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## How to Repair Briggs & Stratton Engines

by: Paul Dempsey

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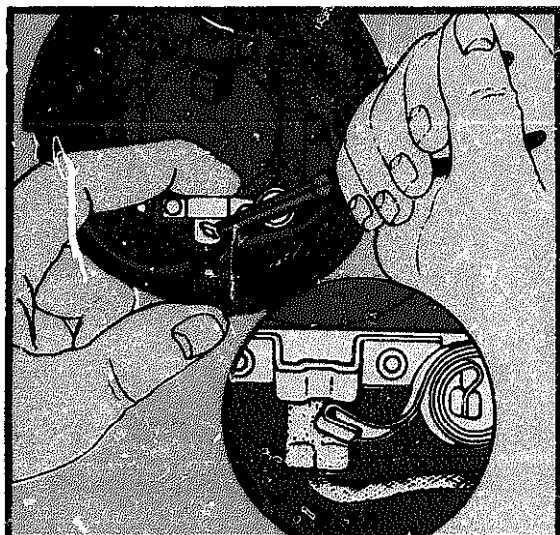
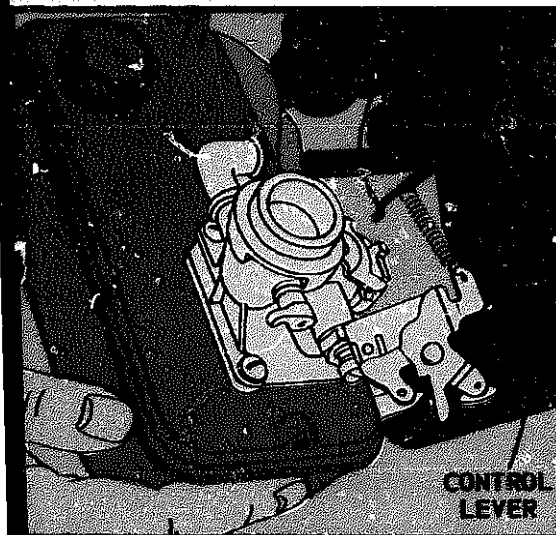
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# How to Repair Briggs & Stratton Engines

A step-by-step guide to understanding, tuning, adjusting, repairing, and overhauling.



**By Paul Dempsey**

# How to Repair Briggs & Stratton Engines

By Paul Dempsey

Now you can maintain and repair any Briggs & Stratton small gasoline engine! Everything you need to know is here in do-it-yourselfer's language, from simple tune-up and carburetor repairs to the serious business of replacing main bearings and resizing cylinder bores.

You'll quickly see how an engine works, how each system—ignition, fuel, lubrication, and cooling—contribute to the proper operation of an engine. And where possible, adjustment and repair procedures appear in step-by-step order.

Special emphasis is given to unique Briggs & Stratton features: the Pulsa- and Vacu-Jet carburetors, the starter clutch, and the vertical-pull starter. And, while Briggs & Stratton engines are work-horses, intended to perform with maximum reliability, they can be made into screamers. Indeed, Briggs & Stratton dominates four-cycle go-cart racing, and given the right preparation, run with the better two cycles. For readers who are interested, material is included on hop-up techniques.

**Paul Dempsey** is a master mechanic and veteran engine/automotive journalist. He is the author of many of the related titles appearing below.

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# **How to Repair Briggs & Stratton Engines**

**By Paul Dempsey**

**TAB BOOKS**

**BLUE RIDGE SUMMIT, PA. 17214**

FIRST EDITION

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## PREFACE

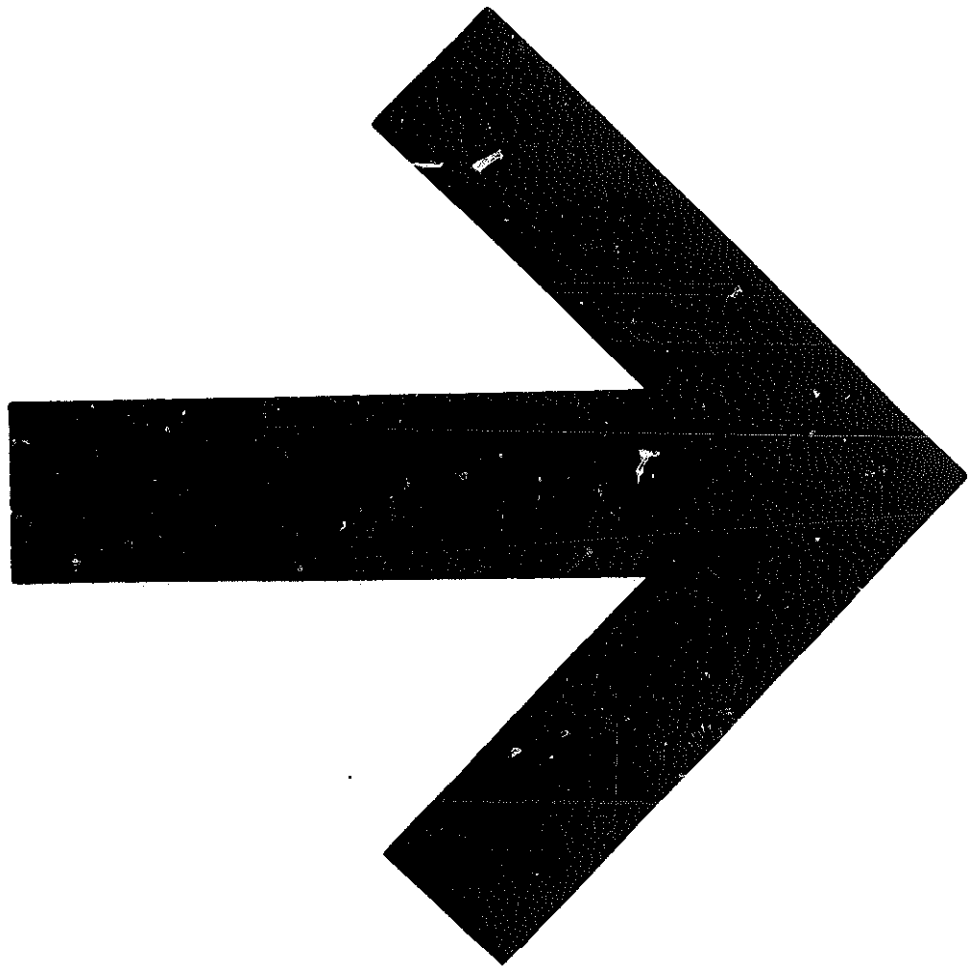
This book describes repair and maintenance procedures for all current and many obsolete Briggs & Stratton engines. These procedures extend to all phases of the work, from simple tune-up and carburetor repairs to the serious business of replacing main bearings and resizing cylinder bores. The material is organized by subject and by engine model, and as much as possible, divided into steps that are easy to follow.

An old mechanic once remarked that he could repair only what he understood. With this in mind, the engine and each of its support systems—ignition, fuel, lubrication, and cooling—is described in functional terms. Special emphasis is given to the unique characteristics of Briggs & Stratton technology; that is, the Pulsa-Jet and Vacu-Jet carburetors, the starter clutch, and the vertical pull starter.

While Briggs & Stratton engines are workhorses intended to perform their humble tasks with maximum reliability and decades between overhauls, they can be made into screamers. Indeed, Briggs & Stratton engines dominate four cycle go-cart racing, and given the right preparation, run with the better two cycle engines. For readers who are interested, some material is included on hop-up techniques.

Paul Dempsey





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# CHAPTER 1

## BASICS

During its lengthy history, Briggs & Stratton has confined itself to single-cylinder, air-cooled, four-stroke-cycle engines. Displacements have ranged from five to thirty-two cubic inches.

### NOMENCLATURE

Figure 1-1 illustrates a very simple single-cylinder engine. The piston slides up and down in the cylinder bore and is linked to the crankshaft by means of a connecting rod. Timing gears synchronize valve action to piston movement. This example, similar to Briggs engines, has a single cylinder and is cooled by air moving over fins cast into the cylinder barrel and head.

The piston, rod, and crankpin produce the engine power. The connecting rod is split at the lower, or big, end for accessibility. The small end, sometimes called the rod eye, is detached from the piston by retracting the piston pin. The rod is made of aluminum and has no bushings or bearings.

### THE FOUR-CYCLE ENGINE

Four-stroke-cycle engines require four up-and-down strokes of the piston (or two crankshaft revolutions) to complete one cycle of operation. Figure 1-2A depicts the first, or intake stroke. As the piston falls, fuel and air rush past the open intake valve to fill the

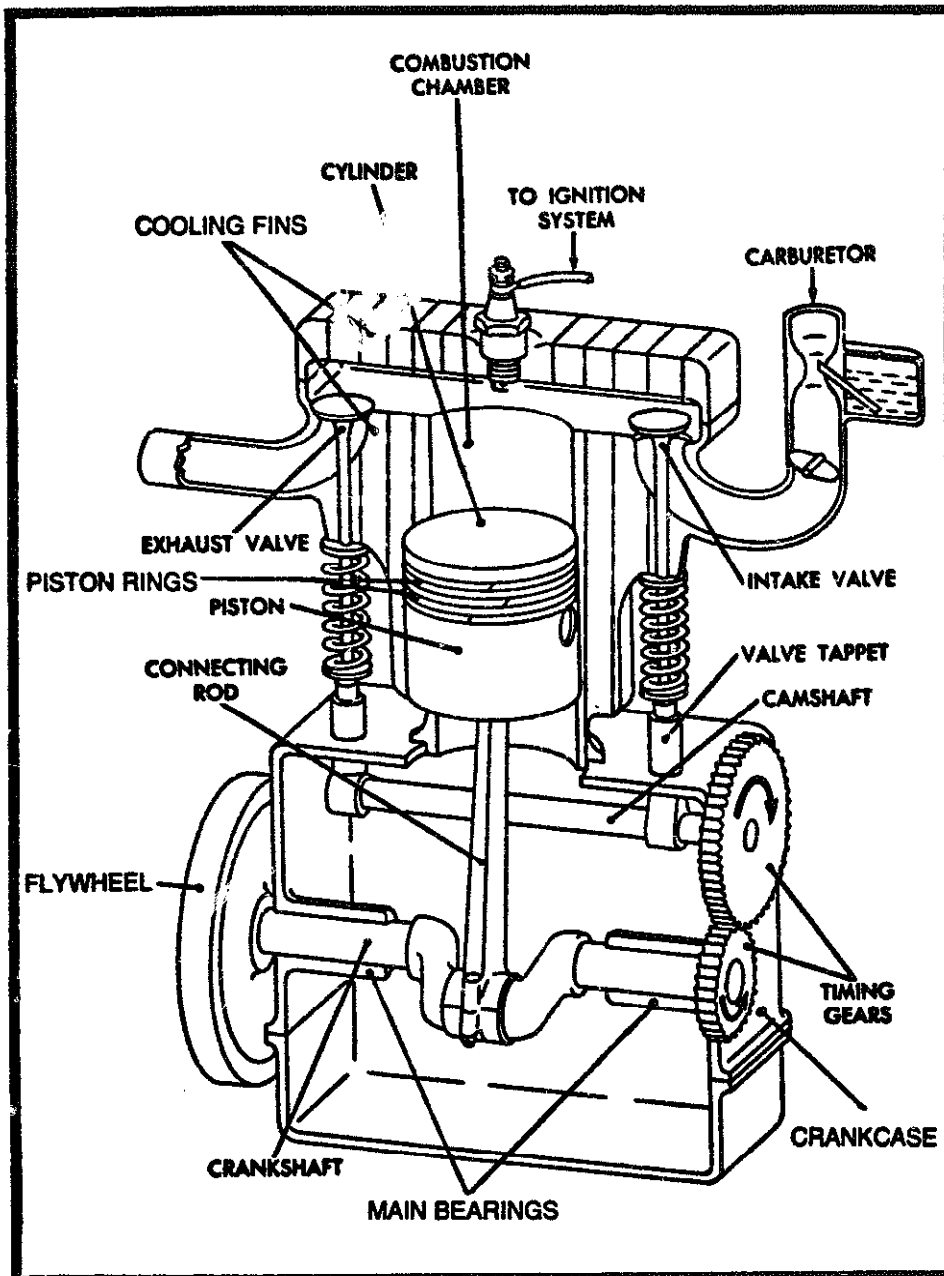


Fig. 1-1. Engine nomenclature.

cylinder. The piston reaches bottom dead center (BDC), or the lower limit of its stroke, and impelled by the inertia stored in the flywheel and crankshaft, continues past BDC and up to top dead center (TDC). As the piston climbs in the bore, the intake valve closes, trapping the fuel and air above the piston (Fig. 1-2B). This is the compression stroke and the prelude to combustion. Just before the piston reaches TDC, the spark plug fires, igniting the com-

pressed mixture. The piston is driven down by the explosion in the power stroke (Fig. 1-2C). This power stroke converts chemical energy into mechanical motion by burning the gasoline's hydrogen and carbon, mixed with the air's oxygen. This conversion of chemical energy to mechanical motion is the purpose of the engine. Near BDC the exhaust valve opens and the cylinder blows down (Fig. 1-2D). Those exhaust gases that are at higher than atmospheric pressure escape past the open valve. As the piston rounds BDC, it forces the heavier residues out in front of it, purging the cylinder for the next cycle that begins with the intake stroke.

For the engine to run properly, it must be cranked fast enough to create a vacuum on the intake stroke, the valves and piston must operate in phase and be reasonably gastight to hold compression, and the ignition spark must occur at the right time.

### **ENGINE POWER**

The bore, or the diameter of the cylinder, and the stroke, or the distance the piston travels from bottom to top dead centers, are the basic engine dimensions (Fig. 1-3). These dimensions determine the displacement, or swept volume, of the cylinder, but do not include the clearance volume above the piston at top dead center. The swept volume of the cylinder, representing the volume of air the engine should "inhale" during the intake stroke, is calculated by the following formula:

$$\text{Bore} \times \text{Bore} \times \text{Stroke} \times 0.7854 \times \text{Number of Cylinders} = \text{Displacement.}$$

If the bore and stroke dimensions are in inches, displacement is expressed in cubic inches, and if in millimeters, the displacement is expressed in cubic centimeters. While Briggs & Stratton continues to use the inch system, some competitors have not. It is useful to remember that one cubic inch equals 16.387 cubic centimeters. Thus an 11-cubic inch engine displaces 180.26 cubic centimeters.

Displacement is important because it is an index to engine power. All things being equal, within the limits of rpm, volumetric efficiencies and compression ratios tend to be relatively constant among small engines. The greater the displacement, the more powerful and fuel-hungry the engine. Thus a ten-cubic-inch Briggs &

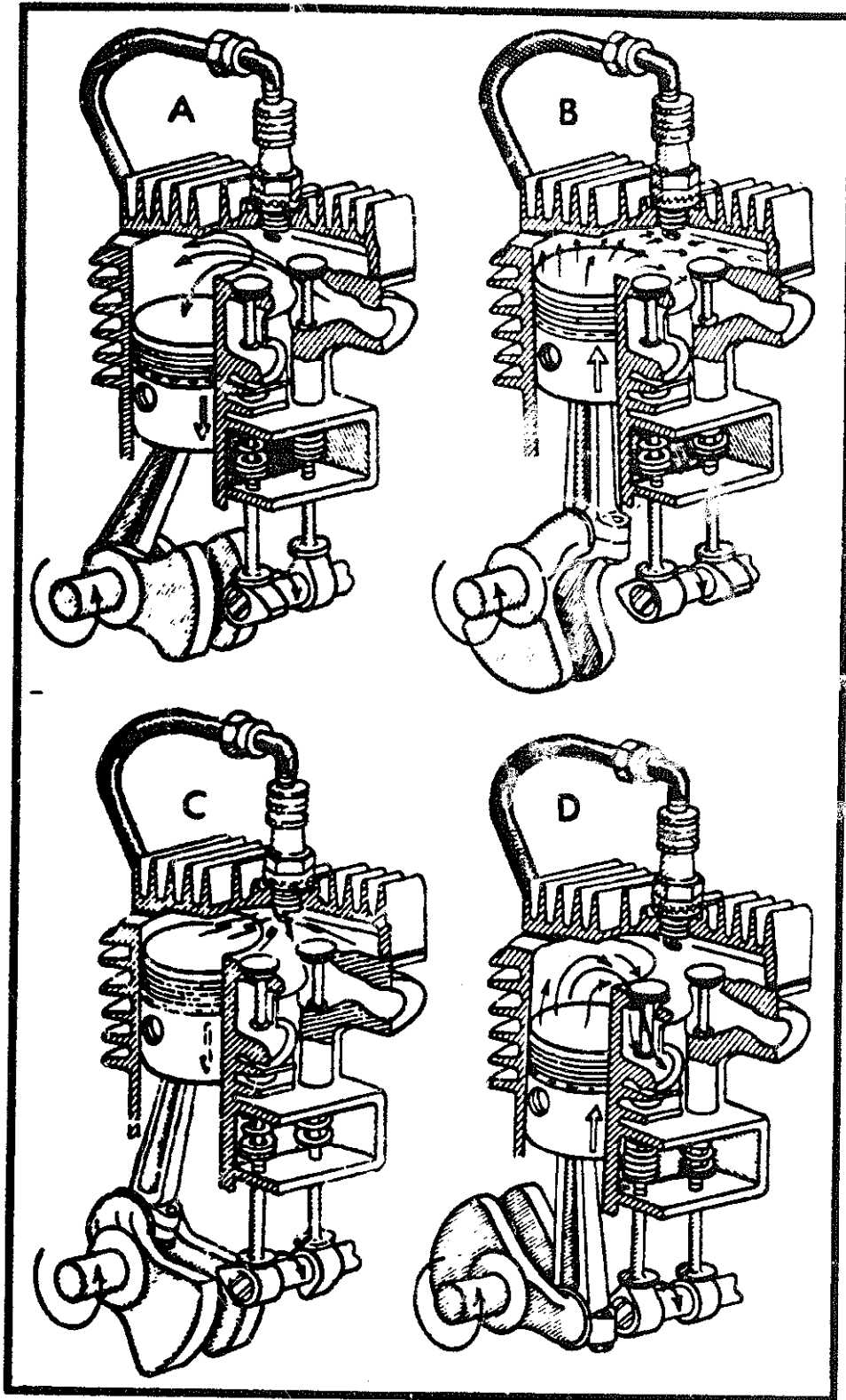


Fig. 1-2. The four-stroke cycle: A.—intake; B.—compression; C.—power, or expansion; D.—exhaust. (Courtesy Tecumseh Products Co.)

Stratton engine (equivalent to  $10 \times 16.387 = 163.87$  cc) should outwork a 144 cubic centimeter Tecumseh engine.

Besides engine displacement, engine power is related to horsepower, volumetric efficiency, and compression ratio. Horsepower depends partially upon crankshaft revolutions per minute. However, small industrial and utility engines are governed very conservatively

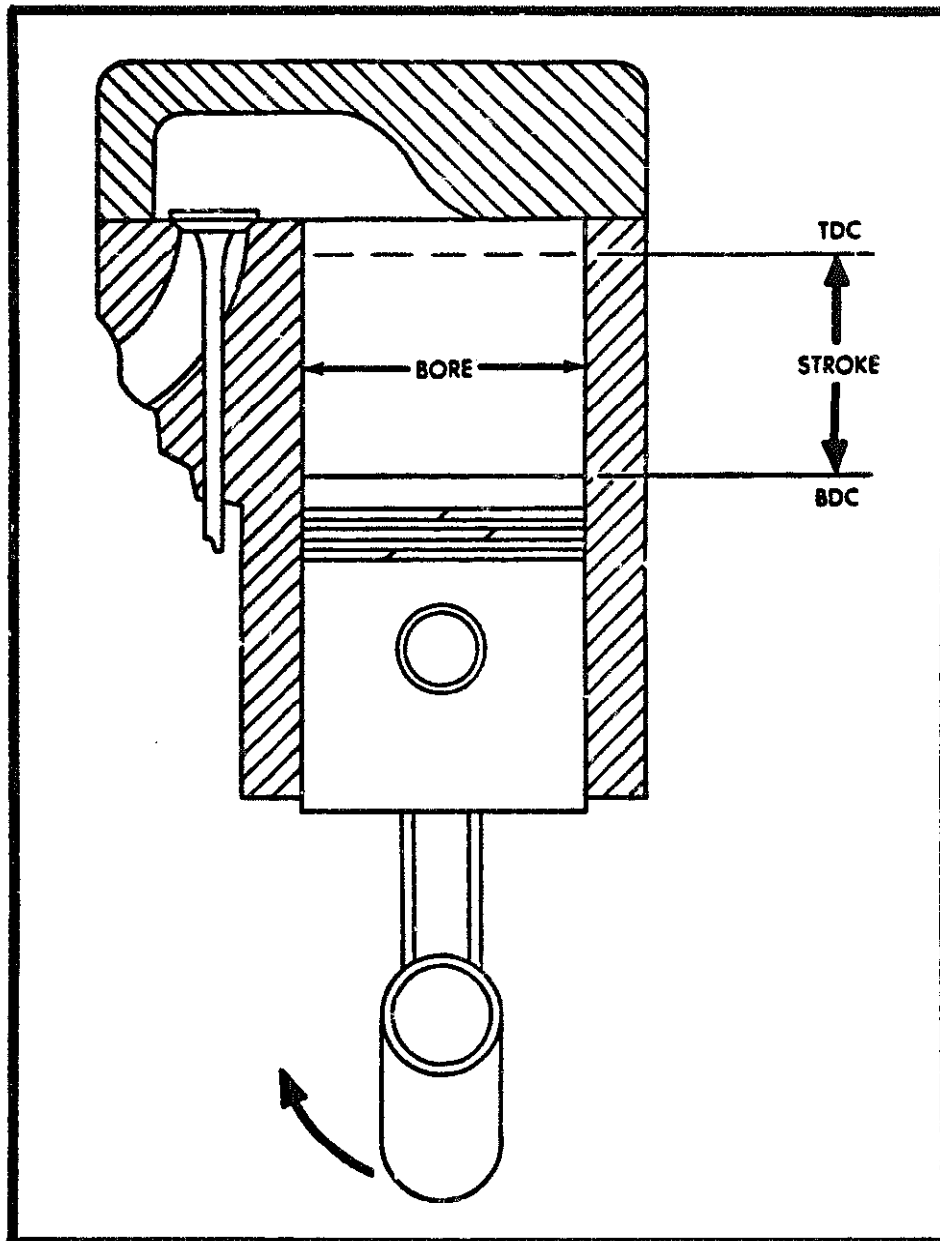
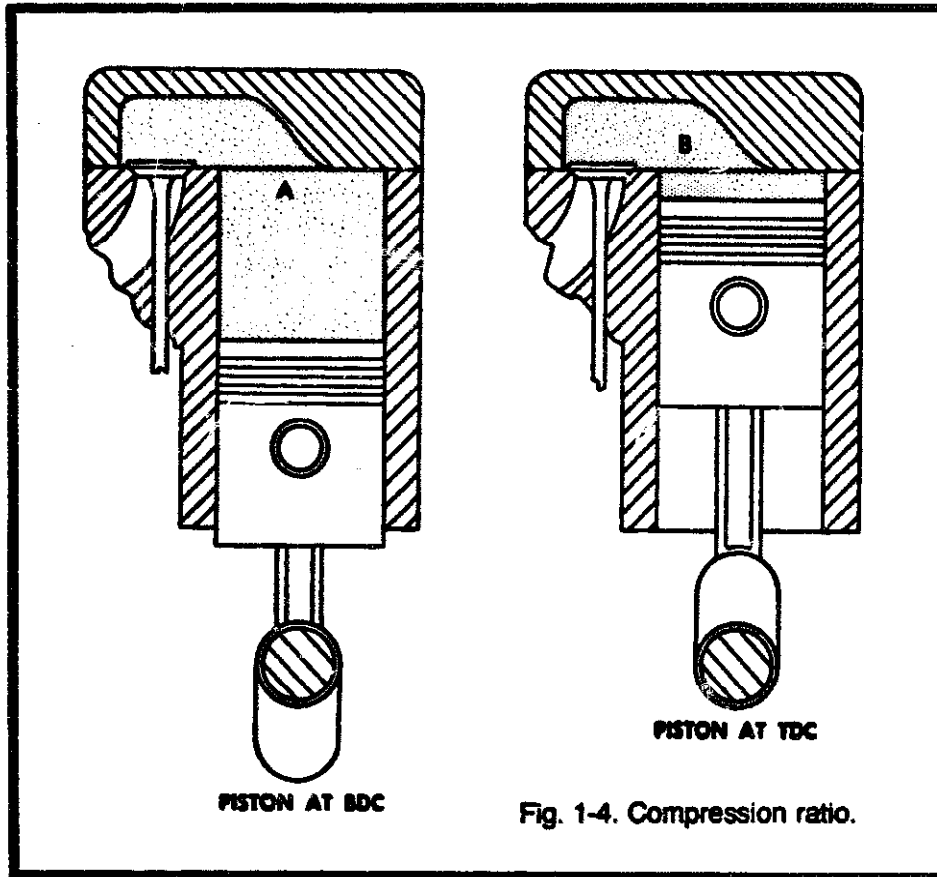


Fig. 1-3. Piston bore and stroke. These dimensions determine the displacement, or swept volume, of the cylinder, but do not include the clearance volume above the piston at top dead center.





to increase durability and, in the case of rotary lawnmowers, to prevent the blade tips from exceeding the speed of sound. The volumetric efficiency is a theoretical measure of how well the cylinder fills during the intake stroke. The compression ratio is a measure of how much "squeeze" is put on the air-fuel mixture before ignition. This ratio is the volume of the cylinder with the piston at bottom dead center divided by the volume at top dead center (Fig. 1-4). Within limits set by the shape of the combustion chamber and the propensity of gasoline to explode spontaneously, the higher the compression ratio, the greater the energy released against the face of the piston.

## ENGINE PROTECTION

### Cooling

Briggs & Stratton engines are fan cooled. The flywheel doubles as a centrifugal fan: air is sucked into the flywheel hub area through the inlet screen and expelled into the sheet metal shroud by impeller

blades cast in the flywheel rim (Fig. 1-5). The shroud conducts the air stream over the cylinder head cooling fins.

It is important that the inlet screen and fins be clean. Dust accumulations on the screen can be washed off with detergent and water. Carbon deposits on the fins respond best to wire brushing, although you can use oven cleaner on iron parts. Gunk Hydroseal works on both aluminum and iron, and is available at airports.

### Lubrication

Oil is stored in the crankcase and distributed about by means of a dipper hung below the connecting rod, or on aluminum engines, by means of a slinger (Fig. 1-6). The slinger is driven by the camshaft. While splash lubrication is considered primitive, the Briggs system has proved adequate in go-cart racing, where engine power is increased by a factor of five.

But splash systems are sensitive. Since no pump is fitted, a filter is impractical and the oil must be changed at frequent intervals. Under normal conditions Briggs recommend 25 hours between oil changes. Use grade SE30 for summer operation (or if the straight weight is not available, 10W-30 or 10W-40). In winter use 10W-30 or 10W-40. Below 0 degrees Fahrenheit, dilute 10W or 10W-30 10% with kerosene. With the engine on a level surface, the oil should reach the top thread of the filler plug or, on engines with a

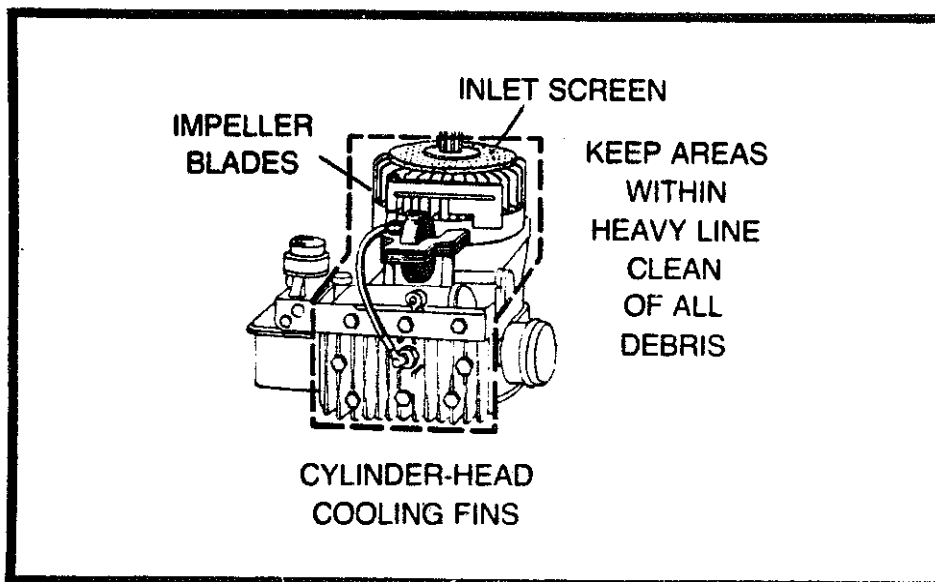


Fig. 1-5. Inlet screen and cooling fins. (Courtesy Briggs & Stratton Corp.)

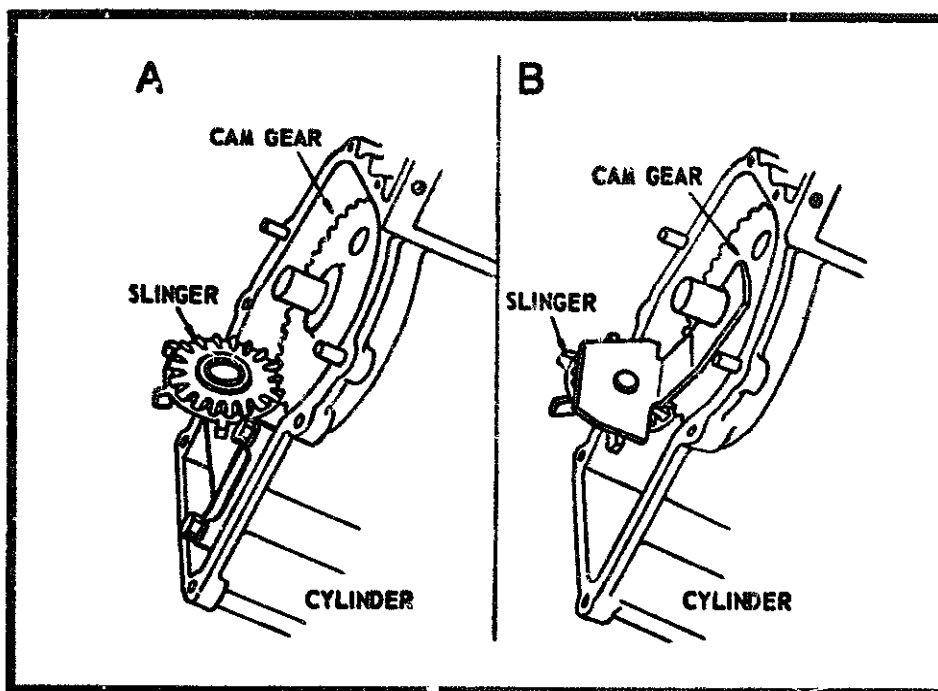


Fig. 1-6. Early Briggs slingers are supported on aluminum die castings (A); late production slingers ride on a sheet-steel bracket (B).

dipstick, the *full* mark. Overfilling costs power, smokes the exhaust, and can blow a seal. Underfilling (and these engines use oil, even when new) will ruin the crankshaft and connecting rod.

Because a splash system does not control the amount of oil thrown about, the crankcase must be kept under a slight vacuum. Oil vapor must be able to escape, but little or no air should enter. If the crankcase is at atmospheric pressure, oil will be driven past the piston rings and into the combustion chamber. The breather (a kind of check valve) must be functional and the crankcase should be airtight.

### ENGINE IDENTIFICATION

All engines carry a number plate on the flywheel shroud or have the number stamped indelibly on the shroud. With early models, it was sufficient to identify the engine by number alone, or a number and letter. The number represented engine displacement in cubic inches. Some aluminum engines were identified with the letter *B*; *N* was used to distinguish iron. Thus a 6B engine was cast aluminum and displaced six cubic inches; a 6N engine had an identical bore and stroke, but was cast in iron.

Briggs & Stratton continues the practice of reserving the first slot in the identification number for displacement, but has expanded the code to encompass design variations unheard of twenty years ago. The first digit after the displacement is the design series and refers to the overall configuration, ignition hardware, and cylinder construction. Numbers 1, 2, 3, and 4 mean a horizontal crank engine with carburetor and governor variants; numbers 5, 7, and 9 refer to carburetor options on vertical crank blocks. Zero, 6, and 8 are open at present, intended perhaps for the long rumored twin cylinder. The third digit after the displacement identifies the type of main bearings and whether reduction gears or auxiliary power takeoffs are fitted. The final digit represents the type of starter—rope, rewind, impulse, AC or DC.

As sometimes happens, the original number plate is lost, or the shroud has been replaced by another. You can determine the displacement by measuring the bore and stroke and plugging these values into the equation given under "Engine Power." This will at least give your parts supplier a clue to identifying your engine. Be sure, however, to compare the parts he selects against the originals.

## **CHAPTER 2**

# **IGNITION**

The ignition system is the most troublesome part of an engine, accounting for more than 80% of an engine's malfunctions. The timing is fixed, but Briggs & Stratton engines have two and, on the more sophisticated designs, three adjustments, all of which are critical.

### **THE MAGNETO**

Briggs & Stratton engines are sparked by magnetos, devices that combine the function of a high voltage generator and an ignition coil. Since most engine failure involves the magneto, some understanding of the mechanism is necessary for the mechanic.

Figure 2-1 illustrates the magneto assembly used on most Briggs & Stratton engines. In this case the breaker, or contact points, are housed under the flywheel and cammed open by the crankshaft. The movable contact in this and most other Briggs & Stratton designs is driven by a plunger to isolate it from side forces developed by the crankshaft cam. Competitive engines do not have this feature.

The magnets are cast into the outer rim of the flywheel. Other designs have the points mounted outside the flywheel where they are triggered by the camshaft. Magnets are sometimes mounted in a rotor, a part that turns with the flywheel, but is distinct from it.

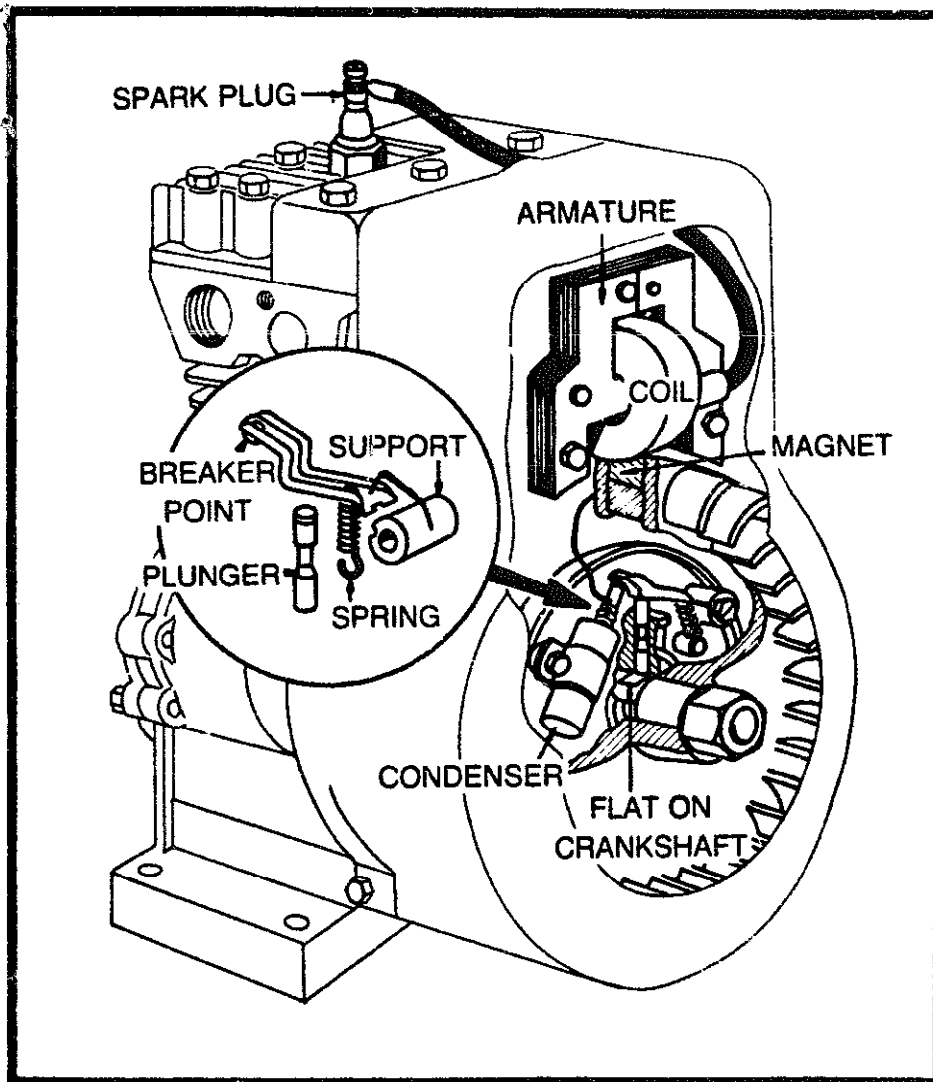


Fig. 2-1. Magneto nomenclature. The movable contact in this and most other Briggs & Stratton designs is driven by a plunger to isolate it from side forces developed by the crankshaft cam. Competitive engines do not have this feature.

Figure 2-2 pictures the wiring of the low voltage, or primary, side of the magneto. When the points are closed, the primary circuit is complete. Current flows from the coil windings through ground (the engine castings) and back through ground to the points and coil windings. When the points open, the circuit is broken and no primary current flows.

The condenser, or capacitor, is a kind of holding tank. Current that would arc across the points is momentarily stored in the condenser. When the points close, the condenser discharges through the primary windings to ground.

Current is generated by the interaction between magnetic force and the primary windings. Each of the flywheel magnets is surrounded by a swarming force field. When these fields pass through the primary windings, a transformation takes place and electric current is generated. The intensity of the current depends upon how rapidly the fields move (which is why the crankshaft must be turned 90 rpm or so to start the engine), and upon the distance between the coil and magnets. The greater the distance, the less efficient the magneto. At running speed, primary current is on the order of 2A with an electrical pressure of about 170V.

However, primary current is insufficient to light the spark plug. For that we need at least 6,000V and preferably 10,000V. The task of boosting primary voltage and delivering it to the spark plug is accomplished by the secondary circuit. The secondary winding, consisting of several thousand turns of hair-fine wire, is impressed over the coil's primary winding (Fig. 2-3). One end of the secondary is grounded and the other connects to the spark plug by way of the high tension lead.

Current flow is accompanied by a magnetic field at right angles to the conductor. The field can be concentrated by looping the conductor over a soft iron core, or armature. Iron acts as a kind of lens for the magnetic lines of force.

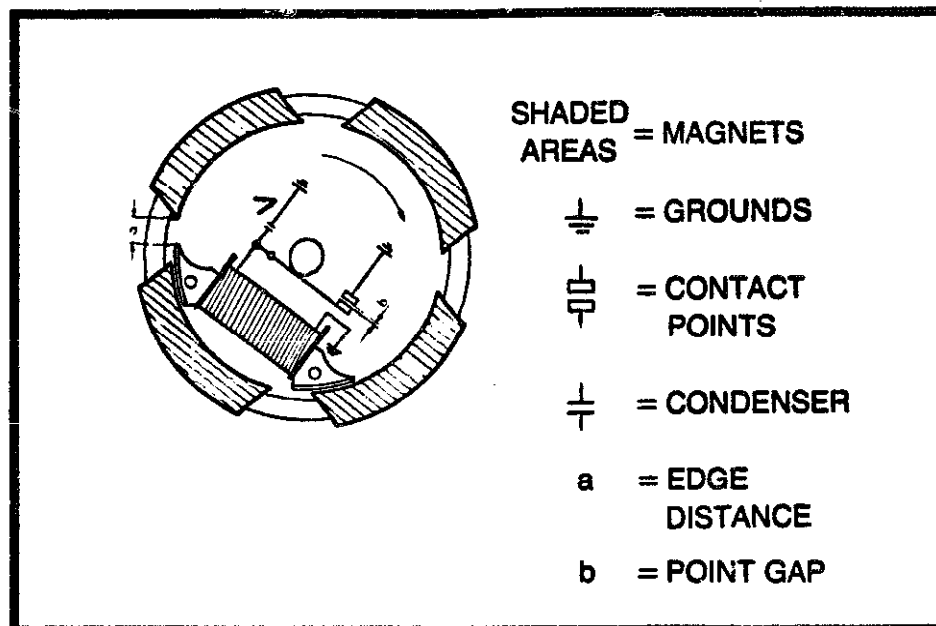


Fig. 2-2. Primary circuit schematic. (Courtesy Fichtel & Sachs.)

Since the secondary winding is impressed over the primary winding, current is interrupted and the field around the primary windings collapses. The field falls in upon itself, cutting through the secondary windings. The secondary winding is therefore subjected to the classic voltage generating situation, a moving magnetic field. How much voltage is generated in the secondary winding depends upon the ratio of turns between the secondary and primary windings, and upon the efficiency of the magnetic coupling. The greater the number of secondary windings relative to the primary, the greater the voltage. Current is proportionally decreased because some energy is lost in the operation of converting one form of energy to another. Briggs & Stratton coils are wound with a sixty to one ratio. Subtracting for coil inefficiency, this ratio gives 10,000V at the spark plug from a primary input of 170V.

For the magneto to function properly, the contact points should break at the moment of peak primary current. Primary current peaks when the flywheel magnet is centered over the coil armature. As far as mechanics are concerned, this position is usually described as a function of edge distance, or dimension "a" in Fig. 2-2. Smaller Briggs engines are sparked by magnetos with fixed edge distances that can only be disturbed by warped flywheel keys or battered keyways. Magnetos for the large engines have edge distances which can be varied.

The three most common causes of magneto trouble are a malfunctioning spark plug, malfunctioning points, or a malfunctioning flywheel.

### **Spark Plug Replacement**

The first step in troubleshooting any single-cylinder engine is to replace the spark plug with one known to be good. The quality of the spark can be tested by disconnecting the high tension lead from the spark plug terminal. Hold the metal end of the lead  $\frac{1}{4}$  to  $\frac{3}{16}$  of an inch from the block, then crank the engine. You should see a spark leap between the lead and the block each time the contact points break. On small engines with self-contained magnetos, the spark occurs once for every flywheel revolution; large engines with remote point chambers fire each second revolution.



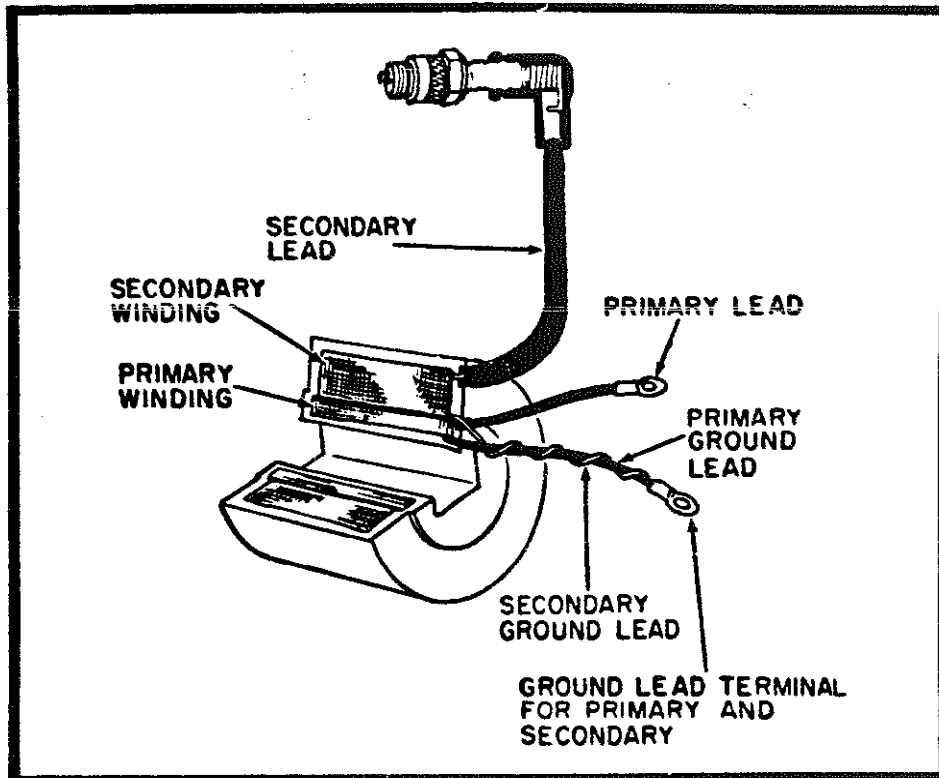


Fig. 2-3. A typical ignition coil in cutaway. (Courtesy Tecumseh Products Co.)

The spark should be as regular as a pulse beat and should be strong. White, spindly sparks, or those that are tinted red, do not have the intensity needed for reliable ignition. A healthy magneto delivers a thick blue spark that sounds like a miniature thunderclap.

Even if you are satisfied with the appearance of the spark, replace the spark plug with one that you know is good. While some forms of plug failure are obvious—carbon fouling, cracked insulators, worn electrodes—other malfunctions escape the eye. Even new spark plugs may not function in a single-cylinder engine.

Since the timing—the moment the spark occurs relative to piston position—is fixed during manufacture, it would appear that these engines would be immune to timing changes in the field. Unfortunately, this is not true. Increasing the spark plug gap causes the points to break early, advancing the timing; decreasing the gap retards timing.

The gap—the distance between the side and center electrode—is 0.030 in. for all Briggs & Stratton engines in production. Many mechanics prefer to use a wire gauge, but the familiar,

flat bladed gauge can be just as accurate if held dead parallel between the electrodes. Gap adjustments are made by bending the side electrode closer to, or farther away from, the center electrode.

Wipe any dirt accumulation from the gasket surface around the spark plug port. Dirt will cause the plug to overheat and may unseat it enough to firecut a channel through the threads, ruining the cylinder head. Put the spark plug in by hand to prevent cross-threading, and torque to specification:

| Thread Size | Cylinder Head Material |                 |
|-------------|------------------------|-----------------|
|             | Aluminum               | Cast-Iron       |
| 14mm        | 13 to 22 ft-lbs        | 26 to 30 ft-lbs |
| 18mm        | -----                  | 32 to 38 ft-lbs |
| 7/8 inch    | -----                  | 35 to 43 ft-lbs |

### Points Replacement

The contact points are preternaturally sensitive—point sets that appear normal may refuse to fire or miss at speed. Used point sets, at least those which are only superficially pitted, can be salvaged by filing the oxidation from the contacts. When you are finished, the contacts should be bright, should have no more than a few pinholes, and should meet square. However, filing points is an expedient to get the engine running, not a substitute for new points and a new condenser.

Specific installation procedures are described under the various magneto types. Here it is enough to say that the point chamber should be relatively free of oil. An oily mist is more or less inevitable, but puddles of oil mean that the upper main bearing seal or, depending upon the magneto, the point-plunger oil seal has failed. Replace these parts before you install new points. Any oil that is present should be wiped up, particularly under the stationary contact. Oil is an insulator and will break the ground circuit.

The point gap is measured at the widest extension of the points when the movable arm is "on the cam." All Briggs & Stratton engines have a point gap specification of 0.020 in. Set the points with a clean feeler gauge—wiping the gauge leaf with your fingers is

almost guaranteed to make starting difficult. As a further precaution, buff the points with a business card after installation.

On nine cubic inch and larger engines, it is sometimes necessary to register the moment of point separation. This is not as easy as it sounds, particularly if the contacts are worn. The quickest way to determine the moment of separation is to close the point contacts over a strip of cellophane. Turn the flywheel in the normal direction of rotation. When the cellophane flutters free, the points have opened. The error involved, the thickness of the cellophane, is doubled at the piston since the camshaft and the point contacts operate at half crankshaft speed.

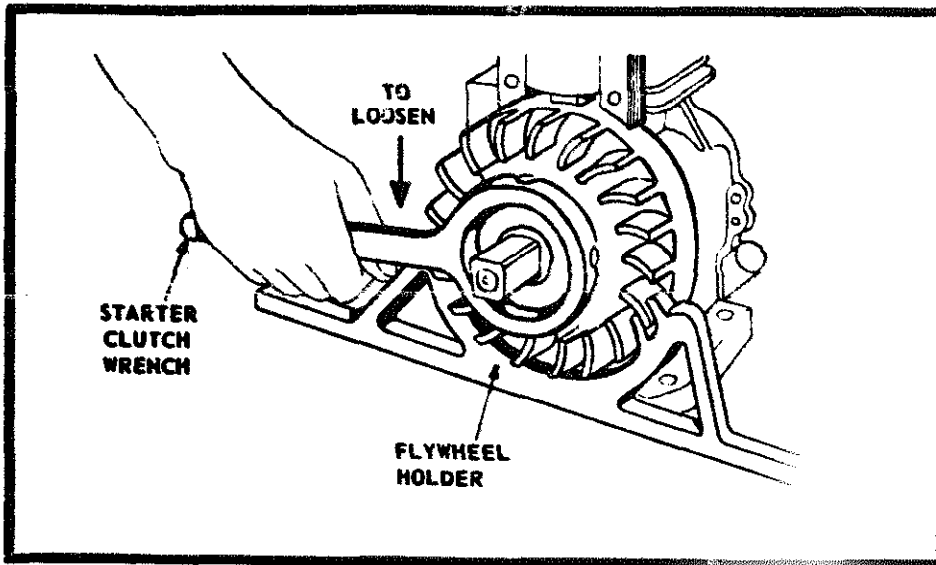
A more accurate method of determining the instant of point separation is to use an ohmmeter, or one of the "buzz boxes" sold for this purpose by motorcycle and snowmobile dealers. Clip one lead to the movable point arm, the other to a good ground. Depending upon the sensitivity of the instrument, it may be necessary to disconnect the coil primary lead at the point set. The points open when the ohmmeter deflects toward infinity or the buzzer goes silent.

### **Flywheel Repair**

Remove the cooling shroud by taking out the bolts passing through the crankcase and cylinder head. It is neither necessary nor desirable to undo all of the cylinder head bolts. The flywheel is mounted on the crankshaft stub by means of a nut or lockwasher, or on engines with rewind or impulse starters, by means of a threaded starter clutch and spring washer.

Large cast-iron flywheels have enough fin strength to tolerate wedging with wooden blocks. Smaller cast-aluminum flywheels are fragile and should be held with a strap wrench available from plumbing supply houses or with the appropriate Briggs & Stratton holding fixture. Figure 2-4 illustrates these tools.

Flywheel nuts can be removed with a deep-well socket. With the exception of the ½ inch nuts used on rope-start engines, all crankshafts have right hand threads. Turn overhand and left to loosen. Starter clutch assemblies respond best to the Briggs & Stratton tool number 19114 (Fig. 2-4). While this tool is a necessity for a serious mechanic, it is possible to remove and install the starter clutch with a hardwood block and hammer. Remove the four self-



**Fig. 2-4.** A bronze starter-clutch wrench is a necessity for the serious mechanic, although a suitable flywheel holder can be improvised. (Courtesy of Briggs & Stratton Corp.)

