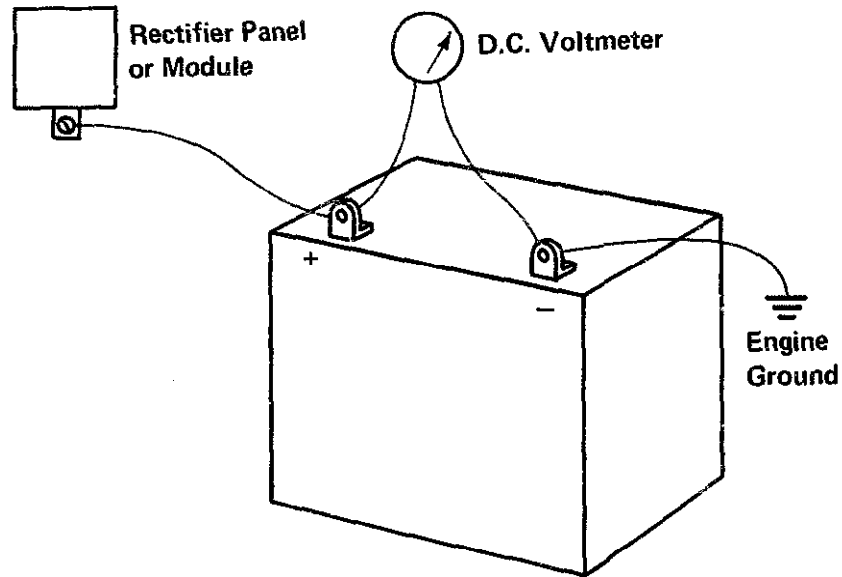


Chart 92

FLYWHEEL ALTERNATOR SYSTEM TESTING

Although flywheel alternator systems vary somewhat, they are similar in operation and lend themselves to some common tests. Many of the components have been molded into modules which if found defective by simple tests must be replaced.

OUTPUT VOLTAGE TEST

Before starting the engine, connect a D.C. voltmeter that will read at least 16 volts to the battery terminals. Read the battery voltage carefully and record.

Battery volts with engine stopped (should be 12.6 volts)

Crank the engine briefly. Recheck the battery volts.

Battery volts after short load (should be 12.6 volts)

Start the engine. Allow the engine to run at 3,000–3,600 rpm near wide open for one minute. CAUTION: Do not rev an unloaded engine. Read the battery voltage while the engine is still running 3,000–3,600 rpm.

Battery voltage, engine running rated rpm

TEST RESULTS	PROBLEM
Battery volts before running are 12.6 volts or higher. If higher, probably the battery has recently been charged.	OK.
Battery volts are less than 12.6.	Check battery. See Battery Test section.
While the engine is running, the battery volts are higher than before running.	Charging circuit OK.
Battery volts do not increase after engine has been run 3,600 rpm for one minute.	Possible charging circuit problem.
Battery volts during running are 15 volts or higher.	Overcharging. If it is an unregulated unit, remove one diode during extended operation.
Battery volts increase, but battery becomes discharged periodically.	Reduced output. Check diodes and perform ammeter test. Possibly the unit is being started frequently. Boost charge battery periodically.

Chart 92 (continued)

FLYWHEEL ALTERNATOR SYSTEM TESTING

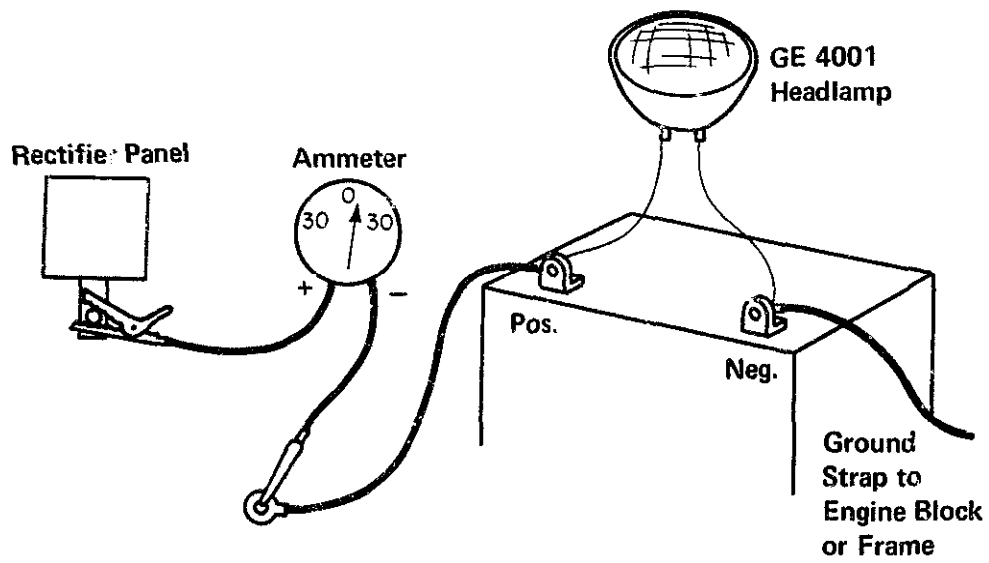


Chart 92 (continued)

FLYWHEEL ALTERNATOR SYSTEM TESTING

AMMETER OUTPUT TEST

An ammeter can be used to determine the amount of charge being placed on the battery. Connect a D.C. AMMETER (available at automotive stores) in series with the charging lead. Remove the charging lead from the rectifier. Clip one lead from the ammeter to the rectifier output and the other lead to the battery charged lead. The output current will now flow through the ammeter. Bring the engine speed to 3,600 rpm and observe the ammeter reading. Look carefully. A very low output may be difficult to detect on a 30-ampere meter.

If little or no output is observed, use an automotive headlamp (GE No. 4001) as a battery load. Connect the lamp directly to the battery terminals with test leads. Again, bring the engine to 3,600 rpm and read the ammeter carefully. Failure to produce output indicates charging circuit problem. Continue the charging circuit tests.

Chart 93

FLYWHEEL ALTERNATOR COMPONENT TESTING

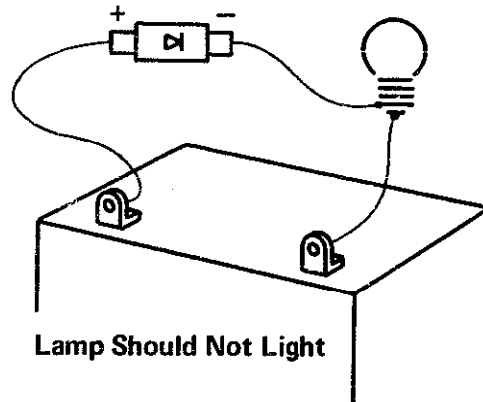
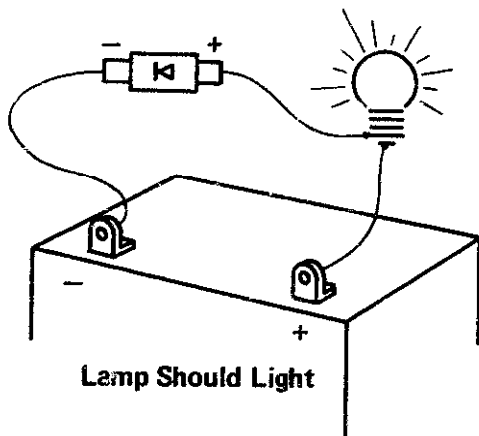
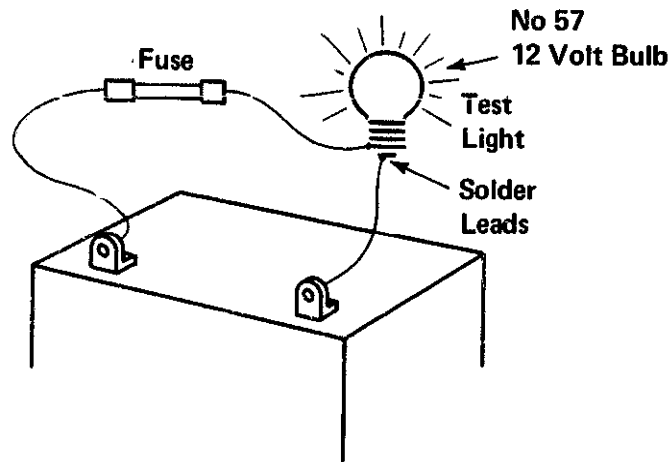
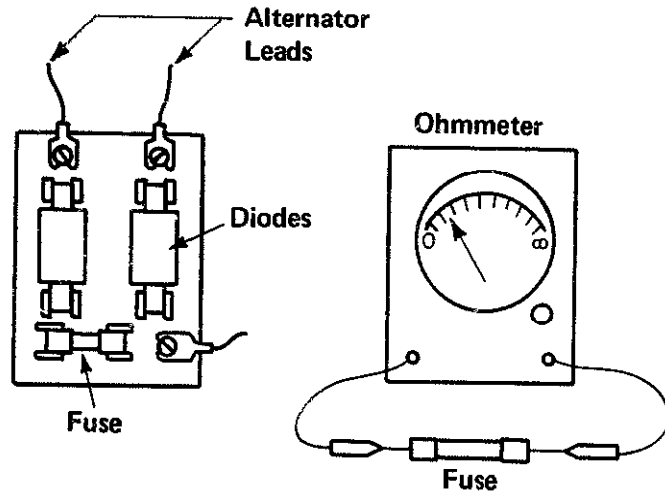


Chart 93

FLYWHEEL ALTERNATOR COMPONENT TESTING

As you have seen on the diagrams of the simple flywheel alternator, there are no friction causing, moving parts and unless abused, they usually cause no trouble. Components such as the fuse and the diodes will take very little abuse. A loose wire or terminal can make momentary opens or shorts in the circuit which could blow the fuse or diodes. A visual check of leads, plugs, terminals, and the clip-in mountings may reveal such a problem.

To check the fuse, remove it from the fuse holder and test for continuity with an ohmmeter. If an ohmmeter is not available, a small light bulb and battery can be used. A good continuity tester can be made by soldering test leads to a bulb. Placing the fuse in question in series with the bulb and battery so that the current must flow through the fuse to light the bulb will determine if the fuse is still good (continuous). Clean the fuse and fuse holder terminals before replacing the fuse. Use emery paper or fine sandpaper if necessary to assure good contact.

Check the diodes with an ohmmeter or battery and test light as shown. In one direction, the diode should read ZERO ohms. Reverse the diode and the meter should read infinity or high resistance. If the diode is connected in series with a test lamp and battery, the lamp should light when connected one direction and should not light when reversed. If the diode symbol is printed on the diode, or if the polarity is marked, the lamp should work as shown in the bottom two illustrations.

DIODE TEST RESULTS	CAUSE
Continuity one direction. No continuity when reversed.	Good diode.
Continuity both directions.	Shorted diode. Replace.
No continuity either direction.	Open diode. Replace.
Continuity one direction. Some continuity when reversed. Low meter reading or lamp glow.	Leaking diode. Replace

Clean the diode contacts the same way as the fuse contacts. Check all wires and connections. When replacing covers make sure that wires are not pinched causing a short circuit.

To check the stator winding, use the ohmmeter or test lamp and battery to check continuity through the coil winding. A break in a wire or a bad connection will be detected by this test. Disconnect the alternator leads from the diodes before testing. Test each coil.

Chart 94

REGULATED FLYWHEEL ALTERNATOR

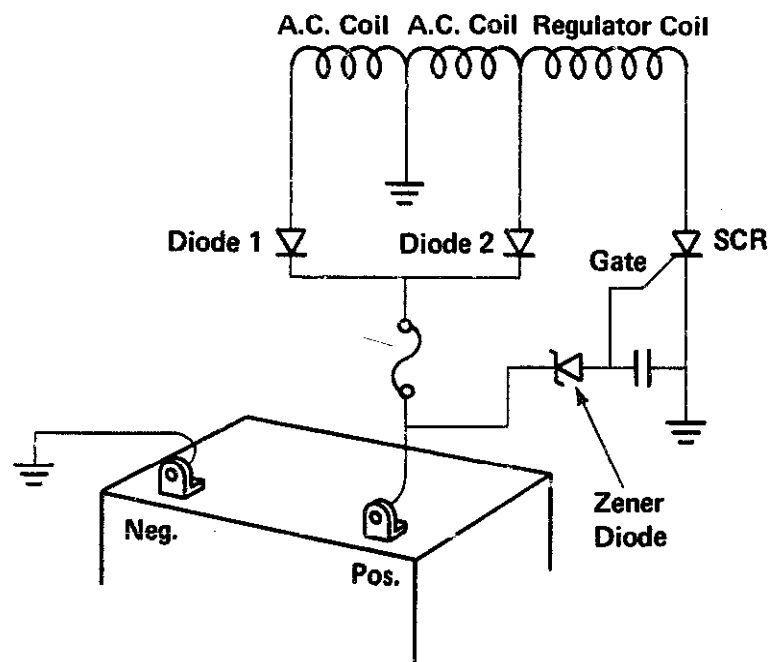


Chart 94

REGULATED FLYWHEEL ALTERNATOR

The unregulated flywheel alternator will do an acceptable job of charging the battery on lawn and garden equipment that is normally run for a predictable time between each start. As pointed out earlier, if an unregulated unit is operated for short periods or at low speeds, external recharging may be necessary occasionally to supplement the small output of the flywheel alternator. If the unregulated unit is operated for long periods at high rpm, the battery will be overcharged. The REGULATED flywheel alternator overcomes these disadvantages with increased output to recharge the battery faster and a voltage regulator to prevent overcharging.

The REGULATOR COIL is added to the charging coils. One lead from the regulator coil is connected to the battery (+) plus lead of one of the A.C. coils. The other lead goes to ground through the SCR. The SCR, when electrically switched ON, allows current flow in the regulator coil. The current flow in the regulator coil sets up a magnetic field that opposes the A.C. coils reducing their output. When the SCR is not ON, there is no current flow in the regulator coil and it has no effect on the charging coils, permitting full output.

The SILICON CONTROLLED RECTIFIER (SCR) is an electronic switch that has no moving parts. When a small voltage is applied to the gate connection, the SCR is turned ON. Until voltage appears at the gate, the SCR remains OFF to current flow through the SCR from the regulator coil to ground.

A ZENER DIODE is a very sensitive electronic device that allows a small amount of current flow only when the applied voltage exceeds a certain level (breakdown voltage). Zener diodes are available in a wide range of voltages. When the voltage reaches the firing voltage of the Zener diode, the diode turns ON (fires) allowing current flow. In this circuit the Zener diode is connected to battery positive. As the battery becomes charged, the voltage begins to rise above the normal battery voltage (12.6 volts). The Zener diode is usually set to fire at about 14.5 volts. When the battery voltage reaches 14.5 volts, the Zener diode fires applying voltage to the gate of the SCR. The SCR is turned ON permitting current flow through the regulator coil which opposes the A.C. coils and thus reduces output.