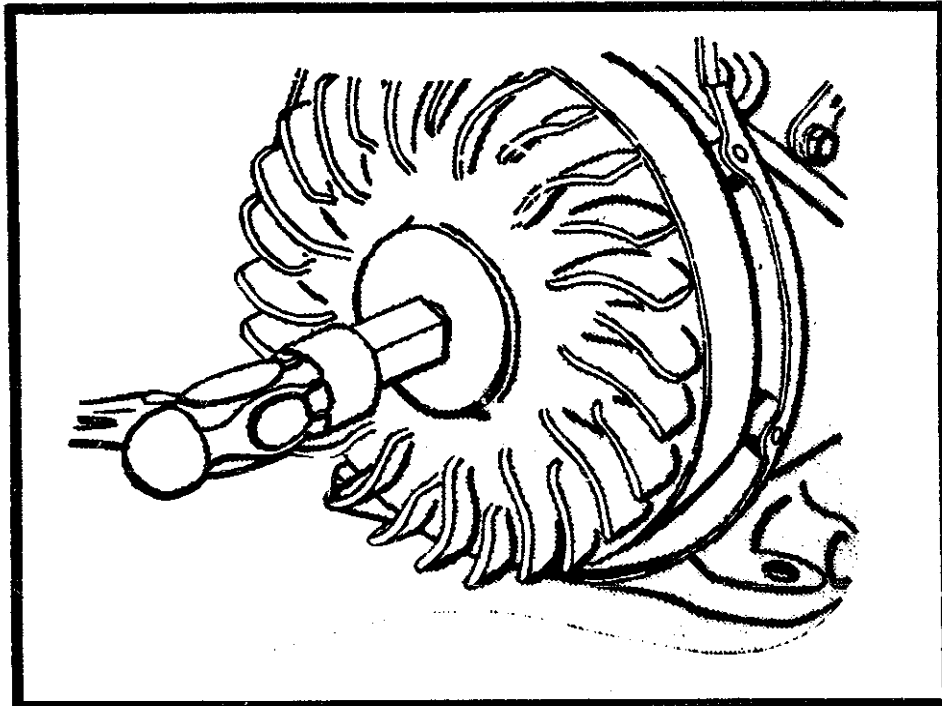
tapping screws and the screen. Using the screw lugs for purchase, tap the clutch assembly counterclockwise to loosen.

The flywheel mates to the crankshaft by means of a taper and key. Some force is required to separate the parts, particularly if the flywheel is aluminum. Briggs & Stratton insists that one of five factory pullers be used to remove the various flywheels. These pullers thread into holes cast into the flywheel hub.

To save time, most mechanics prefer to use a flywheel knocker (Fig. 2-5). The knocker is a heavy steel bar, threaded like the flywheel nut, or smooth bored to match the starter clutch. It is held against the flywheel and given a sharp hammer blow. Sometimes it is helpful to pry against the inner edge of the flywheel with a screwdriver as the knocker is struck.

While effective, flywheel knockers are brutal tools and can seriously damage the crankshaft. Excessive force will buckle the crankpin, and a glancing blow on the knocker can snap the crankshaft end. Repeated pounding can even scramble the flywheel magnets.

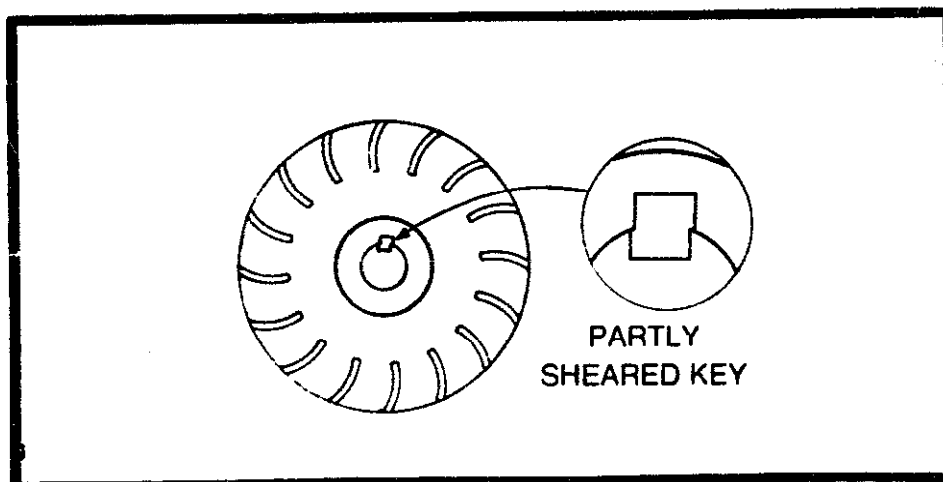
Once the flywheel is off, inspect the hub for cracks and for evidence of keyway wallow. Do the same for the crankshaft. If either is damaged, replace the part, since no repair is practical or safe. By the same token, replace a deformed key with an identical key from Briggs & Stratton (Fig. 2-6). Do not substitute a steel key for the



**Fig. 2-5.** A flywheel knocker in use.

original aluminum one. The key is a kind of safety valve protecting the crankshaft and the flywheel from driveline shock, and to serve this purpose, must be soft and malleable.

Upon installation, torque the flywheel nut to specification. Starter clutches are tightened by "elbow torqometer" since the special tool cannot be adapted to a torque wrench. Tighten the clutch until it binds solid with the flywheel, signaling that the spring washer



**Fig. 2-6.** Key damage affects the edge distance and can make starting difficult or impossible.

has fully collapsed. Install the cooling shroud, making certain it is centered over the flywheel.

## **BRIGGS & STRATTON MAGNETO TYPES**

Aside from an under-the-crankcase design seen on a few vertical shaft models, Briggs & Stratton engines are fitted with any of three magneto types. While many parts of a given magneto type are interchangeable, many are not. At least two flywheels have been used on the small (under nine cubic inch) engines, neither one of which is magnetically compatible with the other.

### **Internal Point Set Magneto**

The magneto shown in Fig. 2-1 is the most popular of all Briggs & Stratton types. Only the coil and optional kill switch are outside of the flywheel.

### **Points and Condenser**

After the spark plug, the contact point assembly is the most vulnerable part of the system. The magneto in Fig. 2-1 has crankshaft-driven points, an arrangement that doubles point wear since there is one spark per revolution (larger magnetos spark at half engine speed).

Two point sets have been used: early production engines employ a remotely mounted condenser (Fig. 2-7A; later models feature the integral point-and-condenser set in Fig. 2-7B). When servicing the early type, tuck the condenser lead well clear of the flywheel. Assembling the current type is a little tricky. The ground strap on the movable breaker arm routes over the post and not, as one might suppose, under it. The primary lead, represented by the heavy black line in the upper center of Fig. 2-7B, is secured to the condenser stationary contact with a coil spring. Each replacement point set is packaged with an assembly tool, a plastic thimble used to compress the spring. Without this tool, you insert the lead into the condenser stud and thread the spring over it until the last coil of the spring passes through the wire. Turn the spring with a small pair of pliers.

Point gap is 0.020 of an inch regardless of the point style. Turn the crankshaft to fully open the points. Since point closure is signaled

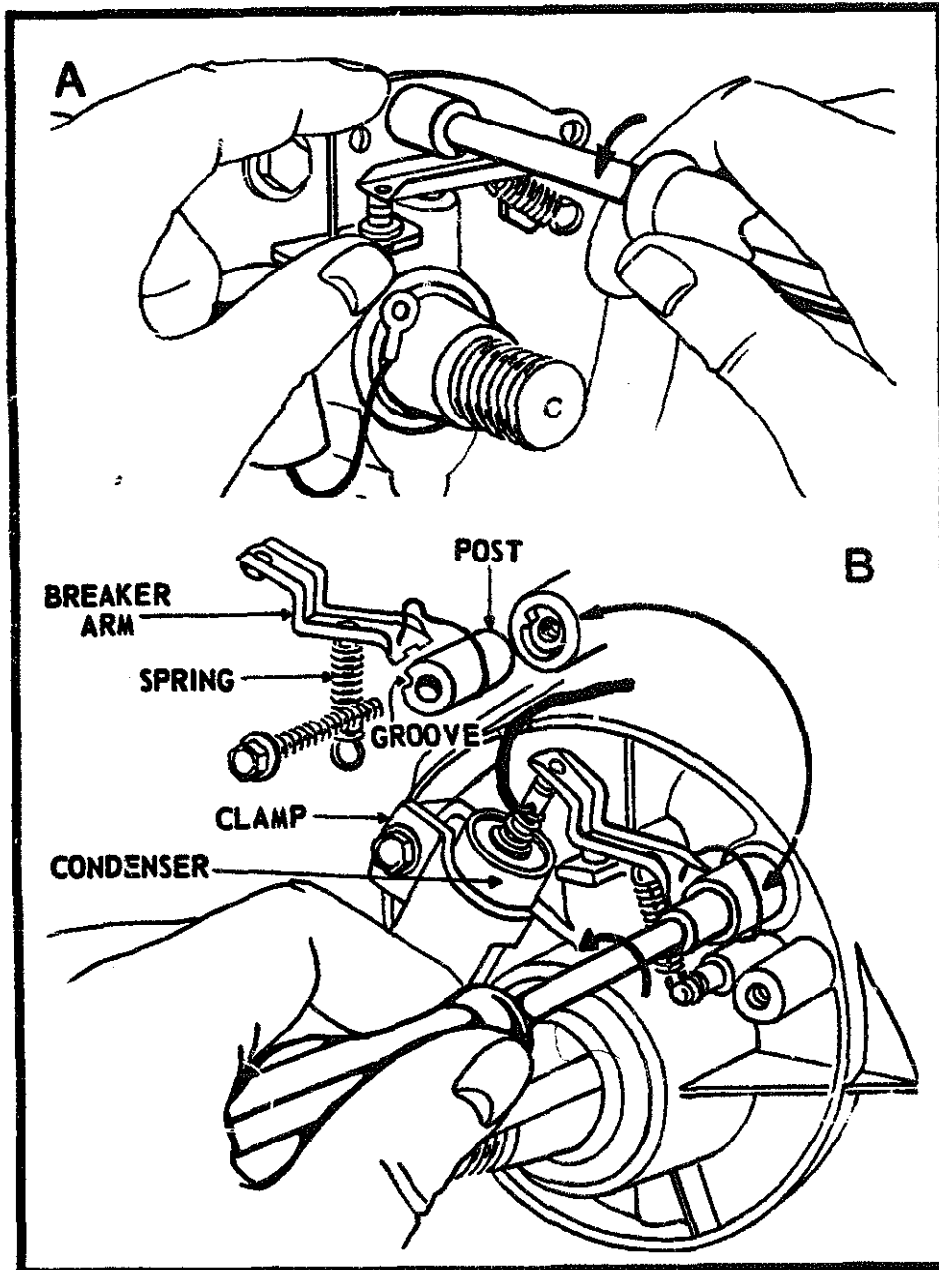


Fig. 2-7. Point sets are secured by a single screw: the older version used a detachable condenser (A); current production combines the condenser and the stationary contact point (B). (Courtesy Briggs & Stratton Corp.)

by a flat ground on the crankshaft, the full-open position is not difficult to find. Insert a clean 0.020 inch feeler gauge between the contacts, resting the gauge flat on the contact surfaces. If the adjustment is correct, you will be conscious of a slight drag as you withdraw the gauge. The early point set, the one with the separate

condenser, adjusts by loosening the bracket screw and moving the bracket (Fig. 2-8A). The current design adjusts by loosening the condenser clamp screw a half turn and levering the condenser with a screwdriver (Fig. 2-8B). Tighten the clamp and check.

After adjustment, clean the points with lighter fluid, or by passing a strip of cardboard between the contacts. Even a fingerprint can prevent ignition. Lightly grease the crankshaft cam surface with high temperature lubricant.

Assemble the dust cover, dabbing a bit of gasket sealant over the exit notch for the coil and kill switch leads. Install the key in the crankshaft and lower the flywheel into place.

Unscrew the spark plug, connect the high tension lead, and with the spark plug resting on the cylinder, spin the flywheel by hand. Do not cut yourself on the governor vane. Each flywheel revolution should produce a healthy spark. If not, clean the points again, check the flywheel wiring for shorts, and trace out the kill switch circuit. If these measures fail to uncover the problem, assume that the coil is defective.

## **Coil**

The coil may be removed from the engine and checked on a Merc-O-Tronic machine or the equivalent. The armature should be in place during this test.

The air gap—the running clearance between the flywheel rim and the ends of the coil armature—is critical. Too wide a gap compromises magneto efficiency; too narrow a gap may allow the flywheel to rub the armature. The specification is 0.008 of an inch for coils with two legs and 0.014 of an inch for the three-legged variety. Although mechanics sometimes set the air gap with a postcard, this method is only approximate. Use shim stock of the appropriate thickness (available at auto parts stores) and follow this procedure:

- Turn the flywheel magnets away from the coil.
- Loosen the armature holddown screws.
- Insert the shim stock between the armature ends and the flywheel.
- Bring the armature into light contact with the shim.
- Tighten the holddown screws and extract the shim.
- Turn the flywheel by hand to detect possible rubbing.



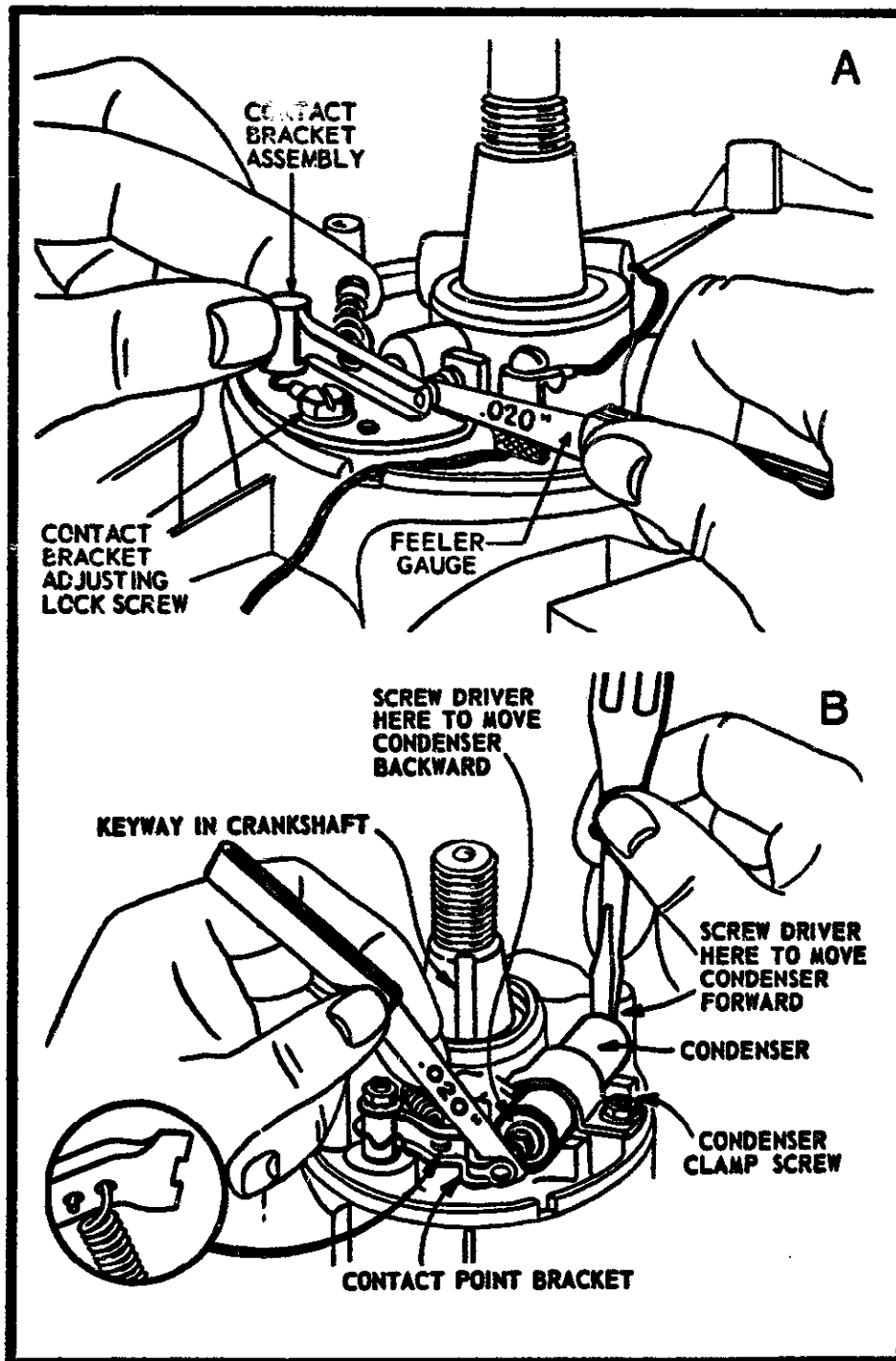


Fig. 2-8. Point gap adjustment: the early point set is held by a screw (A); the later version by a screw and clamp (B). (Courtesy Briggs & Stratton Corp.)

You may find that it is impossible to maintain the specified air gap because of shaft distortion or main-bearing wear. Make the necessary repairs and recheck.

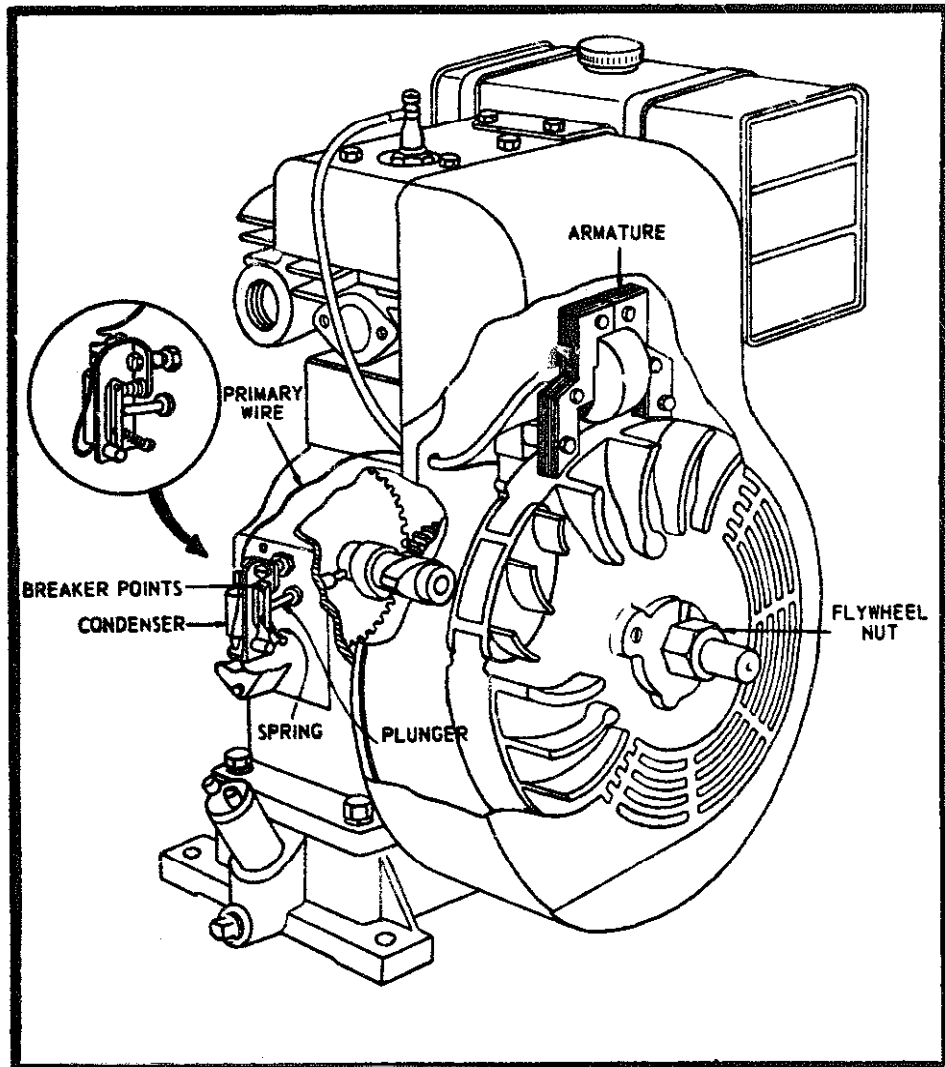


Fig. 2-9. Flywheel magneto with external points found on Models 193000, 200000, 233000, 243000, 300400, and 320400. Models 19D and 23D are distinguished by detail differences in the flywheel, coil, and point plunger. (Courtesy Briggs & Stratton Corp.)

### External Point Set Magneto

This magneto, used on the 193000, 200000, 233000, 243000, 300400, and 320400 engines, combines flywheel magnets with an external point-and-condenser set (Fig. 2-9). Models 19D and 23D are distinguished by detail differences in the flywheel, coil, and point plunger. To disassemble, follow this procedure:

- Turn flywheel until the points open.
- Remove the upper mounting screw (Fig. 2-10).
- Lift off the condenser, leaving it dangling from the breaker terminal screw.

- Remove the lower mounting screw.
- Slack off the locknut and breaker point screw.
- Disconnect the coil lead at the breaker assembly.
- Remove the breaker assembly.

To replace the coil, reverse the above operation, gapping the points at 0.020 of an inch. Install the breaker assembly cover, filling the primary wire exit notch with sealant to keep dust and moisture out.

**Oil Seal.** Late model engines incorporate the oil seal pictured in Fig. 2-11. This seal, together with the retainer plate and eyelet, can be retrofitted to earlier engines to guard from oil contamination. The seal is fragile and must be carefully worked over the plunger.

**Timing.** The timing drill for models 193000, 200000, 233000, 243000, 300400, and 320400 consists of aligning arrows on the coil bracket and flywheel at the instant of point break. Since the flywheel is keyed internally to the crankshaft, allowing no independent motion between the parts, the coil bracket must be moved to match the arrows.

Remove the cooling shroud, flywheel, ignition coil, and contact point cover and follow this procedure:

- Turn the crankshaft until the points are fully open.
- Set the point gap at 0.020 of an inch.
- Position the flywheel over the crankshaft stub.

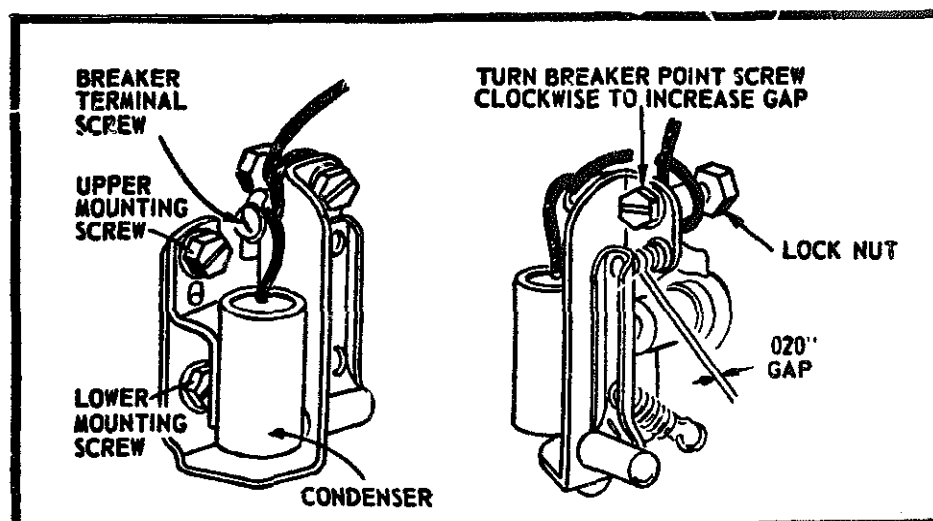


Fig. 2-10. The breaker-point screw determines the point gap. (Courtesy Briggs & Stratton Corp.)

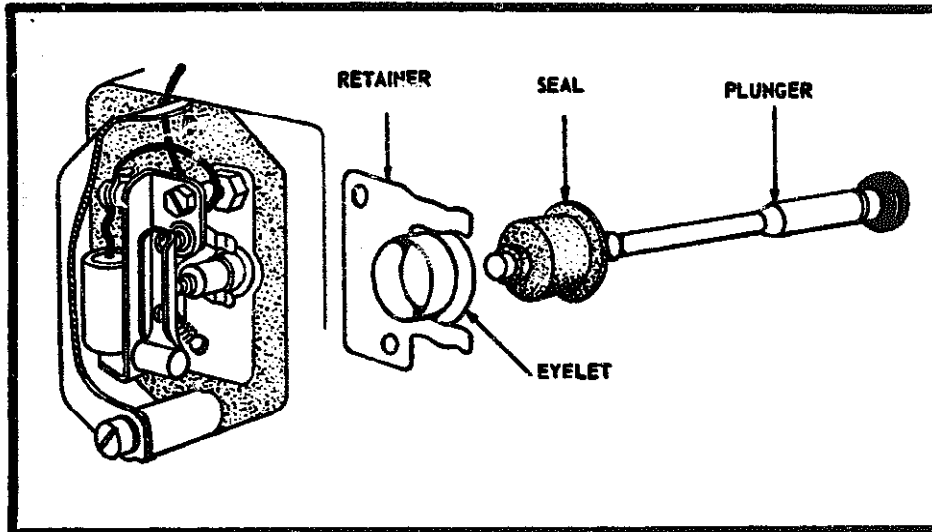


Fig. 2-11. The oil-seal assembly. (Courtesy Briggs & Stratton Corp.)

- Align the flywheel and crankshaft keyways. Insert the key.
- Lightly tighten the flywheel.
- Turn the flywheel clockwise until the points break. For accuracy, use a timing indicator as described under "Points Replacement."
- Check the arrow alignment (Fig. 2-13).

If the arrows match, then proceed to torque the flywheel nut as described below. If the arrows do not match, you must remove the flywheel without disturbing the crankshaft in the process, and match the arrows as follows:

- Loosen the armature bracket screws a few turns.
- Mount the flywheel and key, again exercising care not to turn the crankshaft.
- Gently tap the armature until the arrows match.
- Remove the flywheel and tighten the armature bracket screws in the X-pattern.
- Install the flywheel and key one more time.

Assuming that the arrows now match, you may proceed:

- Torque the nut 115 ft-lb on model 193000 and 200000 engines, and 145 ft-lb on the others.
- Turn the flywheel to bring the magnets away from the armature bracket.
- Lightly tighten the coil holddown screws.

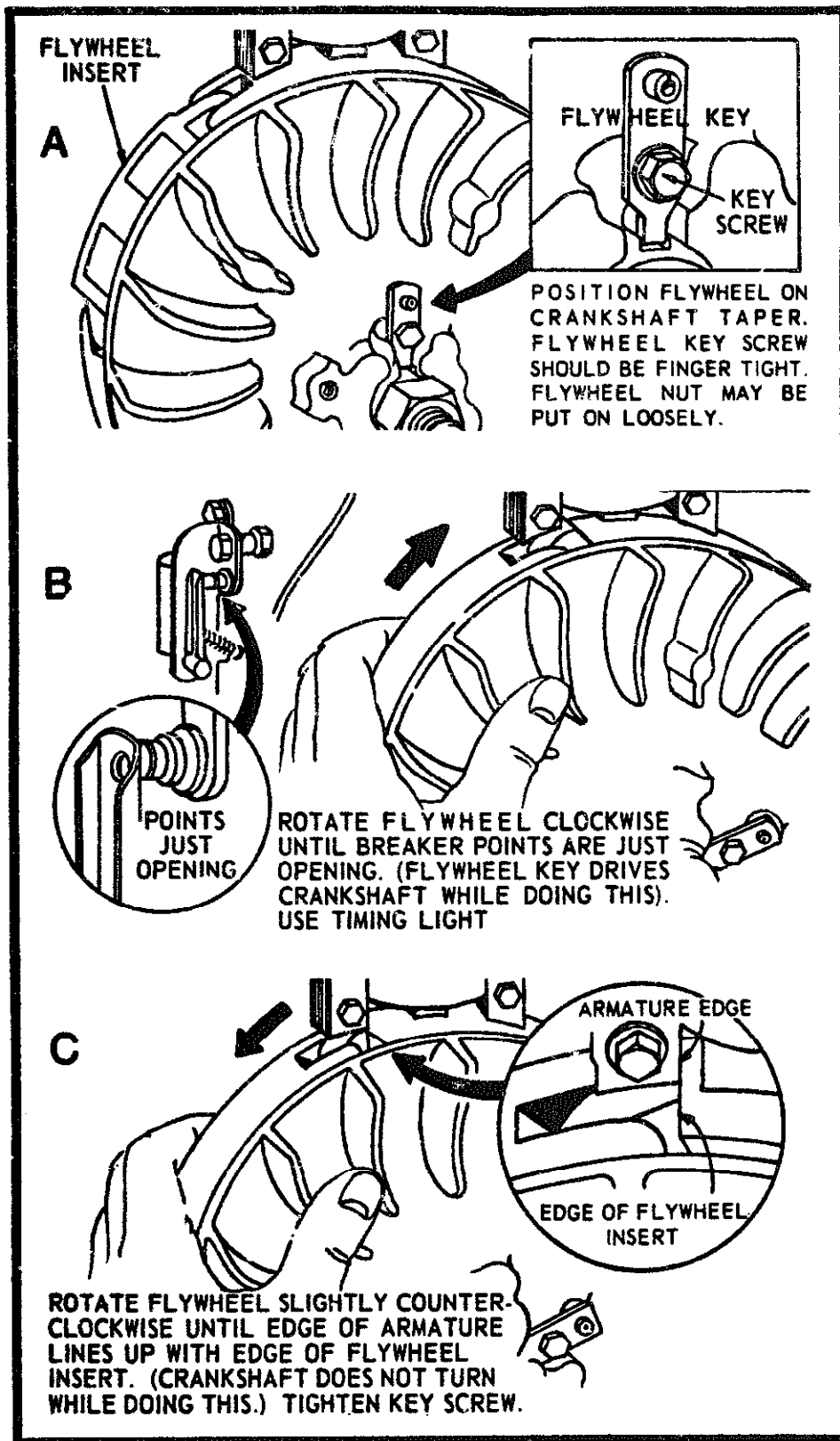


Fig. 2-12. Timing models 19D and 23D. (Courtesy Briggs & Stratton Corp.)

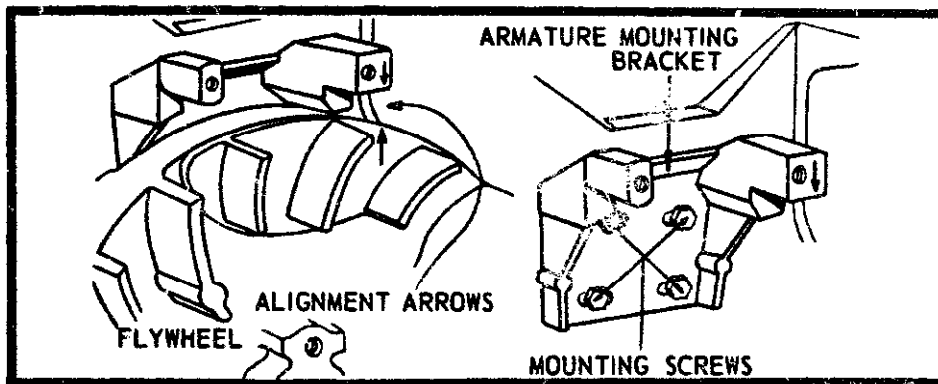


Fig. 2-13. Aligning the armature bracket arrow to the flywheel arrow. (Courtesy Briggs & Stratton Corp.)

- Insert a 0.010–0.014 inch shim between the armature legs and flywheel rim (Fig. 2-14). Press the armature down lightly on the shim.
- Tighten the coil holddown screws.
- Withdraw the shim and pull the flywheel through a few turns to see that it clears the armature legs.
- Replace the cooling shroud and contact point cover.

As noted previously, models 19D and 23D employ an externally mounted flywheel key held against the flywheel hub with a capscrew. With the key removed, the flywheel can be turned independently of the crankshaft. The timing drill establishes the edge distance by synchronizing the flywheel magnets with the coil armature at the moment of point separation. These differences in design require a different timing procedure from the other external point set magnetos. To time the magneto, remove the shroud, the flywheel, and contact point cover and proceed as follows:

- Turn the crankshaft to open the points to their widest extension.
- Set the point gap at 0.020 of an inch.
- Position the flywheel over the crankshaft stub.
- Install the key, tightening the holddown screw with your fingers (Fig. 2-12A).
- Lightly tighten the flywheel nut. With the attaching hardware loose, the flywheel can be rocked a few degrees without turning the crankshaft.
- Turn the crankshaft until the points just break (Fig. 2-12B). See “Points Replacement” for further information.

- Once you have determined point opening, rock the flywheel counterclockwise to align the inner edge of the leading coil armature with the flywheel insert (Fig. 2-12C). The crankshaft does not move during this operation.
- Tighten the key holddown screw.
- Torque the flywheel nut: model 19D to 115 ft-lb; model 23D to 145 ft-lb.

### Magna-Matic

Used on models 9, 14, 19, 23, 191000, and 231000, the Magna-Matic is unique in the complexity of its point set and in its use of a magnet bearing rotor in place of the usual flywheel magnets (Fig. 2-15). The rotor is mounted concentrically with the flywheel and, for timing purposes, is matched with the coil armature.

**Points.** Remove the dust cover and rotate the crankshaft to open the points to their maximum extension (this step will save time upon reassembly). Become familiar with the disassembly procedure illustrated in Fig. 2-16 before proceeding as follows:

- Remove the terminal screw.
- Remove the spring screw, releasing tension on the movable-point arm.
- Undo the breaker shaft nut, turning it counterclockwise until it is flush with the end of the breaker shaft.
- Lightly tap the nut to free the point set from the tapered breaker shaft.
- Remove the breaker shaft nut and lockwasher.
- Lift out the movable point arm, together with the breaker plate.

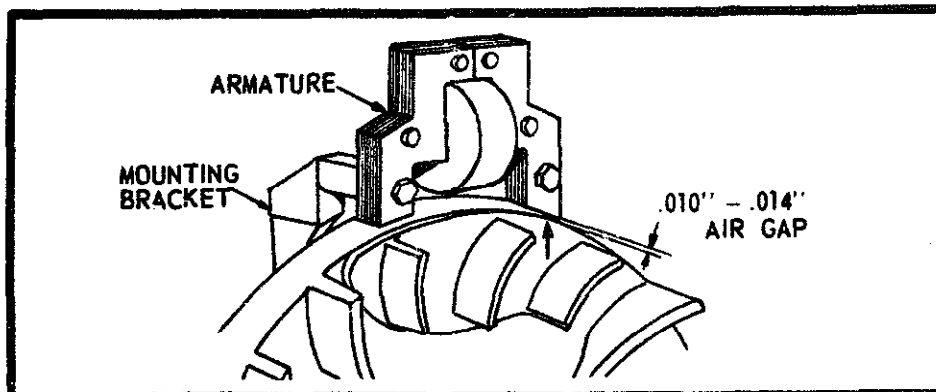


Fig. 2-14. Adjusting the armature air gap. (Courtesy Briggs & Stratton Corp.)

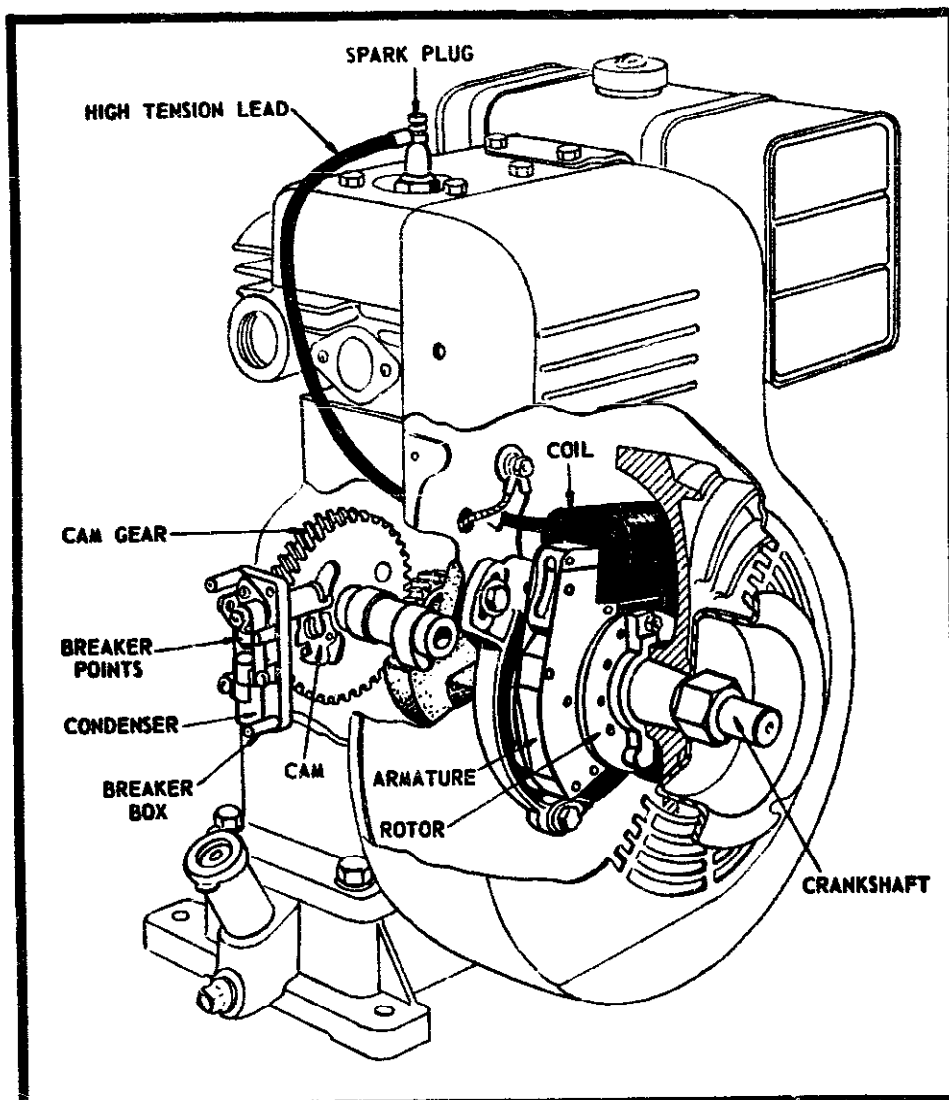


Fig. 2-15. The Magna-Matic, Briggs & Stratton's most complex, powerful mag-  
neto.

If the point chamber is oily, or if there is a telltale splatter of burnt oil under the contacts, remove the oil seal. Pry the seal out with an icepick. To reassemble the Magna-Matic with new contact points, proceed as follows:

- Press in a new oil seal, metal side out. Careful mechanics wipe the seal bore with laquer thinner and coat the seal's outside diameter with liquid silicone (a thin coat is sufficient).
- Position the breaker plate over the insulating plate with the detent on the underside of the breaker plate aligned with the



matching hole in the insulating plate (Fig. 2-17). Improper assembly will warp the breaker plate, causing point misalignment.

- Snug the breaker plate screw down firmly enough to hold the plate in position, but not so tightly that the plate cannot be moved.
- Turn the eccentric screw (Fig. 2-16) to bring the left hand edge of the breaker plate parallel with the left side of the breaker box (Fig. 2-18).
- Turn the breaker shaft clockwise to the limit of its travel.
- Holding the shaft against its stop, slip the movable point arm over the shaft. Place the lockwasher over the end of the shaft and tighten the shaft nut.
- Install the terminal and spring screws.
- Unless the crankshaft has been moved, the breaker points should be on the cam, in their full open position.
- Turn the eccentric screw to obtain 0.020 of an inch gap between the contacts. Check the point gap with a clean feeler gauge.

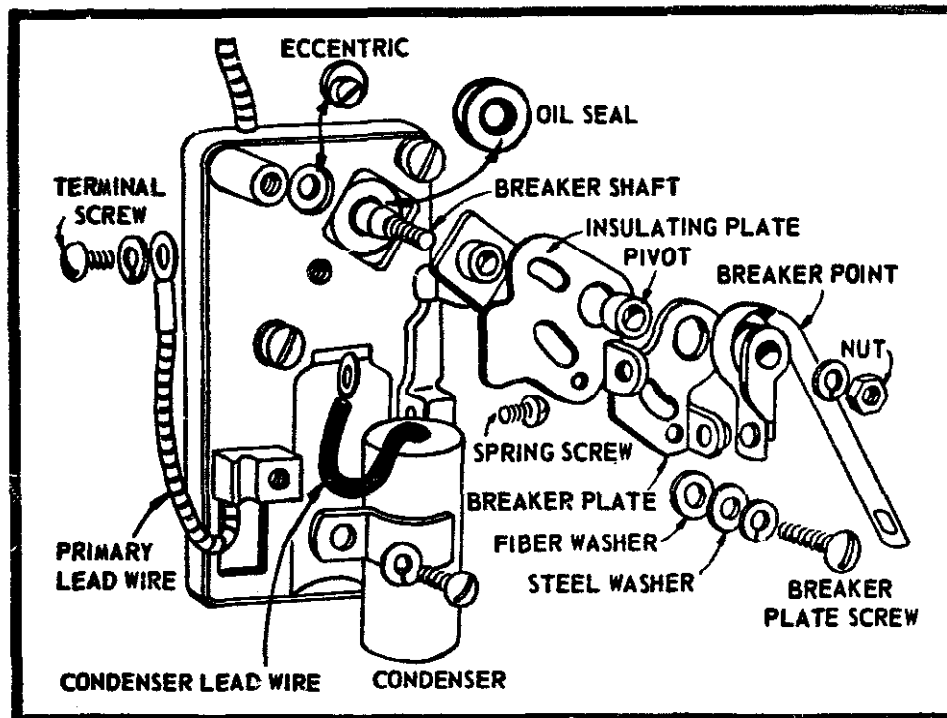


Fig. 2-16. Disassembly procedure for the Magna-Matic. (Courtesy Briggs & Stratton Corp.)

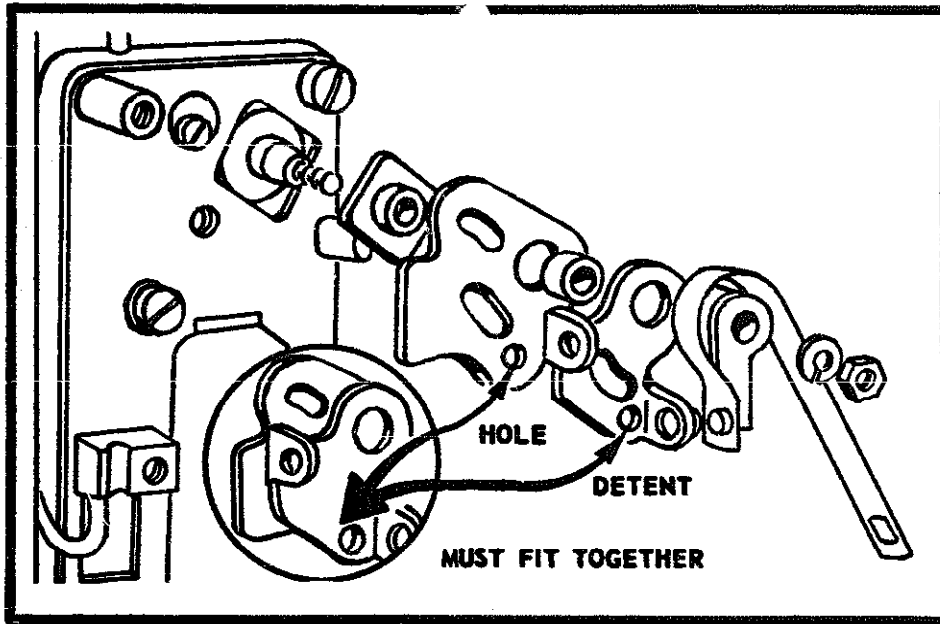


Fig. 2-17. Alignment of detent in breaker plate and hole in insulating plate. (Courtesy Briggs & Stratton Corp.)

- Tighten the breaker plate screw and recheck the point gap.
- Turn the flywheel to close the points, and draw a business card between them to wipe off any contamination.
- Check for ignition spark.

**Rotor.** The rotor is mounted under the flywheel where it is secured to the crankshaft by either of two locking arrangements.

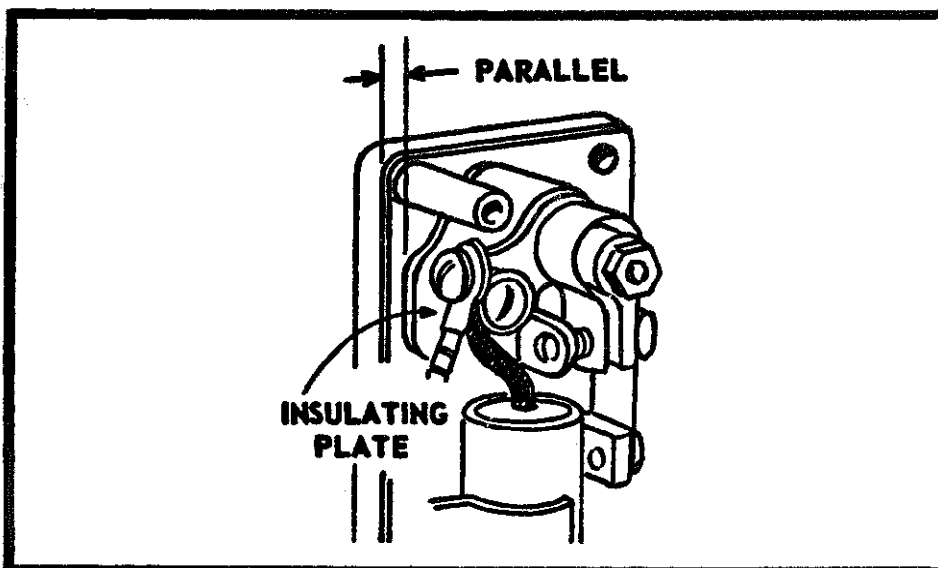


Fig. 2-18. Insulating plate should be parallel with the left-hand edge of breaker box. (Courtesy Briggs & Stratton Corp.)

Formerly a setscrew, lockscrew, and crankshaft key was used (Fig. 2-19A); current production rotors are held by a pinch clamp and crankshaft key (Fig. 2-19B). The clamp forms part of the magnetic circuit; when the rotor is detached from the crankshaft, the clamp must remain on the rotor. Separating the clamp and rotor on the bench weakens the rotor magnets, a condition that causes hard starting and early spark plug failure.

To remove the rotor, disengage the locking devices and slip the rotor off the crankshaft taper. If the rotor refuses to move, gently pry it from behind, turning the crankshaft for new purchase. In extreme cases, a small gear puller, its jaws ground and shaped to slip past the armature, is useful.

Thanks to the setscrew, the early production rotor aligns itself automatically upon reassembly. All the mechanic need be concerned with is the timing. The current rotor, however, must be installed with 0.025 of an inch clearance between it and the mainbearing support to allow the crankshaft to "float." The break in the clamp should be centered between the rotor slots. Figure 2-20 makes these operations clear.

**Timing.** Rotor timing is relatively fixed. The initial factory timing can be trusted so long as the armature has not been removed

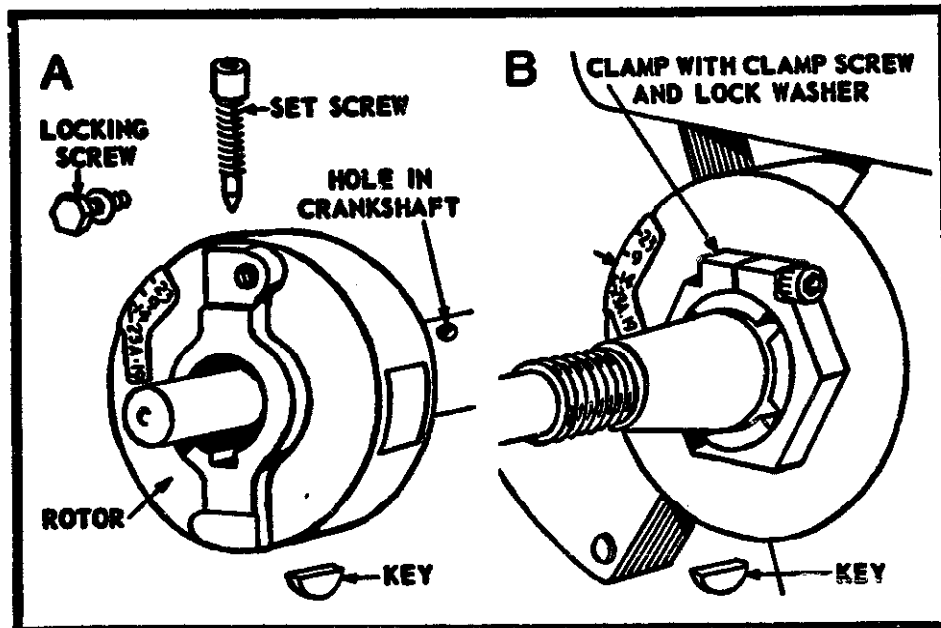


Fig. 2-19. Older rotors are located by a setscrew and hole in the crankshaft (A); the current production rotors employ a pinch clamp (B). (Courtesy Briggs & Stratton Corp.)

and so long as the original cam and crankshaft are used. Replacing these parts, however, may change the timing. If you must time either rotor style, proceed as follows:

- Turn the flywheel to open the points to their maximum extension.
- With all the precision that you can muster, adjust the point gap to 0.020 of an inch.
- Turn the crankshaft in the normal direction of rotation through point closing.
- Connect a timing lamp between ground and the movable, or hot, point arm. Refer to "Points Replacement" for instructions.
- The arrow stamped in the left side of the coil armature should be matched to the number corresponding to the engine model number (Fig. 2-21).
- Turn the crankshaft until the lamp indicates that the points have just separated. You may have to rock the crankshaft a few degrees in either direction to pinpoint the moment when the points are no longer electrically conductive. At this

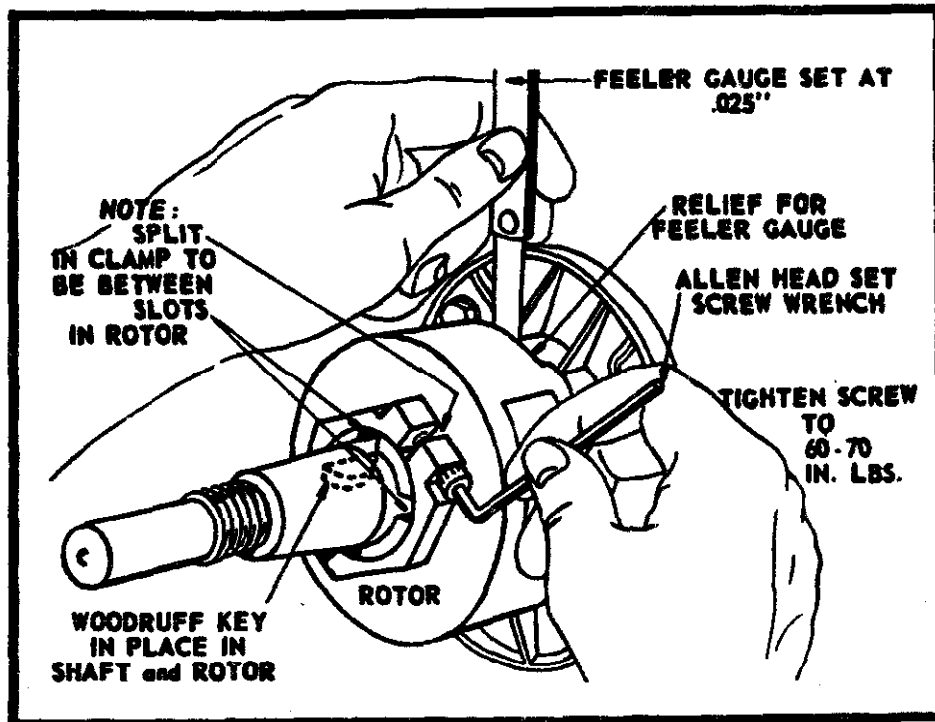


Fig. 2-20. Current production rotor positioned 0.025 inch from main bearing case. (Courtesy Briggs & Stratton Corp.)