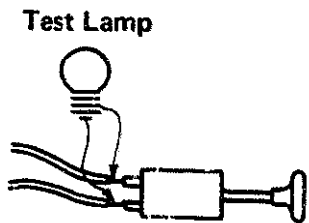
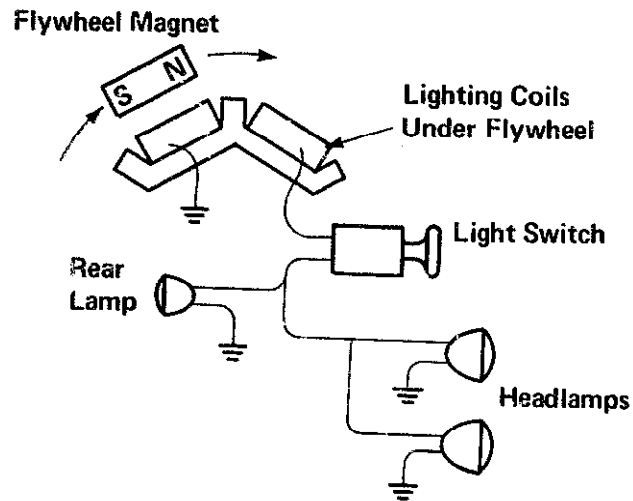
The VARIABLE RESISTOR may be used to permit an adjustment in regulator output. Changing the resistor would change the firing voltage of the Zener.

The CAPACITOR is quickly charged by the current flow through the Zener diode to build up the voltage to cause the gate to fire the SCR.

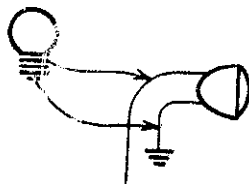
The SCR, Zener diode, resistor, and capacitor are all molded in a compact MODULE and are not accessible for testing. If an overcharging or undercharging condition exists, check the battery condition (see Battery Tests), check the fuse and diodes (see Component Tests), and check physically all wires and connections. If these are not at fault, replace the regulator module or check the manufacturer's literature for specific checks.

Chart 95

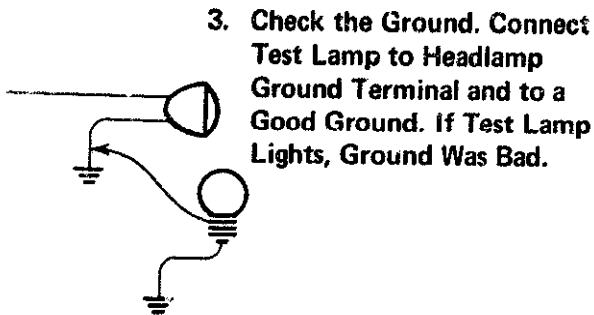
A.C. LIGHTING CIRCUIT



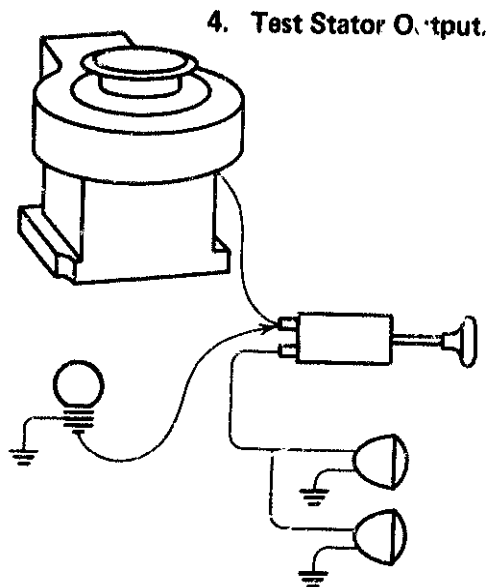
1. Test the Switch. If the Lamp Lights When the Switch Is ON, Switch Is Defective.



2. Test the Bulb. If the Test Lamp Lights, Headlamp Is Defective.



3. Check the Ground. Connect Test Lamp to Headlamp Ground Terminal and to a Good Ground. If Test Lamp Lights, Ground Was Bad.



4. Test Stator Output.

A.C. LIGHTING CIRCUIT

Some lawn and garden tractors are equipped with a headlamp that is powered directly from A.C. charging coils. The lights are not connected to the battery in any way. Some of these systems appear on units without battery or electric start or they may be used with a flywheel alternator and electronic ignition. The A.C. lighting system is completely independent of the battery charging circuit. The charging coils are sometimes contained in the same molded module.

The A.C. lighting circuit is similar to the low output flywheel alternator except that it does not require the rectifying diodes. The lights are operated with the alternating current created in the charging coils. The brightness of the headlamp depends on engine speed. This circuit has been common on motorcycles for several years.

To test the circuit, use a 12-volt test light with lead attached as for diode testing. Operate the engine at about one-half throttle with the light switch ON and make these tests.

1. Test the switch. Connect the test lamp to the switch terminals. If the lamp lights, the switch is defective.
2. Test the bulb. Connect the test lamp to the bulb connections. If the test lamp lights, the bulb is defective.
3. Test for headlamp ground. Connect the test lamp to the headlamp ground connections and to a good engine ground. If the test lamp lights, the headlamp is not making a good ground. Inspect carefully for bad connections and *rust*. Clean all connections.
4. Test for stator output. Turn the light switch OFF. Connect the test lamp to the charging coil lead at the light switch. Touch the other test lamp lead to a good engine ground. If test lamp lights, the stator is producing current and the problem is one of the above. Check wiring carefully for bad connections, frayed insulation, loose connections or *rust*.

Chart 96

THE GENERATOR

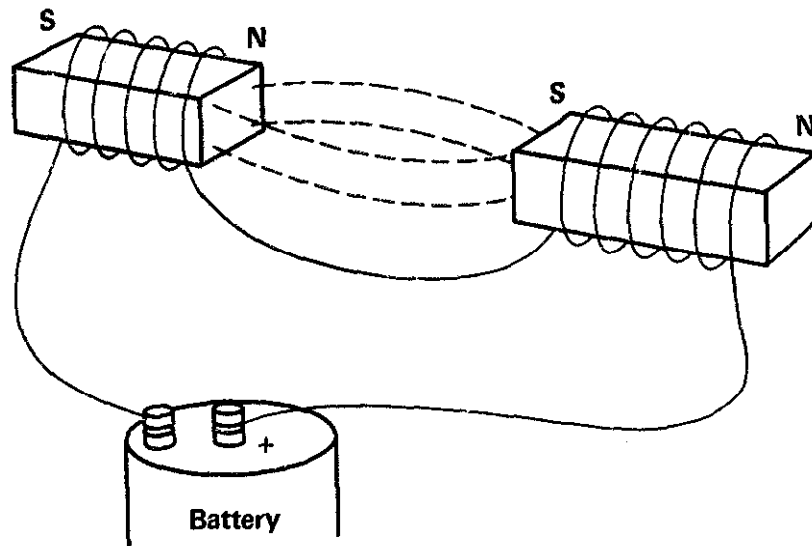
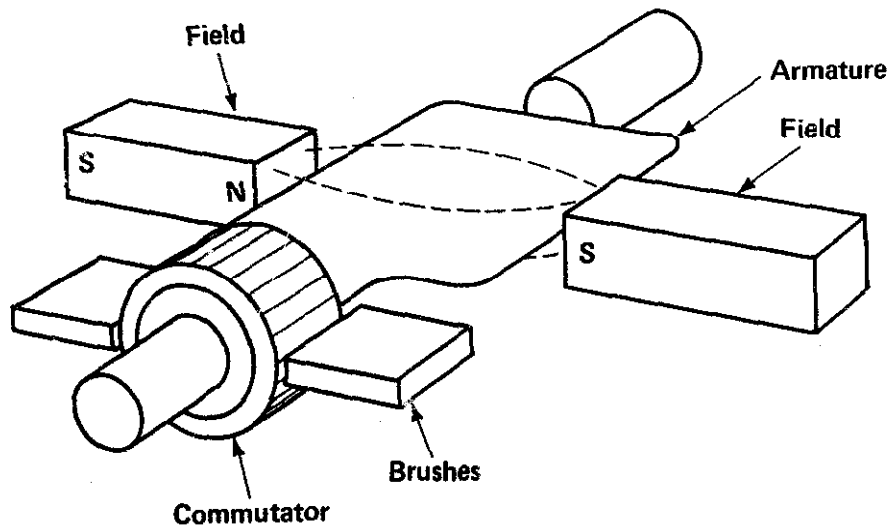


Chart 96

THE GENERATOR

Until inexpensive and dependable diodes were available, the D.C. generator was used to create current flow for accessories and for recharging the battery. The generator is somewhat the reverse of the alternator in that it has a stationary magnetic field, referred to as the field, and a rotating coil (armature) that turns within the magnetic lines of force set up by the field windings. Instead of moving the magnet past the coil of wire, the coil of wire (armature) is turned in the magnetic field.

The FIELD is two electromagnets wound in series. When voltage is applied to the field windings, they become strong magnets creating lines of force through the space between them. When power to the field windings is shut off, the field pole shoes on which the windings are wound retain some of the magnetism (residual magnetism).

The ARMATURE consists of several turns of heavy wire that moves through the magnetic lines set up by the field magnets. The generator output current is induced in these windings. Since this is the output current, the wire in the armature must be large enough to carry the output current.

The COMMUTATOR is a number of copper segments insulated from each other and fastened to an insulated hub on the armature shaft. The armature windings are connected to the commutator segments. The output current flows through the commutator to the brushes.

The BRUSHES are stationary and ride against the commutator providing a path for the output current. The brushes are fixed in their relationship to the field coils so that the brushes are always connected to the armature winding that has the maximum current flow.

The RECTIFYING action of the commutator and brushes keeps the current flow going in the same direction in the brushes at all times. The output of the generator is D.C. The armature passes both a north pole and a south pole as it makes one revolution; thus A.C. current is produced in the winding.

Study the diagram. Note that the side of the winding passing a magnetic pole is always connected to the same brush. The direction of current flow induced in that winding will always be the direction of current flow in that brush. The action of the commutator and brushes changes A.C. to D.C.

Chart 97

THE GENERATOR CHARGING CIRCUIT

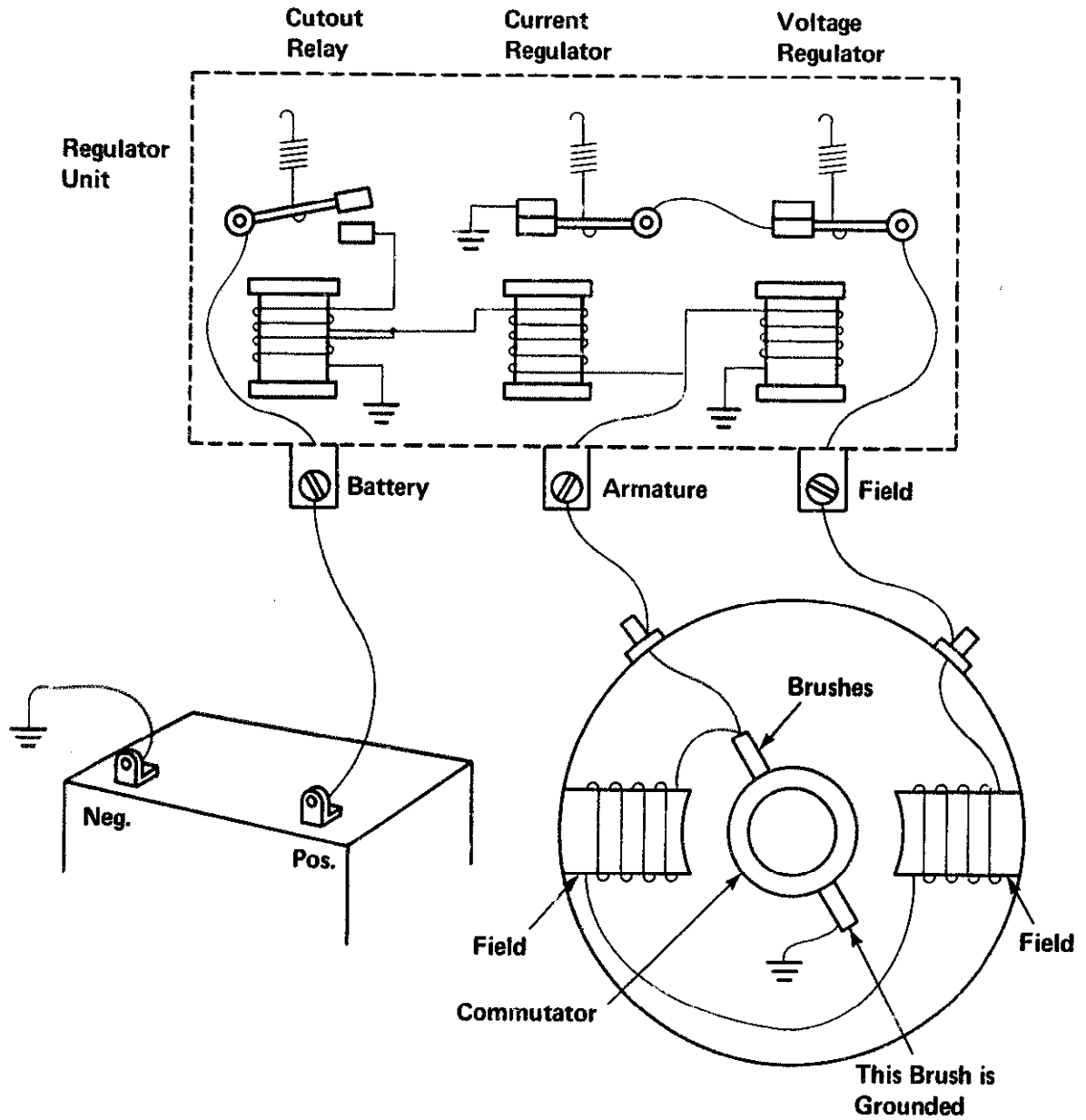


Chart 97

THE GENERATOR CHARGING CIRCUIT

The strength of the magnetic field created by the field windings determines the amount of current that will be induced in the armature windings at any speed. Turning the generator faster also increases output. In order to produce a strong magnetic field, the field windings must be connected to the battery.

Trace the field winding circuit. One wire from the windings goes to the generator "F" terminal which is connected to the "F" terminal on the regulator unit. Inside the regulator unit the circuit passes through two sets of contacts to the engine ground. These contacts are spring held in the closed position so that the field is now connected to the battery negative terminal through the engine ground.

The other winding lead is connected to the positive brush which in turn is connected to the generator "A" terminal. The generator "A" terminal is connected to the "ARM" terminal of the regulator unit where it is connected through the cutout relay to the battery positive terminal. Note that the cutout relay prevents the current from flowing through the field windings while the engine is not running.

1. If the cutout relay is open, the entire generator is disconnected from battery positive.
2. If either the current regulator contact points or the voltage regulator contact points open, the field windings will be disconnected from battery negative. Opening either of these contacts would turn the field OFF which would reduce the output of the generator.

The voltage regulator coil is connected to the generator output. The coil is magnetized by the generator output. When the output voltage becomes excessive, it pulls the contacts open and cuts down the field strength. Thus the generator output is reduced and the battery is protected from overcharge.