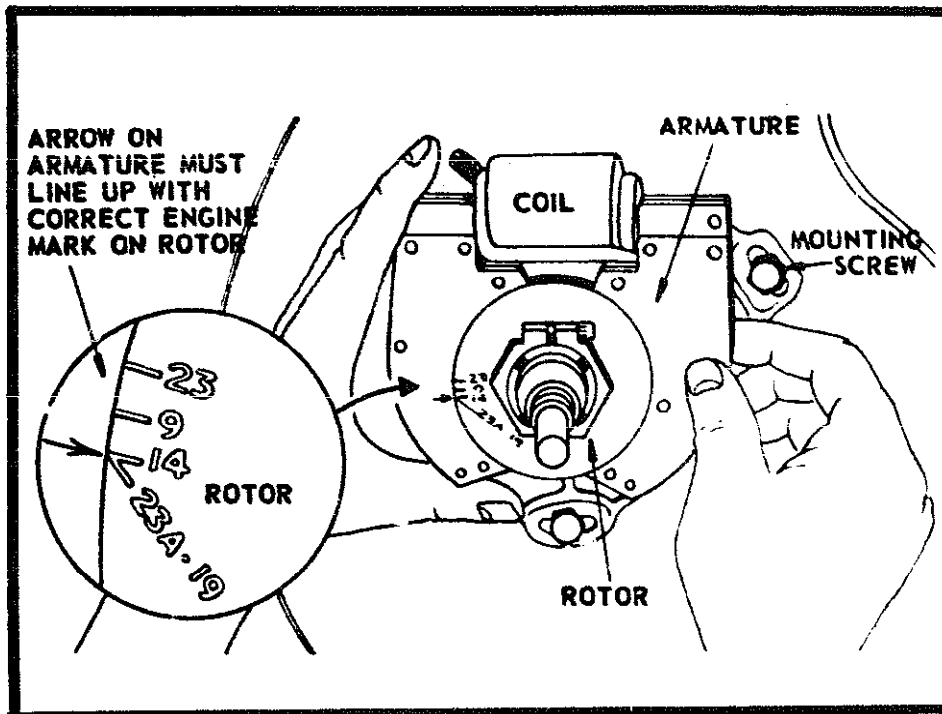


Fig. 2-21. Aligning arrow with engine model number. (Courtesy Briggs & Stratton Corp.)

position, the appropriate mark on the rotor should match with the arrow on the armature.

- If the rotor and armature are out of sync, loosen the three armature holddown screws and turn the armature as necessary. (This operation will not upset the air gap between the rotor and armature.)
- Retighten the screws and turn the engine through to check the timing.

**Coil.** The coil is secured to the main armature assembly with spring clips and, once the clips are disengaged, lifts off with the upper armature element. The usual test apparatus requires that the coil remain mounted on the armature segment. However, the coil can be slipped off the segment for replacement purposes. The rounded side of the coil faces outward, toward the flywheel. The coil has three electrical connections: the paired and twisted uninsulated wires go to ground, the small insulated wire connects to the point set, and the high tension lead goes to the spark plug. On model 9 engines, the high tension lead is knotted on the coil side of the backing plate, about half an inch from the coil.

## CHAPTER 3

# CARBURETORS

The carburetor is the most mechanically complex part of the engine, and the part least susceptible to "common sense" fixes. You will need some knowledge of carburetor theory to perform needed repairs.

A carburetor has three functions. First, it atomizes the fuel, breaking the liquid gasoline into droplets so that it can burn readily. Secondly, the carburetor automatically adjusts the strength of the fuel mixture, the relative amount of fuel to air, to suit engine demands at different speeds and loads. Thirdly, it limits the total amount of fuel and air passing to the engine so that the operator can control engine speed.

A carburetor is a pressure-differential device, operating upon the well known principle that nature abhors a vacuum. Air pressure is nominally 14.7 pounds per square inch at sea level, a figure derived from the weight of a column of air one square inch in area extending vertically from the earth's surface to the limits of the atmosphere. During the intake stroke, the engine acts as a vacuum pump, exhausting most of the air in the intake pipe. The pressure differential between the partial vacuum left by the descending piston and the weight of the atmosphere pressing in on the air filter is the source of power for the carburetor.

### THE VENTURI

A restriction in the bore known as the *venturi* creates the vacuum. Normally the venturi is streamlined to reduce turbulence

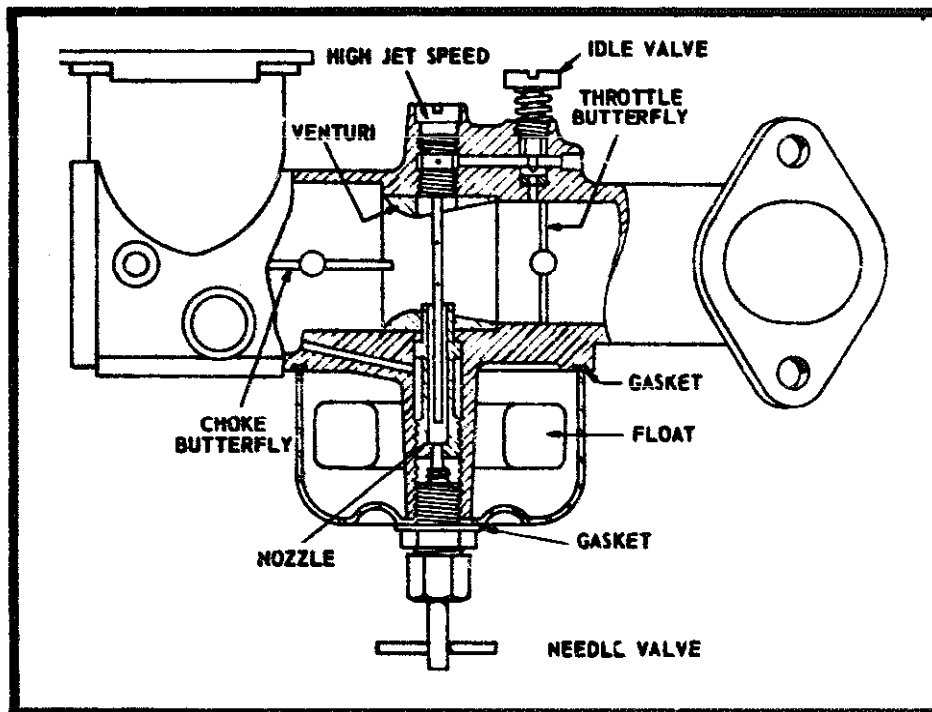


Fig. 3-1. Carburetor nomenclature. (Courtesy International Harvester Co.)

and fluid friction losses (Fig. 3-1); but any restriction in the bore serves. As air passes through the venturi, its velocity increases. The pinched in walls of the carburetor bore lengthen the air's path, and since the same amount of air enters the bore as leaves it, the air stream must move more quickly through the venturi. An increase in velocity would appear to cause an increase in the energy of the air stream, but this is not the case. Instead, a transformation occurs in the venturi analogous to what happens in an ignition coil. As the air speed increases, air pressure drops. Pressure falls well below sea-level values, and thus the energy level of the air stream remains constant, less the losses generated by fluid friction.

The increase in air velocity is useful in that it whips the fuel into a froth or, as engineers say, atomizes it. Once the fuel mist enters a warm engine, it undergoes a further reduction in pressure and becomes a highly combustible vapor. The loss of pressure causes the fuel to pass through the main jet and into the venturi where it is swept into the engine. Some Briggs & Stratton carburetors deliver fuel to the venturi by way of a nozzle as shown in Fig. 3-1. Others have a jet—a threaded brass plug with an orifice in the center—positioned in the high-vacuum zone of the venturi.

Unfortunately, a given venturi is efficient only over a narrow range of air velocities. At lower velocities, the venturi stumbles and loses its vacuum; at higher velocities it becomes restrictive, robbing the engine of power, and because the vacuum increases as a function of air speed, delivering too much fuel for the available air. The engine gets "indigestion" from the gasoline-rich mixture.

### **THE THROTTLE VALVE AND IDLE PORT**

The *throttle valve* determines the amount of air and fuel going to the engine. In Fig. 3-1 it is pictured as wide open. At lesser angles, air and fuel are restricted and the venturi works at less than optimum efficiency. It no longer can assure consistent fuel delivery. For this reason, Briggs & Stratton (and all other carburetor makers) provides a second source of fuel independent of the main venturi. This source is known as the *idle port* and is adjustable, the amount of fuel passing through it determined by the position of the throttle valve (Fig. 3-1). As the throttle closes, it obstructs more and more of the bore, becoming a kind of crude venturi. The idle port is located in the low pressure zone created by this throttle-valve "venturi."

The idle port, sometimes called the low speed port, functions at part throttle, although there is some overlap between it and the main jet. Needle valve and idle valve adjustments are interrelated and, to some small degree, are interdependent.

There is enough separation between the two systems to allow different mixture strengths at different throttle settings. This dual fuel source is important since the engine requires a gasoline rich mixture at idle (on the order of one part of air to eight parts of gasoline vapor), and a leaner mixture at cruise. At wide open throttle, the vacuum mixtures at midthrottle are in the neighborhood of seventeen parts air to one part fuel. At full throttle, the air stream moves very quickly, generating a high vacuum in the venturi. The mixture richens to a fourteen or fifteen to one ratio. This additional fuel allows the engine to develop full power and plays a small, but important, role in piston cooling.

Cold starting requires a very rich mixture of two or three parts of air to one part fuel. With cold starting, most of the fuel condenses upon contact with the engine castings; only the lightest hydrocarbons vaporize. Hence surplus fuel is necessary to generate enough vapor to start the engine.



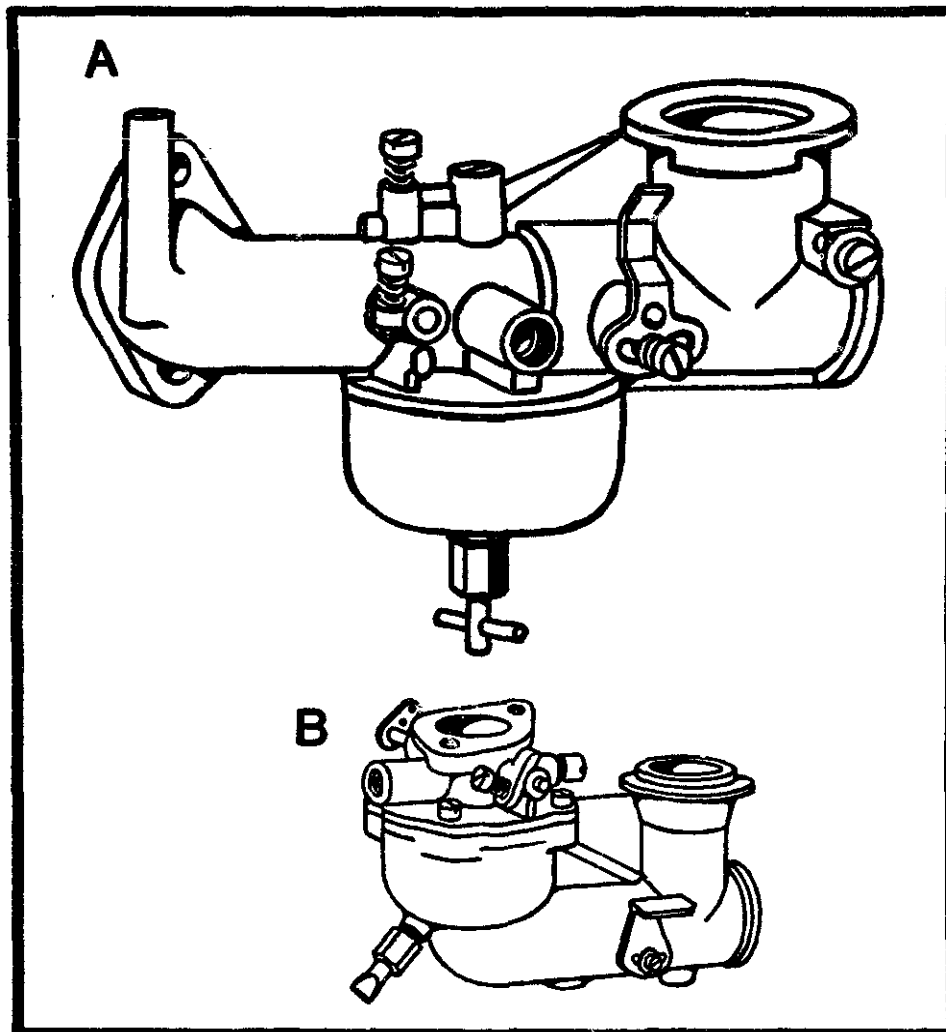


Fig. 3-2. The Flo-Jet carburetor. The one piece variant is built around a single casting (A); the two-piece version has the throttle body cast separately (B). (Courtesy International Harvester Co.)

Briggs & Stratton carburetors employ the familiar choke valve upstream of the venturi. When the valve is closed, the carburetor is subject to intake pipe vacuum. Both the main and idle circuits deliver fuel that mixes with the scant air supply to give an extremely rich mixture. Once the engine warms, the choke must be opened, either manually or automatically.

The internal fuel level of the carburetor—the level of fuel in the passageways—is critical. The higher the level, the greater the amount of fuel that will be delivered through the main jet and idle port. By the same token, the lower the level, the greater the distance the fuel must move before delivery, and the leaner the mixture.

The internal fuel level must be independent of the level of the fuel in the tank, or of the pressure exerted upon it by the fuel pump. The carburetors under discussion employ either of two mechanisms to control the internal fuel level.

Carburetors that Briggs & Stratton calls the Flo-Jet series employ a float like the one shown in Fig. 3-1. There are three versions of these carburetors: a one piece design, and a large and small two piece design (Fig. 3-2). Fuel enters the float chamber through the float needle and seat (more often known as the inlet needle and seat). At a preset level, the float closes the needle against the seat. No more fuel can enter until the engine consumes enough to lower the level in the chamber. As the float drops, it releases pressure on the needle and more fuel enters. This operation takes place as often as two hundred times a minute and, because of its short reaction time, does a good job of keeping the internal fuel level constant. However, the engine must be kept relatively level. Flo-Jet carburetors are not the ideal choice for power lawnmowers that are expected to work in hilly terrain.

Briggs & Stratton Vacu-Jet carburetors employ a pickup tube which extends into the gasoline tank (Fig. 3-3). Briggs & Stratton

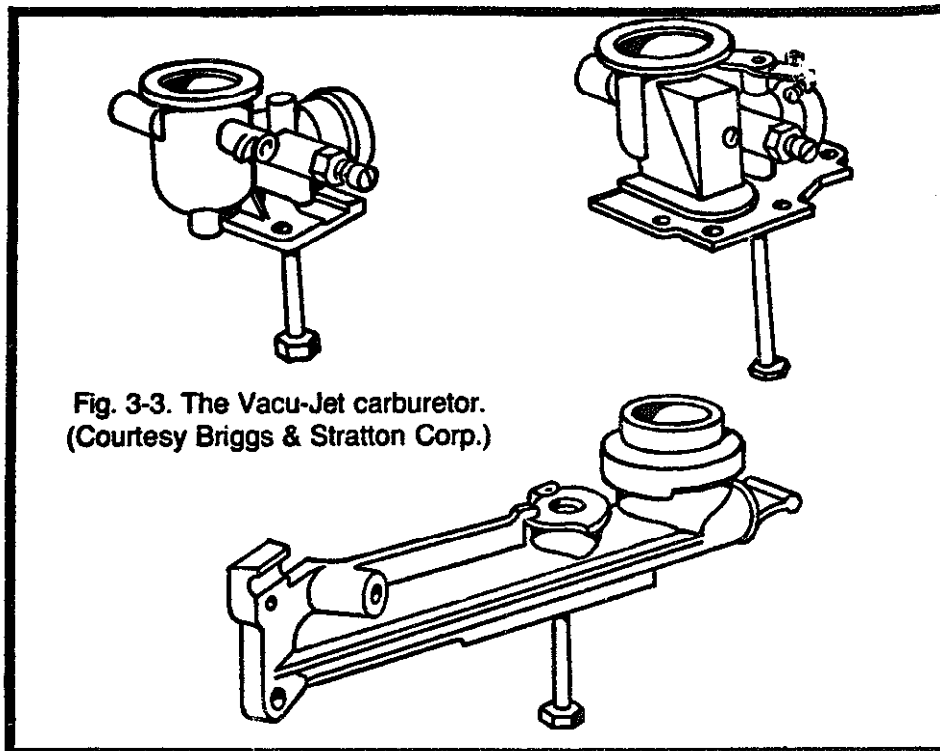


Fig. 3-3. The Vacu-Jet carburetor.  
(Courtesy Briggs & Stratton Corp.)

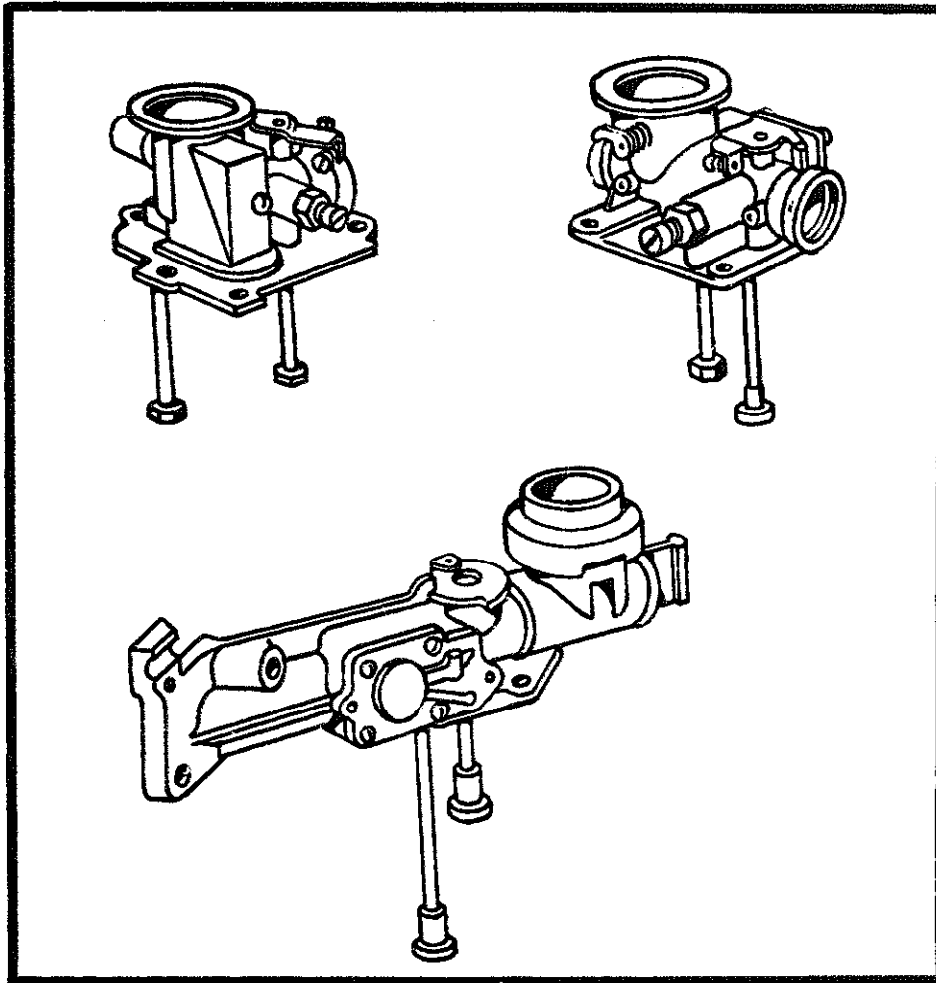


Fig. 3-4. The Pulsajet carburetor. (Courtesy Briggs & Stratton Corp.)

offers three versions of this carburetor, and some of the parts are interchangeable. The principle is not unlike the pickup tube in a flit gun. While this device is admirably simple, involving only a single moving part (a check ball in the tube), Vacu-Jet carburetors are sensitive to the amount of fuel in the tank. The mixture becomes progressively leaner as the tank empties.

Pulsajet carburetors are a variation of the pickup-tube principle of the Vacu-Jet carburetors (Fig. 3-4). Briggs & Stratton offers three versions. The longer of the two tubes is the inlet pipe for a self-contained fuel pump. It reaches almost to the bottom of the fuel tank. The pump delivers fuel to a cup from which the pickup tube feeds. The cup is built into the top of the fuel tank and its upper edge is notched to form a spillway. Since the pump delivers more fuel than the engine can use, the cup is always full to the spillway. The pickup

tube operates at a constant fuel level, and the mixture remains consistent.

The only drawback to these carburetors is that the cup must be full before the engine will start. Normally it is full. But if the engine has been out of service for several weeks, fuel in the cup evaporates. The cup can be replenished by topping off the tank—sending fuel back through the spillway—or simply by cranking the engine until the pump delivers sufficient fuel to the cup.

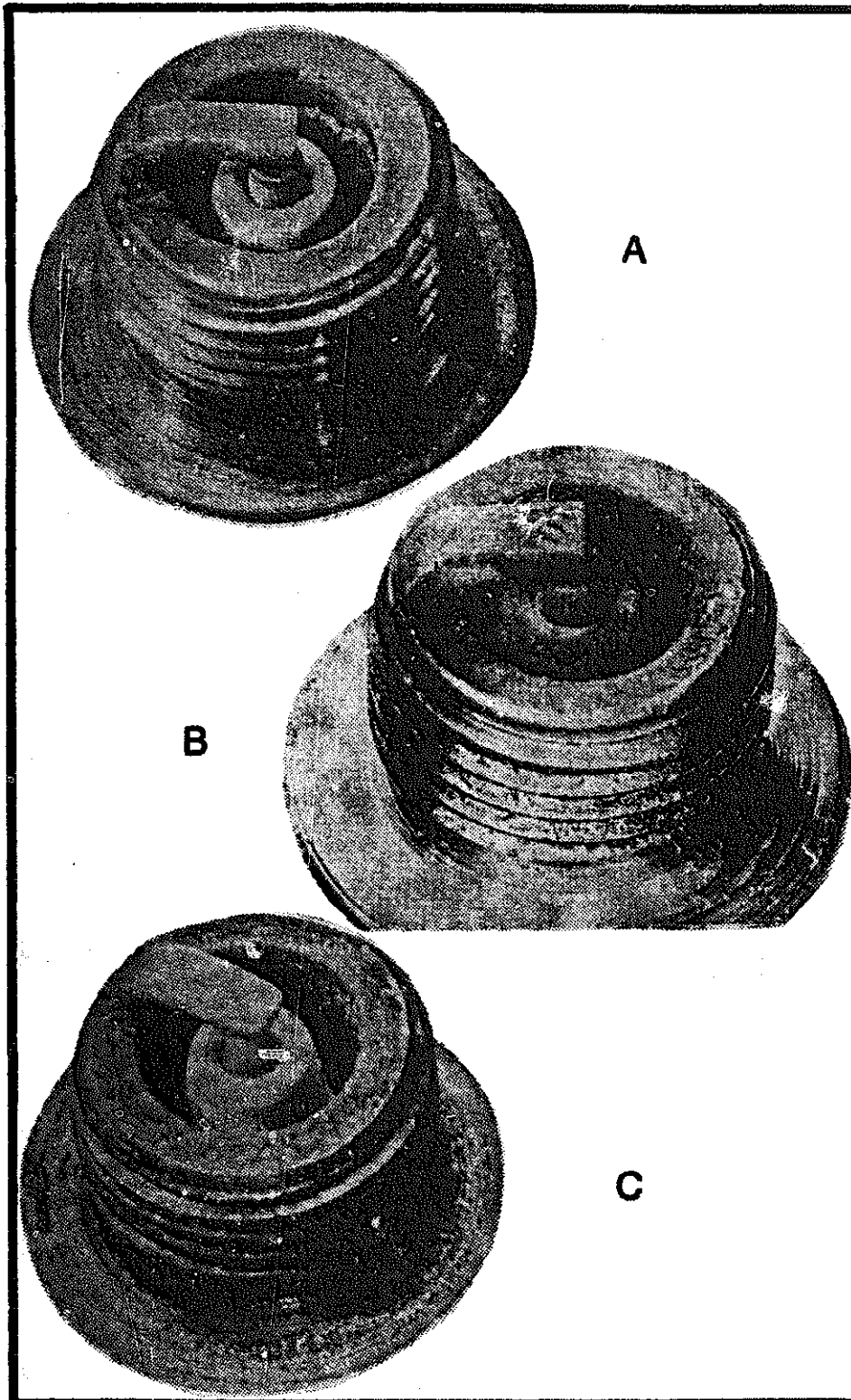
Assuming clean, fresh fuel is used and that the air filter is in working order, a carburetor should give little trouble. Other than the Flo-Jet needle and seat, there are few parts that can spontaneously fail. Carburetors do not in any real sense wear out.

Before assuming the carburetor is guilty, change the spark plug and point set as described in Chapter 2. Ignition system failures give the same symptoms—hard starting, erratic idle, high speed misfiring—as carburetor problems, and they do so more frequently. Once you have decided that the carburetor is at fault, check the fuel. Gasoline has a shelf life of about six months; after that it turns into a gummy soup of varnish, water, and heavy hydrocarbons. Stale gasoline is difficult to ignite and highly corrosive, rusting the tank and attacking gaskets.

## **TROUBLESHOOTING THE CARBURETOR**

The basis of troubleshooting is to examine the firing tip of the spark plug. For this to be valid, the spark plug must be capable of firing. That is, it must be an electrically sound plug and one that is not already sodden with raw fuel. If the engine has severely flooded from a carburetor malfunction, or as the result of persistent cranking, the combustion chamber must be dried before further troubleshooting. The quickest way to do this is with compressed air, but if compressed air is not available, you can remove the spark plug and simply wait until the surplus fuel evaporates.

If the engine refuses to start, the spark plug can tell you whether or not it is receiving fuel. Crank the engine several times and remove the spark plug. The firing tip should be damp and smell of gasoline. If the tip is soaking wet, the chamber is flooded; clear it as described in the previous paragraph. A dry firing tip means that no fuel is entering the chamber.



**Fig. 3-5.** The firing tip of a spark plug should be light brown or tan (A); fluffy black carbon deposits indicate an overrich mixture (B); white deposits mean a dangerously lean mixture. (Courtesy Champion Spark Plug Co.)

Once the engine starts and reaches operating temperature, the color of the spark plug tip gives valuable clues about the air to fuel ratio. The correct ratio will leave tan or light brown deposits on the tip (Fig. 3-5A). Black carbon, usually dry and fluffy but sometimes wet and reeking with gasoline, means that the mixture is too rich (Fig. 3-5B). The carburetor is maladjusted or malfunctioning. White tip deposits point to an overly lean mixture (Fig. 3-5C). Combustion temperatures, fanned by the excess oxygen, are too hot. In extreme cases, the side electrode will show blue temper marks and may actually melt. Check for carburetor stoppage, improper adjustment, and for air leaks between the carburetor and engine.

Rich fuel to air mixtures blacken the exhaust and give the engine a kind of liquid sound, almost as if it were running under water. Power will be weak, and the engine may be hard to start when hot. Lean mixtures increase engine temperature, sometimes to an obvious degree, and cost power. The engine may backfire through the carburetor, and the exhaust may be flecked with red. If the lean condition originates with the main jet, the engine will stumble under sudden acceleration.

### **Symptoms of Malfunctioning**

**Refuses to Start:** If flooded, check the float level, main jet adjustment, choke functioning. If starved, check the fuel level in tank, and with Flo-Jet models, in the float chamber. Determine that the choke valve closes completely. Blow out the main jet. Look for large air leaks at the carburetor mounting flange.

**Runs Rich:** Check choke opening, mixture adjustments, and, where applicable, float adjustment. Vacu-Jet carburetors will run rich if the pickup-tube check ball is stuck open.

**Runs Lean:** Check mixture and float adjustments, and inspect the mounting flange for air leaks. Blow out the main jet and allied circuitry.

**Hard to Start Cold, But Runs Normally Once Started:** Determine that the choke closes completely.

**Hunts, or Refuses to Run at a Steady, No Load Speed:** Check adjustments and for wasted motion at the governor spring. Vacu-Jet models will hunt when adjusted for best wide open throttle power.

**Carburetor Dribbles Fuel:** During cranking, two piece Flo-Jets dribble fuel; if the condition continues after the engine catches, replace the float needle and seat on this and the one piece model. Pulsa-Jets may leak because of a ruptured pump diaphragm or gasket.

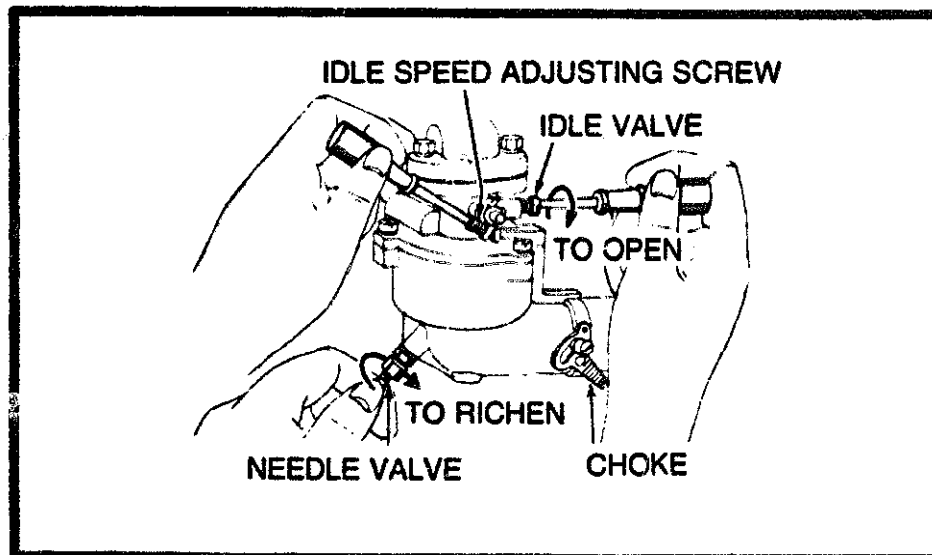
### Adjustments

Carburetor adjustments should be made to the engine under normal working conditions, that is:

- The fuel tank should be half full of clean, fresh gasoline.
- The air filter should be oiled (see below).
- The choke should be fully open.
- The engine should be running at normal operating temperature.

Only if these conditions are fulfilled will the carburetor adjustment be correct.

Briggs & Stratton engines have two (with the Vacu-Jet), or three adjustments: needle valve, idle speed screw, and idle valve. The terms needle valve and idle valve are peculiar to the company. Most mechanics know these parts as the high speed or main jet screw, and the low speed or idle mixture screw. Both adjustment



**Fig. 3-6.** Carburetor adjustments: the idle speed adjusting screw, or idle rpm screw, determines throttle plate angle; the idle valve or low speed needle regulates the amount of fuel passing the low speed port; the needle valve, or high speed needle, regulates fuel through the main jet. (Courtesy International Harvester Co.)

screws terminate in a needle. Tightening either one reduces the flow of fuel, leaning the mixture. The idle speed screw threads into the throttle valve and acts as the low speed stop (Fig. 3-6). Tightening the idle speed screw opens the throttle and increases idle rpm.

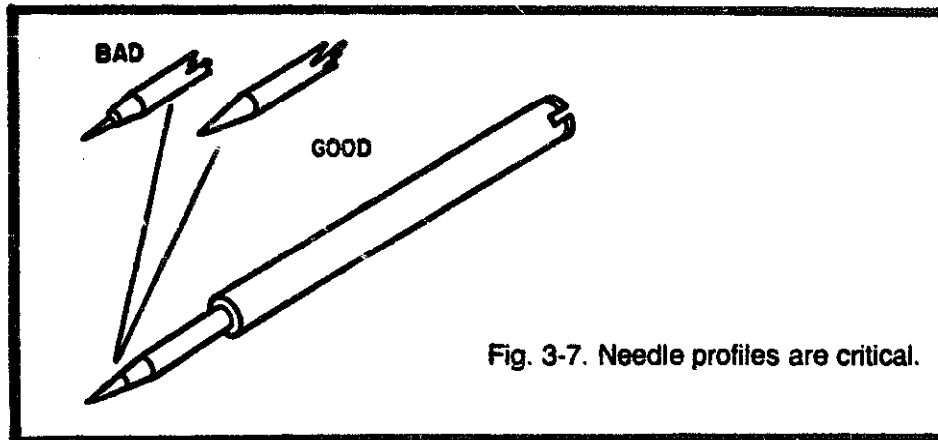
The idle speed screw is easy to distinguish, since it bears against the idle stop. The low speed screw is always near the throttle valve, and the high speed screw is closer to the air filter. Vacu-Jets and Pulsa-Jets have two adjustments: low speed mixture and idle rpm. Flo-Jets have all three: low and high speed mixture, and idle rpm.

**The Flo-Jet Carburetor (both one and two piece).** The initial, or starting, adjustment is  $1\frac{1}{8}$  turns out from lightly seated on both mixture screws. Allow the engine to reach operating temperature and tighten the high speed mixture screw until the engine misses, a condition known as lean roll. Back the screw out to induce rich roll. The midpoint between these two extremes is the approximate adjustment. Do the same for the low speed mixture screw, first leaning, then richening the mixture, and finally splitting the difference. Check the adjustment on the high speed screw again, since the low speed screw will have had some effect upon it. Finally, allow the engine to idle and open the throttle quickly. The engine should accelerate smoothly. If it hesitates or sputters, open the high speed mixture screw a fraction of a turn.

While these engines will "Cadillac," or tick over so slowly that you can almost count the revolutions, be aware that low idle speeds are extremely dangerous. The cooling fan ceases to deliver much air to the fins, and lubrication becomes faulty. Sudden acceleration after a few minutes at low idle speeds sometimes throws the rod through the side of the block. Keep idle speed high, between 1750 rpm and 1800 rpm. For accurate adjustment, use a vibrating reed tachometer, or an electronic tachometer calibrated for single cylinder magnetos. These tools are available through engine jobbers. However, the exact idle rpm is less important than full-throttle rpm (see the next chapter for governor adjustments), and at this stage, one can usually guess at idle rpm.

**The Vacu-Jet and Pulsa-Jet Carburetor.** Initial adjustment of the low speed mixture screw is  $1\frac{1}{2}$  turns out from lightly seated. After the engine reaches operating temperature, flip the throttle.





Hesitation means that the mixture should be richened a fraction of a turn. Idle speed is 1750 rpm.

### **Cleaning**

Obstructions in the jet orifices and feed circuits can usually be cleared by removing the adjustment screw and applying compressed air to the jet. By OSHA regulation, air pressure must be no higher than thirty pounds per square inch; greater pressures can penetrate human skin and form bubbles in the blood stream. Do not pressurize float chambers, since thirty pounds per square inch can collapse the float.

If compressed air is not available, you can clear the jet with a broomstraw. A wire or other metallic probe can deform the jet, making adjustment difficult or impossible. If the jet is removed, grind the screwdriver for a close fit with the slot. Sloppy screwdriver fits batter the slots and disturb fuel flow through the orifice. By the same token, seating the adjustment needles hard against the jets deforms both parts (Fig. 3-7). A blunted or grooved needle passes fuel erratically. Fingertight is enough. Wear on the inlet needle and seat shows as an annular groove on the needle tip (Fig. 3-8). Replace the needle, seat, and gasket, sizing the screwdriver blade to fit the seat slots. Tighten firmly.

While plastic gasket rings can be reused, it is good practice to replace any gasket that has been disassembled. This is particularly true of Pulsa-Jet diaphragms and mounting flange gaskets.

Chemical immersion cleaning is sometimes necessary, particularly if the carburetor has been contaminated with stale or water-

logged fuel. Completely disassemble the carburetor with the purpose of removing all rubber and plastic parts, including plastic choke valves and pickup tubes.

Soak the metal parts for a half hour or so in carburetor cleaner. Most mechanics seem to prefer Bendix cleaner, although other brands work as well. Delco-Remy markets a water-soluble cleaner. Gunk packages theirs in small tins which are ideal for this work. In any event, carburetor cleaners are powerful chemicals, dissolving paint, scale, rust, and human skin. Avoid breathing the fumes and protect your hands with rubber gloves. Wash off the cleaner with kerosene or, in the case of Delco X-55, with hot water. Allow the carburetor to dry before reassembly.

### BRIGGS & STRATTON CARBURETORS

The three basic models, Flo-Jet, Vacu-Jet, and Pulsa-Jet, take various forms (Figs. 3-2 through 3-4). Despite shape and size variation within each model type, parts are often interchangeable.

#### Flo-Jet (One and Two Piece)

The two piece Flo-Jet is shown in cross section in Fig. 3-9. The one piece variant was pictured in Fig. 3-1. Disassembly procedures are for the most part obvious, with these exceptions:

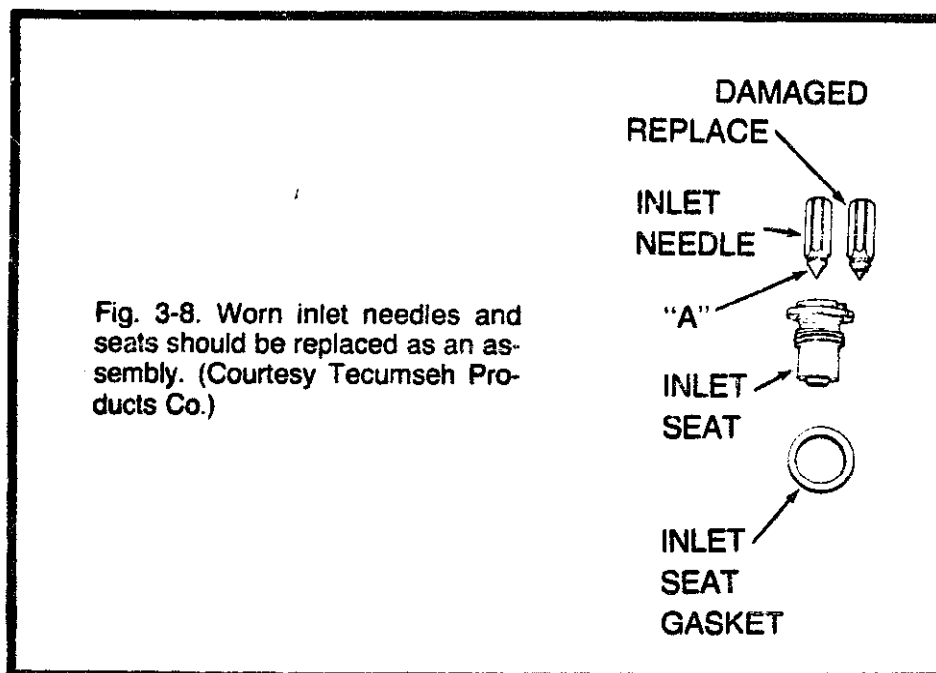


Fig. 3-8. Worn inlet needles and seats should be replaced as an assembly. (Courtesy Tecumseh Products Co.)

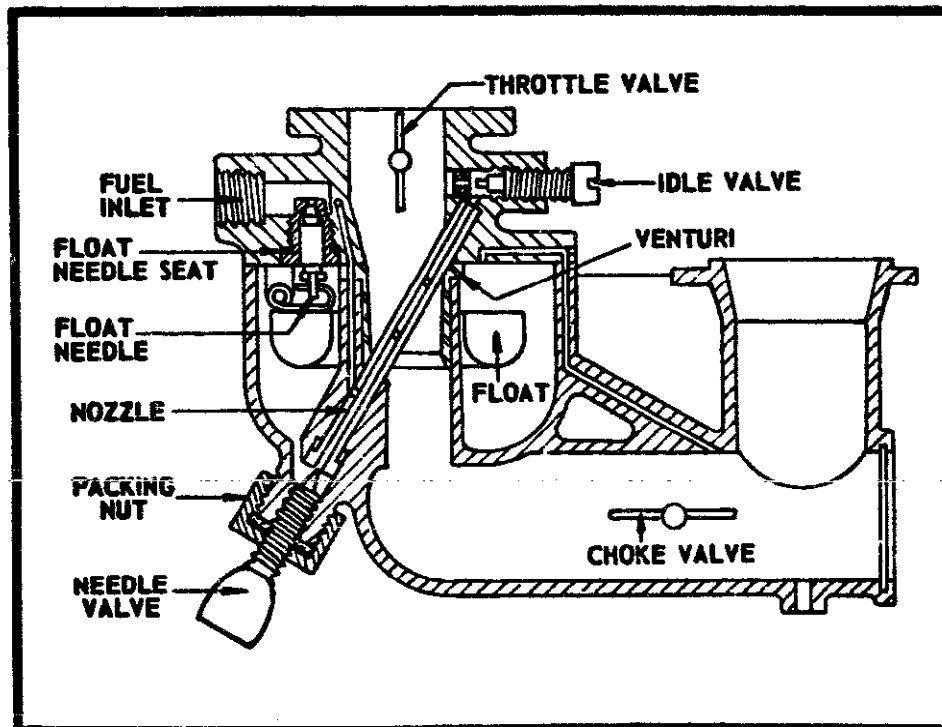


Fig. 3-9. The two-piece Flo-Jet, cross section view. (Courtesy International Harvester Co.)

- The throttle lever is pinned to the throttle shaft. If you wish to remove these parts (not necessary for cleaning), drive the pin out with a punch, remove the screws holding the throttle valve to the shaft, and extract the shaft (Fig. 3-10).
- To remove the nylon choke shaft, carefully unseat the Welch plug (Fig. 3-11). Insert a sharp tool between the shaft and choke valve to break the grip of the nylon. Withdraw the choke valve with a pair of long nosed pliers and remove the shaft. Upon installation, seal the Welch plug with liquid silicone.
- The two piece design consists of two castings, the upper, or throttle body, and the lower, or carburetor body. To separate these parts, remove the screws at each corner of the float housing. Gently tap the throttle body to break the hold of the gasket. Once free, guide the carburetor body down and away from the air filter to disengage the fuel nozzle.

**Throttle Bushings.** Flo-Jet carburetors are intended for long service, in many cases outlasting the engines to which they are affixed. The replaceable throttle shaft bushings attest to the longev-

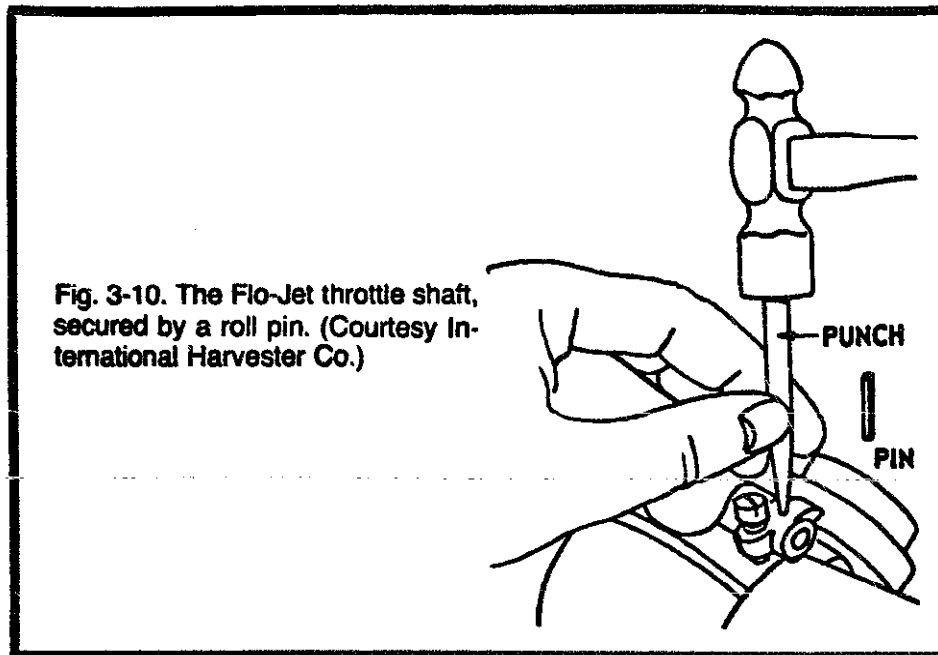


Fig. 3-10. The Flo-Jet throttle shaft, secured by a roll pin. (Courtesy International Harvester Co.)

ity of Flo-Jet carburetors. Lesser carburetors, including those built by Clinton, Tecumseh, Tillotson, and Walbro, do not have this feature. When the throttle shaft wears its pivots, the whole carburetor must be replaced.

To replace the bushings, remove the throttle valve and shaft. Withdraw the bushings with the help of a  $\frac{1}{4}$  inch  $\times$  20 tap, or equivalent sized thread extractor (Fig. 3-12). Install a new throttle shaft and test for free operation; should the shaft bind, ream the bushings by hand with a  $\frac{7}{32}$  inch drill bit. Replace the throttle shaft and lever.

**Inlet Valve Seat.** One piece and older two piece Flo-Jets have brass inlet valve seats. Replace the seat and needle if the carburetor

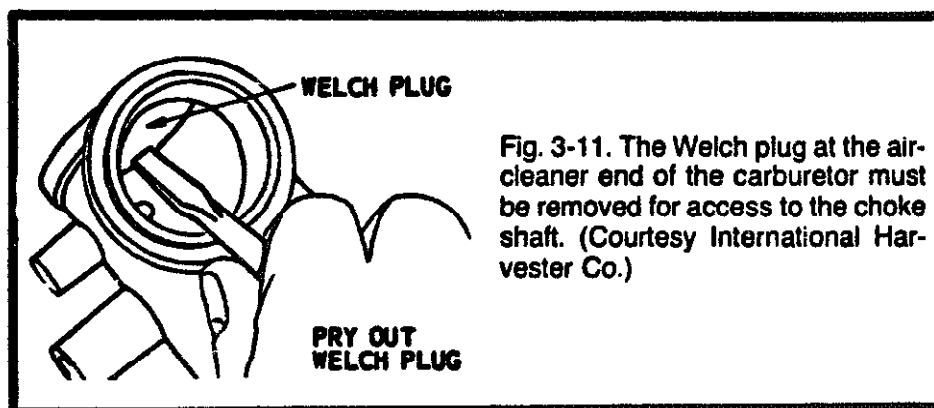


Fig. 3-11. The Welch plug at the air-cleaner end of the carburetor must be removed for access to the choke shaft. (Courtesy International Harvester Co.)

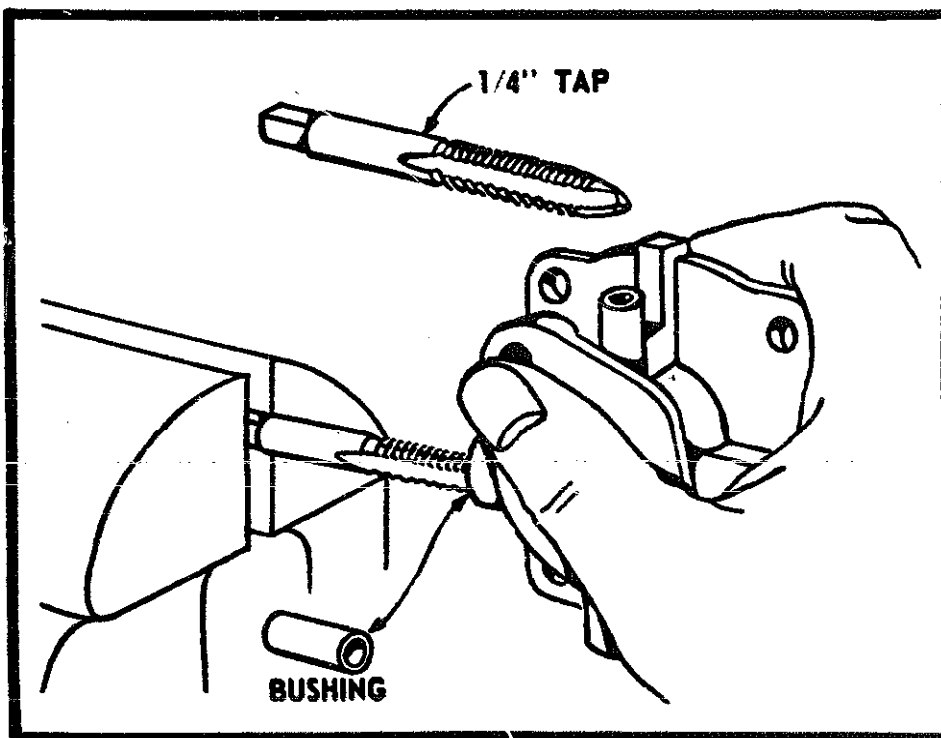


Fig. 3-12. Throttle shaft bushings can be removed with a ¼ in. tap or screw extractor. (Courtesy International Harvester Co.)

floods, or if the needle is grooved around its contact face. Late model one piece Flo-Jets employ a Viton seat that should outlast several needles. If the seat appears damaged (any visible wear is grounds for rejection), extract the old seat with a self-tapping sheet metal screw (Fig. 3-13). Using the old seat as a buffer, press in a replacement flush with the carburetor casting. (NOTE: Gravity fed carburetors require inlet seat number 23109; pump fed carburetors require seat number 23019.)

**Float.** If flooding has been a complaint, check the float for leaks. The best way to do this is to place the float in a container of hot water; pinholes will expand and the float will take on water. While these carburetors will tolerate resoldered floats, this practice is not recommended. Replace a damaged float rather than attempt to repair it.

The float level—measured between the upper edge of the float and float cover gasket—is 3/16 of an inch on the large two piece Flo-Jet, and 5/16 of an inch on the smaller versions of the same carburetor. As a practical matter, the float on these and one piece Flo-Jets should be parallel with the gasket when inverted (Fig. 3-14).