Output current passes through the current regulator coil. If the current flow becomes excessive, the contacts will be pulled open. Again, the field will be turned off and the generator output will be reduced, thus protecting the generator from overheating or burning out.

Chart 97 (continued)

THE GENERATOR CHARGING CIRCUIT

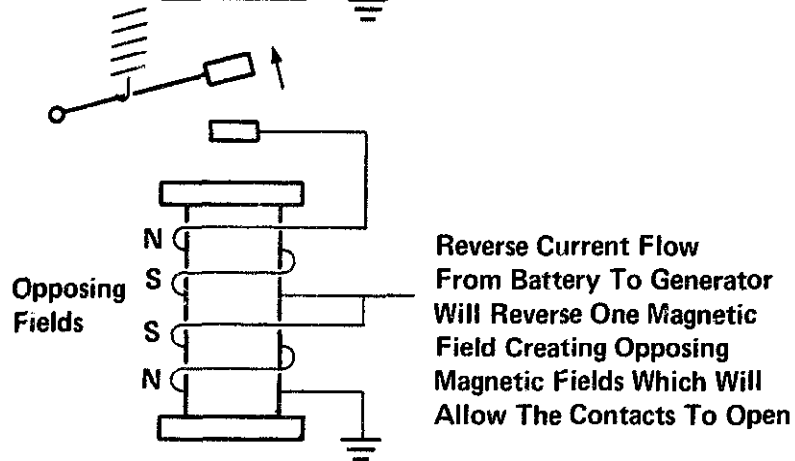
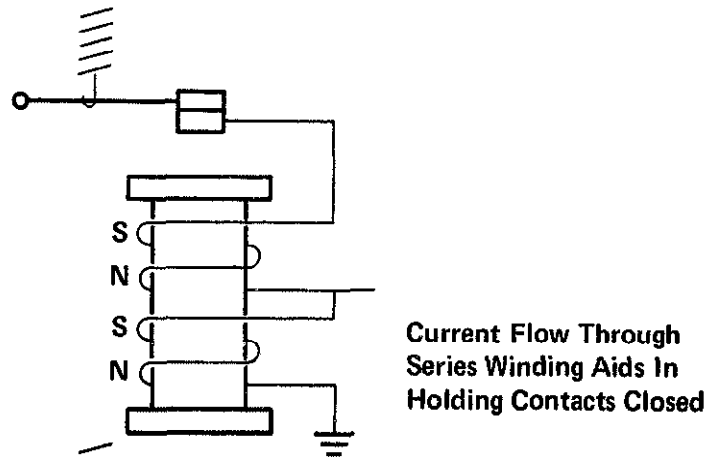
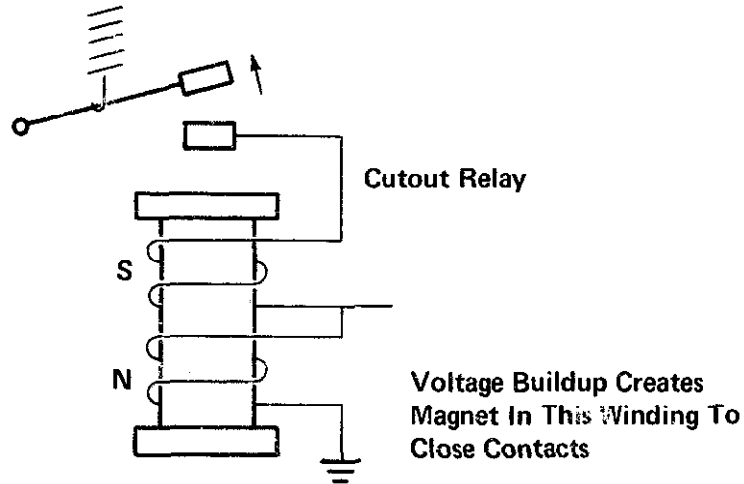


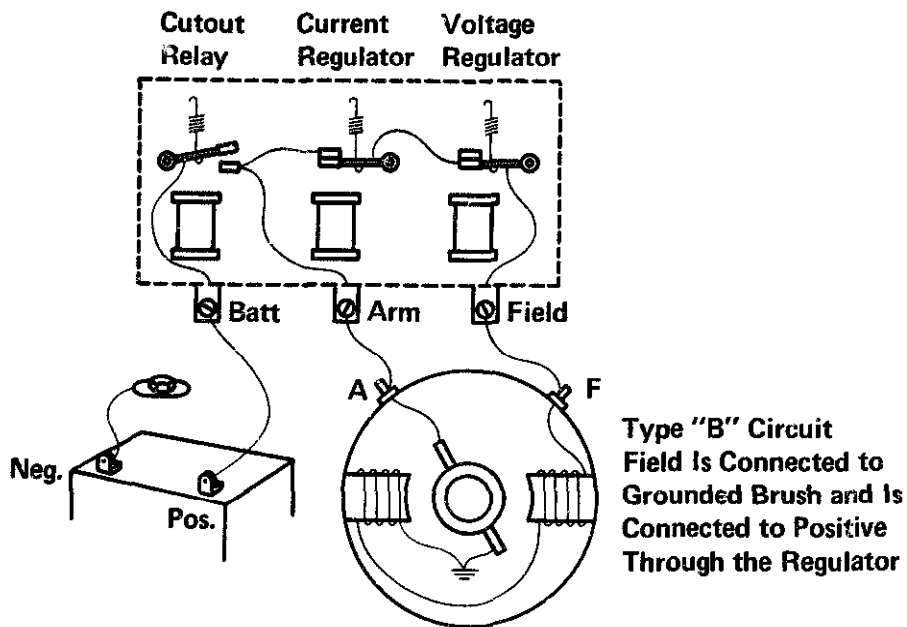
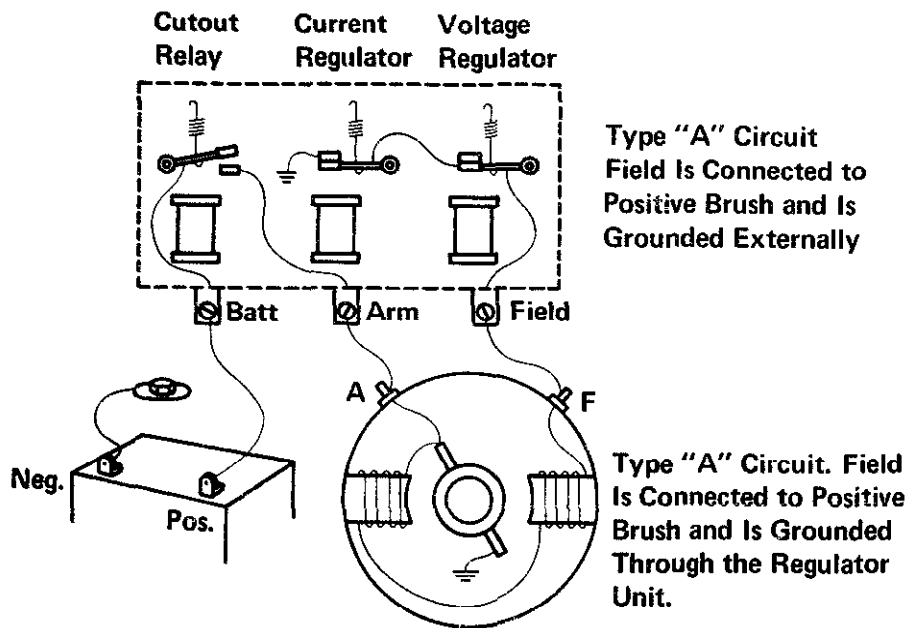
Chart 97 (continued)

THE GENERATOR CHARGING CIRCUIT

The cutout relay is held open by the spring and is normally open when the engine is OFF. The shunt winding of the cutout relay is connected to sense generator voltage. When the generator voltage is equal to the battery voltage (12.6), the cutout relay contacts are pulled closed by the shunt winding to connect the generator armature to the battery. Generator output current flow through the series winding adds to the magnetic pull of the shunt winding to help hold the cutout relay contacts closed. When the engine is stopped and generator voltage drops below the battery voltage, the current will momentarily flow backwards from the battery to the armature. This reverse flow through the series winding will create a magnetic field which will oppose the magnetic field of the shunt winding. This will open the cutout relay so that the battery will not continue to discharge through the armature winding while the engine is not running.

Chart 98

GENERATOR CIRCUIT VARIATIONS



GENERATOR CIRCUIT VARIATIONS

Although the end result is the same, some manufacturers connect the field to the positive brush and go to ground through the regulator. This circuit is referred to as the EXTERNAL GROUND or TYPE "A" circuit. Note that the field windings are not connected to battery positive and negative. Either the voltage regulator contacts or the current regulator contacts can disconnect the field winding from ground.

Some manufacturers connect the field to the grounded brush and connect the field to positive in the regulator. This circuit has an INTERNAL GROUND for the field and is a type "B" circuit. The regulator controls the field on the positive side of the circuit.

Whether the generator has a type "A" or type "B" circuit must be determined before tests are made. If a label on the generator or regulator does not specify this, consult the owner's manual or if the manual is not available, remove the generator end frame and determine whether a wire from the field windings is connected to the positive or grounded brush.

Chart 98 (continued)

GENERATOR CIRCUIT VARIATIONS

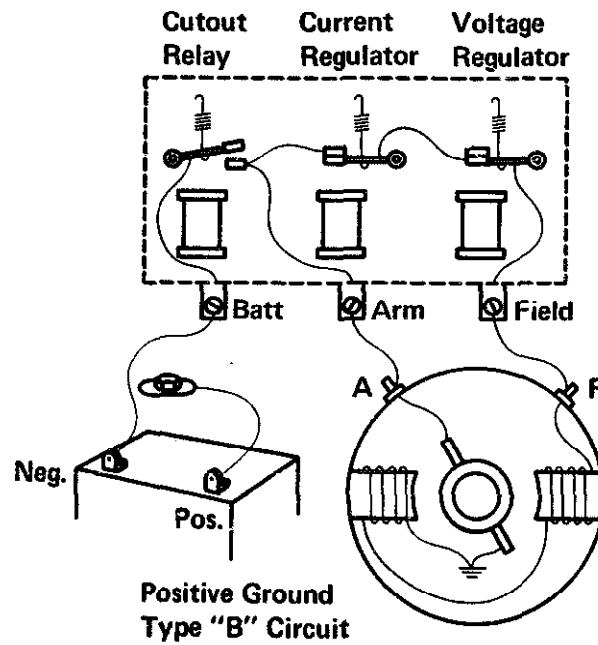


Chart 98 (continued)

GENERATOR CIRCUIT VARIATIONS

Some equipment manufacturers connect the batteries' POSITIVE terminal to the engine ground instead of to the negative terminal. Be sure to check this before removing the battery or making any tests on the charging circuit.

POLARIZING

Whenever leads have been disconnected from a generator for any reason, the generator should be polarized. This means briefly running the current flow through the field windings to make sure that the pole shoes are correctly magnetized. Reversed polarity may result in arcing and burning of the regulator contacts. On a type "A" circuit momentarily connect a jumper wire from the "B" or battery terminal of the regulator unit to the "A" or armature terminal. A quick touch is all that is needed. A small spark may be visible.

On a type "B" circuit it is necessary to remove the "F" or field wire from the regulator terminal and momentarily touch it to the "B" or battery terminal.

Polarize the generator after the leads are reconnected and before the engine is started. Do not attempt to polarize alternators.

Chart 99

THE GENERATOR AND ALTERNATOR COMPARED

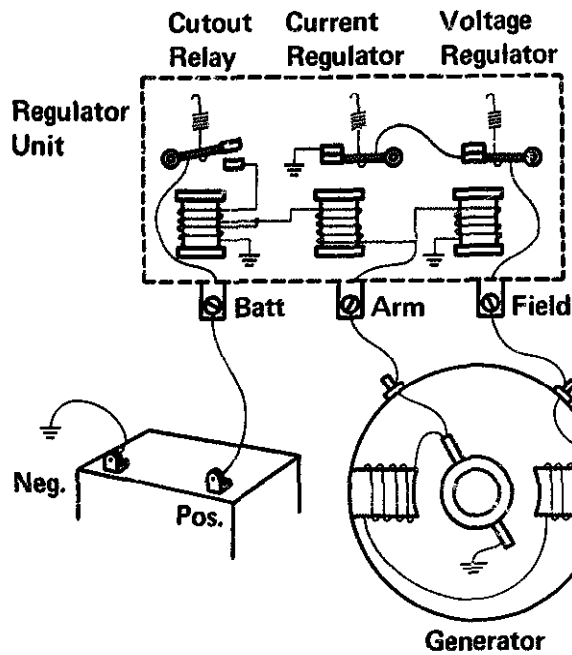
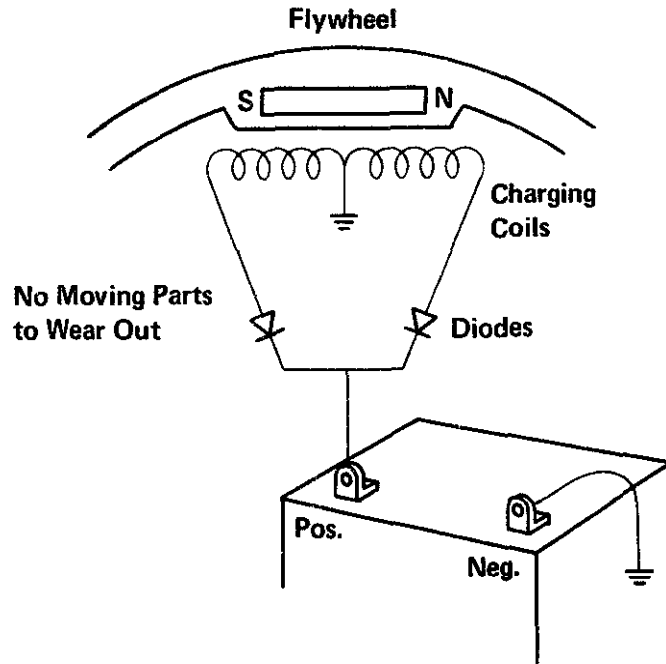


Chart 99

THE GENERATOR AND ALTERNATOR COMPARED

	GENERATOR CIRCUIT	ALTERNATOR CIRCUIT
Output	From the turning armature through the commutator and brushes. Limited by the amount of current the brushes can carry. Brushes must be replaced periodically.	From nonmoving stator windings. No limit to wire size or amount of current the stator could produce. Output travels through solid-state diodes. No moving parts in the output circuit.
Field	Two coils wound in series on pole shoes which retain residual magnetism. The generator can charge a dead battery.	On flywheel alternator systems a permanent magnet or magnets embedded in the flywheel. Limited output because of limited magnetic field. On externally mounted alternators the rotor is an electromagnet powered by the battery.
Voltage regulation	Must have a voltage regulator.	On low output units, not needed because of limited output. Output can be reduced manually if overcharging occurs. Larger models need voltage regulation to prevent overcharging. Usually in solid-state module.
Current regulation	Must have current regulator to prevent generator overheating or burning out.	Self-regulating.
Cutout	Must have cutout relay to prevent battery from discharging through field when engine not running.	Diodes prevent return flow of current.
Dependability	Commutator must be turned occasionally. Brushes must be replaced occasionally. Contacts in the regulator burn out. Bearings fail.	Diodes are damaged by misuse. Flywheel magnets destroyed by misuse. On externally mounted types bearings may fail.
Polarity	May be type "A" or type "B" field circuit. May be negative ground or positive ground.	Flywheel alternator has no field circuit. Always negative ground.