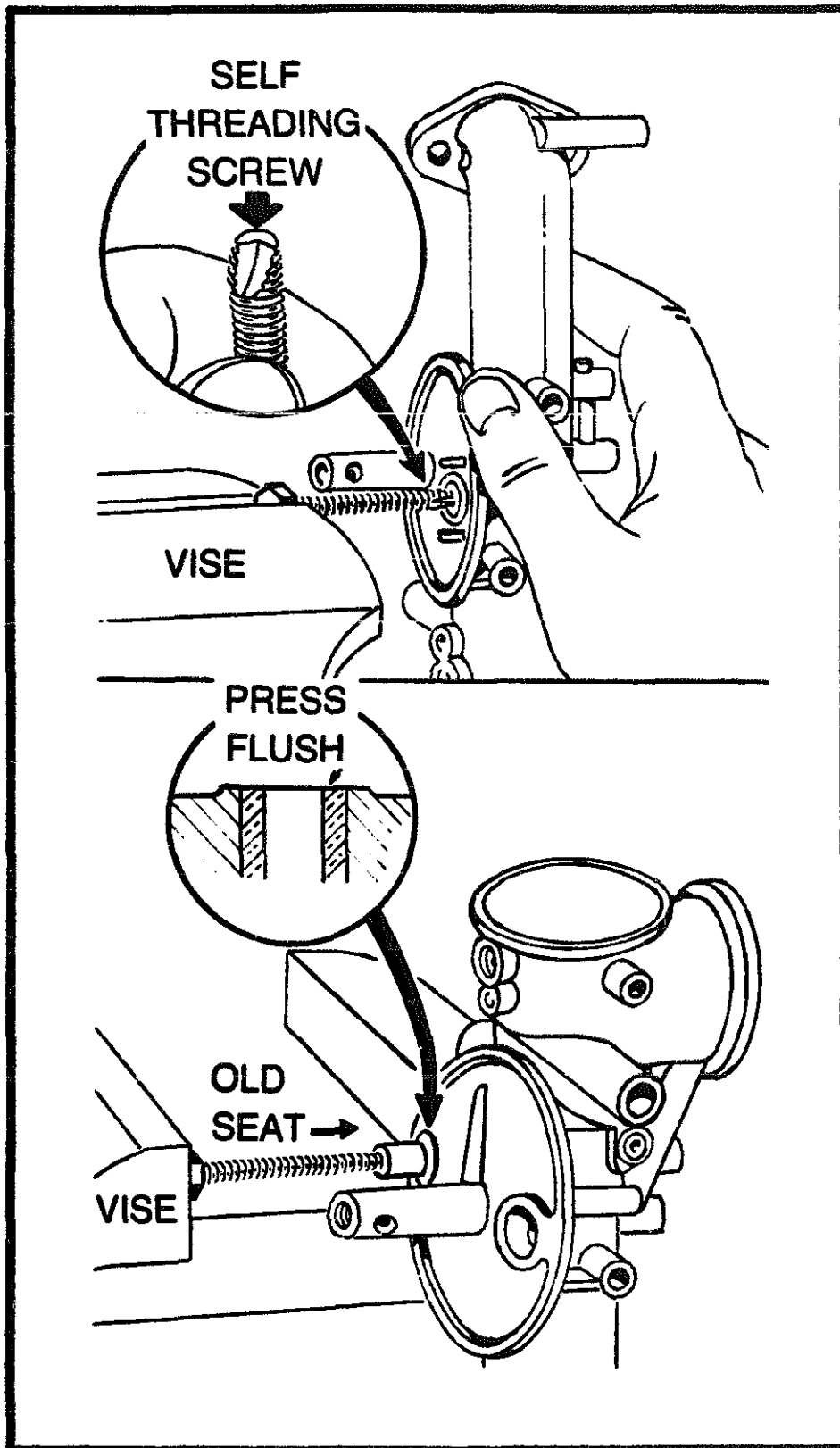


Fig. 3-13. Viton seats are extracted with the help of a self-tapping screw.

These carburetors are less sensitive to float level variations than competitive designs are. When adjusting the float, bend the tang—the part that bears against the needle—with a pair of long nosed pliers. Do not apply force to the needle, particularly a plastic needle.

**Remote Controlled Choke.** Adjust the linkage to close the choke valve completely without denying full throttle. This can be accomplished on cable operated systems by moving the cable in its anchor screw. A second method is to judiciously bend the choke trip link.

### **Vacu-Jet**

The Vacu-Jet is available in three variants, all of which operate on the same pickup tube principle (Fig. 3-3). The earliest of these variants, the type shown at the bottom of the drawing, mounts to the engine with capscrews. These screws can become loose in service (particularly if the crankshaft is bent, or if the load is unbalanced) and cause an air leak at the flange. Later models benefit from an improved flange and tank brackets.

**Pickup Tube.** Very early Vacu-Jets employed a small brass pickup tube without a check valve. Later variants have a check valve in a brass or nylon tube.

If the engine has been stored with fuel in the tank, expect the ball check valve to be stuck closed. The filter screen (at the base of the pickup tube) may be clogged and the lower half of the tank will be covered with foul smelling gum and varnish. Clean the tank as described under “Fuel Tanks” and, if at all possible, replace the pickup tube assembly. In theory brass tubes can be cleaned by immersion, but in practice this rarely works.

But even in the best run shop, a mechanic does not always have parts and must make do with what he has—in this case a stuck check valve. Introduce a fine wire through the filter screen and gently unseat the ball. Do not force it to the upper stop, for should the valve stick open, the carburetor will run excessively rich.

**Metering.** Fuel passes through an adjustable jet before discharging through ports in the carburetor body. This jet is accessible for cleaning by removing the adjustment screw and gasket. The high and low speed discharge ports are sized to match drill numbers 56 and 68 respectively.

**Choke.** The plug choke must close completely (that is, be fully extended out of the carburetor body) during cold starts. Most of these carburetors are controlled remotely with a linkage that regulates choke action, speed, and engine shutdown. Make the initial adjustment at the tie point for the control cable. Moving the cable to the rear should cause the lever movement to engage the choke sooner. If this does not help, or if it prevents shutdown, bend the choke link, effectively shortening it.

### **Pulsa-Jet**

The Pulsa-Jet exists in three varieties: one with the traditional Briggs & Stratton carburetor along with an intake pipe, and two short coupled designs for use with separate intake pipes (Fig. 3-4). As noted earlier, the elongated model can work loose in service, particularly if the crankshaft is bent. The "bob-tailed" types give very little trouble in this regard, but will, of course, leak air if the intake pipe is distorted.

**Throttle Plate.** Early Pulsa-Jets used throttles cast in the form of a cylinder with flats milled on the sides. These throttles can be lifted up and out of the carburetor body once the idle speed screw is backed off. Two piece throttles of the pattern shown in Fig. 3-1 are secured by a Phillips screw. Remove the screw and, using long nosed pliers, extract the throttle plate from the carburetor bore. Lift out the throttle shaft. Installing the throttle plate is a bit tricky on the elongated Pulsa-Jet because of space limitations. Working from the engine end of the carburetor, you have to align the hole in the

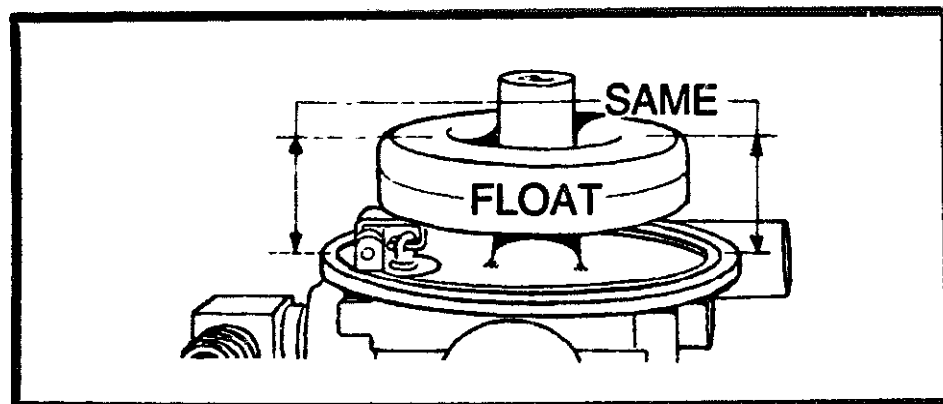


Fig. 3-14. The float should be level with the carburetor body. (Courtesy International Harvester Co.)



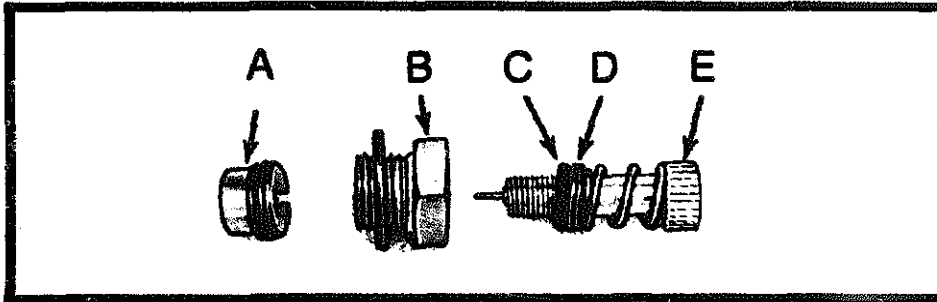


Fig. 3-15. Mixture adjustment screw and related hardware. (Courtesy International Harvester Co.)

throttle plate with the threaded hole in the throttle shaft. Briggs & Stratton engineers suggest mounting the plate on the sharpened end of a wooden pencil. Once the parts are in position, the pencil can be withdrawn and the screw installed. Another technique is to hold the parts with a screw starter. (Phillips screw starters are fairly rare tools, but are stocked by some large hardware dealers.) Position the screw in the holder, balance the throttle plate over the end of the screw, and install the parts in one rapid motion.

**Spiral.** A few of these carburetors have a sheet metal spiral in the bore, to the rear of the throttle plate. The spiral can be extracted with long nosed pliers. Upon installation, the spiral should be flush with the flange gasket surface.

**Metering.** The mixture adjustment screw limits fuel flow through the jet (Fig. 3-15A), and so determines the air fuel ratio. This screw threads into a packing gland (Fig. 3-15B) and is sealed by an O-ring (Fig. 3-15C). Washers (Fig. 3-15D) protect the O-ring from shearing damage as the screw is turned.

**Pump Elements.** The pump diaphragm is a masterful example of engineering economy (Fig. 3-16). This single part combines the functions of pump diaphragm, suction and exhaust valves, and pump gasket. These functions depend upon the elasticity of the diaphragm, a quality that is difficult to judge by feel. Wise mechanics replace the diaphragm whenever the pump cover is removed.

The cup, situated between the inner edge of the diaphragm and the coil spring, was solid in the original version. Any of these solid cups, if still in use, should be replaced with the new hollow type.

Bob-tailed Pulsa-Jets have the pump vacuum chamber built into the top of the fuel tank. It is vital that the machined surfaces on the tank be true; distortion, particularly along the shaded areas in Fig.

3-17, may short circuit the main jet. In other words, fuel can leak past the diaphragm from the carburetor side of the pump and collect in the vacuum chamber. Since the chamber is evacuated by means of a port on the side of the carburetor body, fuel in the chamber is eventually pulled into the engine. Lay a precision ground, or machinists, straightedge across the tank as shown in the drawing. Replace the tank, or attempt a repair with kit No. 391413 if you can insert a 0.002 inch feeler gauge between the straightedge and the critical tank surfaces.

**Fuel Pipes.** Nylon pipes are threaded into the carburetor casting and are easily removable, a convenience since these pipes must not be allowed in carburetor solvent. Brass pipes are press fitted into the casting. To separate the pipes from the casting, fix the pipe in a vise and carefully pry and twist the casting off. Using the vise as a press, force the replacement pipe to the depth of the original.

Fuel screens are difficult to clean, particularly when attached to a nylon pipe. Replace the whole assembly. Brass pipe screens are pressed on, and can be ordered by part number (Fig. 3-18).

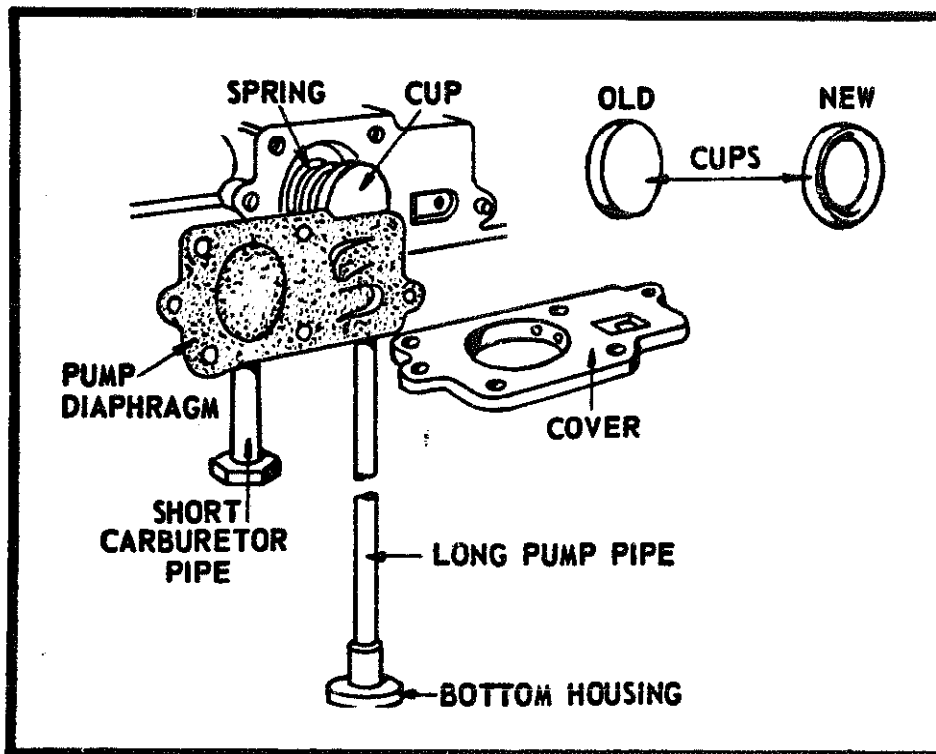


Fig. 3-16. Palsa-Jet pump assembly. (Courtesy International Harvester Co.)

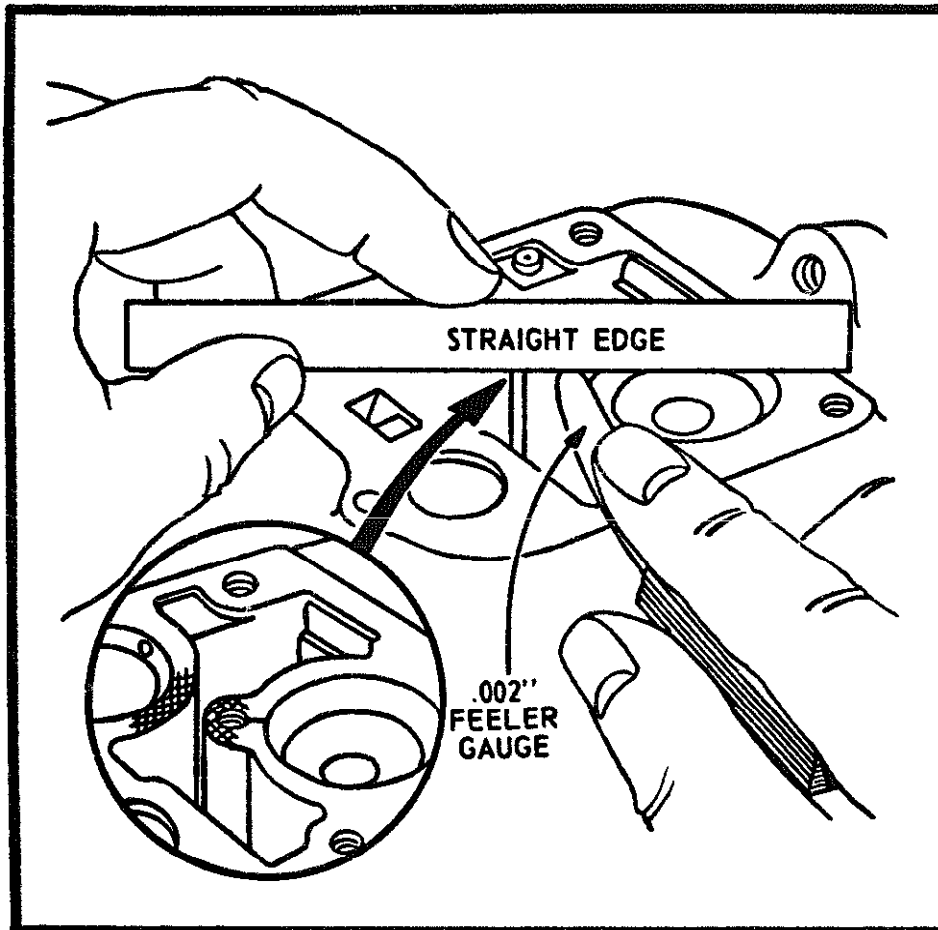


Fig. 3-17. Distortion of more than 0.002 in. at the shaded areas can disable the pump or automatic choke. (Courtesy International Harvester Co.)

### **AUTOMATIC CHOKES**

An automatic choke is an example of a closed loop servosystem. The choke valve must be closed for cold starting, and should progressively open as the engine warms and reaches operating speed. The choke valve is suspended between opposing forces: a coil spring attempts to close the valve while Venturi vacuum, or a combination of cooling air pressure and a thermostatic spring, try to force it open.

### **Flo-Jet Chokes**

Big bodied Flo-Jets employ a very sophisticated choke that responds to engine speed and cylinder block temperature. The spring, a laminate of iron and copper, increases tension as the block warms and provides a progressively greater opening force on the choke valve. Engine speed is sensed by a vane positioned in the

cooling air stream. As speed increases, the air vane moves to open the choke, allowing more air to enter the carburetor. Conversely, as speed drops, the vane reduces pressure of the valve and allows it to partially close. Once the engine reaches operating temperature, the thermostatic spring overrides the vane and holds the choke valve fully open.

To service, loosen the set screw at the thermostatic spring lever, disengaging the spring from the choke valve (Fig. 3-19). Cycle the choke valve by hand to detect possible binds in the mechanism. Center the valve on its shaft, or clean the shaft pivots as necessary to restore freedom of movement.

Turn the spring shaft clockwise while holding the valve  $\frac{1}{8}$  of an inch open, with the thermostatic spring horizontal and pegged against its near side stop (Fig. 3-19A). Tighten the set screw. Reverse the procedure, turning the spring shaft counterclockwise until its stop rests against the opposite side of the tube (Fig. 3-19B). The position of the valve should remain the same with the thermostatic spring at the opposite extreme of travel. Without releasing the shaft, close the choke valve by hand. There should be a  $\frac{1}{8}$  inch clearance between the valve's lower edge and the bottom of the carburetor bore. If this dimension is off, check the initial adjustment.

### Vacu-Jet and Pulsa-Jet Chokes

These chokes open in response to venturi vacuum, sensed by a spring loaded diaphragm. In the Pulsa-Jet application, the diaphragm

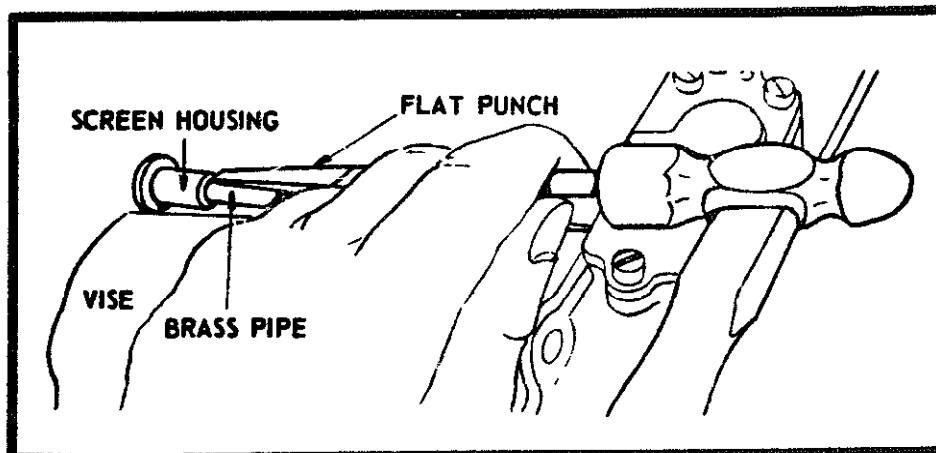


Fig. 3-18. Brass tube screen housings are replaceable. (Courtesy International Harvester Co.)

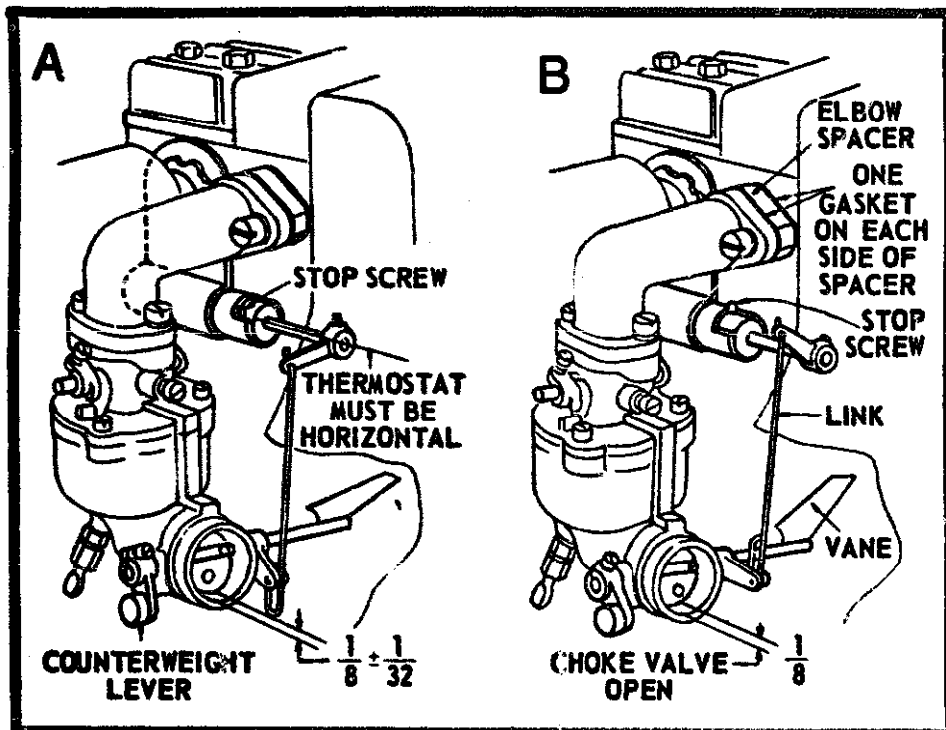


Fig. 3-19. Large one piece Flo-Jet automatic choke adjustment. (Courtesy Briggs & Stratton Corp.)

doubles as the fuel pump element. While the choke does not respond to changes in engine temperature, it acts as an accelerator pump. Automotive carburetors generally have a pump linked to the throttle lever. Upon sudden acceleration, the pump delivers a stream of raw fuel into the carburetor bore. Without this boost, the engine would momentarily go lean and falter. Air is, of course, lighter than gasoline and responds much more quickly to throttle opening. A few seconds is required for the fuel to "catch up" and restore the mixture balance. The Briggs & Stratton choke mimics accelerator pump action. When the throttle valve pivots open, venturi vacuum momentarily decreases and the choke valve closes, richening the mixture.

### Troubleshooting

With the engine stopped, remove the air cleaner and observe the position of the choke valve. It should be closed and, when opened by hand, returned to the closed position. Failure of the choke to close can be traced to any of the following causes:

- Carbon or varnish deposits on the choke shaft pivots.
- Interference between the air cleaner stud and the choke valve.

- Insufficient diaphragm preload (see below).
- Loss of diaphragm spring tension.

The more frequent complaint is failure of the choke to open. Remove the air filter and crank the engine. The choke valve should flutter with each intake stroke. Once the engine starts, it should open, although some pulsation under acceleration is normal. Check for these defects:

- Carbon or varnish deposits on the choke shaft pivots.
- Interference between the air cleaner stud and the choke valve.
- Excessive diaphragm spring tension.
- Punctured diaphragm.
- Fuel or oil in the diaphragm chamber.
- Tank top distortion.

The tank top should be flat to within 0.002 of an inch. Figure 3-20 illustrates the gauging procedure for Vacu-Jet tanks; the procedure for Pulsa-Jet tanks has been shown previously in Fig. 3-17. The shaded areas in the drawings are critical.

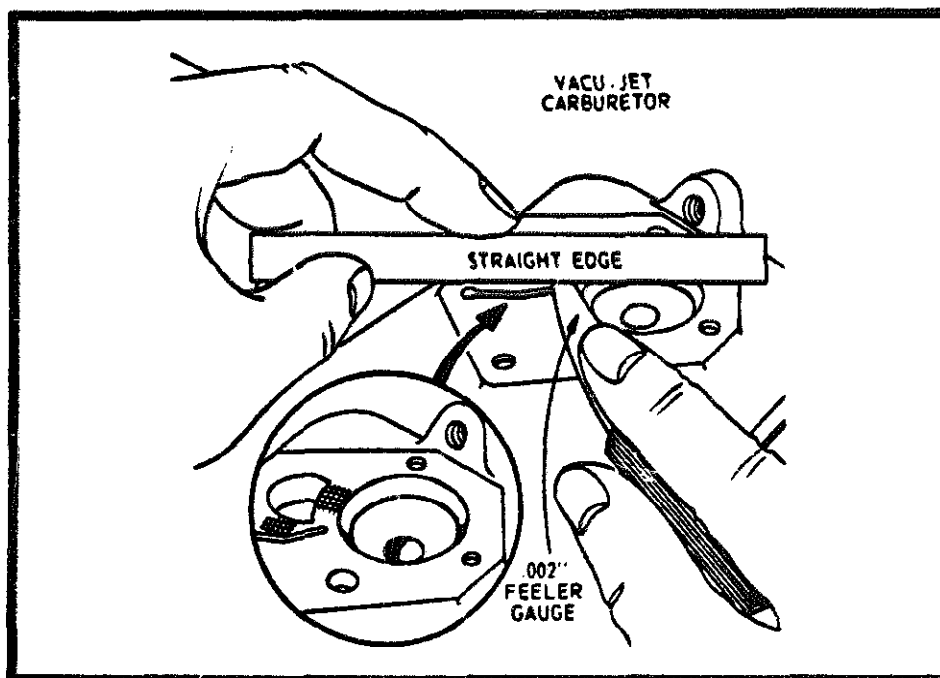


Fig. 3-20. Vacu-Jet tank distortion is critical between the two wells and between the smaller well and vacuum slot. (Courtesy Briggs & Stratton Corp.)

The choke link is secured to the diaphragm by a clip and spring (Fig. 3-21). The free standing length of the spring should fall between these limits:

| Model                                 | Minimum          | Maximum       |
|---------------------------------------|------------------|---------------|
| Pulsa-Jet (all)                       | 1 1/8 in.        | 1 7/32 inches |
| Vacu-Jet (except engine model 110900) | 15/16 of an inch | 1 inch        |
| Vacu-Jet (engine model 110900)        | 1 5/16 inches    | 1 3/8 in.     |

Pulsa-Jet diaphragms have a second spring for the fuel pump function (Fig. 3-21). The spring is located by a well in the carburetor body and its free end bears on the diaphragm through a cup.

While the original diaphragm may be used as long as it is not

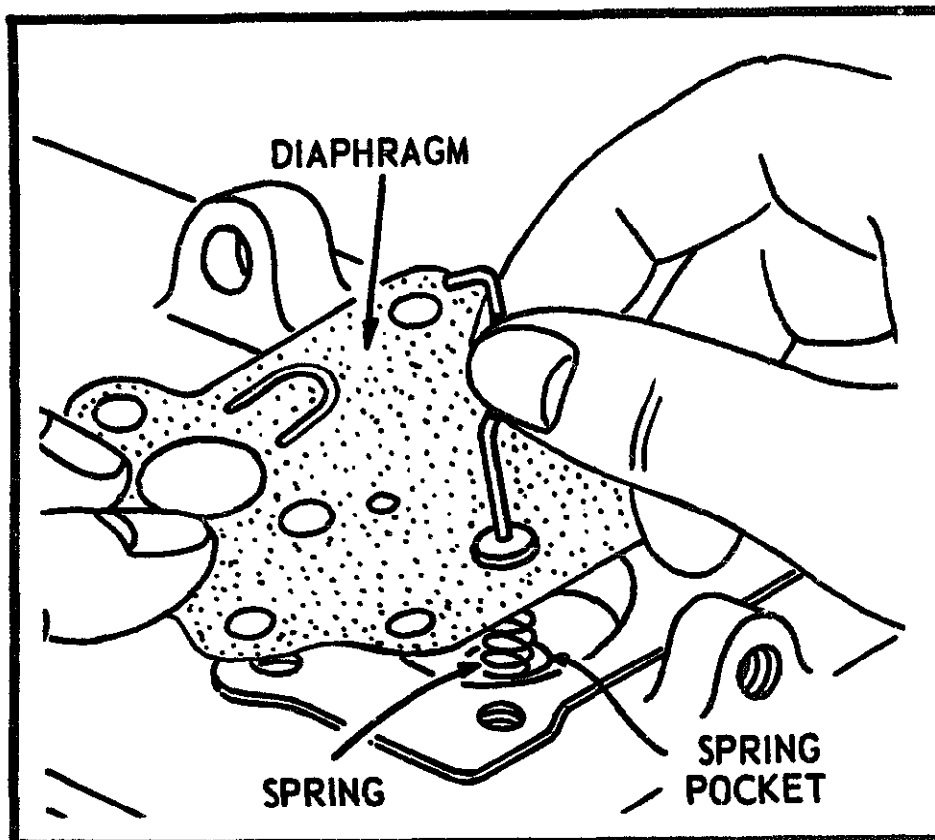
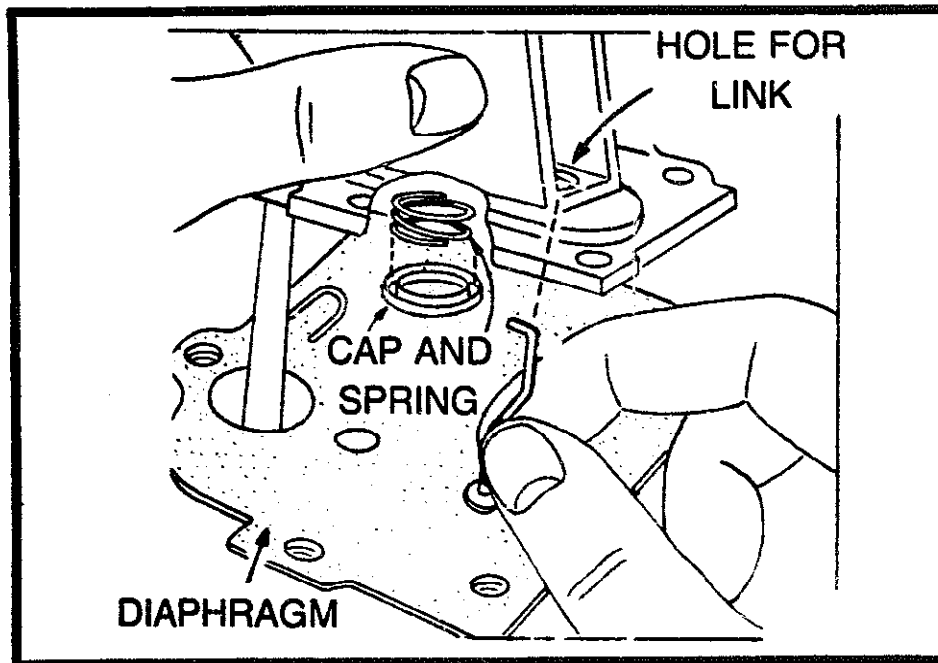


Fig. 3-21. The choke spring fits under the diaphragm with the choke link positioned as shown. (Courtesy Briggs & Stratton Corp.)



**Fig. 3-22.** The cap and spring ride on the diaphragm, located by a recess in the carburetor body. The link passes through a hole in the body. (Courtesy Briggs & Stratton Corp.)

punctured, creased, or work hardened, most mechanics replace the part each time a carburetor is disassembled. Mount the choke spring and link, being careful not to distort the spring in the process. Position the pump spring and cup on the Pulsa-Jet and thread the mounting screws a turn or so into the fuel tank. Holding the choke valve closed with your finger, connect the link to the choke shaft.

Without releasing the choke valve, draw down the carburetor mounting screws. Tighten the screws evenly in a crisscross pattern to equalize stresses on the tank. The choke should be closed and, when you flip it with your finger, return to the closed position. The diaphragm or, more exactly, the choke spring, is preloaded.



## **CHAPTER 4**

# **GOVERNORS**

Governors have two functions: to limit no load rpm, and to hold rpm constant under changing loads. This limiting of speed is important because the weakest link in a small engine is the connecting rod. Inertial forces on the rod increase as the square of rpm; that is, at 6000 rpm the rod is subject to nine times the stress it is subject to at 2000 rpm. In addition, the blade tips of rotary lawnmowers must not exceed 19,000 feet per minute. A 26-inch blade, driven directly from the crankshaft, will reach this critical speed at a leisurely 2791 rpm. For these reasons, it is strongly suggested that you set the maximum speed of the governor with the help of a tachometer. Most mechanics use a vibrating reed tach, one whose reeds go into harmonic vibration with exhaust pulses. Electronic tachometers are available, but are expensive and must be connected in parallel with the points. On small engines without magneto kill switches, electronic tachometer hookup involves pulling the flywheel.

The ability of the governor to hold a predetermined engine speed under varying loads is also important. Few loads are constant; without a governor, the operator would have to make continuous throttle corrections.

Briggs & Stratton engines employ two types of governor, pneumatic and centrifugal.

## PNEUMATIC GOVERNORS

Figure 4-1 is a representative drawing of a pneumatic, or air vane, governor. While details of this drawing differ from specific Briggs & Stratton models, the functional relationships are the same.

The throttle valve is suspended between a spring that will open it and an air vane that, once the engine starts, acts to close it. The air vane is mounted in the cooling air stream under the shroud and is free to pivot under the effects of air velocity. The faster the engine runs, the higher the velocity, generating a greater force by the vane to close the throttle.

Should the load increase, the engine momentarily bogs down, airstream velocity drops, and the vane allows the spring to open the throttle. Once this compensation is made, engine speed returns to its original level. By the same token, if the load relaxes, engine speed increases, and the vane, subsequently closes the throttle.

The governor has a manual override: the operator can increase spring tension by opening the throttle lever. This action causes the carburetor throttle valve to open wider, increasing the speed of the engine and the velocity of the cooling airstream. Throttle plate equilibrium is established at a higher point on the rpm scale. Conversely, closing the throttle lever relaxes spring tension, biasing the throttle position in favor of the air vane.

Do not expect much from a pneumatic governor. These devices have only one recommendation—they can be manufactured for pennies. At low speeds, there is insufficient dampening and the engine *hunts*, picking up a few hundred rpm, losing it, and picking it up again. (This is another good reason for fixing the lowest idle limit at 1700 rpm or so.) And, regardless of engine speed, response is lethargic.

### Troubleshooting

**Erratic Response.** Remove the shroud and work the mechanism by hand. It should move freely. Binding is usually the fault of a bent link, or a link installed backwards and rubbing against the carburetor or cooling fins.

On rare occasions, the vane may bind on its pivots as the result of rust or dirt. Clean the pivot and install the vane dry, without lubrication. On new engines, the throttle valve is sometimes fouled

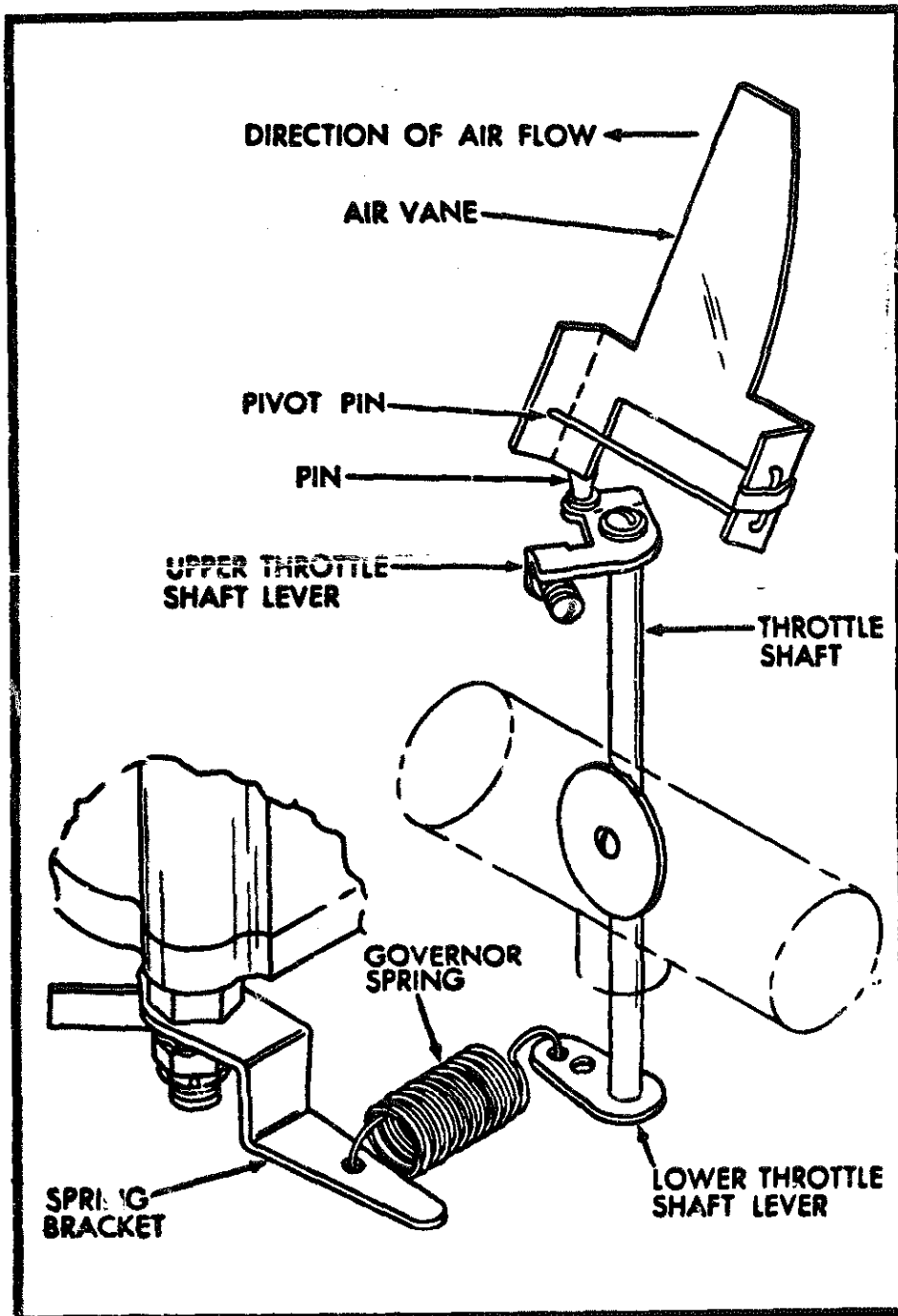


Fig. 4-1. Typical pneumatic governor. (Courtesy Tecumseh Products Co.)

by paint overspray. You can usually clear up this problem without disassembling the carburetor by using an eye dropper to soak the throttle valve pivots with lacquer thinner.

**Hunting.** Assuming a liberal idle speed, hunting results from an improperly adjusted carburetor (usually too lean) or excessive

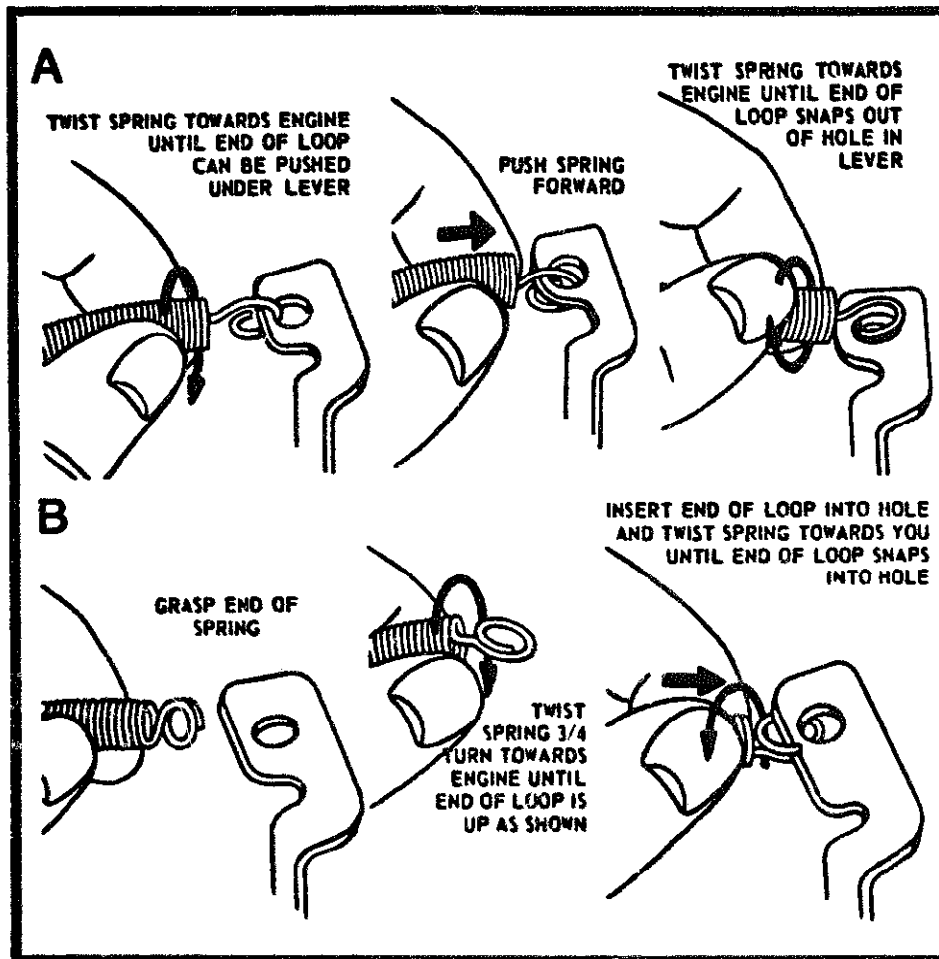


Fig. 4-2. Removing (A) and mounting (B) double coiled governor springs on levers. (Courtesy Briggs & Stratton Corp.)

free play in the governor linkage. Adjust the carburetor to give instant response as the throttle is tripped open.

The spring is the most delicate part of the mechanism, and the cause of most failures. If at all possible, ascertain that the spring is the correct one for the application. There are scores of governor springs, each with slightly different characteristics. Examine the spring ends for deformation, and, gently stretching the spring, look for uneven coil separation. This last symptom means that the coils have fatigued, effectively increasing the length of the spring.

Many springs are double looped for security. Forcing these springs open with long nosed pliers will deform the ends and upset governor calibration. The trick is to twist the spring while disengaging it, as if you were coiling a length of hose. Figures 4-2 and 4-3 illustrate the technique.

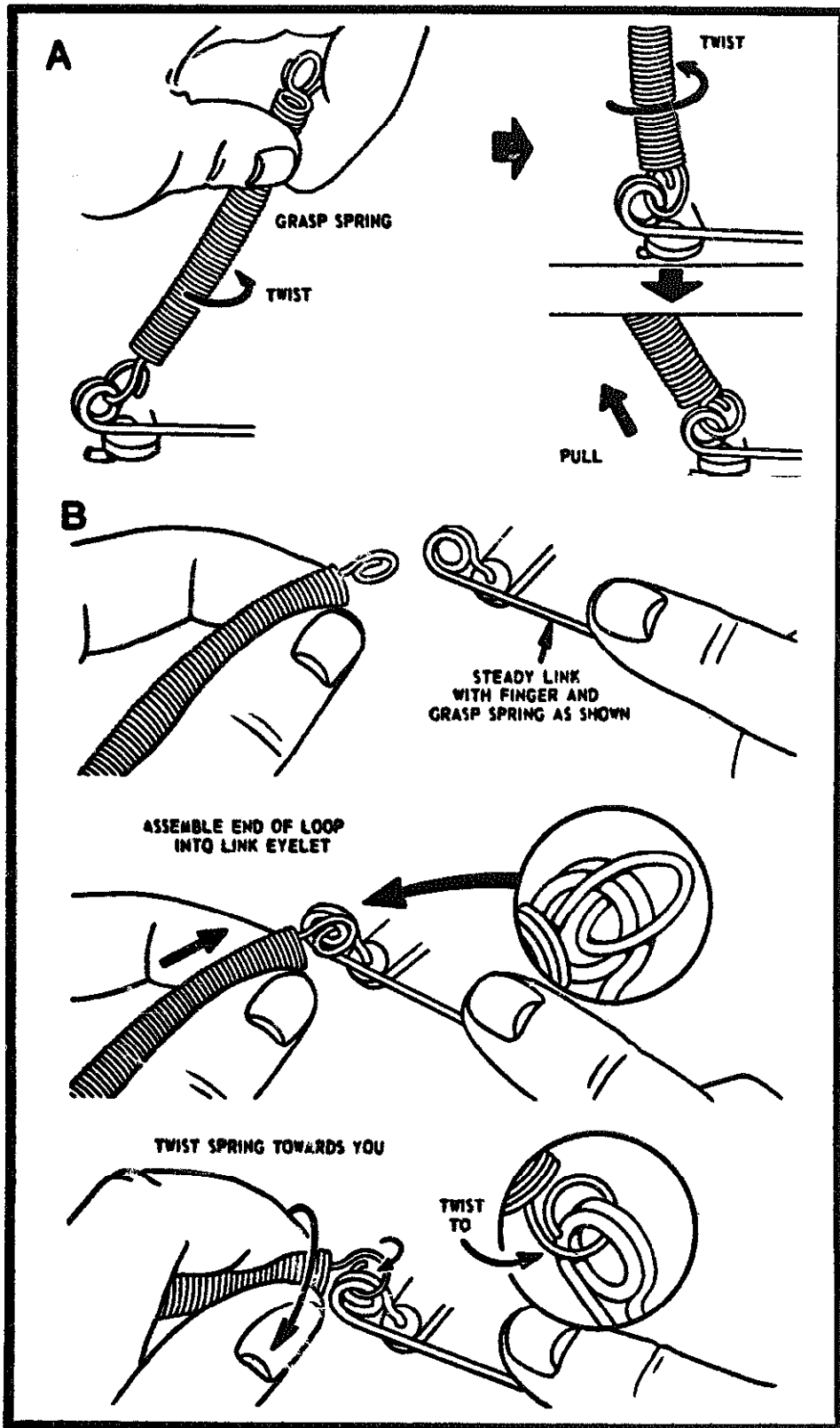


Fig. 4-3. Removing (A) and mounting (B) double coiled springs on governor links. (Courtesy Briggs & Stratton Corp.)

While no great gains can be had from replacing the wire link, wear on the link ends will slow governor response and promote hunting. In extreme cases, the link can saw its ends off, releasing the engine from governor control. In this situation, the engine must be shutdown immediately, or it will self-destruct.

**Engine Will Not Reach Full Governed Speed.** This complaint is common in older engines and is, in a way, benign. Speed kills aging connecting rods. In most cases, this lack of speed can be cured by replacing the weakened spring with the correct one for that model engine. Other possible causes are binds at the link or vane.

**Engine Overspeeds.** Most throttle valves have more than one mounting hole for the spring and link. A mechanic may inadvertently reverse these mounting points, or connect the vane link at a leverage disadvantage. A deformed link or improper throttle spring can also cause this problem.

### **Cautionary Comment**

Air vane governors are delicate devices, controlling engine speed with forces of only a few grams. Attempting to repair one by substituting a nonstock spring, by stretching, clipping, or reforming the old one, or by changing the shape of the link will probably fail and consequently destroy the engine.

### **CENTRIFUGAL GOVERNORS**

The heart of the mechanism is a pair of revolving weights known as flyweights (Fig. 4-4). The weights are driven by a gear and revolve with the engine. Centrifugal (or, more precisely, centripetal) force flings the weights outward, with only the pivots restraining them. This outward motion is proportional to the square of engine speed, increasing dramatically at high rpm. As the weights move, they slide the cup to the left, camming the follower and its attached lever.

The motion of the lever tends to close the throttle. This force is counteracted by a spring that holds the throttle open. One end of the spring is attached to the manual throttle or control cable, the other end to a bellcrank as shown, or directly to the throttle valve. In either event, opening the manual throttle control increases spring tension and causes the engine to run faster.

Once the throttle control level is set, the engine should hold that speed independently of load. If load increases, the engine momentarily slows, the flyweights relax, and the spring opens the throttle to compensate for the increased load. Should the load decrease, the train of events is reversed: the engine speeds, the weights fling outward, and the throttle valve closes.

Centrifugal governors are quite reliable and are more durable than the engine that drives them. Most complaints involve minor problems centering around the throttle spring and lever adjustment.

### **Troubleshooting**

**Hunting.** This malady—a metronomic gain and loss of rpm under steady or no load conditions—can be caused by a maladjusted carburetor, or intermittent ignition failure. If the governor is involved, the problem can usually be cured by slight changes in the linkage.

On most applications, bellcranks and levers are drilled with rows of numbered holes, giving alternate positions for spring and link attachment. Securing the links and springs near the end of the levers reduces the sensitivity of the governor. Large flyweight movements have small effects on the angle of the throttle valve. Small changes in engine speed go unnoticed by the governor and there is a marked variation between no load and full load rpm. Conversely, mounting the springs and links far outside of the lever pivots makes the mechanism more sensitive. Small changes in engine rpm are sensed and compensated for and no load and full load speeds are closely matched. But this matching can be carried too far. Mounting the hardware too close to the lever pivots makes the governor overly sensitive. *Throttle valve angles change before the engine can react, and the result is hunting.*

**Failure to Reach Governed Speed.** Models N, 6, and 8 have no adjustment provision. Assuming the linkage moves freely, inability to attain full governed speed can be corrected by replacing the spring with another of the same number. Other engine models can be adjusted to compensate for weak springs.

**No Governor Response.** Check for binds at the levers, links, throttle valve, and in the centrifugal mechanism itself. The governor lever must be secured to the governor shaft.

**Runaway Governor.** Shut the engine down immediately and open the governor case for inspection. Expect to find serious mechanical damage, usually triggered by loss of lubrication.

### **Briggs & Stratton Governors**

Although Briggs & Stratton governors are mechanically alike, changes in manufacturing techniques, differences in performance requirements, and variations in engine layout result in variety. Teardown and adjustment procedures differ between models and, in some cases, between vertical crank and horizontal crank engines of the same model.

**Models N, 6, 8.** This governor on these early models has features that mechanics would like to see continued in current models: access from outside of the engine, replaceable thread-in bushing, and factory set maximum speed.

To disassemble, remove the two housing screws and gently pry the housing off the side of the block. The gear and cup will slide out with it. Supporting the governor lever on a wood block, drive out the pin that secures it to the shaft, or, as Briggs & Stratton calls it, the crank. Once the shaft is off, there is room to unthread the bushing. The crank and bushing come out together.

Clean the parts and lightly grease all friction surfaces. Install the crank with the inner lip at the twelve o'clock position. Displace it as far to the right as it will go, and run in the bushing. Pin the lever, and using a new gasket, position the assembly against the side of the engine block. You may have to rock the flywheel to mate the governor gear with the camshaft. Evenly thread the holddown screws to prevent distortion.

Other than the provision for increasing or decreasing sensitivity which has been described under "Hunting," there is no provision for governor adjustment. The factory has the lever spring in the fourth hole, and the upper end of the link in the second hole out from the throttle lever pivot.

**Models 6B, 8B, 60000, 80000, 140000.** This governor, shown in exploded view in Fig. 4-4, is serviced from outside the engine. To disassemble, loosen the pinch bolt on the governor lever and disengage the lever from the governor shaft. Remove the two capscrews holding the governor case to the engine. As the case is



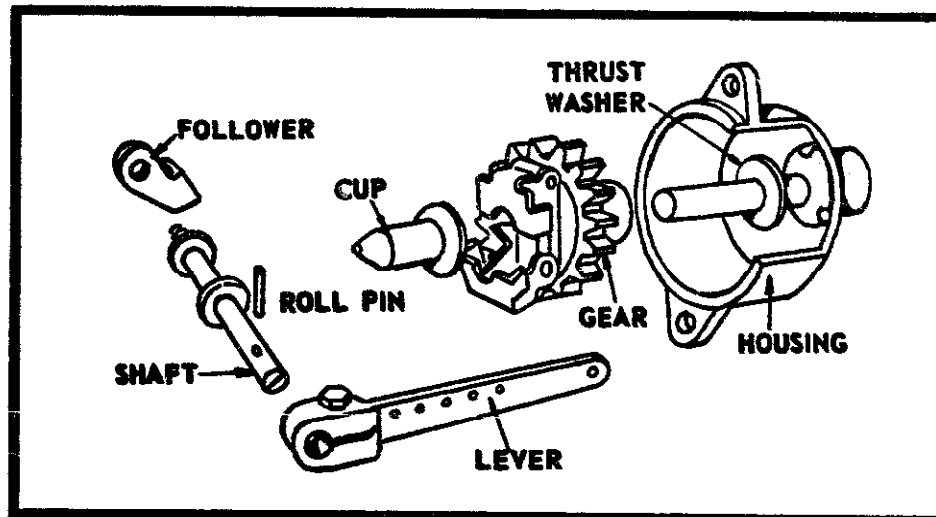


Fig. 4-4. The governor used on models 6B, 8B, 60000, 80000, and 140000 is typical of all centrifugal types. (Courtesy Briggs & Stratton Corp.)