Chart 100

BASIC GENERATOR TESTS

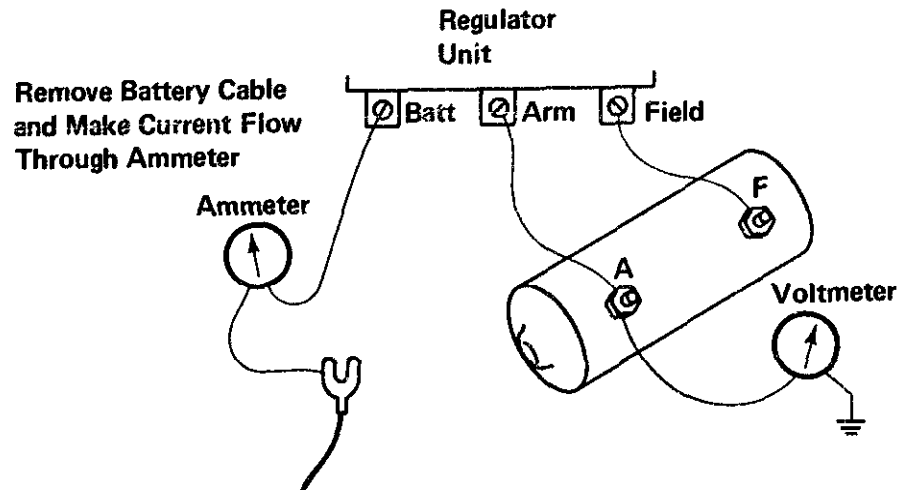
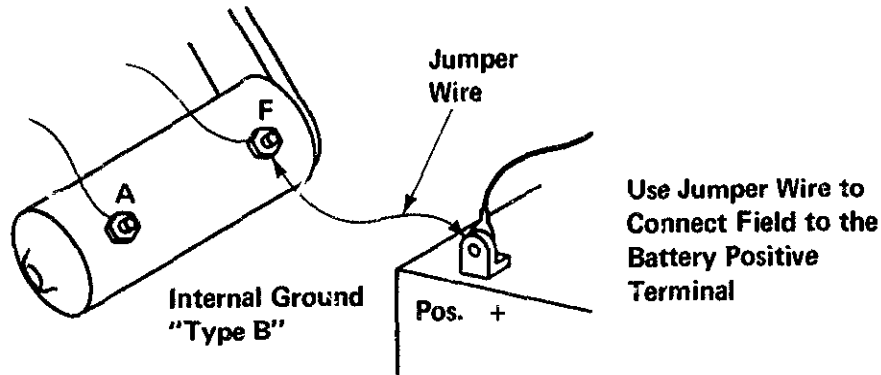
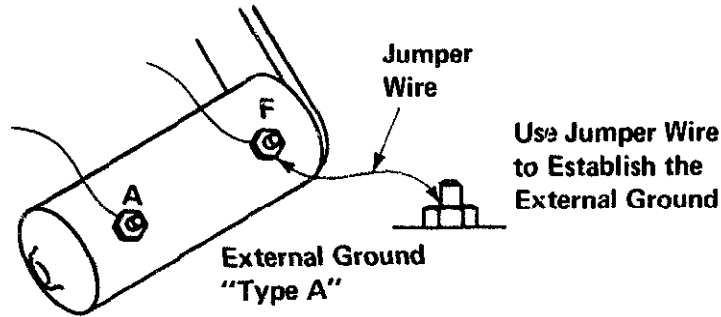


Chart 100

BASIC GENERATOR TESTS

Without going into a great deal of detail, basic generator tests can be made that will usually determine whether it is the generator or regulator unit that is defective.

POSITIVE OR NEGATIVE GROUND

Determine the ground polarity of the unit by checking the battery ground cable. On some equipment the positive battery post is connected to ground; on others the battery negative is connected to ground. If the battery has been removed, look for decals on the equipment which might tell ground polarity. If there are no decals, the manufacturer's manual should be consulted.

Ground polarity _____

INTERNALLY OR EXTERNALLY GROUNDED FIELD

Look for a decal on the generator or regulator which might give this information or consult the owner's manual or service manual if one is available. If these are not available, the type ground can be determined by removing the end from the generator and by checking the field wire connection.

Type ground circuit _____

BYPASS THE REGULATOR

Adjust the engine speed to a fast idle. **DO NOT** accelerate the engine during these tests! Connect a jumper wire from the field terminal to a good engine ground if the generator has an externally grounded field. This eliminates the regulator from the circuit. If the generator is good, it should charge now. Internally grounded generators are bypassed by connecting the jumper to the positive battery terminal and to the field terminal.

If the equipment being tested does not have an ammeter, either a voltmeter or ammeter may be connected as shown at left to determine if the generator is charging. Connect the voltmeter to the generator output terminal and engine ground. Observe polarity when connecting voltmeter. If the generator is charging, the voltage will rise when the engine is speeded up from slow idle to fast idle.

If an ammeter is used, remove the cable from the regulator's BATTERY terminal and connect the ammeter between the regulator terminal and the cable that just has been disconnected so that the current will flow through the ammeter.