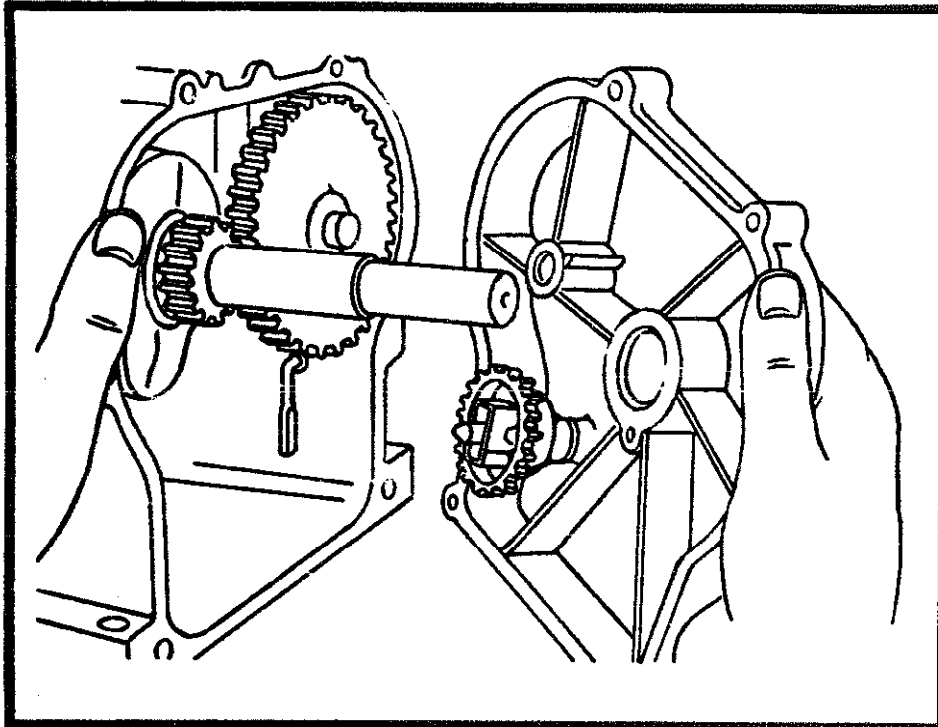
withdrawn, the governor gear will slip off its shaft, together with the cup. Do not overlook the steel thrust washer between the gear and case. The shaft and follower can be unthreaded for replacement.

To reassemble, mount the shaft in its bushing and thread on the follower. Allow the shaft to hang free, with the follower down, at the six o'clock position. The shaft pin, the part that locates the shaft on the outer side of the bushing, should be installed with one end extending out of the shaft. Centering the pin causes rapid wear on the bushing face. Place the thrust washer over the inboard end of the shaft and mount the gear and cup assembly. Draw up the cover screws evenly over a new gasket. Position the governor lever on the shaft, end down, about 30 degrees off the vertical.

To adjust the reassembled governor, gently bow the wire links to make connection at the throttle lever, bellcrank, and governor lever. The spring mounts between the short end of the bellcrank and the third hole in the governor lever.

The end of the governor shaft is slotted for a screwdriver. Turn the shaft counterclockwise until the cup is solid against the flyweights. Holding the shaft, turn the lever counterclockwise as far as it will go. The throttle valve should be hard against its fully open stop. Tighten the pinch screw at the lever.

**Models 9, 14, 19, 190000, 20000, 23, 230000, 240000, 300000, and 320000.** While employing the same linkage as the governor just described, this series is disassembled from



**Fig. 4-5. Reassembling the horizontal shaft governor, models 100000, 130000, 140000, 170000, 190000, and 251000. (Courtesy International Harvester Corp.)**

inside the crankcase. The flyweight mechanism is secured by a cotter pin and thrust washer. The crank is a one piece affair, easy to extract once the flyweights are out of the way. To reassemble, allow the crank to hang loosely, and then mount the flyweight assembly and thrust washer using a new cotter pin.

Adjustment is same as for the series described above.

**Models 100000, 130000, 140000, 170000, 190000, and 251000.** These aluminum block governors differ, depending upon their application. Horizontal crankshaft governors are mounted under the crankcase cover and are driven by the cam; vertical crankshaft governors are mounted under the flange, or baseplate, and are incorporated into the oil slinger. The engine must be opened to service either type.

**Horizontal Crankshaft.** Remove the shaft pulley or drive coupling and polish out any rust or burrs that could score the main bearing. Remove the cover bolts and, using a rubber hammer, jar the plate away from the crankcase.

If the centrifugal mechanism is bad, replace the whole assembly, as component parts are not available separately. Inspect the

governor crank for wear on its rubbing and bearing surfaces. Replace the shaft and bushing as required.

To reassemble, place the engine upright in its normal position (Fig. 4-5). Secure the flyweight assembly to the shaft with a little heavy grease and, using a new gasket, mount the side cover. Tighten down the cover capscrews in a crisscross pattern.

**Vertical Crankshaft.** Remove the engine from the device it powers. This entails removing whatever hardware is on the end of the crankshaft, along with control cables and external wiring. The engine is secured by bolts through the rim of the flange.

Polish the crankshaft and, as a further precaution against bearing and seal damage, dull the sharp edges of the keyway with a file. With the engine on its side, remove the capscrews holding the flange to the block, and separate the flange. If it is stubborn, break the gasket seal with the help of a rubber hammer. Do not pry against the flange parting surface, as this tactic will separate the parts, and in the process, generate an oil leak.

The centrifugal mechanism is built into the oil slinger and should be changed as an assembly. Some engines, such as models 100900 and 130900, have a wave washer outside of the slinger bracket (Fig. 4-6). It is important to install this washer as shown in the drawing.

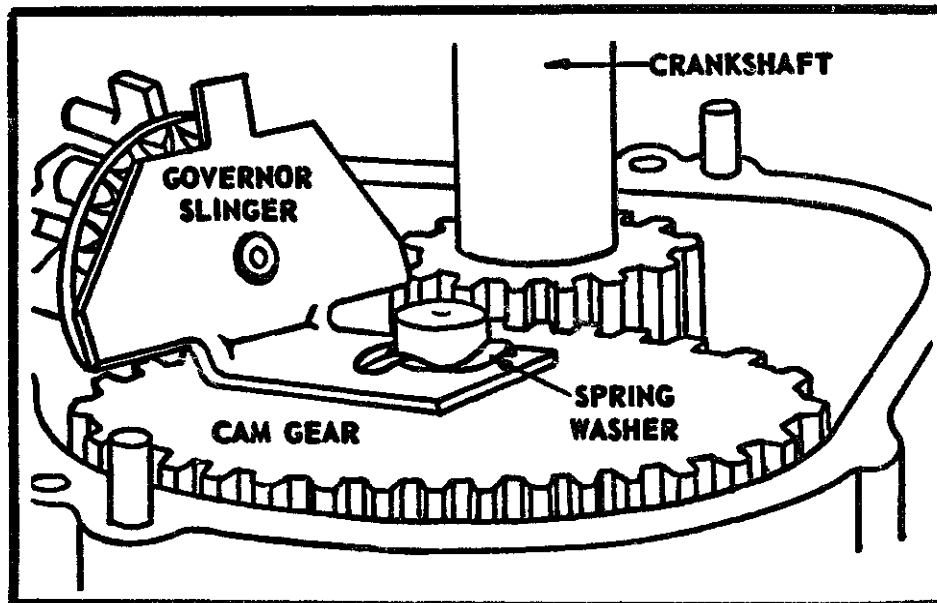


Fig. 4-6. The spring washer mounts between the slinger bracket and flange on vertical shaft models 100000, 130000, 140000, 170000, 190000, and 251000. (Courtesy International Harvester Corp.)

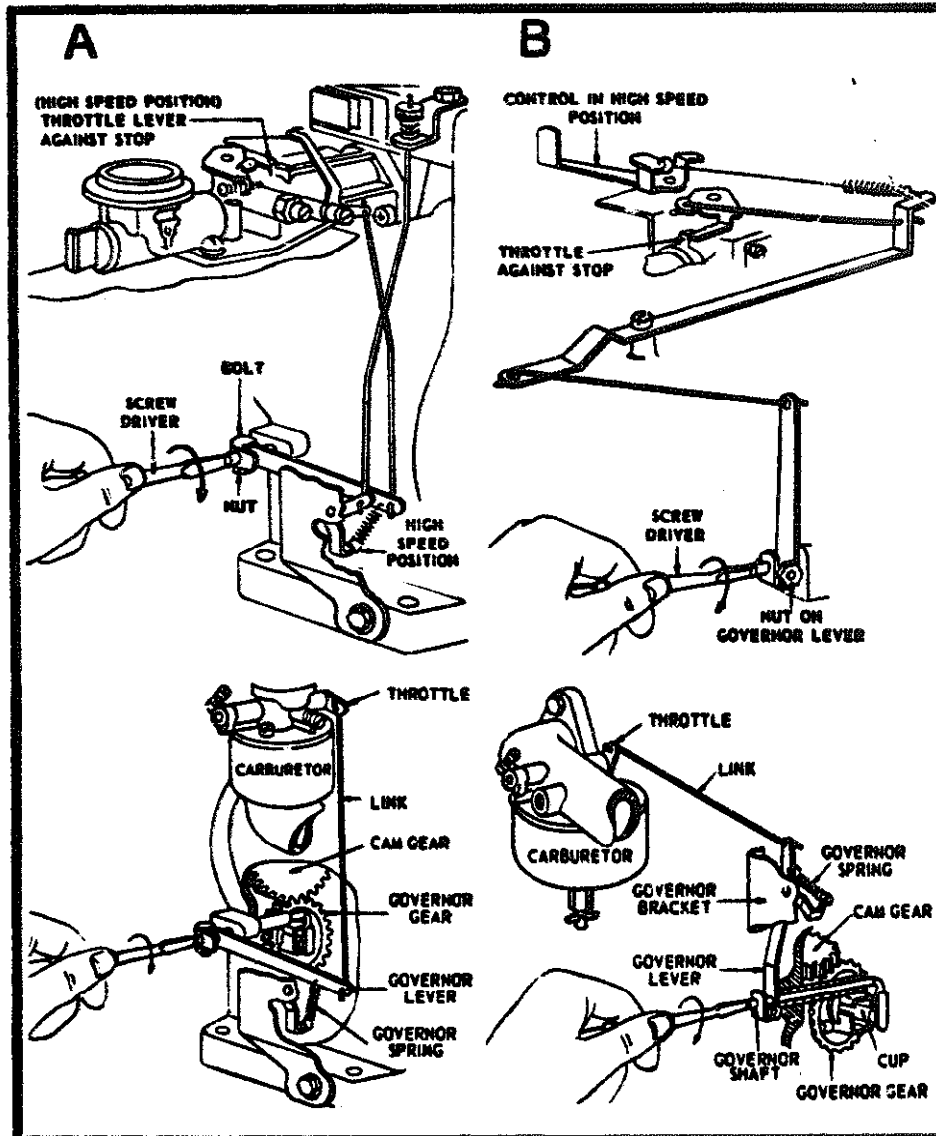


Fig. 4-7. Adjusting the governor on horizontal shaft (A) and vertical shaft (B) engines, models 10000, 130000, 140000, 170000, 190000, and 251000. (Courtesy Briggs & Stratton Corp.)

These horizontal and vertical crankshaft engines can be damaged if run out of adjustment, since the governor spring tension keeps the assembly together. With the throttle full open, loosen the pinch bolt on the governor lever (Fig. 4-7). Using a screwdriver, turn the governor crank counterclockwise until you feel the crank seat against the nylon cup. With the throttle still open, tighten the pinch bolt. The governor is now set.

## **CHAPTER 5**

# **STARTERS**

Because of the many different conditions under which small engines operate, no universal starter system exists. Rewind starters require too much effort for many elderly people. The best impulse, or spring wound, starters have a short operating life. Lead acid battery systems are impractical for engines that are stored and not used part of the year. The 115V AC starters limit an engine's portability. Consequently, Briggs & Stratton offers a large selection of starting systems, each tailored to a particular segment of the market.

### **MECHANICAL STARTERS**

#### **Rewind Starters**

Rewind, or recoil, starters were introduced on small engines fifty years ago by Jacobsen and remain the most popular type. Most failures are the fault of the user. The cord should be pulled out smoothly and held while it retracts. Below are listed some of the problems which arise with rewind starters, and the probable causes of these difficulties.

#### **SYMPTOM**

#### **PROBABLE CAUSES**

Rattles as the engine runs

Misaligned shroud

Shrieks as the engine runs

Dry clutch bearing

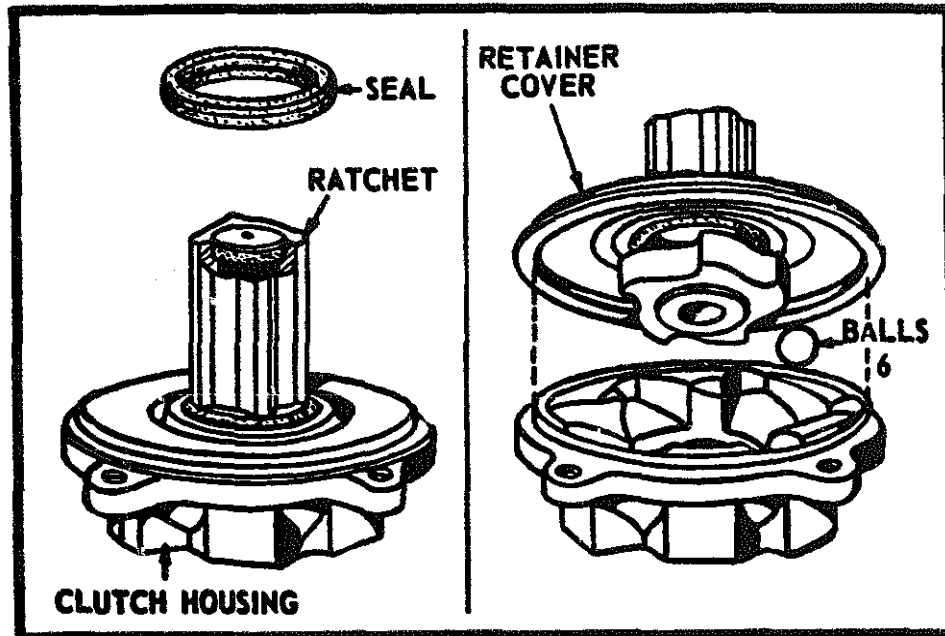


Fig. 5-1. The current production sprag clutch. (Courtesy International Harvester Corp.)

**SYMPTOM**  
Starter slips

**PROBABLE CAUSES**  
Wear or dirt in the sprag clutch;  
bent or worn friction link  
assembly (vertical pull only)

Refuses to rewind

Misaligned shroud, oil on  
starter cord, weak or broken main-  
spring, insufficient mainspring

Refuses to disengage

Broken sprag clutch

**Sprag Clutch.** Recoil and impulse starters drive through a sprag clutch that doubles as the flywheel nut. The clutch housing (Fig. 5-1) threads over the crankshaft. The sprag (*ratchet* in the drawing) is supported by a bushing on the crankshaft stub. Its outside end mates with the starter pulley, and its lower, or inside end, rides against four on six ball bearings in the starter housing. When rotated by the starter pulley, the sprag traps a ball bearing between it and the clutch housing, locking the starter to the crankshaft. Once the engine catches, the ball bearing releases, and the sprag idles on the bushing.

To service the clutch, remove the engine shroud and the screen, mounted to the clutch housing by four self-threading

screws. Disconnect and ground the spark plug lead to prevent accidental starting. Secure the flywheel with a strap wrench or a Briggs & Stratton holding fixture. Unthread the clutch assembly using factory tool number 19114. If this tool is not available, the assembly can be loosened with a hammer and a block of soft wood. Some damage to the screen lugs is inevitable, but is less than fatal if distributed evenly to all four lugs. A spring washer fits under the clutch assembly.

On early models, the retainer cover was secured with a spring wire; on late models the cover must be pried off. Clean the sprag, clutch housing, and ball bearings in solvent. Some deformation of the clutch housing is normal. Wear on the tip of the sprag, the part that makes contact with the bearings, can cause the clutch to slip. Reassemble these parts dry, without lubricant, and lightly oil the bushing.

Install the spring washer and torque to specifications in Table 5-1.

**Horizontal Pull Starter.** To dismantle the starter, remove the shroud and place the assembly upside down on a bench (Fig. 5-2). Cut the rope at the pulley knot and extract it. Using a pair of pliers, pull the main spring out of the housing as far as it will come (Fig. 5-3). The purpose is to bind the spring so that it will not "explode" when the pulley is detached. For further protection, wear safety glasses. Carefully straighten the pulley tangs. Withdraw the pulley, twisting it slightly to disengage the spring. Clean the metal parts in solvent and inspect for damage.

**Table 5-1. Clutch Housing Torque Limits**

| Cast-Iron Series                                    | Torque (ft-lb) |
|---|----------------|
| 6B, 6000, 8B, 80000,<br>82000, 92000, 110000        | 55             |
| 100000, 130000                                      | 60             |
| 140000, 170000, 1717000,<br>190000, 191700, 251000, | 65             |
| Aluminum Series                                     |                |
| 19, 190000, 200000                                  | 115            |

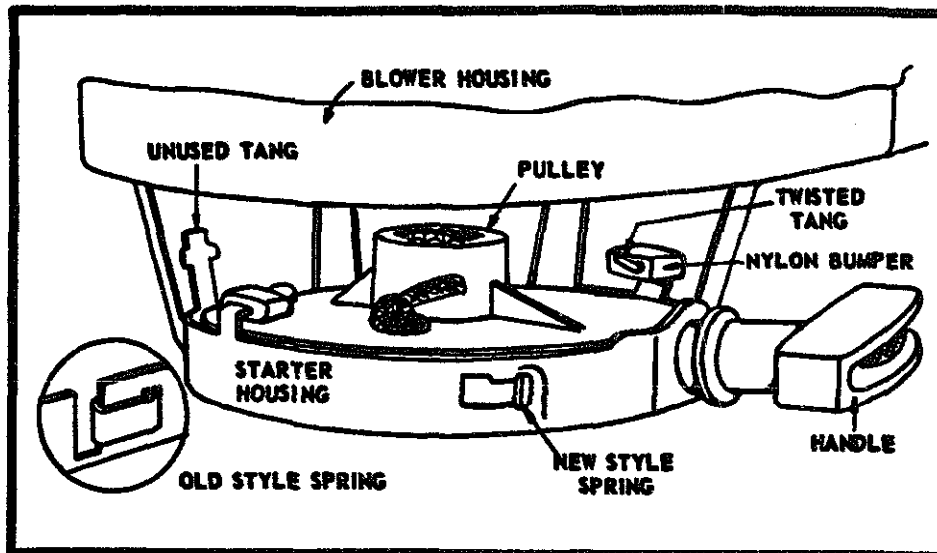


Fig. 5-2. New style spring ends improve the reliability of these starters. (Courtesy Briggs & Stratton Corp.)

Secure the shroud to the workbench with several large nails, or hold the shroud in a large vise. Lightly grease the spring and attach it to the pulley. Thread the three end out through the shroud, past the spring anchor. Cut a short length of one by one to fit the pulley socket. Bend the tangs to make light contact with the pulley. Wind the pulley tight, guiding the spring up and into the anchor slot. Back the spring off one turn to align the rope knot hole in the pulley with the rope guide in the shroud.

Without releasing the pulley, thread the rope into it. Early model pulleys have a guide lug which must be outside of the rope

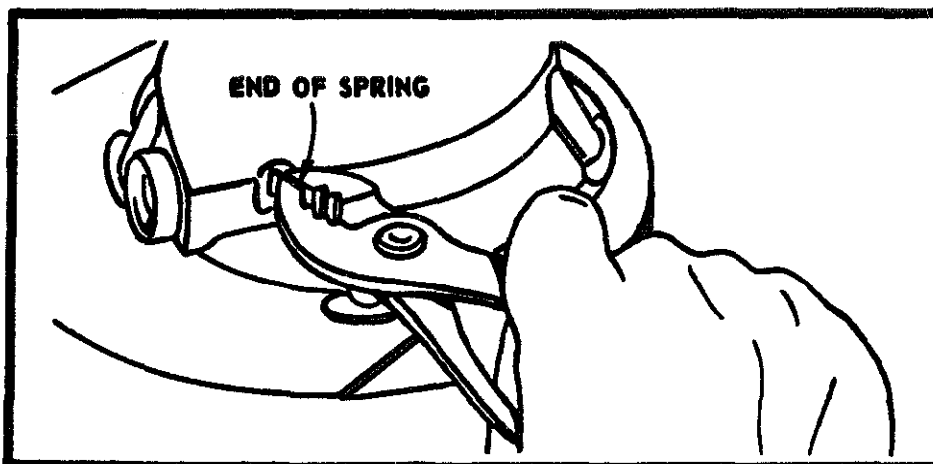


Fig. 5-3. Disarm the spring before disassembly. (Courtesy Briggs & Stratton Corp.)



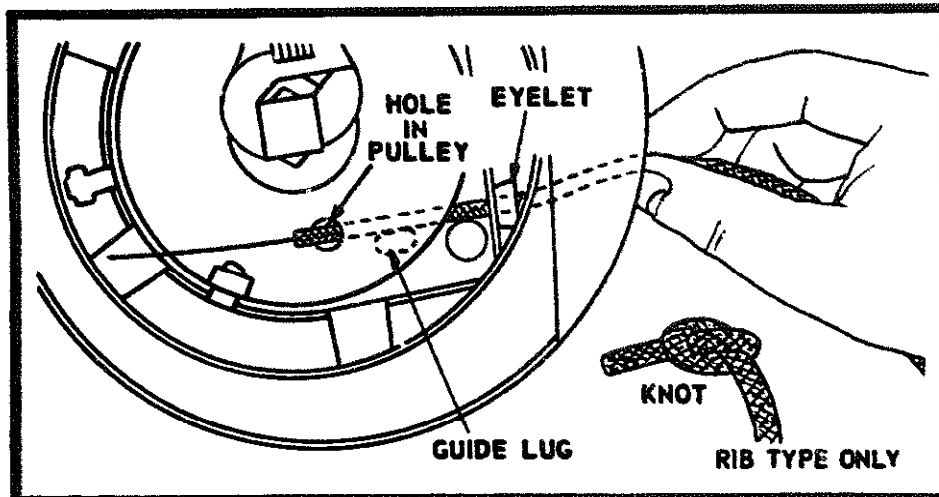


Fig. 5-4. When stringing the old style starter, the rope must pass inside of the lug. (Courtesy Briggs & Stratton Corp.)

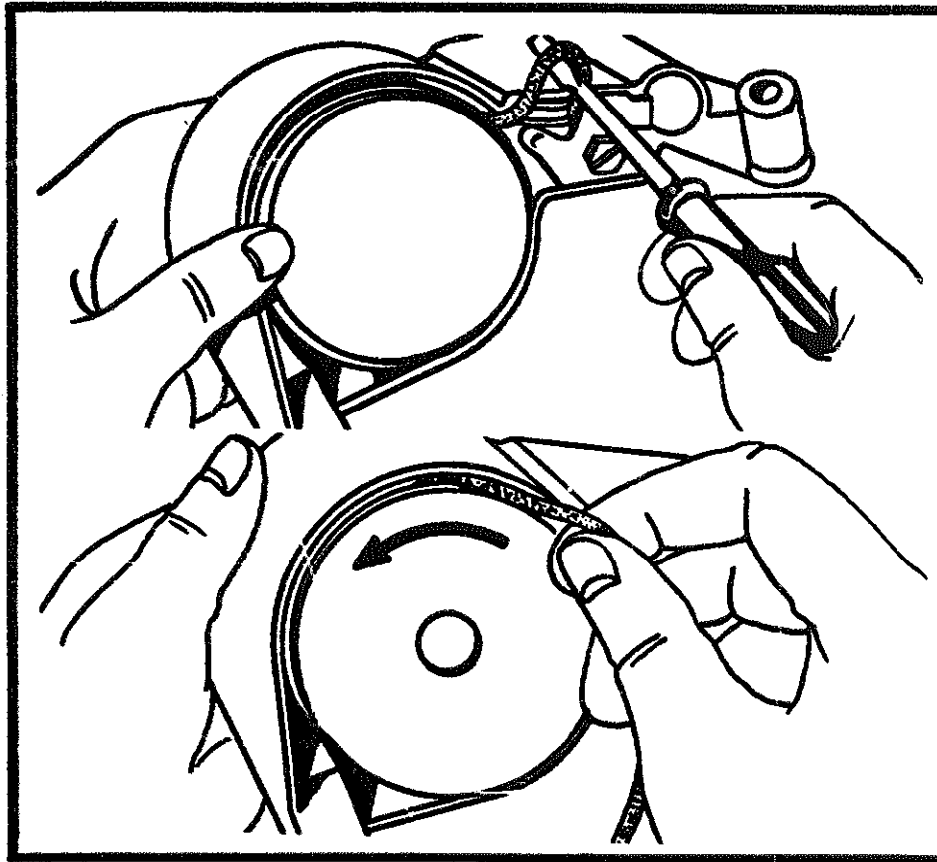
(Fig. 5-4). A length of piano wire is helpful to force the rope past the lug. Fish the end of the rope through the knot hole, tie it, and seal the frayed edges with a match. Push the knot down into the hole for clearance. The process is the same with new style pulleys, except that there is no lug to frustrate your work.

Secure the handle with a figure eight knot, leaving some three quarters of an inch of rope beyond the knot. Seal the end with heat and slip the handle pin through one of the knot loops.

Release the spring in a controlled manner and allow the rope to wind. Bend the lugs so that the nylon bumpers are one sixteenth of an inch below the pulley (the bumpers were against the pulley during winding for better control). Install the shroud assembly on the engine, centering it over the flywheel. Test the starter. If it is slow to retract or binds, loosen the shroud and reposition it.

**Vertical Pull Starter.** The vertical pull starter is a convenience on vertical crankshaft engines which prevents the operator from having to crouch alongside the engine to start it. This starter is considered a safety feature on rotary lawnmowers. Pulling on the rope sends a nylon gear into engagement with the ring gear on the underside of the flywheel. The nylon gear moves on a thread by virtue of a friction spring and link (an arrangement reminiscent of that used on bicycle coaster brakes). Once the engine fires, the gear retracts back down the thread.

The main spring is under some tension and you should wear



**Fig. 5-5.** Disarm the Briggs vertical pull starter by lifting a foot or so of rope out of the pulley groove.

safety glasses when servicing this starter. Disarm the spring by lifting the rope out of the pulley groove and winding the pulley, together with the freed section of rope, several turns counterclockwise (Fig. 5-5). When you are finished, there should be no tension on the pulley and approximately one foot of rope should be free. Observe the warning stamped on the plastic starter cover and, using a screwdriver, gently pry the cover off. Do not pull on the rope with the cover disengaged.

Remove the anchor bolt and anchor, noting how the spring mates with it (Fig. 5-6). If the spring is to be replaced, carefully work it out of the housing. Remove the rope guide, observing the position of the link (Fig. 5-7) for assembly reference. Using a piece of piano wire in conjunction with long nosed pliers, pull the rope far enough out of the pulley to cut the knot. Clean mechanical parts in solvent. The friction spring and link are the most vulnerable elements in this mechanism. See that the link and spring assembly move the drive

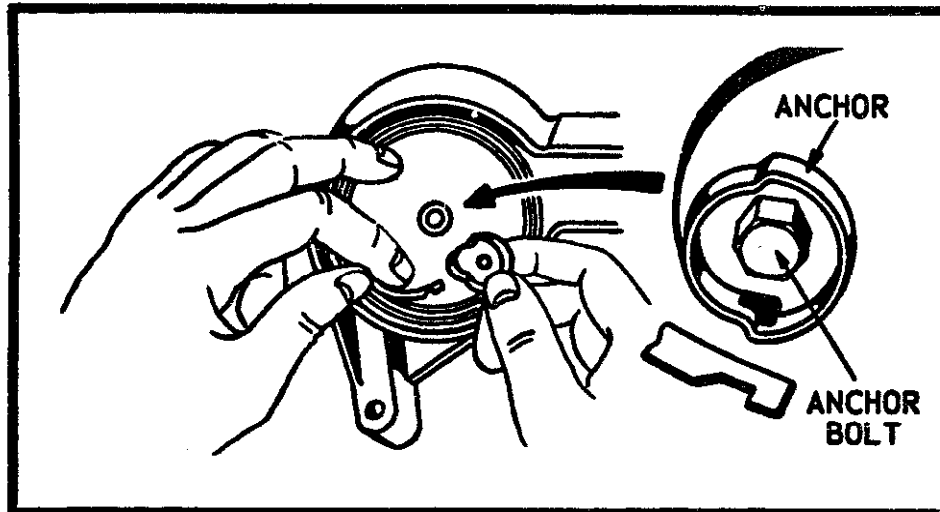


Fig. 5-6. Remove the anchor bolt and spring. (Courtesy Briggs & Stratton Corp.)

gear to its extremes of travel. If there is any hesitation, replace these parts.

Begin reassembly by installing the spring in its housing. Slip one end into the retainer slot and wind the spring counterclockwise (Fig. 5-8). Using a length of piano wire or a jeweler's screwdriver, snake one end of the rope into the pulley. Extract the end of the rope from behind the pulley, and tie a small, hard knot. Space is critical, and no more than a sixteenth of an inch of rope should extend beyond the knot. Melt the ends with a flame, wiping down the melted fibers with

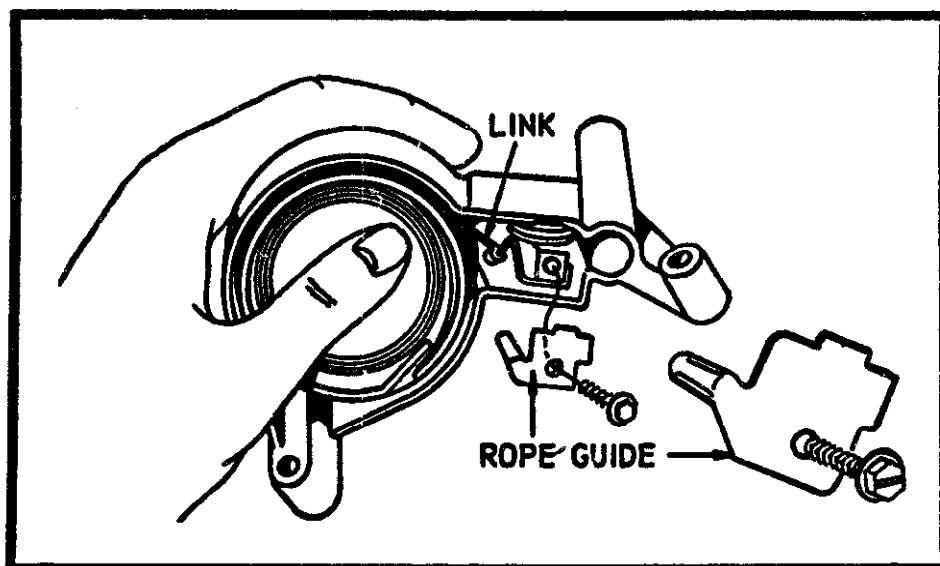


Fig. 5-7. Observe the position of the friction link before disassembly. (Courtesy Briggs & Stratton Corp.)

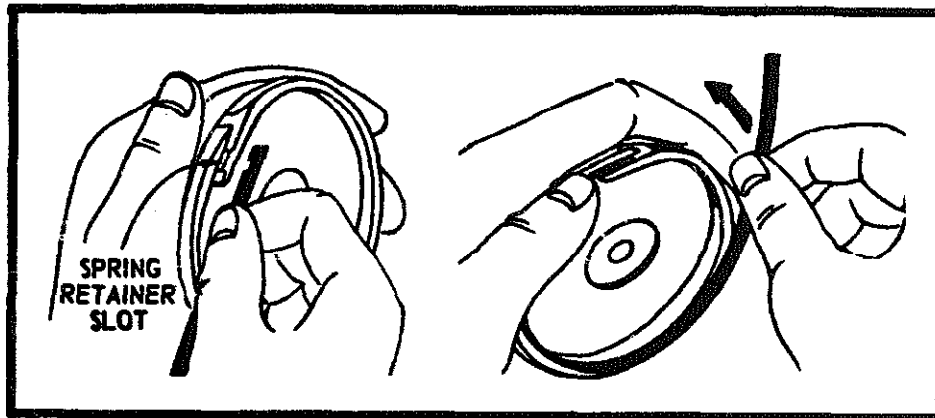


Fig. 5-8. To install the spring, anchor it in the retainer slot and wind counterclockwise. (Courtesy Briggs & Stratton Corp.)

a shop rag to reduce their diameter. Pull the rope tight, and check that the knot clears the threads.

Install the rope guide with the link positioned as it was originally found (Fig. 5-9). Wind the spring counterclockwise with your thumbs to retract the rope (Fig. 5-10). Once the handle butts against the starter case, secure the spring anchor with 80-90 in-lb of torque. Lightly lubricate the spring with motor oil.

Snap the starter cover into place and disengage approximately one foot of rope from the pulley (Fig. 5-11). Give the rope and pulley two or three clockwise turns to preload the main spring, and to assure that the rope will be rewound smartly.

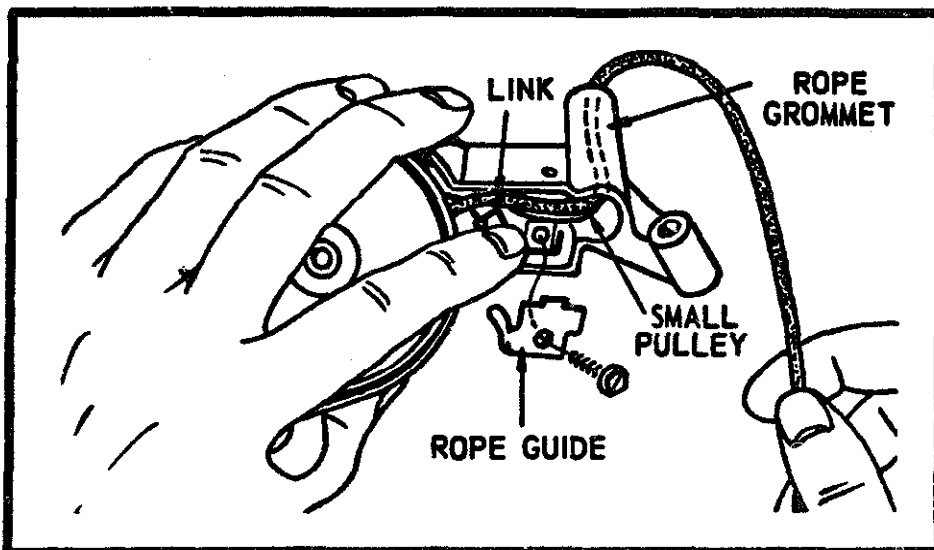


Fig. 5-9. Install the friction link behind the rope guide. (Courtesy Briggs & Stratton Corp.)

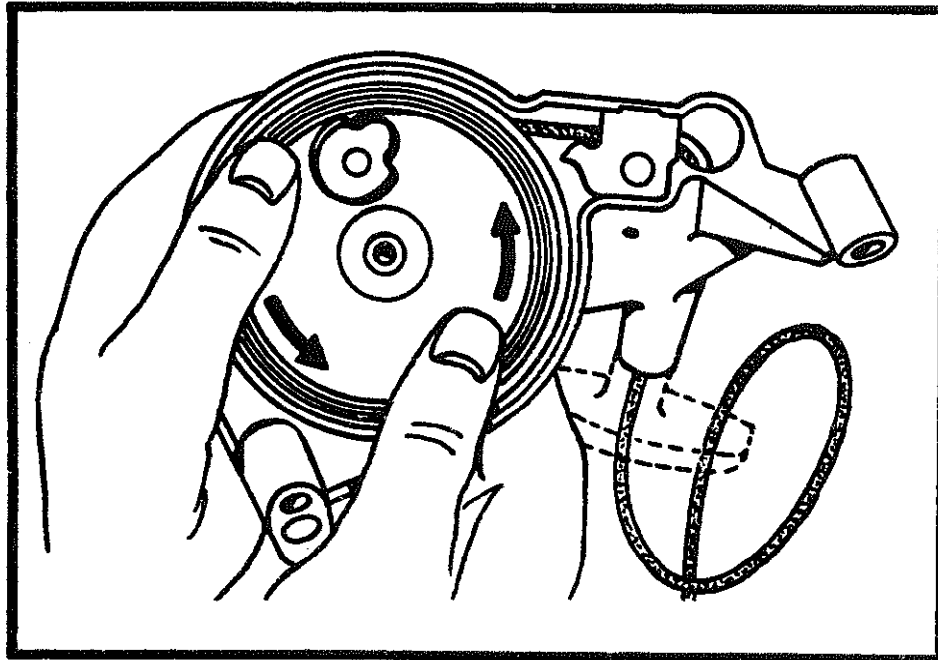


Fig. 5-10. Wind the spring counterclockwise to retract the rope. (Courtesy Briggs & Stratton Corp.)

### Impulse Starter

The purpose of the impulse, or ratchet, starter is to reduce peak cranking effort. And this it does. But the average effort is increased since one must store enough energy in the spring to spin the engine and to overcome the inefficiency of the crank, ratchet,

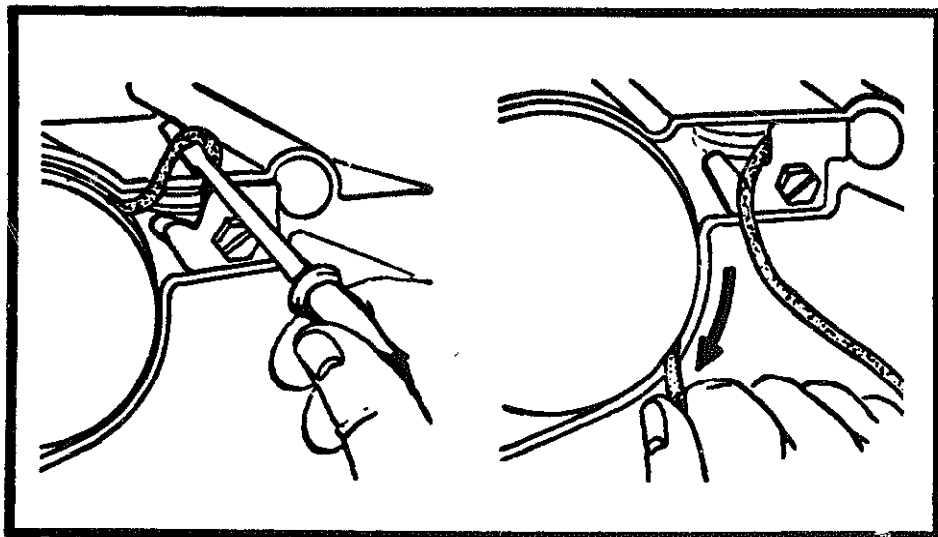


Fig. 5-11. Preload the spring two or three rotations. (Courtesy Briggs & Stratton Corp.)

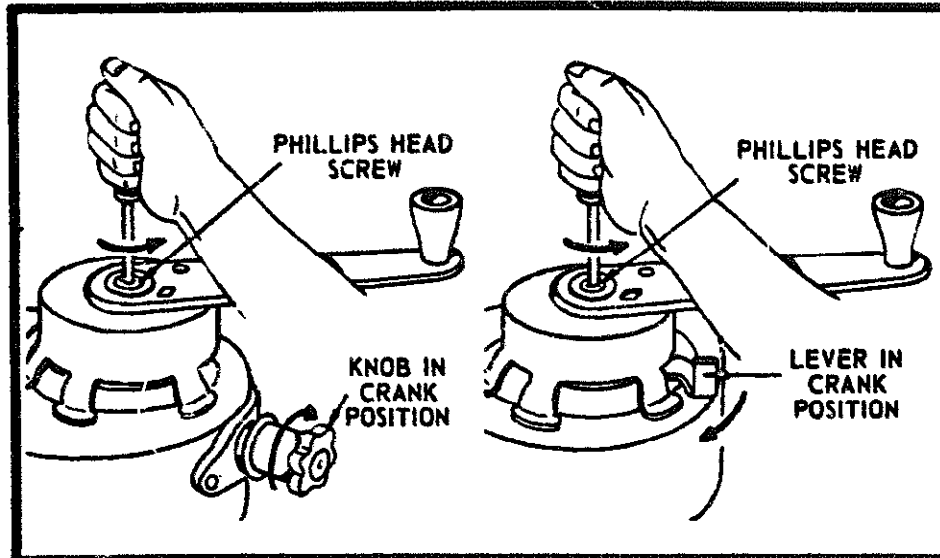


Fig. 5-12. Disarm the Briggs ratchet starter by loosening the central Phillips screw. (The drawing is misleading—do NOT place your forearm in the path of the crank, but stand clear and hold the crank with your free hand.)

and spring. As any men mechanic knows, attempting to start a baulky engine with one of these devices is exhausting.

Considerable energy is stored in the spring, enough to break an arm. The spring must be disarmed before the starter is disassembled and the spring must remain in its retainer at all times. Do not attempt to service a starter with a broken spring retainer.

The two models that Briggs & Stratton builds, one with a trigger that bears against the flywheel fins, and the other with a ratchet release, are more reliable than the impulse starters fitted to other engines. But do not be surprised to find worn sears, broken flywheels (on the direct release model), damaged sprag clutches, or broken main springs.

Release spring tension by placing the control knob or remote control lever in the *start* position. If the engine is locked and the starter fails to unwind, turn the knob or lever to the *crank* position. To prevent serious injury, hold the crank handle in one hand and remove the Phillips screw at the top of the assembly (Fig. 5-12).

A quick way to check for a broken spring is to place the control on *start* and wind the crank. If the spring is whole, both the flywheel and starter clutch ratchet will turn.

Clean the parts in solvent, replacing those that show evidence of severe wear. The direct release starter, the model with a sear

that engages the flywheel fins, uses the old style, four ball clutch. The lever release model uses the six ball clutch. Note the spring washer between the retaining plate and main spring retainer. Except for the sprag clutch, grease all parts that are subject to severe wear (Fig. 5-13). Bend the shroud tabs down securely over the retaining plate.

### ELECTRIC STARTERS

Depending upon the model and the date of manufacture, Briggs & Stratton engines may be fitted with any of five distinct electric starting systems. Three of these systems operate from a 12V lead

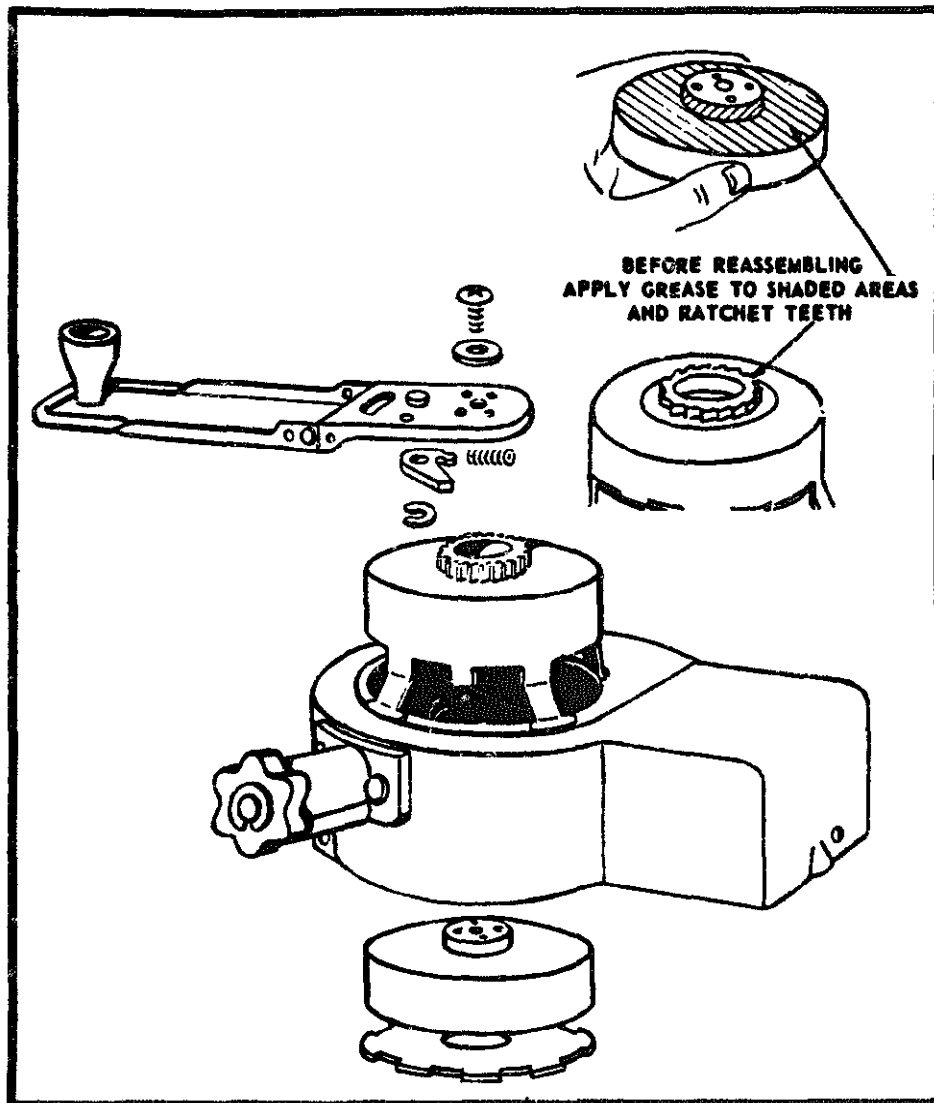


Fig. 5-13. Grease the parts indicated. (Courtesy Briggs & Stratton Corp.)

acid or Nicad battery, two from 110V line voltage. Below are listed some of the problems which arise with electric starters, and the probable causes of these difficulties.

| SYMPTOM        | PROBABLE CAUSES  |
|----------------|--|
| Does not crank | Low battery<br>Low line voltage (110V model)<br>High resistance connection<br>Open starter switch<br>Heavy load<br>Defective motor or rectifier (110V model) |
| Cranks slowly  | Low battery<br>Low line voltage (110V model)<br>High resistance connection<br>Worn motor bearings<br>Worn or sticking brushes<br>Heavy load                  |

### **Starter Motors—All Models**

Figure 5-14 illustrates the three starter motors available for the 140000, 170000, and 190000 series engines. In so far as basic constructional features are concerned, these motors are typical of all gear driven types. Delco-Remy and Prestolite belt drive motors are distinguished by field coils.

Briggs & Stratton suggests two test parameters, no load rpm and no load current draw, for the motors that dealer mechanics service (excluding Delco and Prestolite motors). To perform these tests, you will need a hand held tachometer, an ammeter, and a power supply. Depending upon the starter motor, the power supply is a fully charged 6V or 12V lead acid battery or 12V Nicad battery, or a 110V AC source. The current readings in Table 5-2 are steady draw readings—disregard initial surges.

Mark the end cap and motor frame for assembly reference and remove the two through bolts that secure the cap to the frame. Take off the brush cover and cap. The armature can be withdrawn from the drive side with the pulley still attached. Starter motor failure can be traced to:



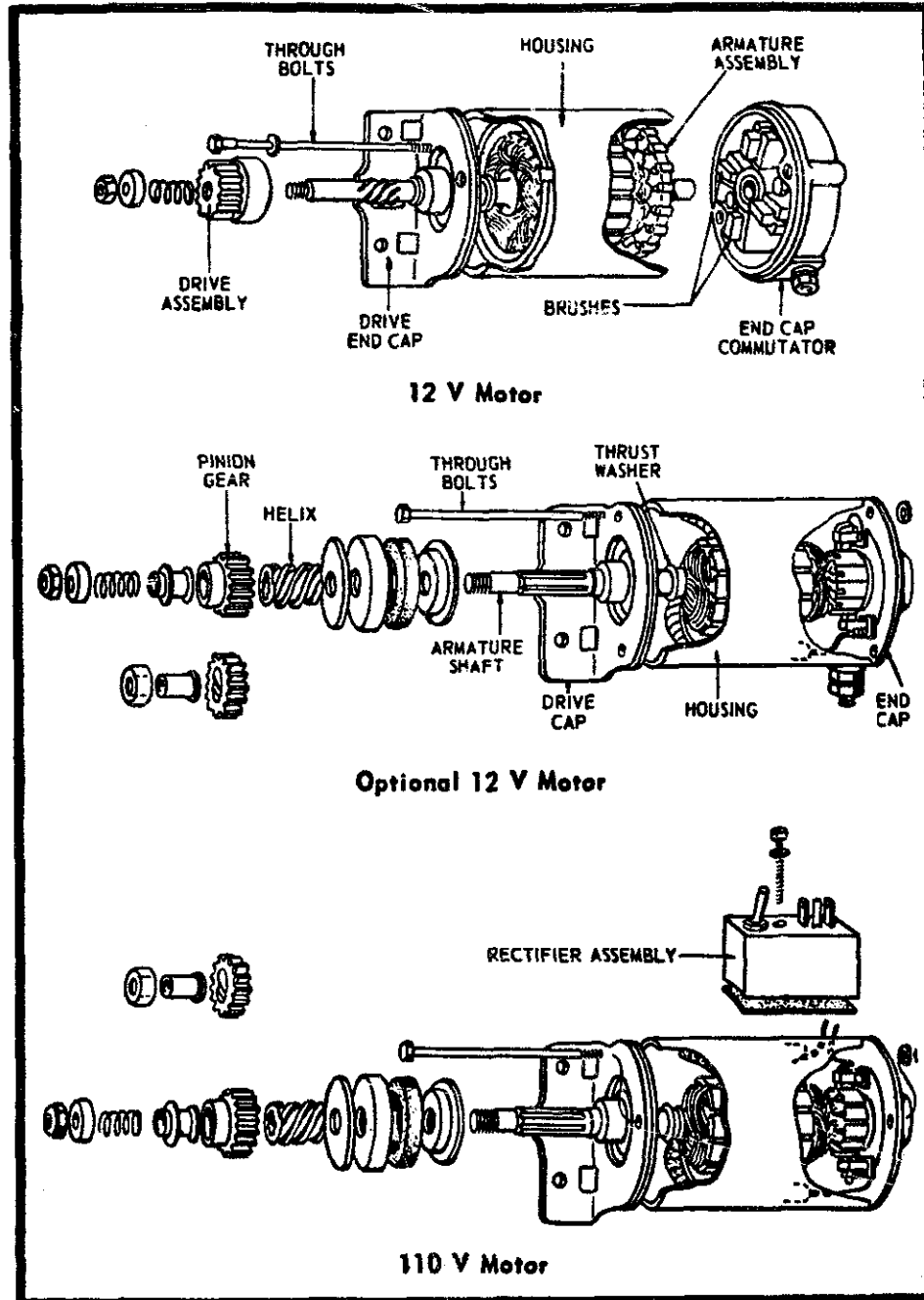


Fig. 5-14. Typical starter motors. (Courtesy Briggs & Stratton Corp.)

- Binding (scored or dry) armature shaft bearings
- Worn armature shaft bearings
- Shorted, opened, or grounded armature
- Shorted, opened, or grounded field
- Brushes worn to half or less of their original length
- Brushes sticking in their holders

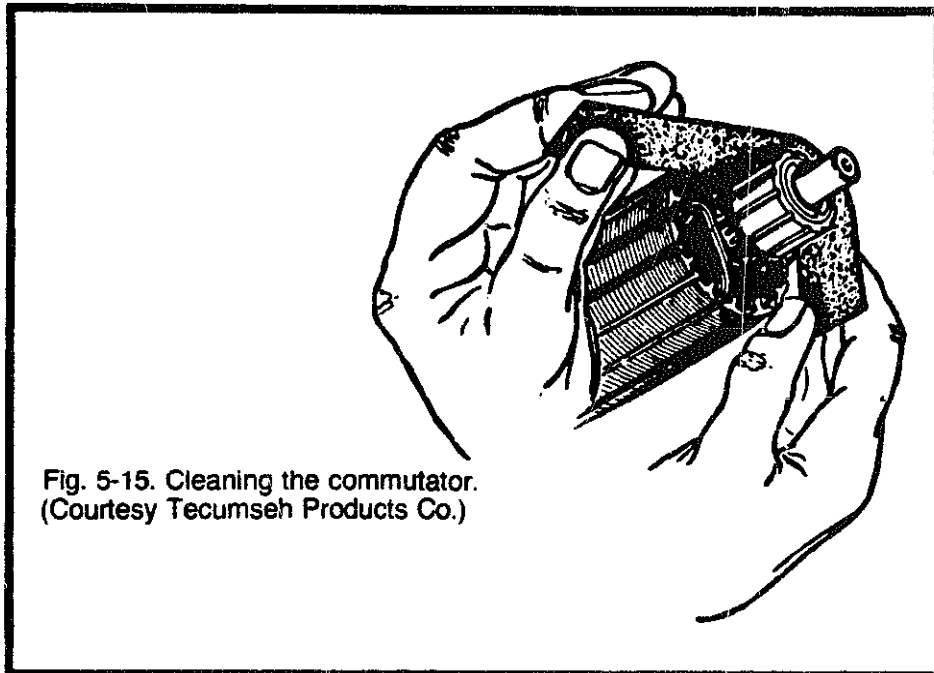
Table 5-2. Steady Draw Current Ratings.

| Motor  | Engine Model           | Minimum (rpm) | Maximum Current Draw | Power Supply      |
|--|------------------------|---------------|----------------------|-------------------|
| 12V DC geared                                      | 140000, 170000, 190000 | 5000          | 25.0A                | 6V battery        |
| 12V DC geared<br>(American Bosch No.<br>SMH 12A11) | 140000, 170000, 190000 | 4800          | 16.0A                | 12V battery       |
| 110V AC geared                                     | 140000, 170000, 190000 | 5200          | 3.5A                 | 110V AC           |
| 12V DC geared                                      | 130000                 | 5600          | 6.0A                 | 12V battery       |
| 110V AC geared                                     | 130000                 | 8300          | 1.5A                 | 110V AC           |
| 12V AC geared                                      | 300400, 320400         | 5500          | 60.0A                | 12V battery       |
| 12V DC geared<br>(Nicad)                           | 92000, 110900          | 1000          | 3.5A                 | 12V Nicad battery |

Reddish brown discolorations on the commutator bars are normal and mean that the brushes have seated. Burned commutator bars signal a shorted winding. Glaze and minor imperfections can be removed with number 00 sandpaper as shown in Fig. 5-15. Severe out-of-round, deep pits, or scores should be corrected with a lathe. After any of these operations, cut down the mica with a tool designed for this purpose, or with a narrow, flat edged jeweler's file (Fig. 5-16). Polish the commutator to remove burrs, and clear the filings with compressed air.

Bearings are the next most likely area of failure. The starter may turn freely by hand, but when engaged against the flywheel, groan through a revolution or so, then bind.

Drive out the old bushings, being careful not to score the bearing bosses, and drive in new ones to the depth of the originals. Bushings in motor end covers can be removed by any of several methods. A small chisel can be used to split the bushing. American Bosch end cover bushings have a flange to accept thrust loads that can be used as a purchase point to collapse the bushing inward. The neatest technique is to pack the boss with heavy grease, then ram the bushing out with a punch that matches the diameter of the motor shaft. A sharp hammer blow will lift the bushing by hydraulic pressure.



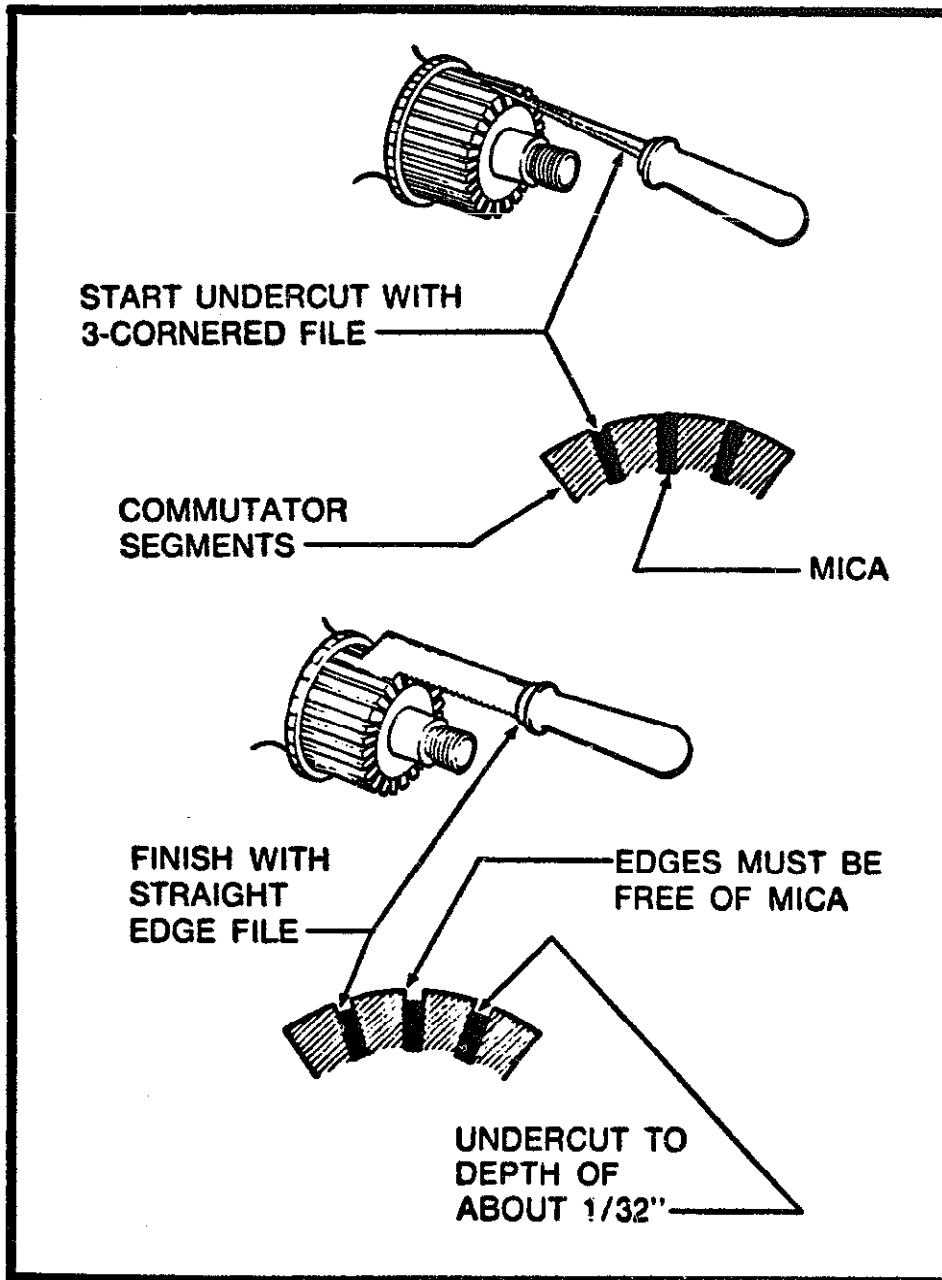


Fig. 5-16. Undercutting the mica. (Courtesy Kohler of Kohler.)

The armature can develop shorts. Check for shorts between the shaft and armature with a 120V test lamp. All iron and steel parts must be electrically isolated from nonferrous (brass or copper) parts. Check adjacent commutator bars by the same method. Handle the 120V probes with extreme caution—holding one in each hand means that an electric current could pass through the vulnerable-thorax.

Internal winding-to-winding shorts can be detected with a growler. These tools are fairly expensive to buy, but a few auto parts houses keep one for customer use. You can build one around the core of a television power supply transformer as detailed in TAB No. 555, *Small Appliance Repair Guide*.

If one of the armature windings is shorted, a hacksaw blade will vibrate when placed over the affected armature segment (Fig. 5-17). An open winding will generate sparks between the blade and adjacent commutator segments. Unless the damage is visible, as for example, a broken connection between the armature and a commutator bar, there is no practical way to repair an armature. Rewinding costs more than a replacement.

American Bosch motors use permanent magnet fields that require no service under normal circumstances. Arc welding on adjacent parts, or extreme vibration can, however, weaken the magnets. Since few shops have the necessary equipment to "re-charge" them, the field must be replaced.

Delco-Remy starter generators employ conventionally wound fields. Test for shorts to the frame with an ohmmeter or 120V probes. If the insulation is not visibly burned, shorts between the windings can sometimes be rectified by warming the starter frame in an oven at 275 degrees Fahrenheit for a few hours. Otherwise, the

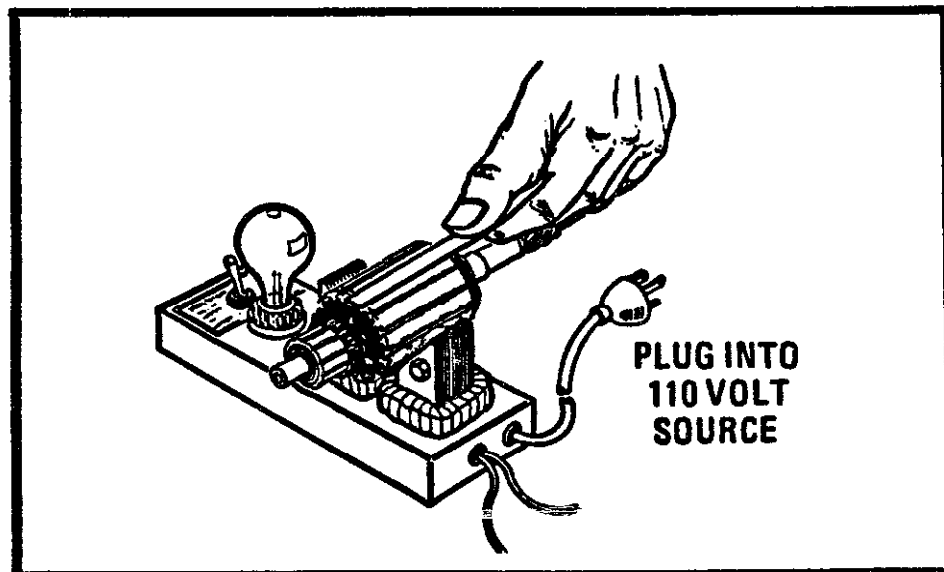


Fig. 5-17. Checking for internal (winding-to-winding) shorts with a growler and hacksaw blade. (Courtesy Tecumseh Products Co.)

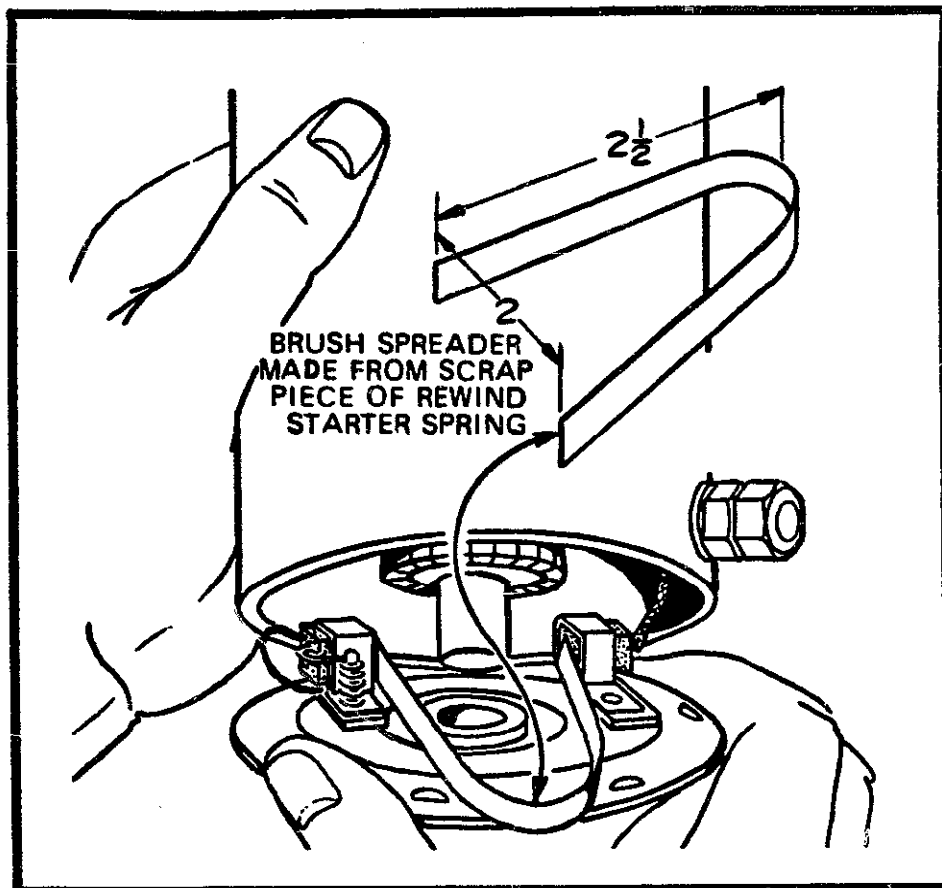


Fig. 5-18. A homemade tool used to overcome brush spring tension during reassembly. (Courtesy Briggs & Stratton Corp.)

fields will have to be replaced. Remove the frame screws with an impact driver and, once the new parts are installed, stake the screws.

The brushes must have at least half of their original length to maintain pressure against the commutator bars. One brush or brush set should be grounded to the frame, while the remaining brush or brush set connects to the armature. The brushes should be free to move in their holders, and the assembly must be free of carbon dust and oil deposits. In most cases, the brushes must be “shoe-horned” over the commutator with a home made tool (Fig. 5-18).

### Starter Drives

The 12V Delco-Remy starter generator combination is driven by a single or tandem V-belt and remains in constant engagement

(Fig. 5-19). The motor may be mounted low on the block or, as shown in the drawing, in the high position. In either configuration, the motor is pivoted and secured by a pinch bolt. Belt tension is correct if there is  $\frac{1}{4}$  of an inch free play between pulley centers. Replace the belt with a heat and oil resistant Briggs & Stratton part if worn, gouged, or cracked along its inner circumference. Tandem belts should be replaced as matched sets.

The 110V Prestolite starter drives through a pulley clutch. The belt should engage with the motor and should disengage as soon as the engine starts. To test, rotate the flywheel by hand to the threshold of the compression stroke. Turn the ignition switch off, connect the power cord to a 110V outlet, and crank the engine with the starter motor. Note the dimensions in Fig. 5-20. The belt should track inside of the restrictor bars and dimension A (Fig. 5-20B). The depth of the belt in the sheave should fall between  $\frac{3}{32}$  and  $\frac{1}{8}$  of an inch. If the dimension is less than this during cranking, move the starter away from the engine (Fig. 5-20C). If the dimension is

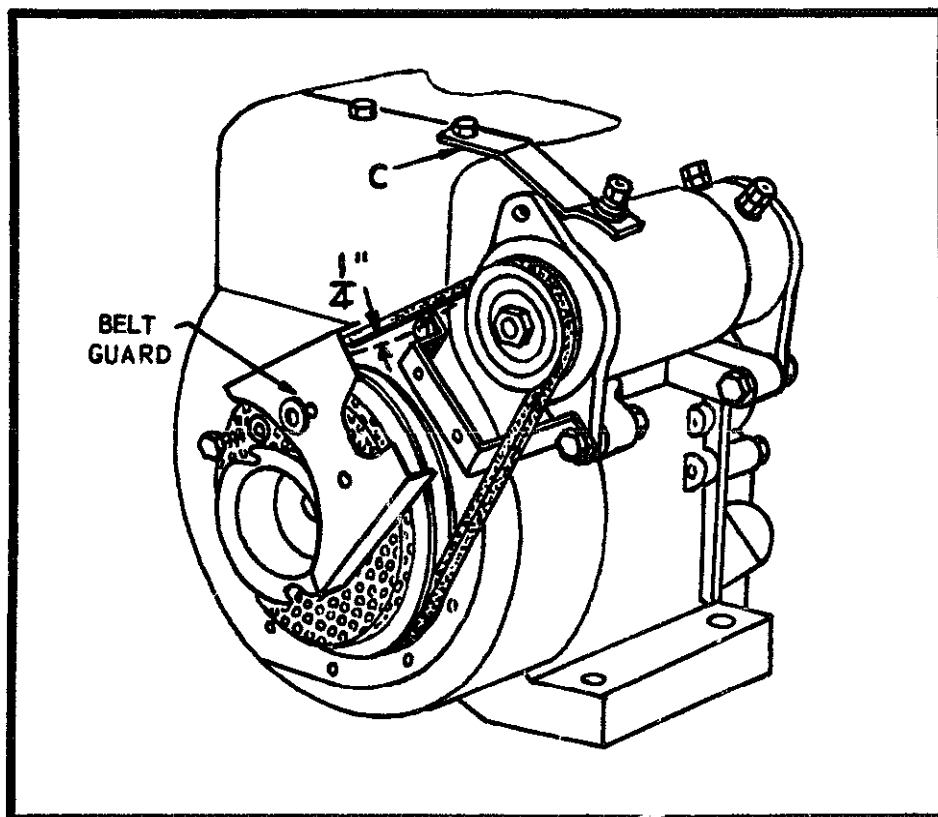


Fig. 5-19. The 12V starter generator combination used on some Briggs & Stratton engines.

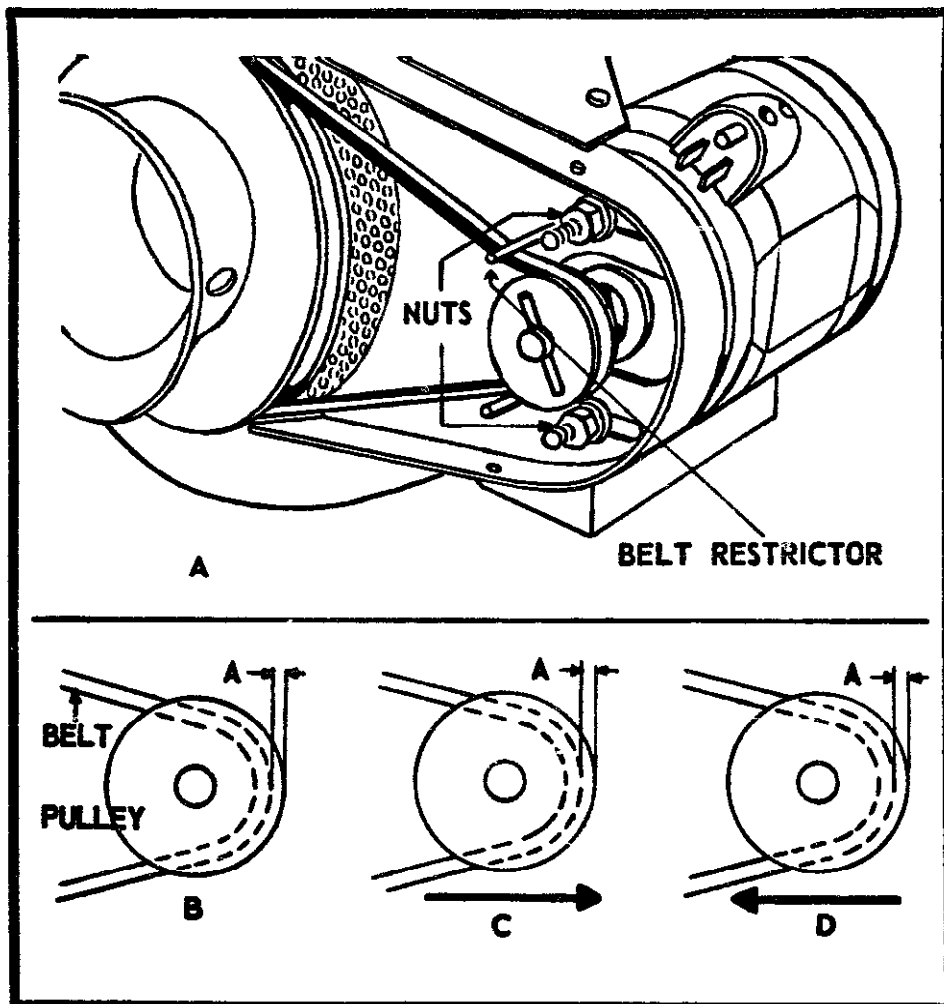


Fig. 5-20. Belt slack is critical for the 12V Prestolite system. (Courtesy Briggs & Stratton Corp.)

greater than  $\frac{1}{8}$  of an inch, move the starter toward the engine (Fig. 5-20D). DO NOT break the line cord connection while the starter motor is engaged. The spark might ignite gasoline vapors.

Other starter motors drive by means of an inertial clutch not unlike the Bendix unit familiar to automotive mechanics (Fig. 5-14). The pinion engages a ring gear on the inboard side of the flywheel, either directly or through the intermediary of a reduction gear.

Remove the starter motor from the engine and visually inspect the pinion and ring gears for burrs and chipped teeth. Some small damage can be expected, since engagement is brutal. In most cases, repairs can be made with a file. The pinion should thread out on the motor shaft when turned counterclockwise. If it sticks, disassemble the unit by removing the spring clip and clean the parts in solvent. No



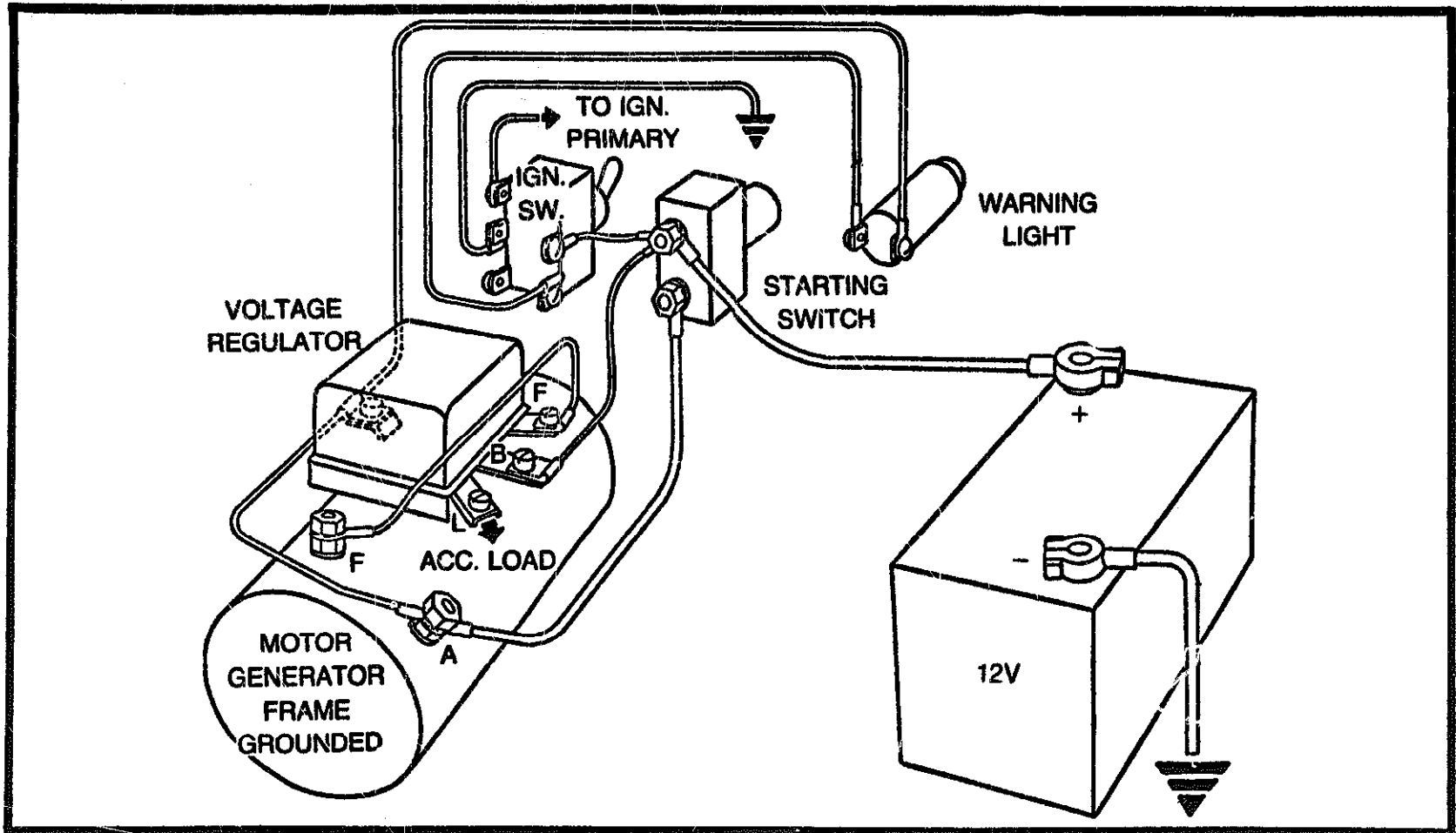


Fig. 5-21. The Delco-Remy 12 volt starter-generator. Wiring varies somewhat with application. (Courtesy Briggs & Stratton Corp.)

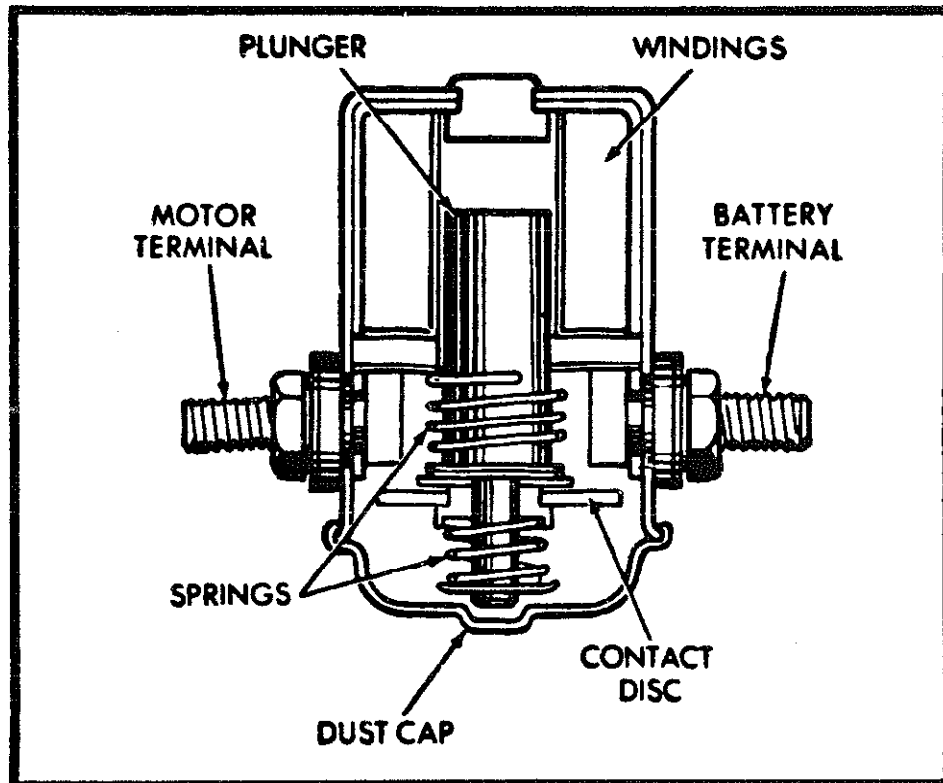


Fig. 5-22. Starter solenoid cutaway. (Courtesy OMC.)

lubrication (other than silicone in cold weather) is allowed. If cleaning does not cure the problem, the assembly must be replaced because, with the exception of the ring gear, spare parts are unavailable.

Combination starter generator sets were once found on a few small imported motorcycles and small-bore Chrysler outboards. The Briggs & Stratton version is built by Delco-Remy. Figure 5-21 illustrates typical wiring, although other examples feature a solenoid rather than a mechanical switch, and an ammeter rather than an idiot light.

Most problems with this system involve the battery. The battery top should be wiped down to prevent leakage between the terminals, and the terminals should be routinely disconnected, scraped bright, and tightened securely. The battery must have a capacity of 40-45 ampere-hours, and each cell should give a hydrometer reading of at least 1.240 with no more than 0.05 points variation between cells.

A low charge can result from battery inactivity—a lead acid battery self-discharges at the rate of one percent a day—or failure of the battery or charging system. Battery failure can be detected by the tests described in the following chapter.

Other than the battery and terminals, the most vulnerable part of this system is the starter switch, or optional solenoid (Fig. 5-22). Test by connecting a heavy gauge jumper between the battery and motor terminals. If the starter works on the jumper, the problem is in the switch or solenoid; if the starter fails to spin, the fault is elsewhere.

A 15 amp ammeter is required to check the charging system. Remove the B (battery) terminal at the voltage regulator and connect the ammeter in series with it. That is, the black, or negative instrument lead goes to the regulator, and the red, or positive lead to the B wire. Start the engine. The ammeter should show a charge at approximately 2000 rpm. How much amperage is delivered depends upon the state of charge of the battery. If the meter shows 10 amps or more, disconnect the F (field) terminal at the regulator. Should output remain high, the generator field coils are grounded and must

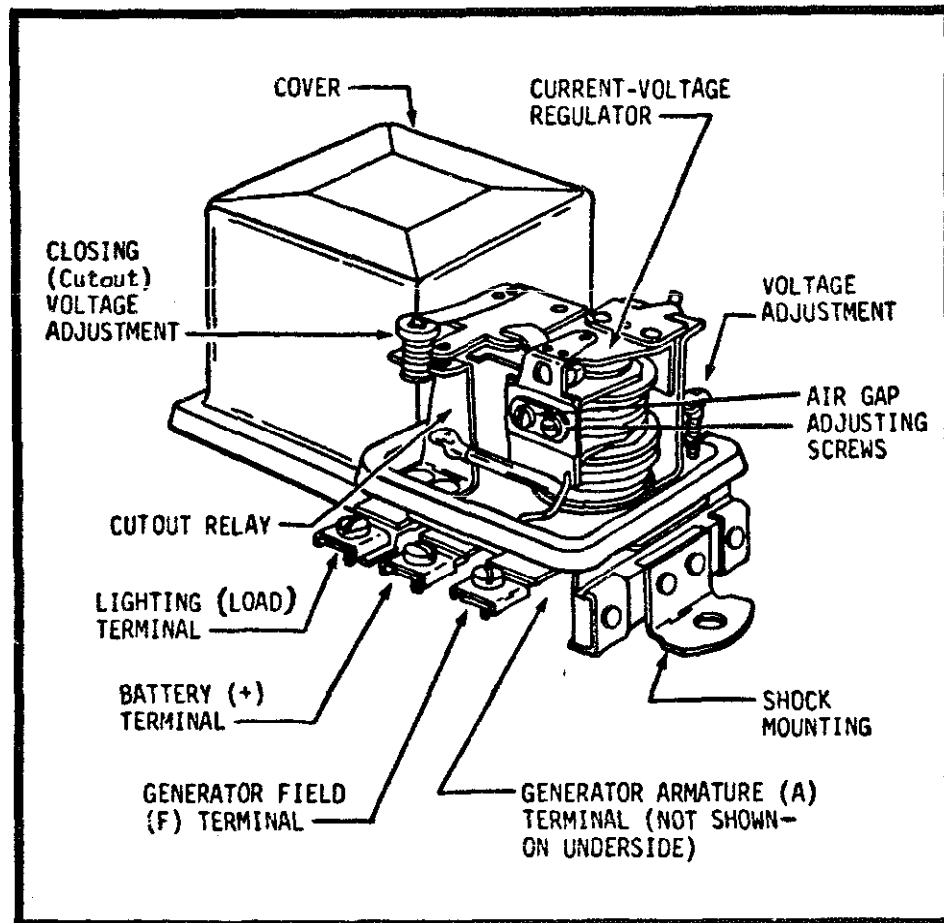


Fig. 5-23. Typical voltage and current regulator. (Courtesy Kohler of Kohler.)

be repaired or replaced. If output ceases, the regulator is defective. If there is no charge with the F lead disconnected, momentarily short the lead to the engine block. A healthy generator will put out 10 amps or more, signaling that the regulator has failed. No charge with the F lead grounded means that the generator brushes or armature have opened or shorted.

The regulator usually goes out in response to trouble elsewhere in the charging circuit (Fig. 5-23). Burned current coils (distinguished from voltage coils by the heavy windings) usually mean a short in the external wiring or battery. Burned points may mean reversed polarity, or high resistance in the charging circuit. But the most frequent cause of cooked points is a poor regulator ground. If the regulator is not electrically one with the engine, run a length of No. 14 wire from a good, paint and rust free engine ground to one of the regulator holddown bolts.

## **CHAPTER 6**

# **CHARGING SYSTEMS**

The various engine models employ five distinct alternators for use with lead acid batteries. The Nicad system is recharged from house current by way of a step-down transformer and rectifier.

### **STORAGE BATTERIES**

Storage batteries can fail either mechanically or electrically. The leading causes of mechanical failure are loose battery hold-down hardware, poor vibration insulation, and owner abuse. The battery straps—the internal busses that connect the cells—are cast as part of the terminals. Twisting the cables or overtightening the terminal bolts can fracture the straps.

Electrical failure is usually associated with chronically low states of charge. The plates become impregnated with sulphate crystals and are no longer able to take part in the ion exchange that generates electrical potential. A partial cure is to trickle charge the battery for a week or more. At least some of the sulphate dissolves and goes back into solution. However the best cure is prevention. Distilled water should be added as needed to cover the plates with electrolyte, and the state of charge should be held above 75%, or 1.1220 on a temperature-corrected hydrometer.

Deep charge-discharge cycles encourage sulphation and, if the system is not properly regulated, can overheat the battery, melting holes in the plates. The extent and rate of discharge can be reduced

by keeping the battery charged and the engine in tune. The less cranking the better, particularly if the battery shows signs of fatigue. Self-discharge can be controlled by frequent transfusions and by keeping the battery top and terminals clean. The rate of charge is, practically speaking, beyond owner control, although it is wise to invest in an ammeter to keep an eye on the system.

Before turning to specific test procedures, it should be noted that the capacity of the battery has some bearing upon its longevity. All things being equal, a larger battery will outlive one that delivers its last erg of energy each time the engine is cranked. But the capacity of the battery, usually measured in ampere-hours, although more sophisticated yardsticks are available, cannot compensate for long term withdrawals. Ultimately, even the large battery must be recharged, and that depends upon the output of the alternator and upon the way the engine is used. A small alternator that is adequate for one start a day may not deliver the current for twenty starts a day.

The first evidence of charging system failure is a low battery. The state of charge—how much potential is available in the battery—is most easily measured with a hydrometer. While hydrometer results do not take the place of a performance test, the hydrometer is the instrument to be tried first.

A hydrometer consists of a squeeze bulb, a float chamber, and a precisely weighted float (Fig. 6-1A). The float is calibrated in units of specific gravity. Water has a specific gravity of 1.000. Sulphuric acid, the other ingredient of electrolyte, has a specific gravity of 1.83. In other words, sulphuric acid is 1.830 times heavier than an equal amount of water. The amount of acid in the electrolyte reflects the state of charge. The more acid in the electrolyte, the greater the charge and the heavier the electrolyte. Each cell in a fully charged battery should have a specific gravity of 1.240-1.280. A completely discharged battery will have a specific gravity on the order of 1.100.

Draw enough electrolyte into the hydrometer to set the float adrift. The float must not touch the sides of the instrument. Sight across the main level of the instrument, disregarding the meniscus that clings to the sides of the chamber, and record the specific gravity for that cell. Repeat the operation on the others. The battery

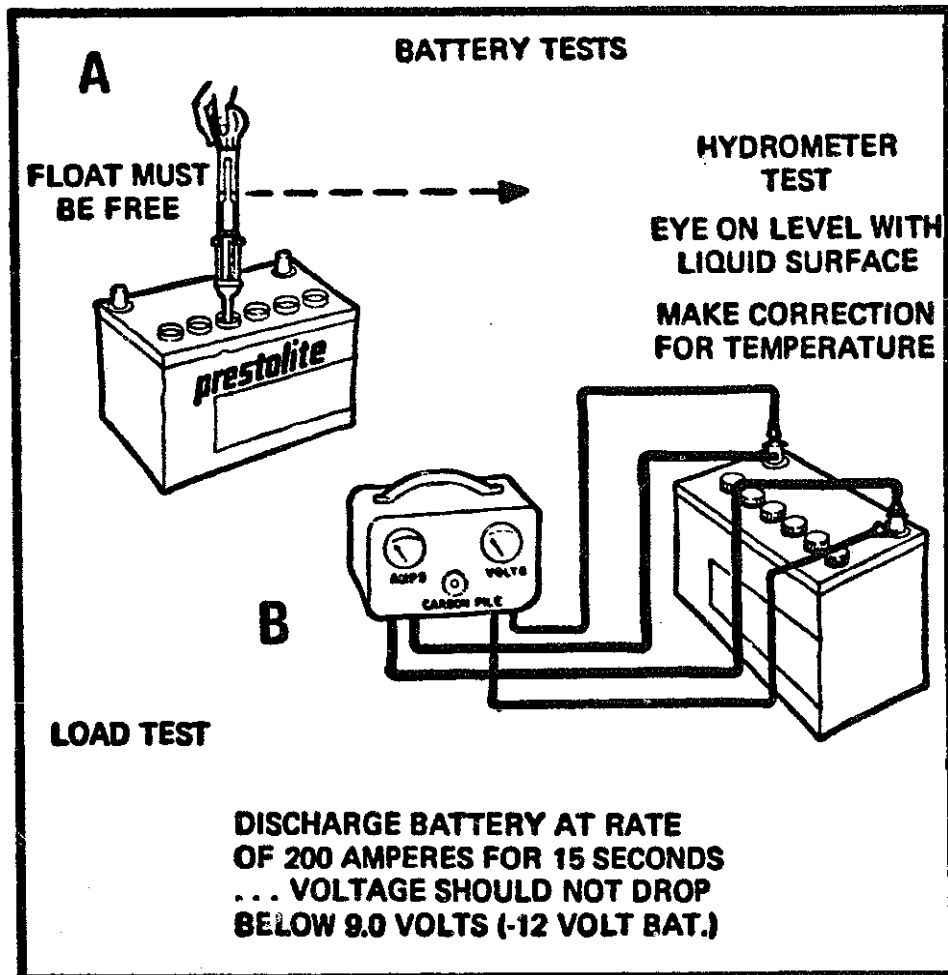


Fig. 6-1. A battery hydrometer and rheostat. (Courtesy OMC.)

should be suspected of malfunctioning if any of the cells fall five points (0.005) below the average of the others.

While raw, uncorrected readings are generally adequate, it should be remembered that acid and water expand when heated. The higher the temperature of the electrolyte, the lower the apparent specific gravity. Expensive hydrometers sometimes incorporate a thermometer in the barrel and a temperature-compensating scale. Any accurate thermometer will work. For each ten degrees above 80 degrees Fahrenheit add four points (0.004) to the reading; subtract four points for each ten degrees below 80 degrees Fahrenheit.

The most reliable field test requires a carbon pile (Fig. 6-1B) or a rheostat and a voltmeter. The temperature-compensated specific gravity should be at least 1.220 to prevent battery damage. Connect

the voltmeter across the terminals and adjust the load to three times the ampere-hour rating. For example, the carbon pile should be adjusted to discharge a 30 ampere-hour battery at the rate of 90 amps. Continue to discharge for fifteen seconds. At no time during the test should the voltmeter register less than 9.6V. If it does, the battery should be suspected of malfunctioning.

## ALTERNATORS

The usual Briggs & Stratton approach is to provide battery charging current with an engine driven alternator and solid state rectifier. The rectifier converts alternating current into pulsating direct current. The more sophisticated systems include a solid state voltage regulator to protect the battery from overcharging and to extend headlamp life. Optional features include an ammeter and an isolation diode. All systems employ a lead acid storage battery.

### The 1.5 Amp Alternator

The 1.5 amp alternator is the peewee of the series, intended to replenish a 12 ampere-hour battery. Other than the resistance of the battery and the engine speed governor, there is no regulator.

To test the alternator output, connect a number 4001 headlamp between the rectifier output and a paint free engine ground (Fig. 6-2). The battery must be out of the circuit. Under no circumstances

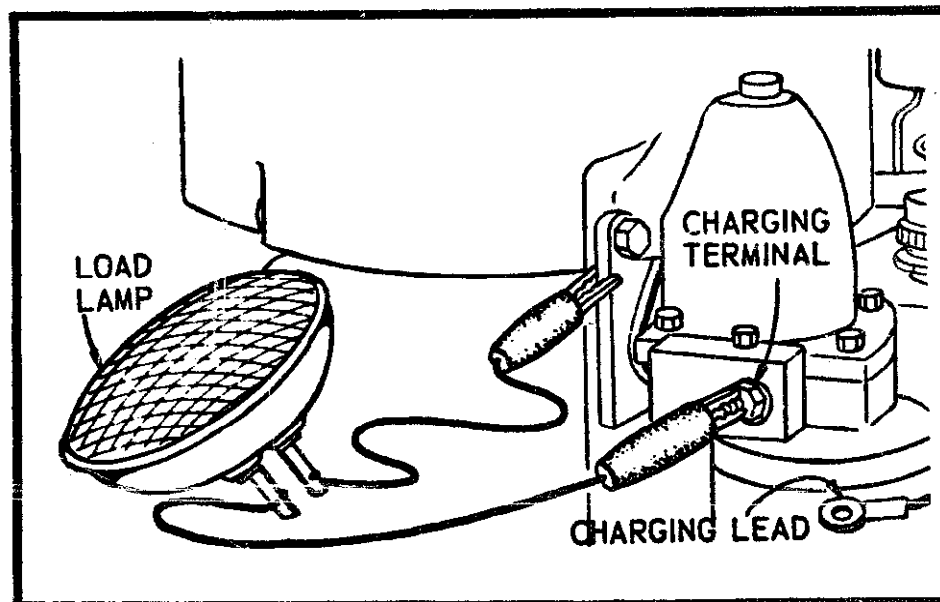


Fig. 6-2. Testing output of the 1.5A alternator. (Courtesy Briggs & Stratton Corp.)



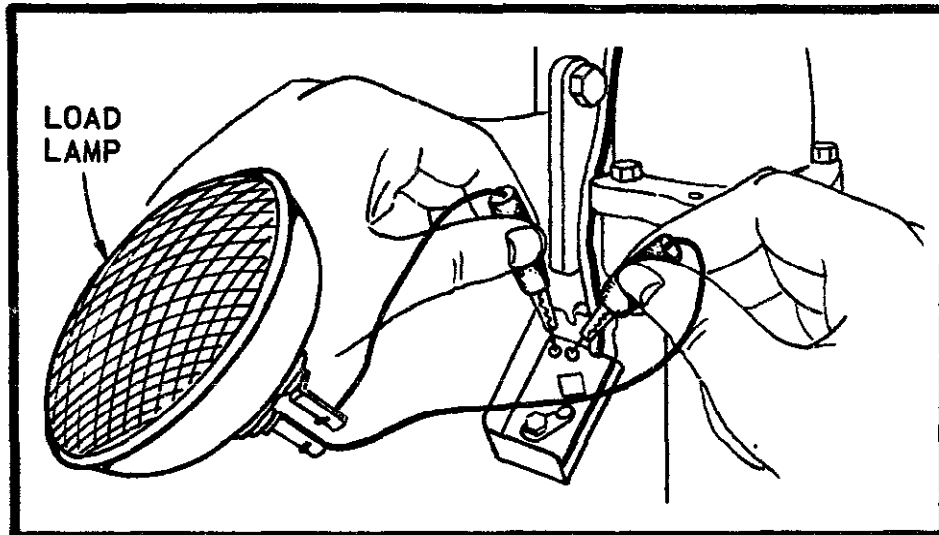


Fig. 6-3. Testing stator of the 1.5A alternator. (Courtesy Briggs & Stratton Corp.)

should the output of this or any other alternator be grounded. To do so is to invite burned coils and fried diodes.

If the lamp refuses to light, the fault is in the rectifier or the alternator. Test the rectifier first, since it is the more likely failure point. With the engine stopped, touch the probes of a low voltage ohmmeter to the output terminal and ground, as shown in Fig. 6-3. You should get continuity in one direction, and high resistance in the other. If not, replace the rectifier box.

Test the stator with a 4001 headlamp connected across the output leads (Fig. 6-3). The lamp should burn. If not, check the leads to the stator for possible fouling. Before deciding that the stator is defective, compare the magnetic strength of the flywheel ring against one known to be good. Failure is exceedingly rare, but not impossible.

Install a replacement stator, torquing the capscrews 18-24 in-lb. See that the output leads are snug against the block, and well clear of the flywheel.

### **The 4.0 Amp Alternator**

The 4.0 amp alternator is a variation of the one just described. It has eight charging coils (instead of three) and is protected by an in-line fuse.

Troubleshooting procedures begin with a short-circuit test. Connect a 12V test lamp between the rectifier output and the

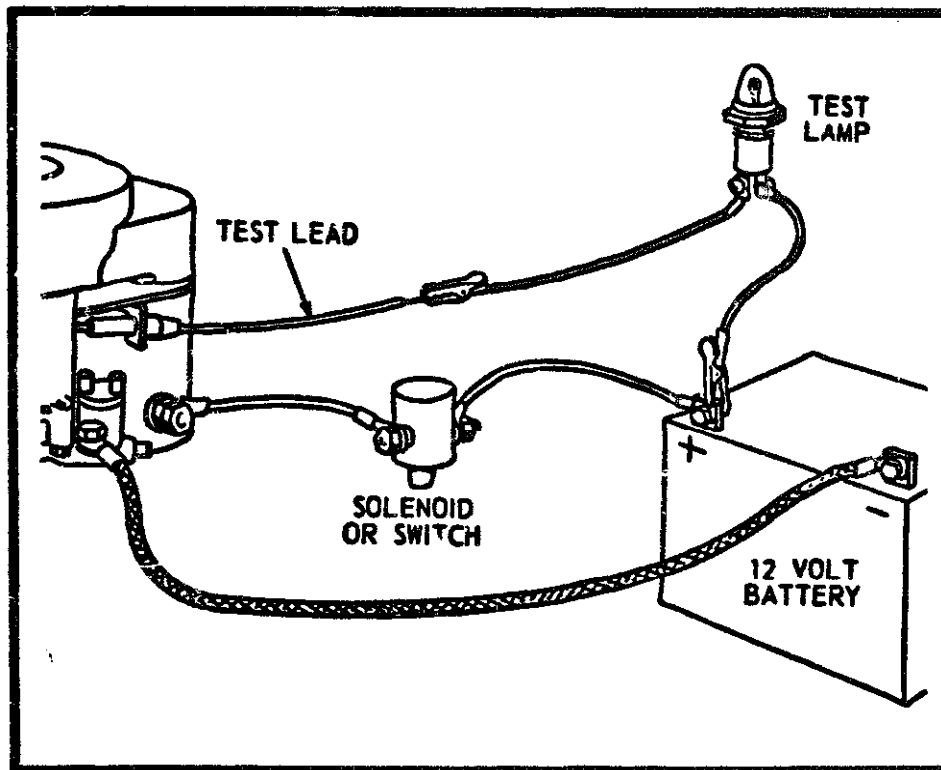


Fig. 6-4. Testing for shorts in the 4.0A, 7.0A and dual circuit alternators. (Courtesy Briggs & Stratton Corp.)

positive terminal of a charged battery (Fig. 6-4). If the lamp lights, battery current is being fed back to ground through the charging circuit. Unplug the rectifier connection under the blower housing. If the lamp goes out, the rectifier is okay and the problem lies in the alternator and associated wiring. If the lamp continues to burn, the rectifier is at fault and must be replaced.

Inspect the output leads from the alternator for frayed insulation or other evidence of shorts before replacing the stator assembly. Make necessary repairs with electrician's tape and silicone cement.

This alternator has four distinct windings, each involving two coils. A break in one of the windings drops output by a third. Check each of the four pins with the fuse holder lead as shown in Fig. 6-5. Each pair of pins supplies current to a diode in the rectifier. Should a diode blow, a quarter of the output is lost. Check each of the four rectifier terminals with an ohmmeter. One probe should be on a good (paintless and rustless) ground on the underside of the blower housing; the other probe should be on one of the diode connection

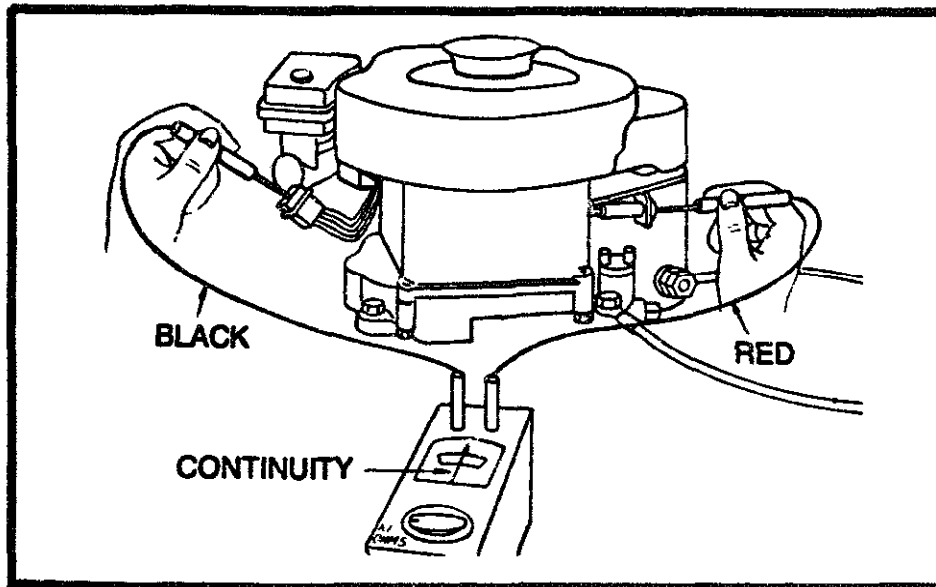


Fig. 6-5. Testing the stator on the 4.0 and 7.0A alternator. (Courtesy Briggs & Stratton Corp.)

points. Observe the meter and reverse the test connections. If the diode in question is functional, it will have continuity in one direction and very high resistance in the other. Repeat the test for the remaining three connection points.