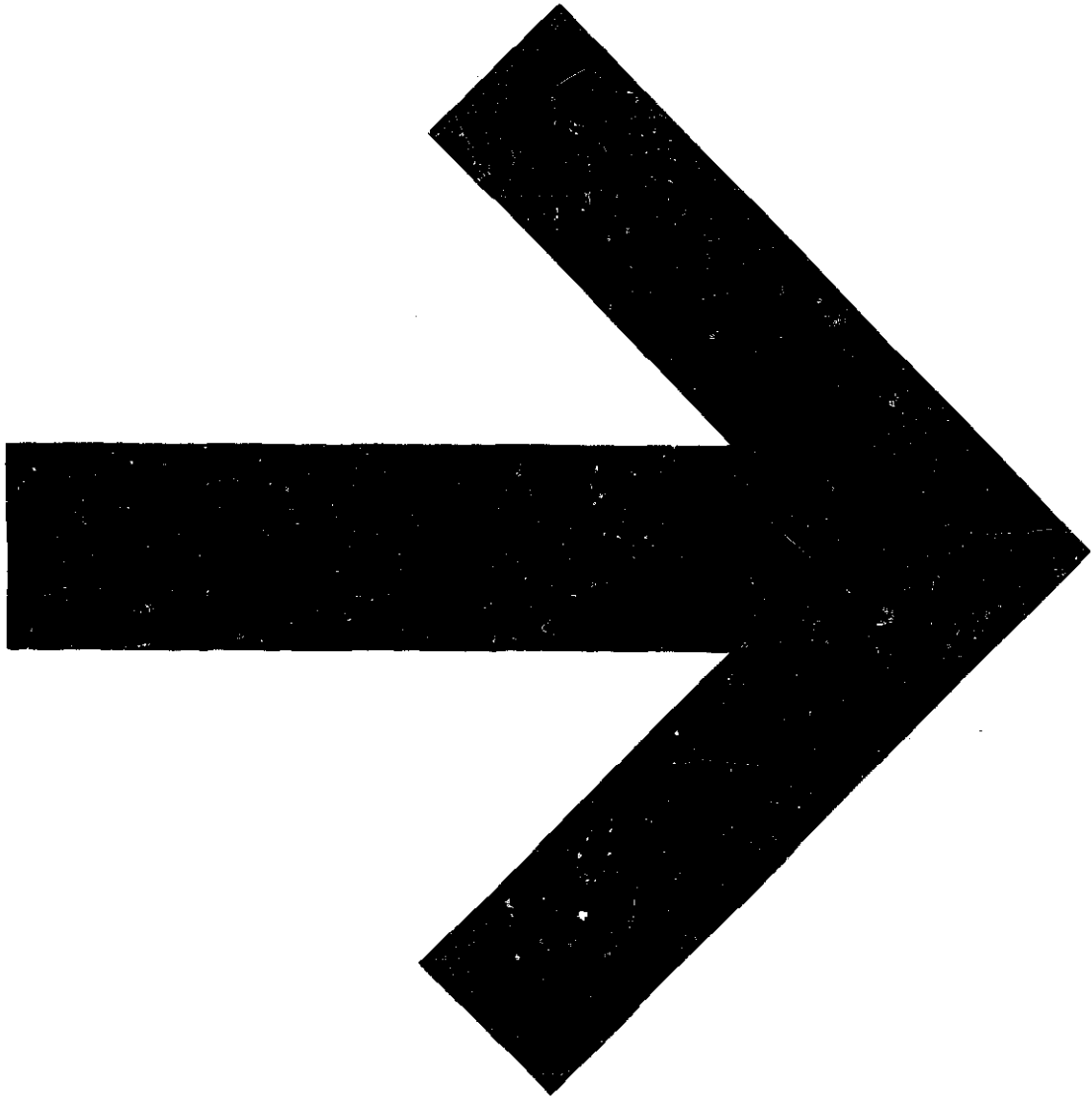
TEST RESULTS

If a charge is indicated when the jumper wire is connected at fast idle, the generator is good and the problem is the regulator unit or *wiring*. Check the wiring for bad connections.

No charge at fast idle with the jumper connected indicates that the generator will not charge and must be repaired or replaced.

Questions for Section VII

- T F** 1. Electromagnets are usually wound on laminated layers of soft iron to reduce heat. (Chart 84)
- T F** 2. If rust bridges across the laminations of an electromagnet, its efficiency may be greatly reduced. (Chart 84)
- T F** 3. A generator is a device which changes mechanical energy to either AC or DC electricity. (Chart 87)
- T F** 4. An ammeter must be connected *in* the circuit so that current flows through the meter. (Chart 87)
- T F** 5. Alternating current cannot be used to charge a battery. (Chart 88)
- T F** 6. Diodes are rated according to their maximum current and maximum temperature. (Chart 89)
- T F** 7. A diode is like an electrical switch which closes to pass current freely in one direction and opens to stop current flow in the other direction. (Chart 89)
- T F** 8. Some diodes require a heat sink. (Chart 89)
- T F** 9. A diode can change AC current to pulsating DC. (Chart 90)
- T F** 10. When the engine is used as electrical ground, current will actually pass through the engine block. (Chart 91)
- T F** 11. Under no circumstance should the positive battery terminal be connected to ground. (Chart 91)
- T F** 12. Flywheel alternators may not have a current regulator or a voltage regulator. (Chart 91)
- T F** 13. If the battery loses water on a flywheel alternator system, removal of one diode may correct the problem. (Chart 91)
- T F** 14. Flywheel alternators require a cutout relay. (Chart 91)
- T F** 15. The power source for the AC lighting system is similar to the flywheel alternator without the rectifying diodes. (Chart 95)
16. Describe the three basic types of magnets. (Chart 84)
17. List three ways a permanent magnet can be destroyed. (Chart 84)
18. Name three ways the strength of an electromagnet can be increased. (Chart 85)
19. What is meant by residual magnetism? How is it achieved? What is a practical application? (Chart 86)
20. What are the three jobs commonly performed by the regulator unit of a DC generator? (Chart 87)
21. Draw or build a diode tester. Connect the diode both ways and explain the results. (Chart 91)
22. What happens if the cutout relay sticks shut as the engine is stopped? (Chart 97)
23. Describe polarizing a generator. (Chart 98)
24. When is it necessary to polarize a generator? (Chart 98)



INDEX

A

AC lighting circuit, 231
Adjustments:
 armature air gap, 53
 breaker points, 49, 51
 carburetor, 25, 67, 69
 connecting rod, 139, 171
 crankshaft end play, 141
 spark plug, 33
 timing, 55
 valve, 143
Air cleaner service, 81
Air-fuel mixture, 25, 65
Alternators, 219, 221, 229
Armature air gap, 53
Assembly, 93, 133, 141

B

Basic engine, 3
Battery, 18 i
Battery storage, 83
Breaker points, 35, 41, 49
Breaker points replace, 51

C

Camshaft checks, 125
Carburetion, 63
Carburetor adjustments, 25, 67, 69
Carburetor circuits, 65, 67, 69
Carburetor service, 79
Charging circuit, 211, 213
Cleaning, 31, 53, 99, 157
Combustion, 5
Compression stroke, 11
Compression testing, 21
Condenser, 35
Cooling system, 31
Crankshaft checks, 103, 121, 163
Crankshaft end play, 141
Current, 37
Cylinder measurements, 111, 163

D

Dial indicator, 89
Diodes, 215, 219
Disassemble precautions, 93

E

Electrical terms, 37, 39
Electronic ignition, 57, 59

Engine identification, 7
Engine systems, 3
Exhaust stroke, 15

F

Feeler gauge, 89
Flywheel inspection, 47
Flywheel removal, 45
Four-stroke cycle, 9, 11, 13, 15
Fuel mixture, 5
Fuel pump, 71, 73

G

Gasket removal, 97
Generator, 233, 235
Generator circuits, 239
Governors, 75

H

Head gasket replacement, 97
Head replace, 93, 145

I

Ignition circuit, 35
Ignition, electronic, 57, 59
Ignition primary circuit, 41
Ignition timing, 55
Intake stroke, 9

L

Lubrication, 29

M

Magnetism, 39, 205, 207, 209
Main bearing, 125
Measuring devices, 89, 91
Micrometer, 91
Model number, 7

O

Oil, 29

P

Piston checks, 115, 165
Piston pin, 119, 165, 169
Piston removal, 107
Piston rings, 137, 167, 169
Power stroke, 13
Principles of combustion, 5

R

Reassembly 135, 141
Reed valve service, 155
Ring ridge removal, 101
Rings, 137

S

SCR, 57, 59
Secondary voltage, 43
Serial number, 7
Spark plug, 33
Spark plug gap, 33, 89
Spark testing, 23
Speed controls, 75
Starters, electric, 193
Starter-generators, 197
Starters, rewind, 189, 191
Storage, 83

T

Telescoping gauge, 89
Tests:
 alternator, 223
 battery, 173, 183, 185, 187
 bearing, 125
 camshaft, 125
 compression, 21
 connecting rod, 119
 crankcase air leaks, 153
 crankshaft, 103, 121
 cylinder, 111
 diode, 215, 227

flywheel magnet, 47
fuel, 77
generator, 243, 245
piston, 115, 167
piston pin, 119
reed valve, 155
rings, 137
spark, 23
spark plug, 33
starter, 195
starter-generator, 199
two-stroke, 153
valve guide, 127
valve lifter, 127
valve seat, 129
Timing, 31, 55
Two-stroke components, 151
Two-stroke cycle, 17
Two-stroke overhaul, 157

V

Valve adjust, 143
Valve guides, 127
Valve install, 143
Valve lifters, 127
Valve removal, 103
Valve seats, 129
Valve service, 131
Venturi, 65
Voltage, 37

W

Winter storage, 83