### The 7.0 Amp Alternator

The 7.0 amp alternator is used on series 140000, 170000, and 190000 engines can easily be recognized by the connector plug, flanked by a regulator on one side and the rectifier on the other (Fig. 6-6). Some installations employ an isolation diode in a tubular jacket

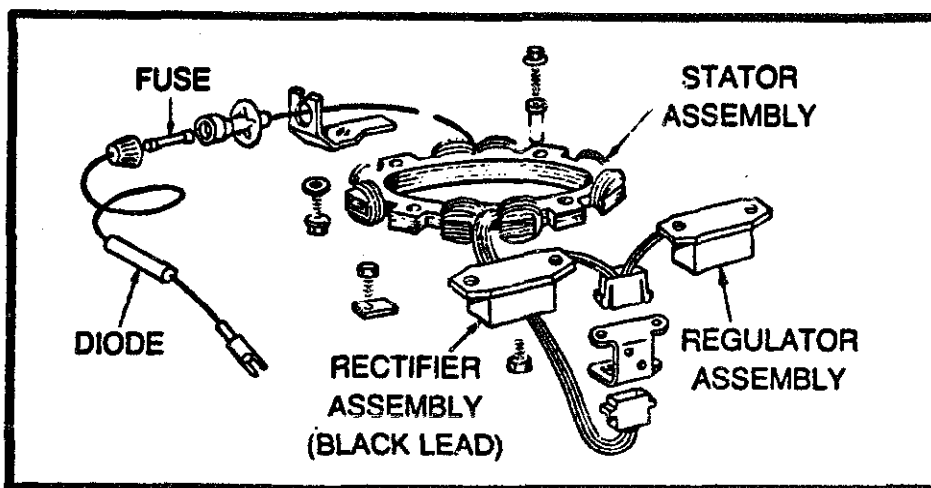


Fig. 6-6. The 7.0A alternator configuration. (Courtesy Briggs & Stratton Corp.)

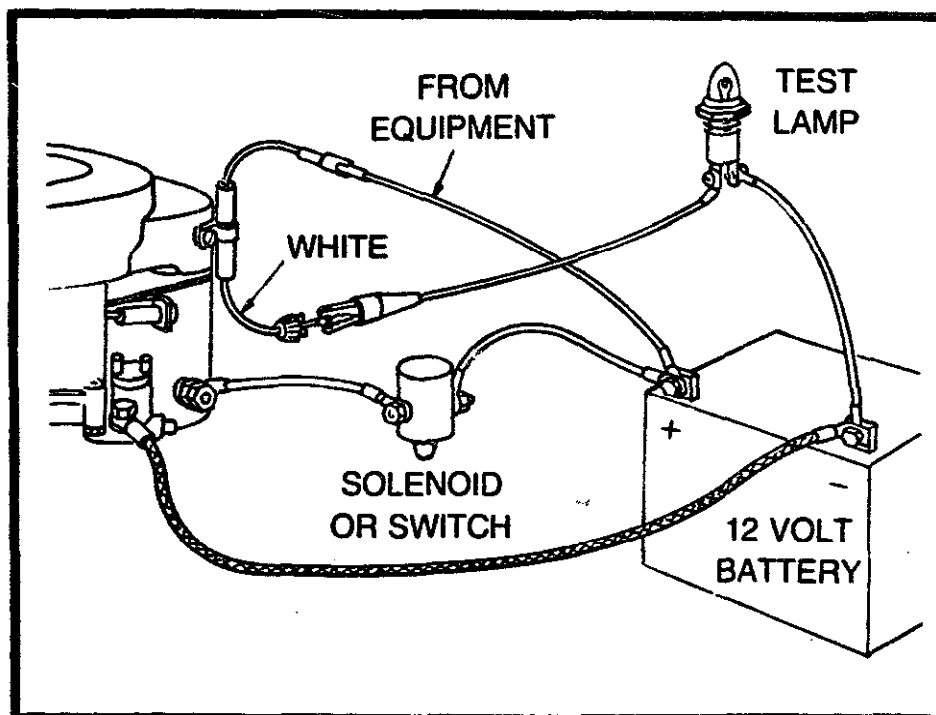


Fig. 6-7. Testing the isolation diode on the 7.0A alternator. (Courtesy Briggs & Stratton Corp.)

on the outside of the shroud. The purpose is to block current leakage from the battery to ground by way of the alternator windings. Applications that do not have this diode isolate the battery at the ignition switch.

Test the isolation diode by connecting a 12V lamp in series with the output (Fig. 6-7). The lamp should not light. If it does, the diode is shorted and must be replaced. Check diode continuity with an ohmmeter connected between the two diode leads. The meter should show zero resistance in one direction and high resistance when the leads are reversed.

To test the stator, regulator, or rectifier, connect a test lamp as shown back in Fig. 6-4. Do not start the engine. If the lamp lights, one of the three is shorted. Disconnect the rectifier regulator plug under the blower housing, removing the stator from the circuit. If the lamp continues to burn, the regulator or rectifier is shorted. Test these two components individually to determine which is at fault.

Test the rectifier as described previously. Two black leads, joined by a connector, go to the rectifier. Each lead services two pins on the rectifier side of the connector. Without removing the rectifier

assembly from the shroud, connect ohmmeter leads between each of the four pins and a paint free ground on the underside of the shroud. Observe the meter reading at each pin and reverse the leads. The pins should conduct in one direction and not in the other. If current flows in both directions, the rectifier is shorted; if no current passes, the rectifier is open. In either event, the assembly must be replaced. Instructions are packaged with the new part.

The regulator is distinguished by one red and one white lead. Test as above. The white lead pin must show some conductivity in one direction and none, or almost none, in the other. The red lead pin should give no reading in either direction. If it is necessary to replace the regulator, instructions are supplied with the replacement part.

Check stator continuity as shown in Fig. 6-5. Each of the four pins must be contiguous with the lead at the fuse holder. If not, check the visible wiring for defects before investing in a new stator.

### **Dual Circuit Alternator**

The dual circuit alternator is technically the most interesting alternator used on Briggs & Stratton engines. Two stator windings are provided, one for the headlights and the other for the battery. Battery output is rectified and rated at 3 amps. Headlight output is alternating and can deliver 5.8 amps at 12V at wide open throttle.

The battery circuit is protected by a 7.5 amps type AGC or 3AG automotive fuse and may be supplied with an ammeter. The AC circuit is independent of the charging circuit, although good practice demands that both be grounded at the same engine mounting bolt. Each circuit is treated separately here.

**Charging Circuit.** Check output with an ammeter in series with the positive battery terminal (Fig. 6-8). The meter should show some output at medium and high engine speeds. No charge indicates a blown fuse, shorted or open wiring, or a failure of the rectifier or alternator.

Connect a 12V test lamp between the battery and the charging section as illustrated in Fig. 6-4. The lamp should not light. If it does, the alternator or rectifier is defective. To isolate the problem, disconnect the plug under the shroud. If the light goes out, the rectifier is good, and the difficulty is in the alternator or its external

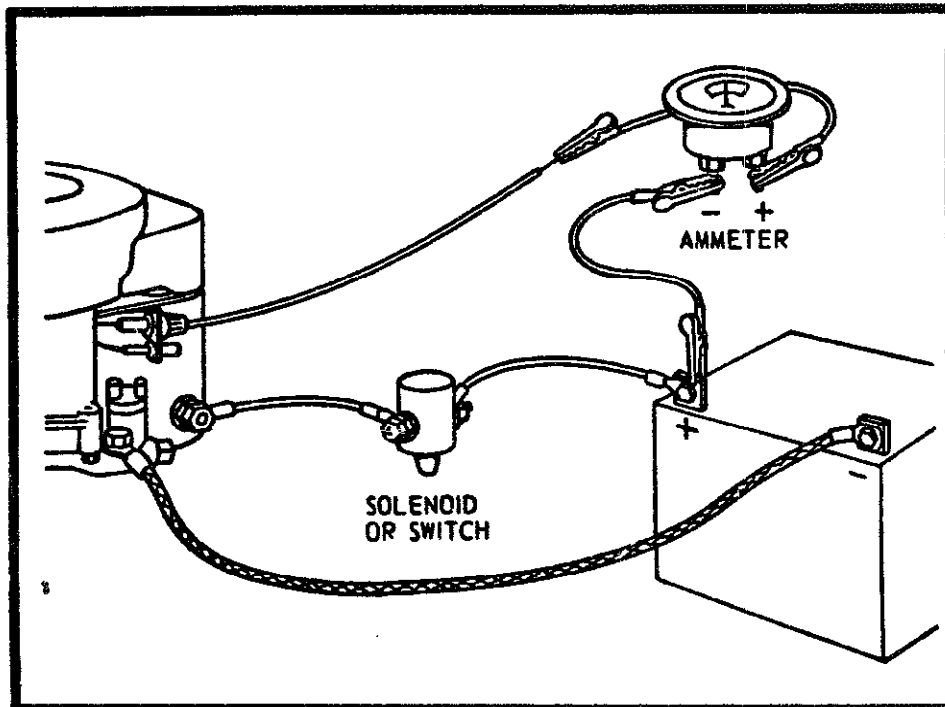


Fig. 6-8. Testing DC output on the dual circuit alternator. (Courtesy Briggs & Stratton Corp.)

circuitry. If the light continues to burn, the rectifier is shorted to ground and must be replaced.

To test the stator, remove the starter motor, shroud, and flywheel. Inspect the red output lead for frayed or broken insulation. Repair with electrical tape and silicone, being careful to route the lead away from moving parts. Test the stator by connecting an ohmmeter between the terminal at the fuse holder and the red lead pin in the connector. The meter should show continuity. If not, the stator is open and must be replaced.

Test for shorts by connecting the ohmmeter between a good ground and each of the three black lead pins in sequence (Fig. 6-9). Test for continuity by holding the probes against the two black pins (Fig. 6-10). If the circuit is open, the stator is good. If the meter shows continuity, the stator must be replaced.

The rectifier mounts under the fan shroud where it is serviced by a three-prong connector plug. Open the plug and connect one test lead from an ohmmeter to the red lead pin, and the other to the underside of the shroud (Fig. 6-10). Observe the meter and reverse the test leads. The meter should report high resistance in one

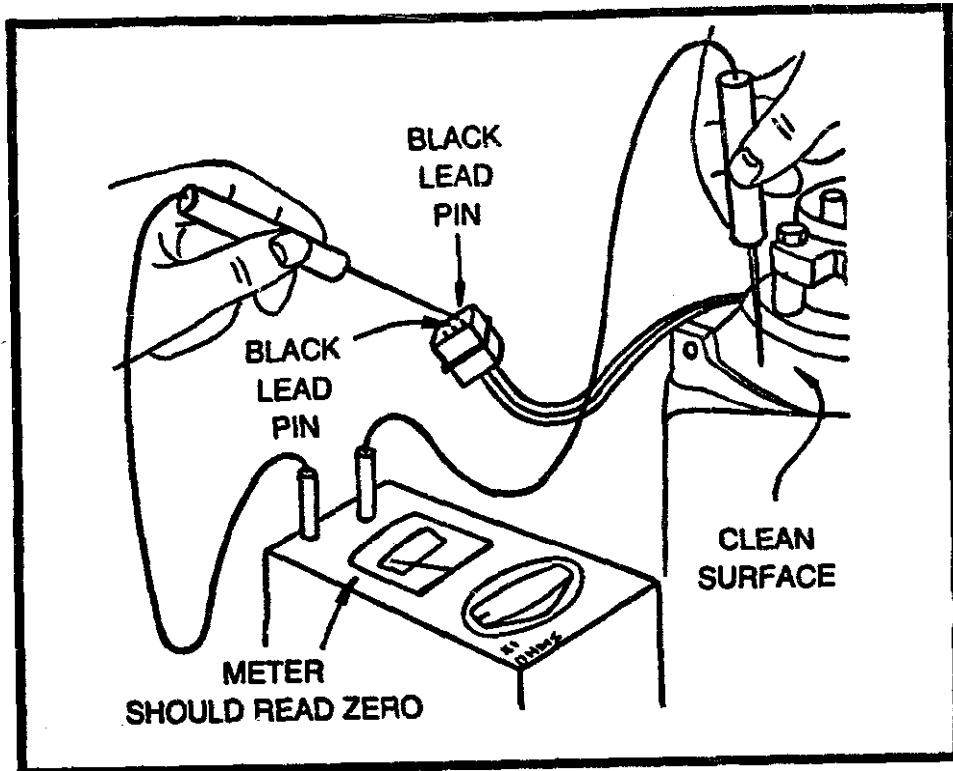


Fig. 6-9. Testing for shorted charging coils in the dual circuit alternator. (Courtesy Briggs & Stratton Corp.)

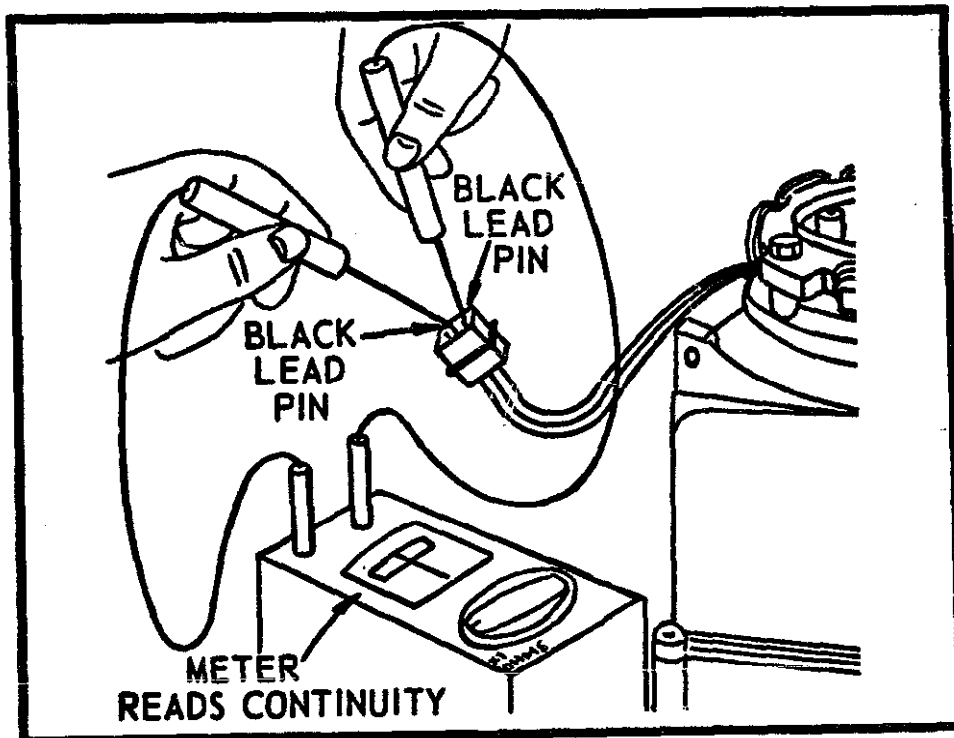


Fig. 6-10. Testing charging coil continuity on the dual circuit alternator. (Courtesy Briggs & Stratton Corp.)

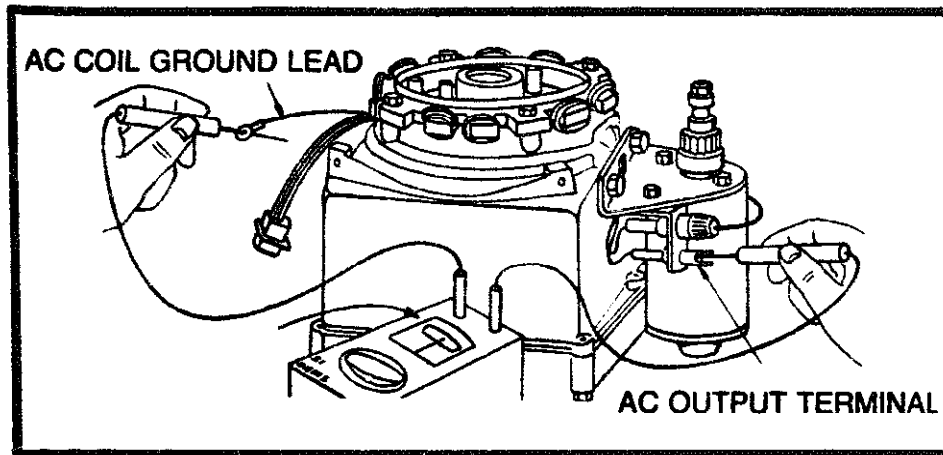


Fig. 6-11. Testing AC circuit continuity on the dual circuit alternator. (Courtesy Briggs & Stratton Corp.)

direction and no resistance in the other. Do the same for each black lead pin.

The lighting circuit should be tested with a number 4001 head-lamp connected between the output terminal and a reliable engine ground. The lamp should burn brightly at medium engine speeds. If it does burn brightly, the problem is in the external circuit, between the engine and the vehicle lights. If the lamp does not light or burns feebly, the problem is in the alternator. Check coil continuity with a ohmmeter as shown in Fig. 6-11. High or infinite resistance means a defective stator.

### The 10 Amp Regulator

Used on the series 200400 and 320400 engines, this alternator is a heavy duty device, delivering better than 4 amps at 2000 rpm and full rating at 3600 rpm. The regulator is more flexible than those used on the smaller engines, and can handle large loads without overcharging the battery.

Check voltage across the battery terminals with the engine turning at full governed rpm. Less than 14V on a fully charged battery means stator or regulator-rectifier problems.

Disconnect the plug at the regulator-rectifier and connect an AC voltmeter to each of the two outside plug terminals (Fig. 6-12). A reading of less than 20V per terminal means a defective stator. Check the regulator-rectifier by default; that is, if the system fails to deliver sufficient charging voltage and the stator appears okay, replace the regulator-rectifier.



## THE NICAD SYSTEM

An option on 92000 and 110900 engines, the Nicad system consists of a gear driven starter motor, starter-ignition switch, plug-in battery charger, and a 12V nickel-cadmium battery. Since this system is intended for rotary lawnmower applications, the starter-ignition switch is mounted on the handlebar where it is electrically isolated from the engine. The switch stops the engine by grounding the magneto primary circuit through the connector clipped on the engine shroud. If the connector comes free of its clip, the magneto will be denied ground, and the engine will continue to run regardless of the switch setting.

The first place to check, should trouble arise, is the battery. Nickel-cadmium cells are by no means immortal. Load the battery with two G.E. number 4001 sealed beam headlamps connected in parallel (Fig. 6-13). Monitor the voltage. The meter should show at least 13.6V after one minute of draw. Readings of 13V and less mean that one or more of the cells are defective. The lights should burn brightly for at least five minutes.

The half wave rectifier supplied with this system should be capable of recharging a fully depleted battery over a period of sixteen hours.

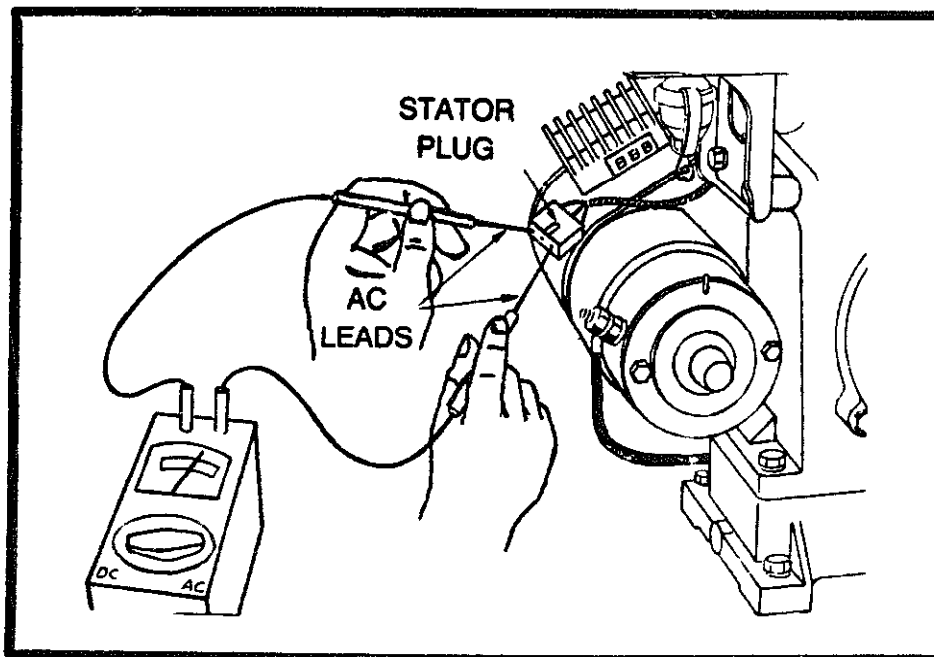


Fig. 6-12. Testing the stator on the alternator. (Courtesy Briggs & Stratton Corp.)

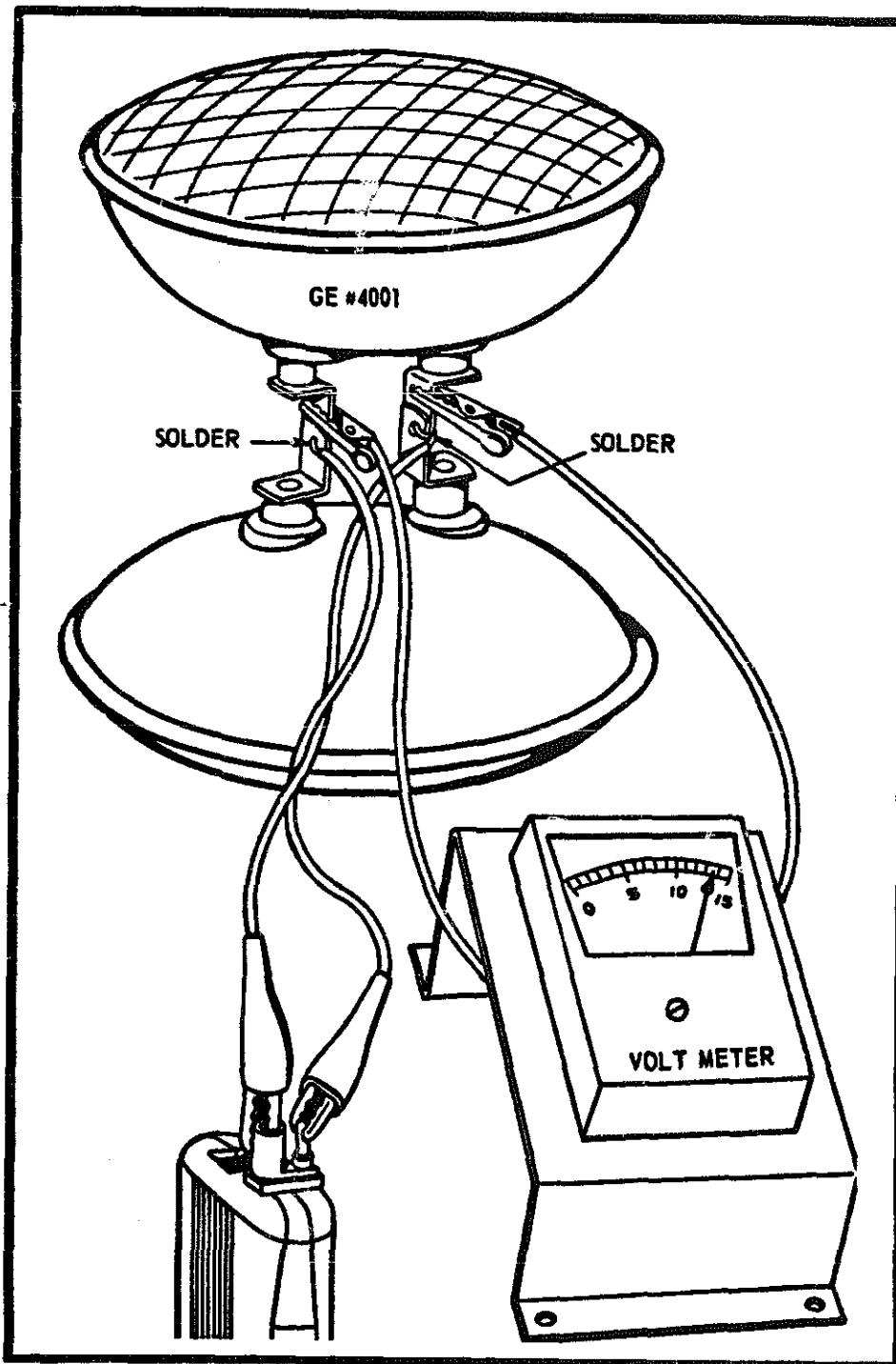


Fig. 6-13. Testing the Nicad battery. (Courtesy Briggs & Stratton Corp.)

An inexpensive tester can be constructed from the following materials:

- 1 1N4005 diode
- 1 red lamp socket (Dialco number 0931-102)

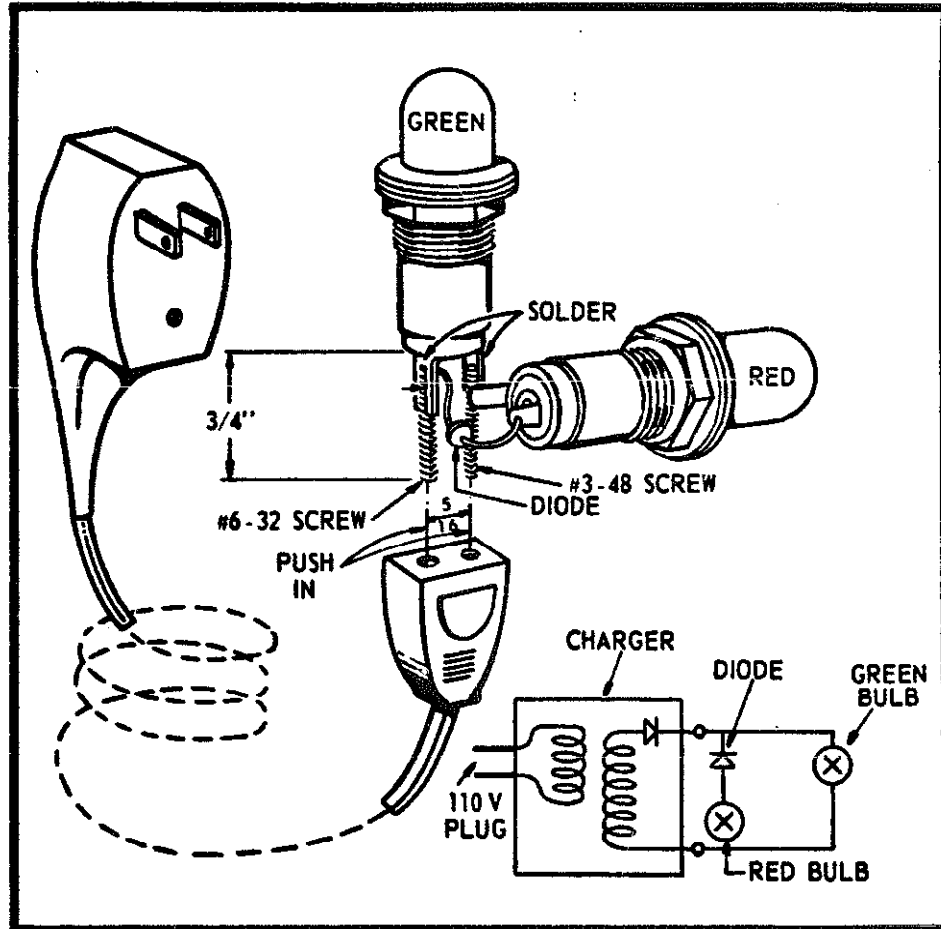


Fig. 6-14. A homemade rectifier tester. (Courtesy Briggs & Stratton Corp.)

- 1 green lamp socket (Dialco number 0932-102)
- 1 neon bulb, number 53
- 1  $\frac{3}{4}$  inch machine screw, number 6-32
- 1  $\frac{3}{4}$  inch machine screw, number 3-48

Wire these components shown in Fig. 6-14. If neither bulb lights, the transformer or charger diode is open; if both bulbs light, the charger diode is open and passing alternating current. A properly working charger will light only the green bulb.

## **CHAPTER 7**

# **ENGINE WORK**

Engine work requires antiseptic cleanliness, careful inspection of the parts, thorough lubrication before reassembly, and strict adherence to torque sequences and torque limits.

### **ENGINE MODIFICATION**

While a Briggs & Stratton engine is an unlikely example of racing material, these engines can be modified to produce one horsepower per cubic inch, or some three times the stock output. Parts and expertise have been developed for four cycle go-cart racing.

The modifications discussed in this chapter are not radical and will increase output by no more than half a horsepower. But these conservative modifications will not adversely affect engine life or tractability. In most cases, starting is easier than before, and fuel economy may be unaffected or slightly improved.

### **SYMPTOMS OF ENGINE TROUBLE**

Unusual noises are the most obvious indication that something is seriously wrong. A loose connecting rod bearing makes a light rapping sound that grows louder and more insistent with time. If the repair is made early, it is usually possible to save the crankshaft. As a general rule, main bearings wear at about a third of the rate of conn

rods. In other words, the engine should wear out three conn rods to one set of mains. But main bearing wear is accelerated by contaminated oil and by failure to keep the crankcase topped off. It is not unusual to find the lower main (on vertical shaft engines) sludge-cut so that the crankshaft appears as if it were threaded.

Main bearings make a distress signal in the form of a dull, rhythmic knock. Another check is to grasp the crankshaft and attempt to move it side to side. Perceptible play means main bearing trouble.

A high-pitched whine is usually the result of a dry starter clutch bushing. A few drops of oil should clear up the problem. A furious rattle, sounding like marbles rolling down a washboard, usually means that the flywheel vanes are touching the air inlet screen. Reposition the shroud cover.

Loss of compression involves the rings, valves, or head gasket. The problem is to determine how much compression is normal. Most Briggs & Stratton engines feature "Easy Spin" starting. A ramp on the cam lobe holds the inlet valve open during most of the compression stroke. Since power depends to a great extent upon compression, it seems almost sacrilegious to bleed compression past an open valve. However the "Easy Spin" system cuts starting effort by half and has no effect upon the rated output. One suspects Briggs & Stratton engineers compensated for the loss with carburetion or ignition timing changes. As far as the mechanic is concerned, "Easy Spin" starting makes a conventional compression check meaningless. To get an honest reading, the flywheel must be spun backwards against the normal direction of rotation at around 100 rpm. Rather than rig some sort of back turning starter, the best approach is to check compression by feel. With the spark plug in place, spin the flywheel backwards. The piston should rebound off compression, as if it had encountered a spring.

Engines without a compression bleed can be tested in the normal fashion (Fig. 7-1). For consistent readings, follow these steps:

- Remove the spark plug and ground the ignition.
- Mount a compression gauge in the spark plug port.
- Open the throttle and choke valves.
- Crank the engine at starting speed.

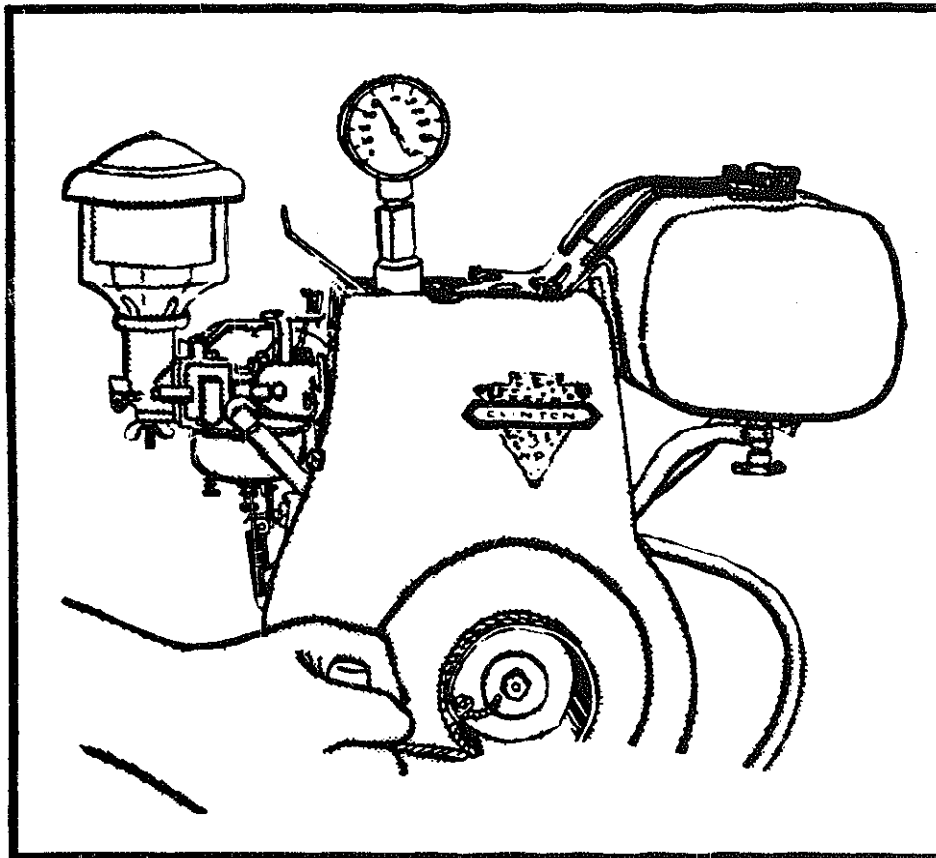


Fig. 7-1. Using a compression gauge. (Courtesy Clinton Engines Corp.)

- As the crankshaft turns, count the compression strokes, taking the reading on the fourth one.

Briggs & Stratton engines have low (5 or 6 to 1) compression ratios and give correspondingly low pressure readings. Expect about 80 pounds per square inch, although the exact figure depends upon how much carbon is in the chamber, how fast the engine is cranked, ambient air temperature, and other variables. An engine that has been dormant for several months will give low readings until the cylinder walls are lubricated. In any event, an engine that generates less than 60 pounds per square inch of compression will not start.

The manometer shown in Fig. 7-2 is a comparative instrument used to gauge the slow decline in engine performance that accompanies wear and age. The U-shaped glass tube is marked off in quarter-inch increments and partially filled with water. The rubber stopper replaces the oil filler plug. Briggs & Stratton and other small

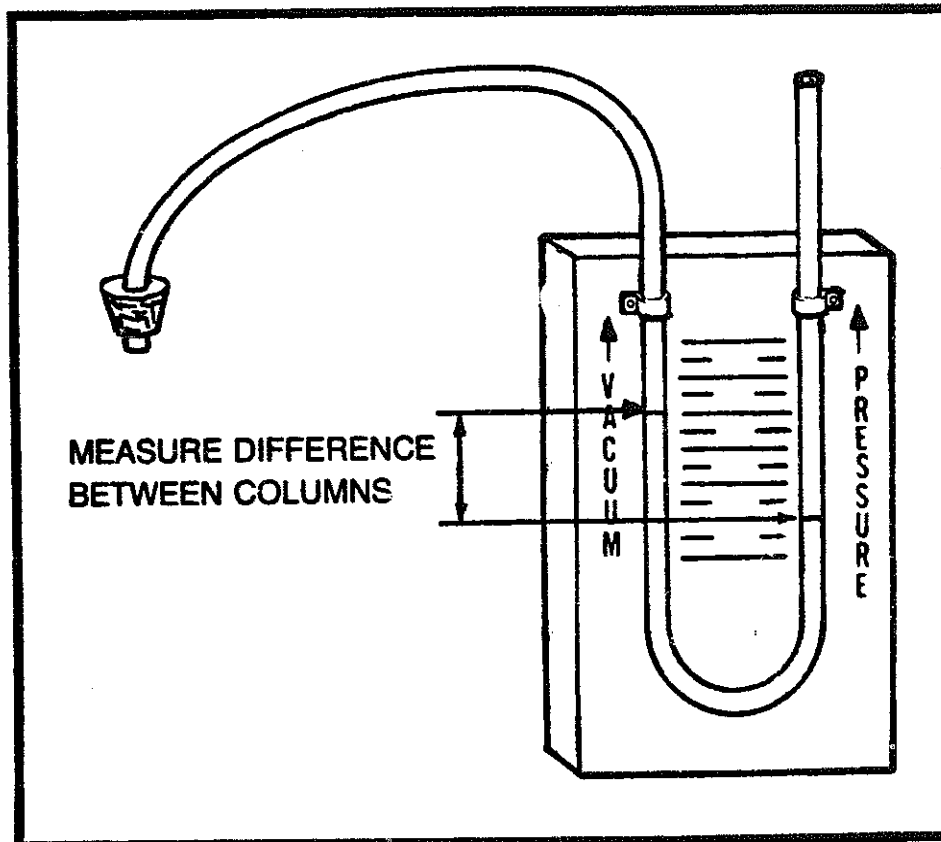


Fig. 7-2. A U-tube manometer. (Courtesy Kohler of Kohler.)

four-cycle engines operate with negative pressure in the crankcase. Once the engine starts, the column of water should move toward the crankcase. The greater the movement, the more vacuum, and all things being equal, the healthier engine. No movement means a blown flange gasket, faulty crankcase breather, or a pinhole in one of the castings.

The most sophisticated engine test, spectroscopic analysis, is virtually unknown in the world of small engines. But as the cost of these engines escalates, spectroscopic analysis of oil should become commonplace. Pioneered by the railroads and perfected by the U.S. Navy, this technique can predict when an engine will fail. All spectroscopic labs have an emergency phone service. More than one pilot has shutdown on the runway upon receiving a message from the tower that his engine is on the edge of self-destruction.

Spectrographic oil analysis is based on the fact that each element gives off a characteristic light frequency when vaporized. The sample is flashed by an electric arc, the light collected, and then

passed through a prism that sorts out the frequencies. A battery of photocells—each sensitive to a particular fraction of the spectrum—converts light intensity to electrical impulses. These impulses can be metered and read directly, then are fed into a computer for a printout.

Typically, used motor oil contains these materials:

|                |                                |
|----------------|--------------------------------|
| Lead.....      | bearings                       |
| Silver.....    | bearings                       |
| Tin.....       | bearings, piston coatings      |
| Aluminum ..... | bearings, block metal, pistons |
| Copper .....   | bushings                       |
| Iron .....     | cylinder walls, piston rings   |
| Chromium.....  | cylinder walls, piston rings   |
| Nickel .....   | bearings, valves               |

Silicon and aluminum oxide particles mean that dust has entered the crankcase. These particles are responsible for most lower cylinder wear and mean death to conn rod bearings. Their presence can usually be traced to sloppy maintenance—opening the engine without cleaning it first, contaminated oil, or a failed air cleaner. Calcium, boron, and zinc are additives found in high grade motor oil, but high concentrations are considered harmful.

A test may log as many as sixteen elements and be run several times. While heavy concentrations of aluminum or iron spell obvious trouble, most of the interpretation is subjective, based on the experience of the technician and what he knows of the engine's history. *If failure is imminent, the lab will call. Otherwise, the reports are mailed.*

The whole process sounds frightfully expensive, but Analysts, Inc. (820 E. Elizabeth Ave., Linder, NJ 07036) will do the work for less than \$15.

### **OVERHAULING VS REBUILDING**

An engine overhaul involves new piston rings, gaskets, oil seals, and remachined valves. As a rule, the shop will rebuild the carburetor and replace the points and condenser as part of the overhaul package.

Rebuilding an engine is a more serious proposition, involving all of the above as well as a new, oversized piston and, when needed, a



new crankshaft, main bearing set, and connecting rod. In theory, rebuilt engines should be equivalent to a new one.

### **ENGINE TEARDOWN**

To prepare the engine for teardown, gather some cans and pasteboard boxes for the large parts. Drain all liquids, disconnect any electrical leads, and remove control linkages. Scrub the engine with a mixture of concentrated Gunk and kerosene. Hose it down and allow the surfaces to dry before proceeding.

Vertical shaft engines are easier to service if supported in a stand like the one shown in Fig. 7-3.

Check the gasket surface for warp. The quick (and wildy inaccurate) way is to place the head on the block, sans gasket. If the head wobbles, it is surely warped. It is relatively safe to assume at this point that the block itself is not warped.

The correct (and tedious) way to check gasket surface for warp is to scrounge a piece of plate glass. Ordinary window glass will not do. Tape a square of medium grit, wet-or-dry abrasive paper to the glass. Number 340 paper is about right. Soak the abrasive with motor oil and, holding the head with both hands to equalize force, scrub it over the abrasive. After a few passes, wipe the oil off and inspect the gasket surface. Chances are that it will be bright near the head-bolt holes and dull in the unsupported areas between them. Continue to scrub away at the gasket surface until it is true, evidenced by uniform brightness.

Since each pound per square inch of compression translates into three or four pounds per square inch of combustion pressure, raising the compression ratio is the high road to performance. The easiest way to raise the compression ratio is to mill the head.

But few engine modifications are as fraught with danger as the compression ratio increases. The additional power must be transmitted by the connecting rod and crankshaft, parts that have a limited life in stock applications. Raising the compression ratio liberates almost as much additional heat as power. Heat must be dissipated by the cooling fins and the engine oil. Cast iron heads with the heat conductivity of thermal underwear should not be modified. Stock aluminum heads will accept some additional heat without

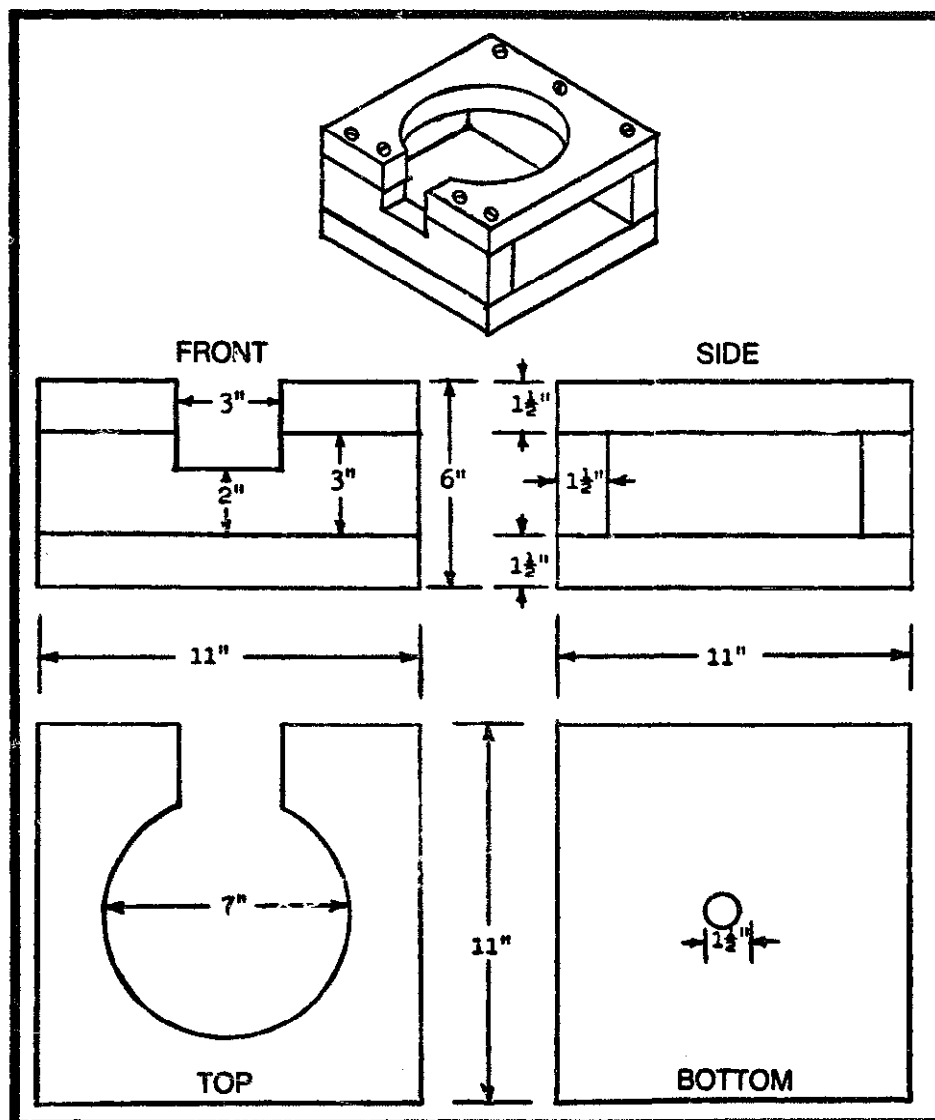


Fig. 7-3. A homemade engine stand. (Courtesy Tecumseh Products Co.)

complaint, but aftermarket heads are the best bet for serious modification.

Disconnect the wiring, making notes as necessary (Briggs & Stratton electrics have one way connectors, but this sanitary arrangement is not always followed by their customers). Disconnect the control linkages and uncouple the crankshaft from the load by removing the pulley, sprocket, and lawnmower blade.

### CYLINDER HEAD

Remove the shroud, fuel tank, and spark plug. Remove the cylinder head, observing the length of the head bolts. Aluminum

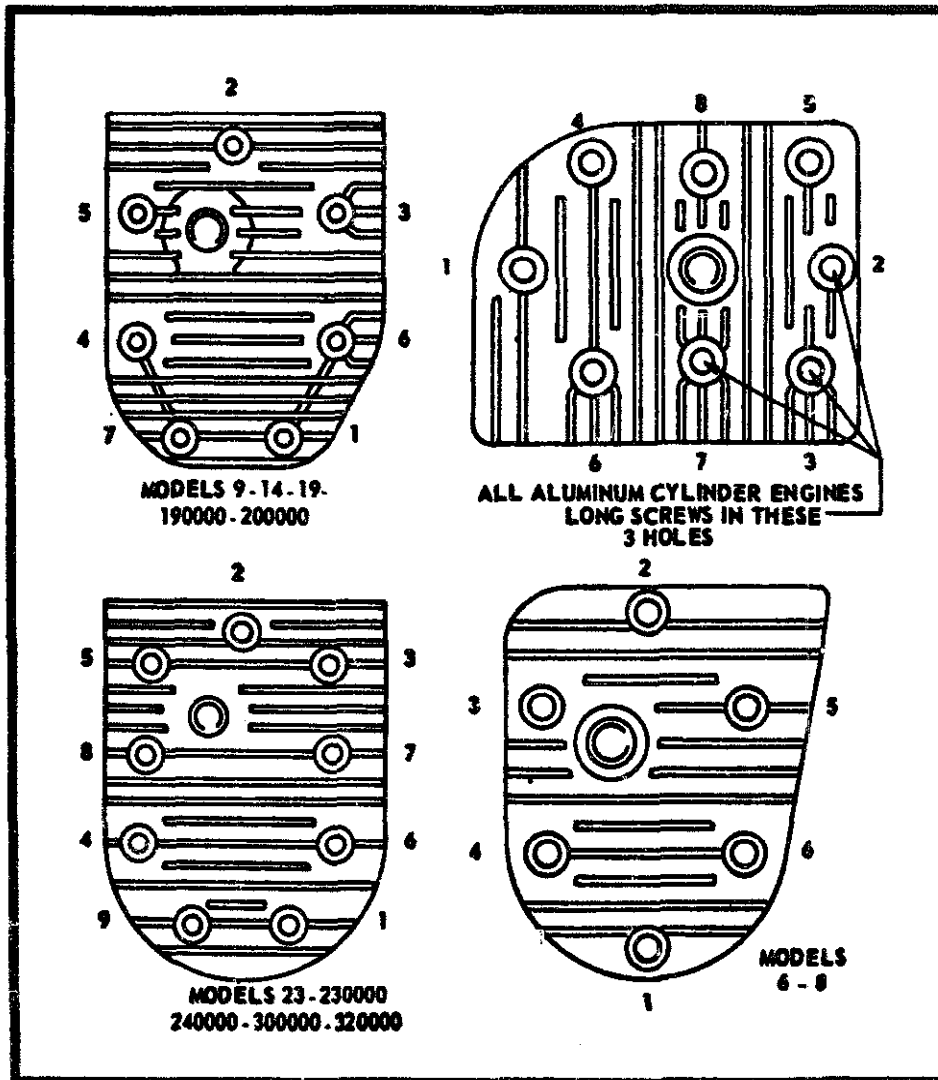


Fig. 7-4. Cylinder head torque sequence. (Courtesy Briggs & Stratton Corp.)

block exhaust valves are flanked on three sides by long bolts; confusing these bolts on assembly can break a cooling fin, or give insufficient support and cause the gasket to blow (Fig. 7-4). The cylinder head usually falls off once the bolts are out, but should it be stubborn, a few taps with a hammer handle will break the gasket seal.

The combustion chamber will be carboned, particularly if the engine has been running at a constant speed. The best way to remove carbon is with an end cutting wire brush sold for this purpose (Fig. 7-5). Side cutting wire wheels, the kind mounted on a mandrel, cannot get into the crannies around the valve pockets. Bring the piston to top dead center and brush the carbon from it and the valves.

Carbon may also be removed with a dull knife, although you should be careful not to gouge the aluminum in the process. Scratches and gouges make decoking more difficult the next time around, and are positively harmful if the damage extends into the gasket surface.

Inspect the head carefully. Look for "hang-nail" spark plug threads that could incandesce and ignite the mixture early. Check the trueness of the head.

Stock Briggs & Stratton engines have puny compression ratios, between 5 and 6 to 1. Prudence dictates that the ratio be raised to no more than 8 to 1. The ultimate compression ratio for side valve, air-cooled engines is about 9.5 to 1, a ratio achieved by Harley-Davidson engineers under the old 45 cubic inch racing formula. Achieving this figure took years of patient research and thousands of racing miles.

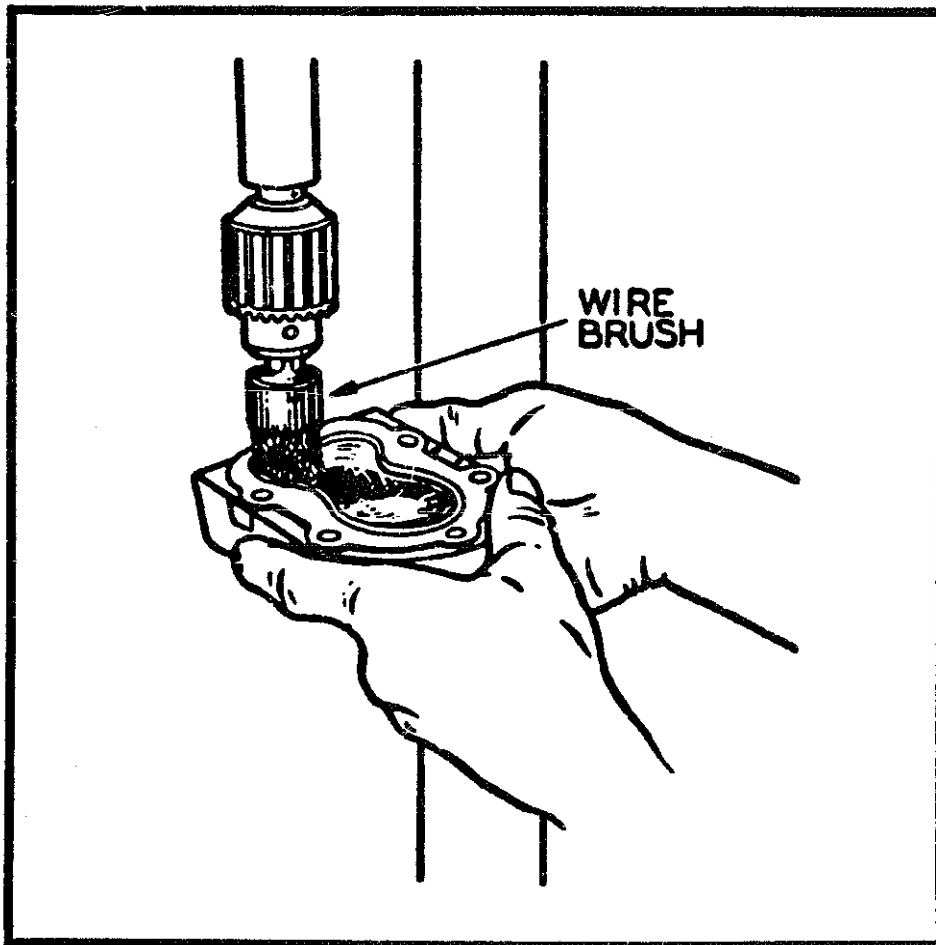


Fig. 7-5. Removing carbon with a cupped wire brush. (Courtesy Clinton Engines Corp.)

The compression ratio is the ratio of the swept volume of the engine (the volume the cylinder displaces as it moves from bottom to top dead center) to the clearance volume. Since Briggs & Stratton pistons rise flush with the fire deck (or top of the block) at top dead center, the clearance volume is the volume of the cylinder head cavity.

Although the first digits in the model number describe displacement, this figure is only an approximation. Model 60000 draws 6.65 cubic inches; model 14 draws 14.31 cubic inches. Measure the cylinder bore and the distance the piston travels between centers, calculating the swept volume by the formula:

$$\frac{3.1416 \times \text{bore} \times \text{bore} \times \text{stroke}}{4}$$

The volume of the cylinder head is difficult to calculate, but easy to determine empirically. With the spark plug in place, carefully level the head with the cavity up. Alternately, you can bolt or clamp a piece of Plexiglas to it, using grease as a sealant on the gasket surface. Using a beaker graduated in cubic inches, fill the combustion cavity with light oil. The amount of oil required to top off the cavity is the clearance volume. Divide this figure into the displacement to determine the original compression ratio.

Mill the head as described previously, using number 220 grit abrasive paper for the initial cut. After 0.015 of an inch has been removed, determine the chamber volume and compression ratio. For readers who do not relish beakers and arithmetic, 0.015 of an inch is a safe figure to use for all engines.

Once you have cut metal, polishing the combustion chamber seems almost anticlimatic. But, as explained earlier, the effort is worthwhile. Polishing requires some sort of power assist. Commercial shops generally use an air powered grinding tool not unlike those used to reface valve seats. But a light duty hobbyist's grinder will suffice for the occasional mechanic and costs a third as much as the professional tool. However, you should purchase a professional quality buffing wheel and an assortment of polishing pastes.

Begin with the block. Turn the crankshaft so that both valves are closed. Casting flash can be removed with a grinding wheel or a raffle (spoon-shaped) file. Apply a dab of course polishing compound to the buffing wheel and hold the tool lightly so it can maintain speed.

Move progressively to the finer compounds, concluding the work with jeweler's rouge.

Repeat the process for the head cavity.

When you are finished polishing the combustion chamber and the head cavity, the surfaces should be burnished like a mirror. Remove all traces of the compound with a rag dipped in solvent and, if the block is case-iron, protect the finish with a light coat of oil.

When reassembling, follow the torque sequence shown in Fig. 7-4, tighten the head bolts in three increments, according to Table 7-1.

## VALVES

The primary symptom of valve failure is loss of compression. If the engine runs at all, power will be drastically curtailed, although engine speed will be unaffected. Intake valve failure is often accompanied by "pop-back" through the carburetor bore. In this regard, a carbon blackened throttle plate is circumstantial evidence of intake valve problems.

The whole purpose of the valve is to form a gas tight seal against the seat (Fig. 7-6). For the seal to be effective, the valve spring must

Table 7-1. Head Bolt Torque Limits.

| Model  | Torque (in-lbs) |
|--|-----------------|
| 5, 6, N, 8, 9,<br>6B, 60000, 8B, 80000,<br>82000, 92000, 110900,<br>100000, 130000 | 140             |
| 14, 140000, 170000, 190000,<br>241000  | 165             |
| 19, 190000, 200000, 23,<br>230000, 240000, 300000,<br>320000                       | 190             |

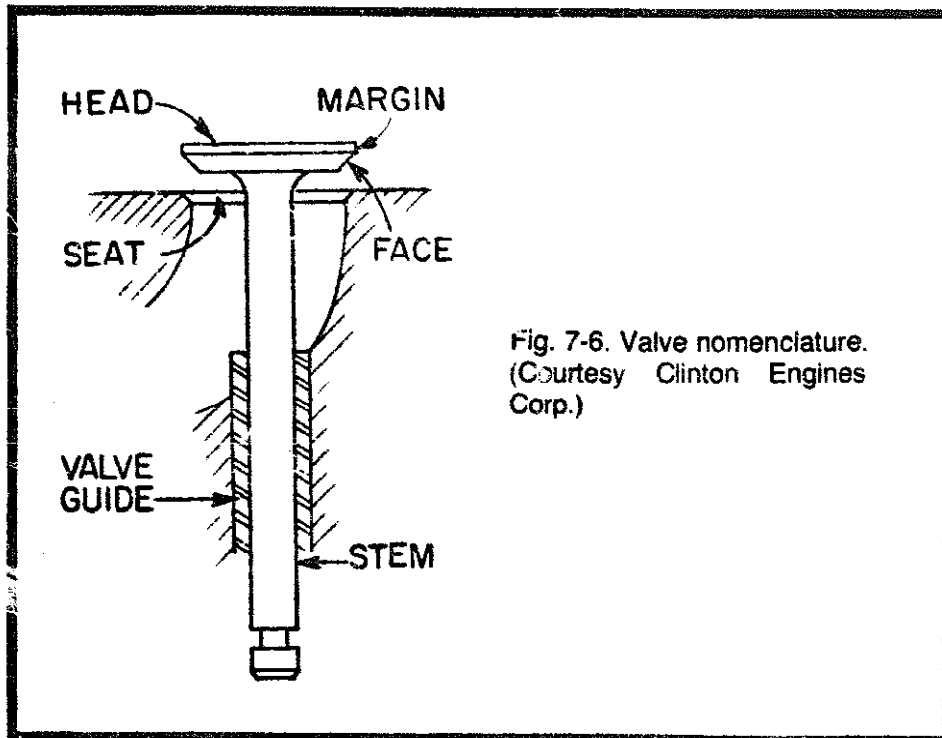


Fig. 7-6. Valve nomenclature.  
(Courtesy Clinton Engines Corp.)

exert sufficient tension to compensate for the small irregularities between the seat and face, the valve guide and stem must be within tolerance to hold the face concentric to the seat, the valve stem must be straight and at right angles to the head, the head must be round, and seat and face must mate without the interference of impacted carbon or displaced metal.

Intake valves are susceptible to all of these failures and have an unfortunate affinity to attract deposits under their head. Coking, or carbon accumulation, is usually present in a lightly loaded engine with a thirst for oil (Fig. 7-7A). Lead buildup (Fig. 7-7B) can sometimes be controlled by switching brands of gasoline, although Briggs & Stratton does not recommend lead free fuel. Gum deposits (Fig. 7-7C) are the mark of a poorly maintained engine, one that has been allowed to run chronically rich. Gum deposits can also be caused by using stale gasoline, and by habitually shutting the engine down before it has reached operating temperature.

The exhaust valve is most susceptible to these maladies and usually fails first. Under head deposits may be brown, yellowish, or tan, in which case they are normal byproducts of combustion (Fig. 7-8A). Stem corrosion (Fig. 7-8B) is not normal, and is caused by moisture in the fuel. It also occurs when the engine is repeatedly

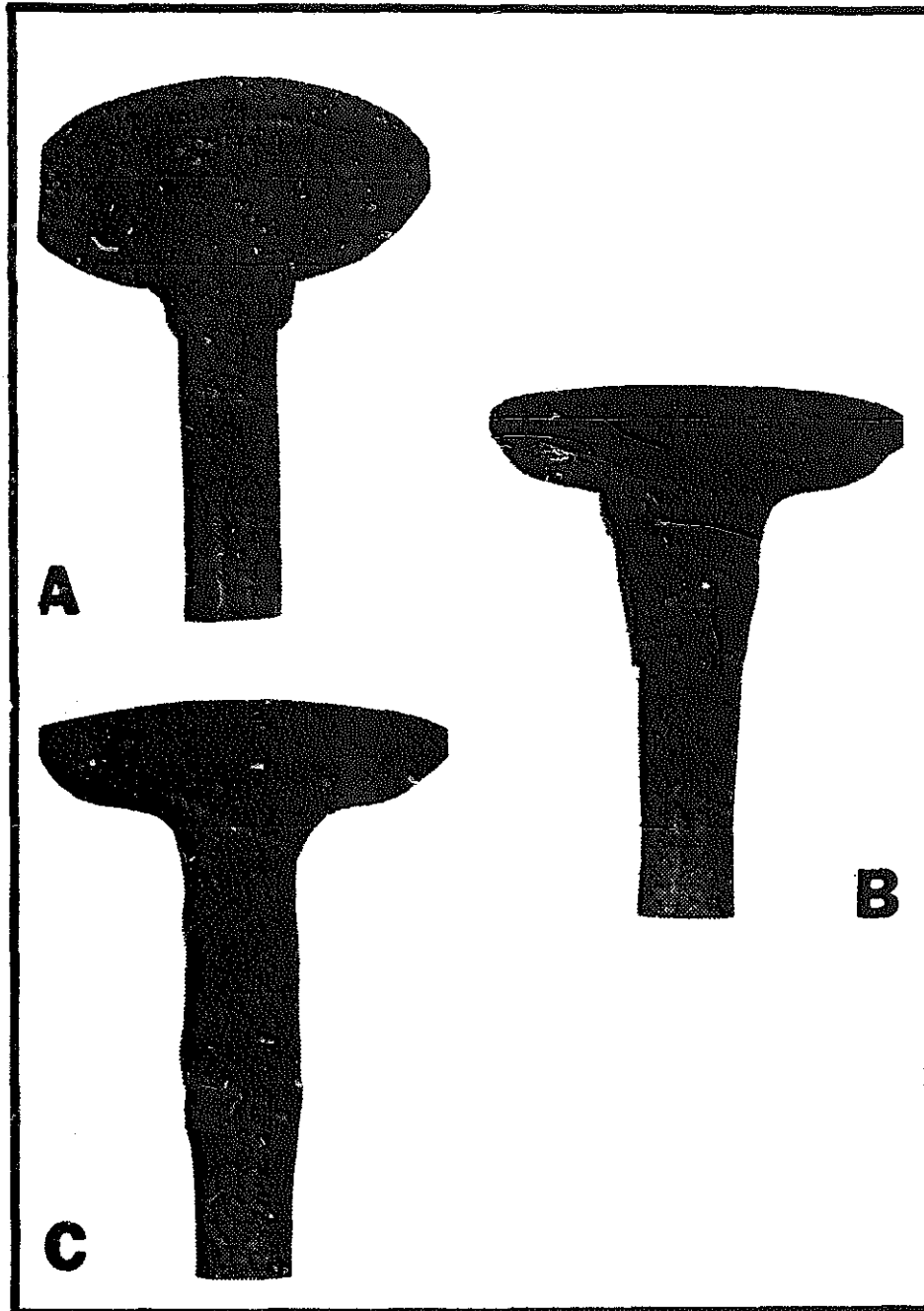


Fig. 7-7. Intake valve maladies: coking (A); lead deposits (B); and gum deposits (C). (Courtesy Kohler of Kohler.)

stopped before it attains operating temperature. Overheating is signaled by a black, polished appearance and the relative freedom from deposits (Fig. 7-8C). Suspect that the stem is bent. Carbon cutting (Fig. 7-8D) is the result of deposits on the edge of the valve seat and can usually be traced to haphazard maintenance practices.



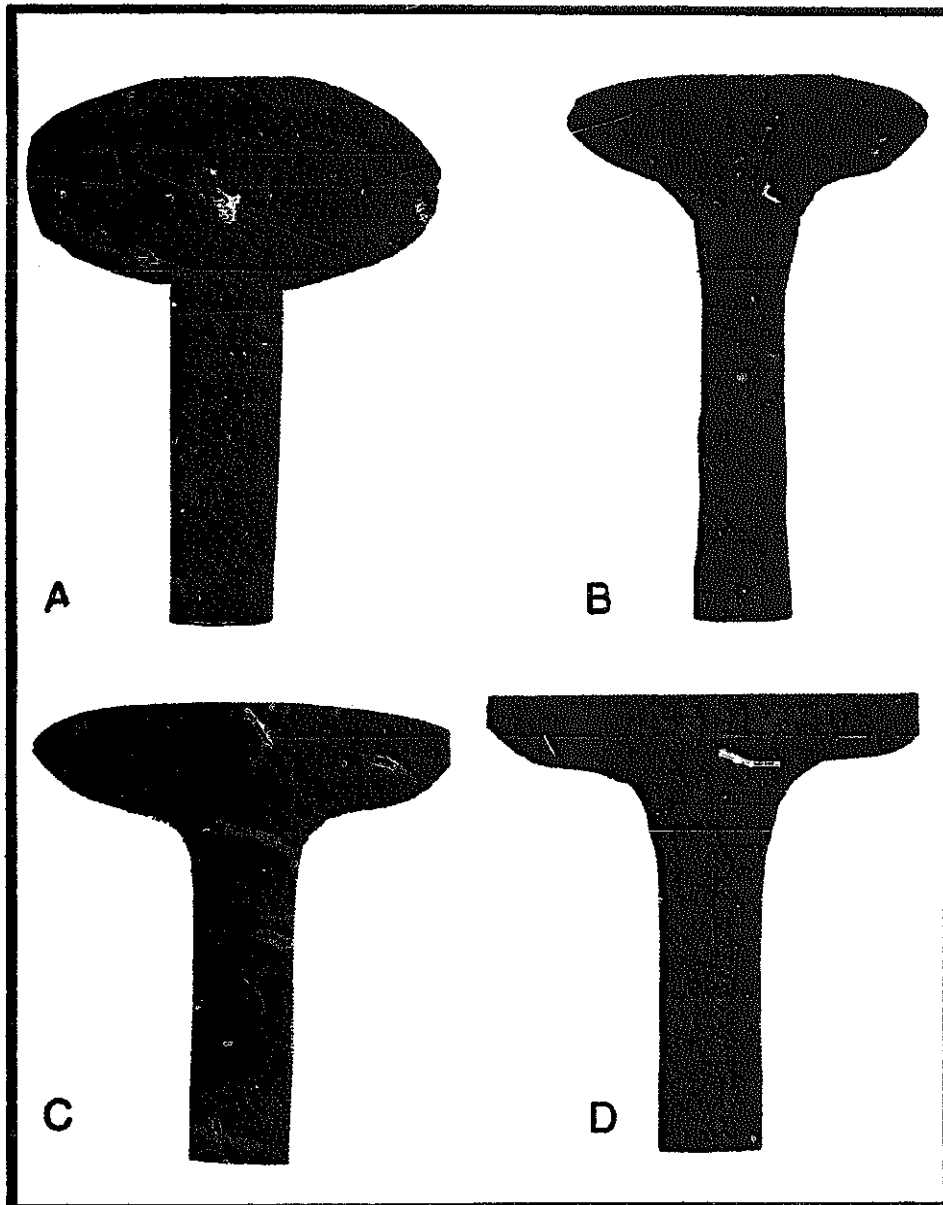


Fig. 7-8. Exhaust valve portraits: normal (A); stem corrosion (B); overheating (C); and carbon cut (D). (Courtesy Kohler of Kohler.)

The valves are secured by keepers, which in turn are held by valve spring tension. Three types of keeper have been used, the late and unlamented pin, the one piece retainer, and the split collet. The pin passes through a hole in the valve stem and bears against a collar. As the engine ages, the hole elongates and the pin bends. If your budget allows, or if events demand new valves, purchase the type with slotted stems. Use one piece retainers (Fig. 7-9) or split collets (Fig. 7-10). Split collets are preferred for modified engines.

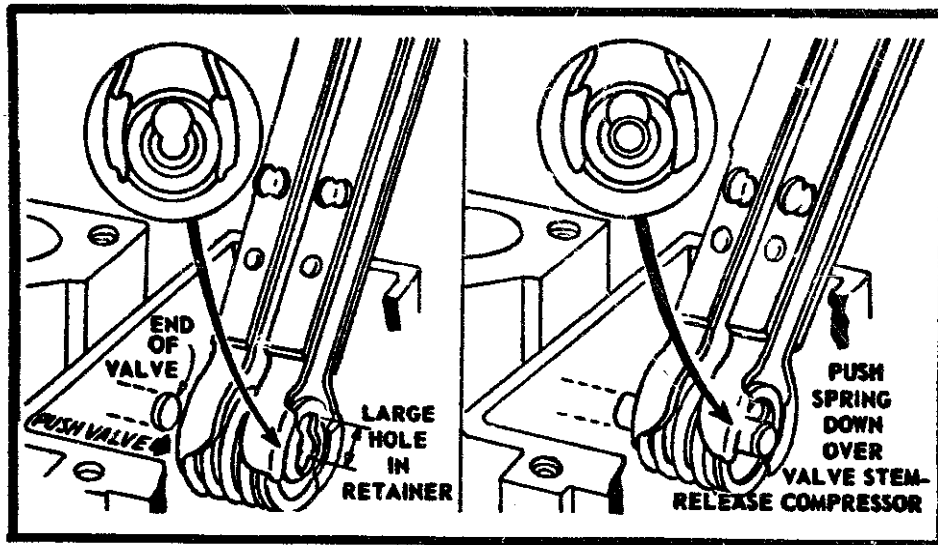


Fig. 7-9. Installing one-piece retainers. (Courtesy International Harvester Corp.)

Both illustrations show Briggs & Stratton tool number 19063, probably the finest valve spring compressor available for small engines. Without this tool, you can make do with a pair of screwdrivers, but the work is awkward. Apply pressure to both sides of the

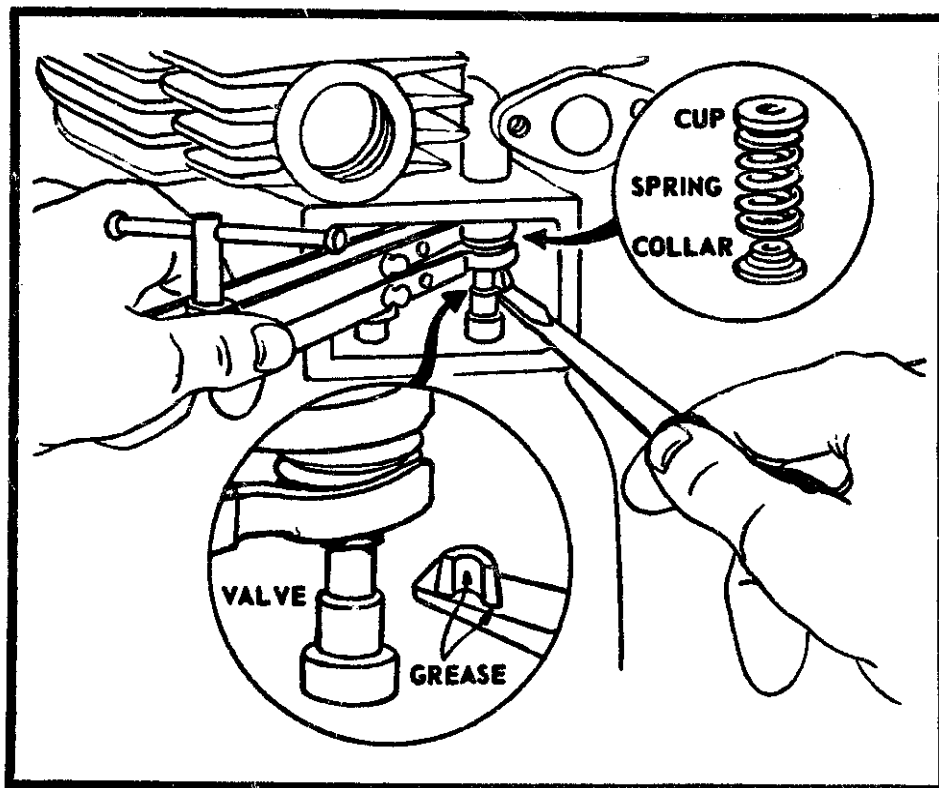


Fig. 7-10. Installing split collets. (Courtesy International Harvester Corp.)

collar (or to one of the lower coils if no collar is fitted) to raise the spring without lifting the valve. Have a helper disengage the keeper. Reverse the procedure when installing the valves.

### **Crankcase Breather**

The crankcase breather vents corrosive gases from the crankcase and, at the same time, maintains the crankcase at a slight negative pressure. The breather assembly doubles as the valve chamber cover and is secured by two fillister head screws. The breather usually vents to the carburetor, an arrangement that explains why a well worn Briggs & Stratton will sometimes run even when the fuel tank is empty. There is enough raw fuel in the oil to support combustion. The symptoms of breather failure are:

- Oil leaks at the flange gasket and crankshaft seals
- Zero vacuum on a manometer
- Oil discoloration and sludging

Wash the assembly in solvent, let it drain, and check the valve clearance. The fiber disc should clear the housing by 0.045 of an inch (Fig. 7-11). Bend the bracket as necessary.

### **Valve Springs**

Briggs & Stratton does not publish valve spring tension specifications, and one must fall back on the old mechanic's rule that the free standing height of a used spring should be at least 90% of the height of a new spring. The spring should stand perpendicular. Tilt means that the coils have weakened. Examine the spring for pitting (the early symptom of fatigue) and for fretting (the sign of coil binding). Replace as necessary.

### **Valve Guides**

Many Briggs & Stratton engines are without valve guides as such, that is, holes bored in the block to center the valves over the seats, dissipate combustion heat, and seal the chamber against air and oil. In defense of this practice, it should be remembered that the valves operate in a vertical plane, without the horizontal forces generated by rocker arms and overhead camshafts. White metal and cast iron are adequate support, at least through the first overhaul.

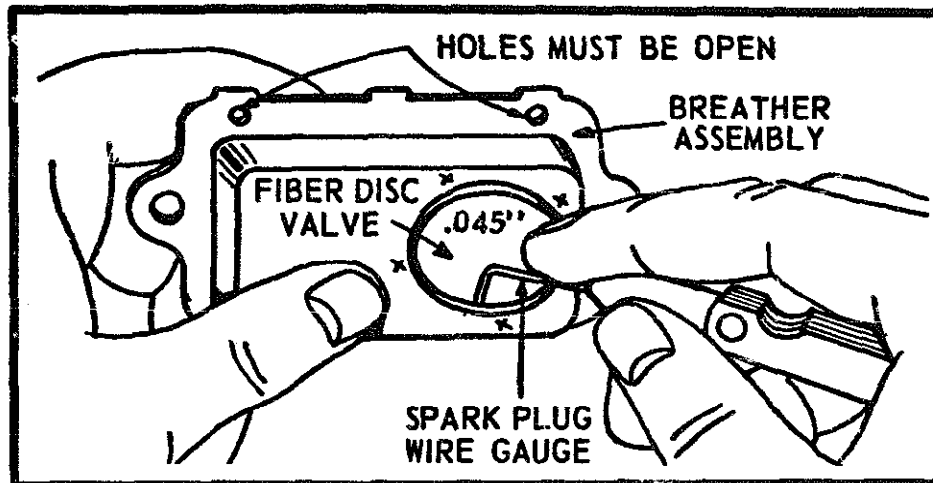


Fig. 7-11. Checking the crankcase breather with a feeler gauge. (Courtesy International Harvester Corp.)

But in so far as longevity is concerned, nothing substitutes for an honest brass or bronze guide.

The traditional (and fairly accurate) test is to raise the valve to its full extension and move it side-to-side. A wobble of 1/16 of an inch or more means the guide has bell-mouthed and should be knurled or replaced. Another method is to use a factory guage, number 19122 for engines displacing 13 cubic inches and less (excepting model 9), and number 19151 for the others. If the guage can be inserted 5/16 of an inch or deeper into the guide, it is worn.

Clinton supplies valve guide knurlers that can be used on Briggs engines. The knurler raises the metal, reducing the internal diameter of the guide and providing oil reservoirs that should give the refurbished guide the life of a new one.

Briggs & Stratton engineers would have the guide reamed oversize and a bushing pressed into place. For smaller engines, drawing no more than 13 cubic inches (except the model 9 with its large valve stems), the necessary tools are:

| Part Number | Name                 |
|-------------|----------------------|
| 19064       | Reamer               |
| 19191       | Reamer Guide Bushing |
| 191065      | Bushing Driver       |
| 191068      | Finish Reamer        |

Centering the reamer with the guide bushing, ream the valve guide 1/16 of an inch deeper than the length of the replacement bushing. Do not ream the guide completely through, for its lower diameter is needed to stabilize the bushing. Drive the bushing flush with the top of the valve guide using the factory tool or a copper punch. Use the finish reamer to side the bushing flush with the top of the valve guide using the factory tool or a copper punch. Use the finish reamer to side the bushing to the valve stem. Both reamers are turned clockwise and lubricated with cutting oil or kerosene.

Engines displacing 14 cubic inches and more, as well as the ubiquitous model 9, require these tools:

| Part Number | Name                 |
|-------------|----------------------|
| 19183       | Reamer               |
| 19192       | Reamer Guide Bushing |

As described in the previous paragraph, ream the valve guide 1/16 of an inch deeper than the replacement bushing. Use a soft copper punch to drive the bushing flush with the top of the guide. Since bushings are finish reamed before shipment, no reaming tool is supplied.

### **Valve and Seat Refinishing**

Once you are satisfied that the valves are basically sound, that the springs generate enough tension to close the valves, and that the guides hold the valves concentric to the seats, the next operation is to refurbish the valve faces and seats. Unless these prior conditions are met, lapping or grinding is a waste of time.

Lapping is a short term fix, an expedient to get the engine back into service until the valves and seats can be properly machined. For lapping to be at all effective, the valve faces and seats must be relatively healthy. Deep pits require heavy lapping, widening the seating surface and possibly grooving the valve face. A wide seating surface tends to collect carbon and to develop less unit area pressure than a narrower seat. The grooving effect becomes serious when the engine reaches operating temperature and the parts "grow."

The engine suffers a hard to diagnose loss of power (Fig. 7-12) when what was a good seal at room temperature suddenly evaporates.

The most popular lapping compound is Clover Leaf brand. An oil based mixture, it is sold in double ended tins. One compartment contains a coarse abrasive for rapid cutting, the other a fine finishing compound. Unless you are dealing with an antique like the model N,

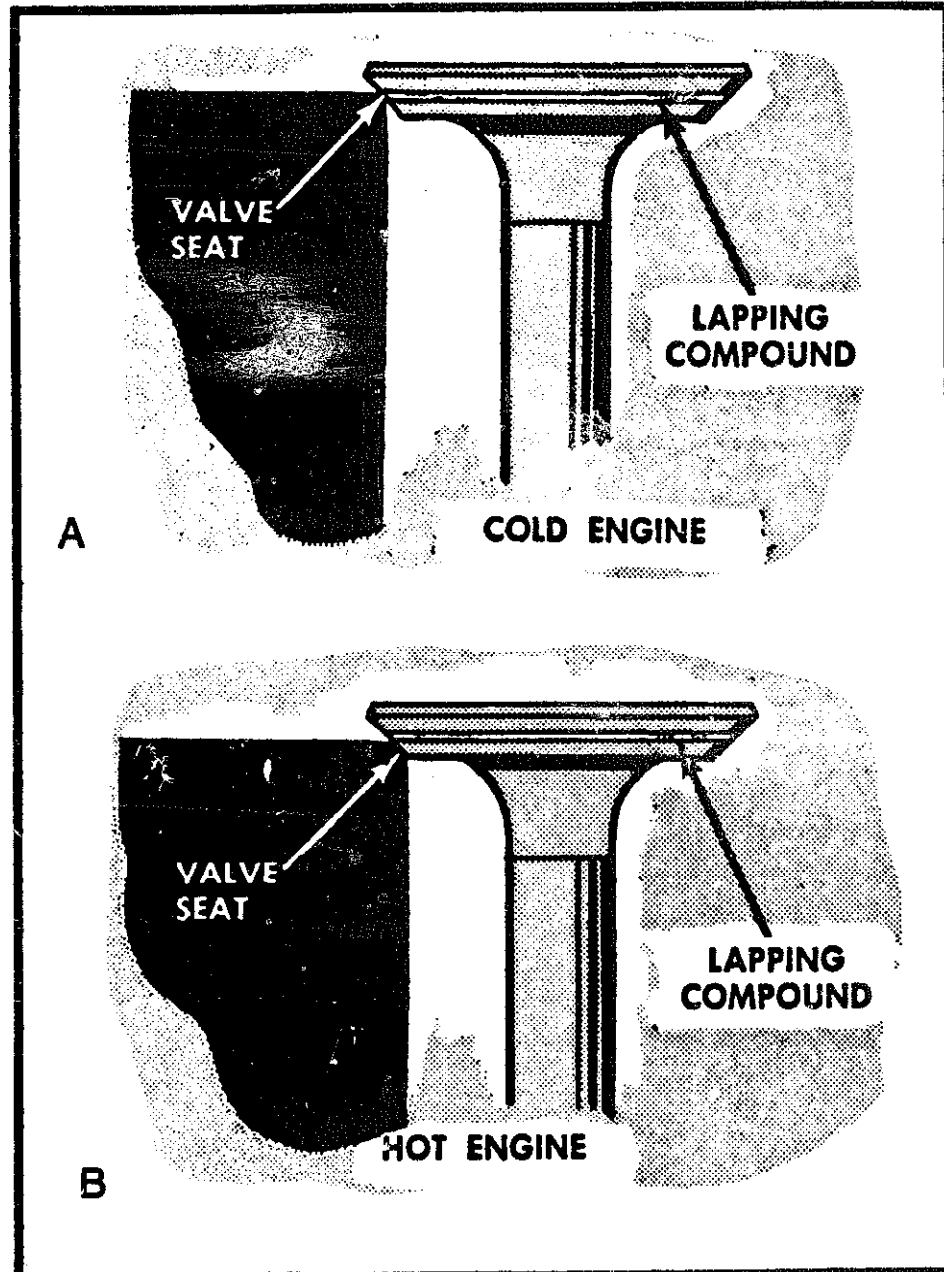


Fig. 7-12. A valve can be lapped gas tight when cold (A), and leak when the engine warms and the valve "grows" (B). (Courtesy Clinton Engines Corp.)

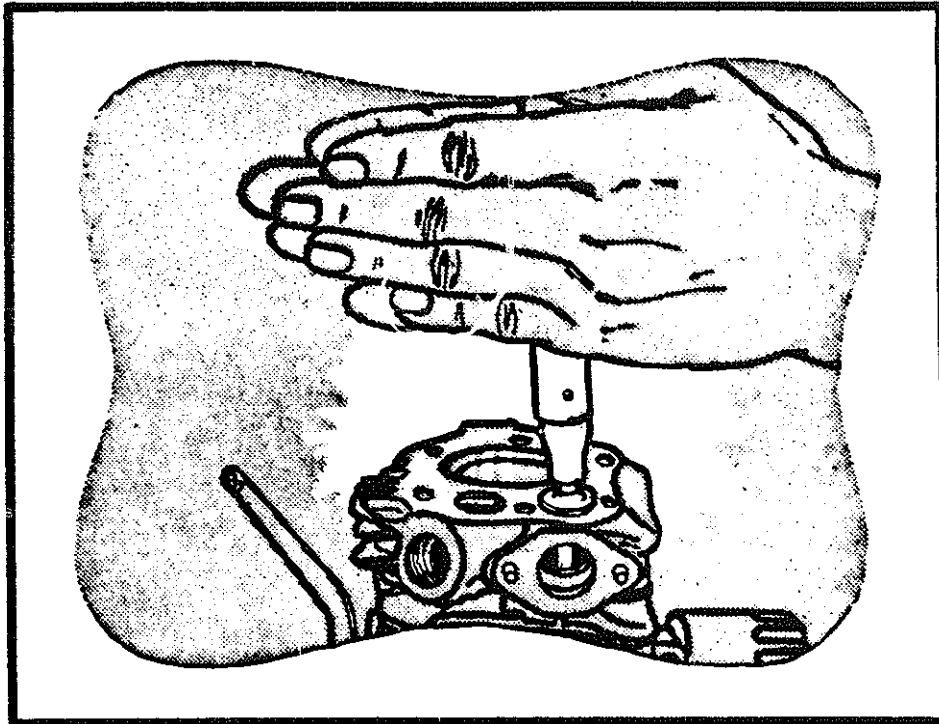


Fig. 7-13. Lapping valves with a suction cup. (Courtesy Clinton Engines Corp.)

you will need some way to turn the valves. K-D markets a small suction cup tool designed for small engines. It is available through most auto supply houses as catalog number 501. But suction cups tend to slip on highly polished valve heads, and it may be necessary to moor the tool with a drop of contact cement.

Apply several dabs of course compound to the valve face with a screwdriver, being careful not to overdo it. Surplus compound may find its way to the valve guide where it would be ruinous. Holding the valve by the suction cup, rotate it back and forth (Fig. 7-13). Every four or five seconds, give the valve a half turn so that the whole surface will be lapped evenly.

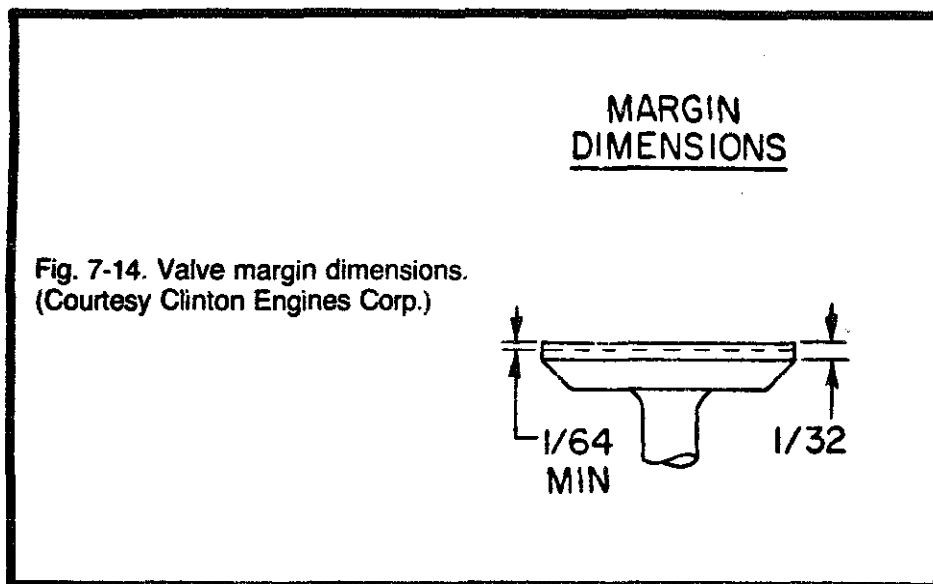
Renew the compound at frequent intervals, and whenever you no longer hear the harsh grating noise that accompanies lapping. Running the valve dry scores the seat and face. Finish the job with fine compound, and clean the parts with a rag dipped in solvent.

Valve grinding involves the use of a valve lathe and a high speed seat grinder. While this equipment is expensive for the amateur or occasional mechanic to purchase, the work can be farmed out to an automotive machine shop for a few dollars. The benefits are consid-

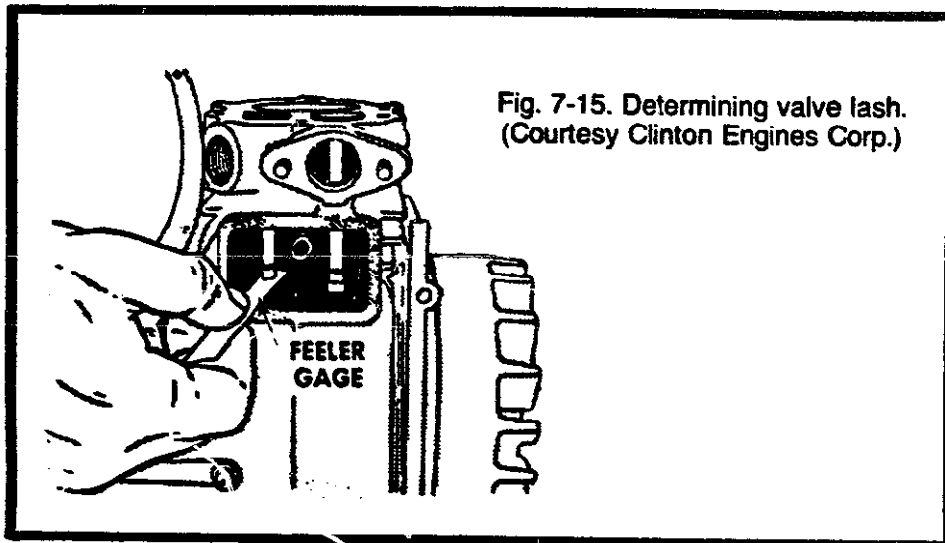
erable. First, since the lathe centers on the valve stem and the grinder on the valve guide, both parts are concentric. Small irregularities, a slightly bent stem or a canted valve guide, are automatically compensated for. Secondly, the valve face and seat are cut as uniform angles, and hence, heat expansion has little effect upon the seal. Thirdly, the seat can be narrowed to factory specifications by using alternate stones. And finally, if the work has been done correctly, no lapping is necessary.

The valve face angle for current Briggs & Stratton production is 45 degrees on both the intake and exhaust. The seats are ground at the same angle, without the half a degree of "interference fit" favored by some other manufacturers. Early Briggs engines had intake valves and seats ground at 30 degrees for better flow. The valve margin should be at least  $1/64$  of an inch thick to control valve temperatures and reduce the possibility of preignition (Fig. 7-14). While it is possible to widen the margin by judicious grinding, the valve should be replaced. Recommended seat width is  $3/64$ - $1/16$  of an inch, and narrower on engines that are modified for increased performance.

Once the valves are lapped or ground, the stems must be shortened to compensate for the metal removed. Place the valves in their guides, but do not install the springs and keepers. Turn the flywheel until one valve is full open. Turn the flywheel one more complete revolution and adjust the clearance between that valve and







the tappet with a feeler gauge (Fig. 7-15) according to the following specifications:

| Cast-Iron Block           | Intake     | Exhaust    |
|---------------------------|------------|------------|
| Models 5 through 20000000 | 0.008 inch | 0.015 inch |
| Models 23 through 320000  | 0.008 inch | 0.018 inch |
| <b>Aluminum Block</b>     |            |            |
| All models                | 0.006 inch | 0.010 inch |

To adjust the clearance, grind the stems flat, “kissing” the wheel to remove a few thousandths of an inch of metal. It is disconcertingly easy to remove too much metal, so check and finish the operation with a file, slightly beveling the square edges. Then repeat the process for the other valve.

### Valve Seats

The intake valves on cast-iron engines run directly on the block. Fortunately, cast-iron is a relatively good seat material. Exhaust valves on iron engines and both valves on aluminum models run on replaceable seats.

Valve seats may crack, wear thin with age, or work loose from the block. In most cases, the port geometry is such that the seat can be driven out from below with a punch. Other engines require a valve seat puller, available from Briggs & Stratton in four varieties to fit

the various models (Fig. 7-16). A substitute can be fabricated easily. Replacement intake valve seats are inventoried for cast-iron engines, although the cost of the counterbore reamer and pilot is prohibitive for an occasional mechanic. It's better to farm this job out to a Briggs & Stratton repair station.

Once the old seat is removed, clean all traces of oil from the recess in the block. See that it is true, flat, and without grooves or other imperfections that would deny a perfect fit between the seat insert and block.

Most mechanics simply drive the seat home using special tool number 19136 and pilot number 19126 on engines displacing less than 14 cubic inches, and pilot number 19127 on larger engines. And some mechanics simply use an old valve as the driver. A more civilized method than either is to heat the block for several hours in the kitchen oven at about 275 degrees Fahrenheit. Support the

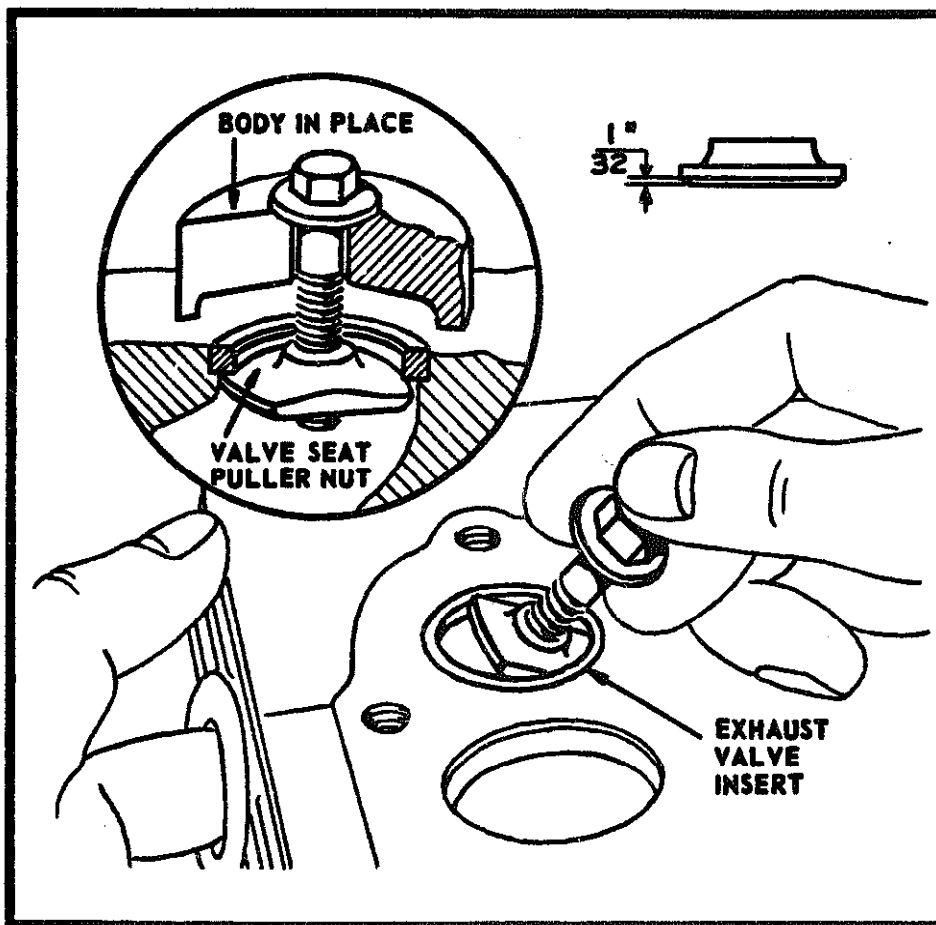


Fig. 7-16. Briggs & Stratton valve seat puller.

casting on bricks to prevent local overheating. Chill the seat insert in the freezer or by packing it in crushed dry ice and alcohol. Working quickly before the parts normalize, drop the seat into the recess with the beveled edge up. The top of the seat should be approximately flush with the firedeck on cast-iron engines and a few thousandths of an inch below it on aluminum blocks. Since the thermal expansion rate of aluminum is four times that of cast-iron, the seats on these engines should be peened around their full circumference (Fig. 7-17).

When building a modified engine, it is worth the effort to replace the standard exhaust valve seat with one made of Stellite. This material is an expensive form of stainless steel, almost immune to burning and acid attack. Complete the job with a Stellite exhaust valve, omitting the Rotocap. Positive valve rotation is a nice feature, but adds mass to the valve gear and requires a shortened spring. These parts are available from the factory for most engines.

After installing a new seat, lap or machine grind a valve as described earlier.

### **FLANGE OR BASE**

The base is the oil sump for horizontal shaft engines and, once detached, gives access to the connecting rod and piston. The flange is the casting, and is present on plain bearing horizontal shaft and present on all vertical shaft engines. The flange supports the main bearing on the power takeoff side. On horizontal crank models, the flange doubles as the oil sump.

The base is held by four screws and their removal and assembly involve no problem. Inspect the base "feet" for fatigue cracks and replace the gasket as a matter of course.

Crankshaft end play, or float, is fixed by the distance between the main bearing thrust shoulders and the thrust journals ground on the outward sides of the crankshaft webs. The specification is 0.002-0.008 of an inch for all models, cast-iron or aluminum. On horizontal engines, the measurement can be made directly with a feeler gauge inserted between a crankshaft web and either main bearing. Using a rubber mallet, lightly tap the shaft in one direction to establish a zero reference, and tap it in the other direction to gage the movement.

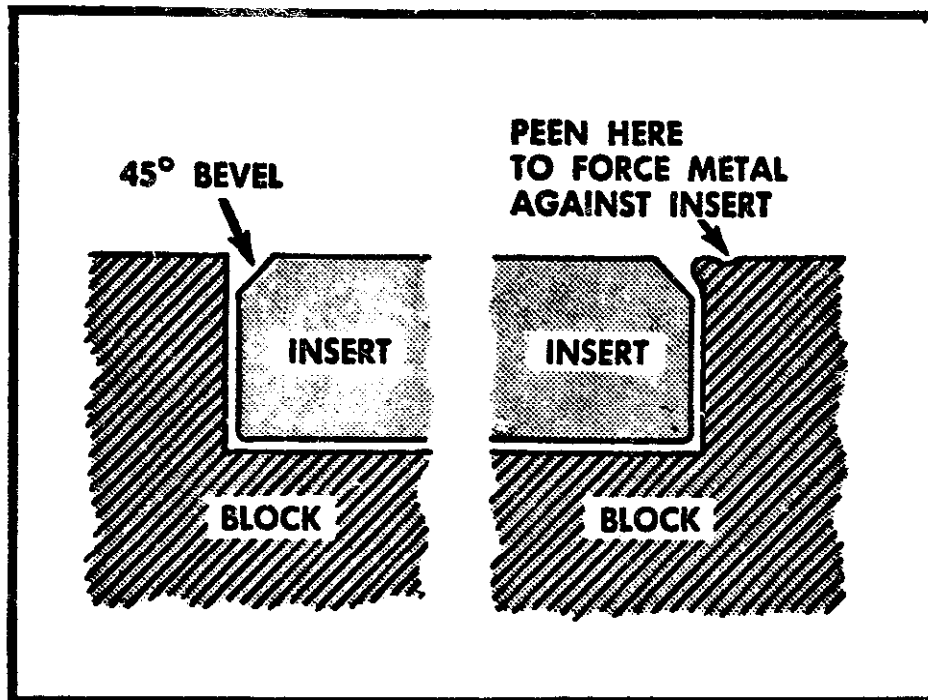


Fig. 7-17. Valve seat inserts should be peened on aluminum engines. (Courtesy Briggs & Stratton Corp.)

The process is not as convenient with vertical shaft engines. Float must be measured from the outside with the engine buttoned up. One way to do this is to mount a dial indicator with the pointer resting on either end of the crank. Tap the shaft in the direction of the dial indicator and adjust the instrument to show zero. Tap the crank in the other direction and read the float.

Another method is to insert a feeler gauge between the flywheel rim and block. The gap is such that you will have to use the whole pack of blades, sometimes buttressed with a spacer.

Remove the pulley, sprocket, centrifugal clutch, or whatever mechanism is attached to the power takeoff end of the crankshaft. Polish the crankshaft stub with sandpaper as shown in Fig. 7-18, and fill out any marks left by mounting screws.

With the cylinder pointed up, remove the flange bolts. Using a rubber hammer, give the flange a few sharp raps to break the gasket seal. It should not be necessary, in fact is usually disastrous, to pry the castings apart.

Once the locating pins have disengaged, the flange should slip easily over the crankshaft stub. If it binds, polish the shaft again,

looking for microscopic burrs that would lock the bearing. The reason the cylinder should be pointing up during this operation is to keep the parts in place. Timing marks are sometimes difficult to see and should be identified before the camshaft is disturbed. The wave washer on models 100900 and 130900 mounts over the governor slinger assembly and not under it, as one might suppose.

Inspect the flange bearing for damage. Some axial scratches are the price of flange removal, but are not in themselves serious. Radial grooves—threadlike grooves around the inner circumference of the bearing—are caused by operating the engine without sufficient oil in the sump. If the flange is grooved, the crankshaft will show matching grooves and both parts must be remachined or replaced.

Adjust the endplay on 300400 and 320400 engines with spacers between the outside main bearing and crankshaft. If play is less than 0.002 of an inch, as sometimes happens when a new crankshaft is fitted, add shims to achieve the following thicknesses:

| Part Number | Thickness  |
|-------------|------------|
| 270513      | 0.015 inch |
| 270514      | 0.010 inch |
| 270515      | 0.005 inch |

Other models are adjusted by flange or, on engines with anti-friction power takeoff bearings, bearing cover gaskets. These gaskets are available in 0.005, 0.009, 0.015 of an inch thicknesses. Aluminum block engines must use a 0.015 of an inch flange gasket for oil integrity. Adjust clearance by adding a thrust washer between the magneto side main bearing and the crankshaft on plain-bearing models, and between the power takeoff side bearing and crank on models with ball bearing mains. Since this washer is relatively thick, compensate by adding one or more flange gaskets. Use a number 220624 washer for the  $\frac{7}{8}$  inch cranks and a number 220708 for the one inch cranks.

When installing the flange, use a new gasket and run the bolts down evenly in a crisscross fashion. If the crankshaft or flange have to be replaced or machined, check the end play.

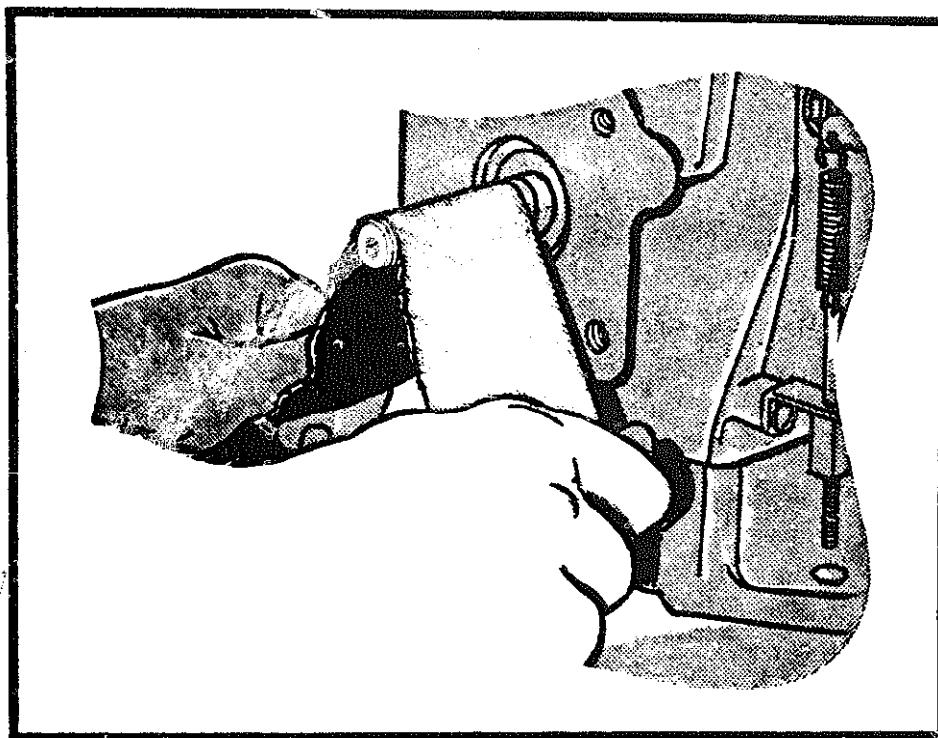


Fig. 7-18. Polishing the crankshaft stub. (Courtesy Clinton Engines Corp.)

### **CAMSHAFT**

Note the location of the timing marks. On plain bearing engines, the timing marks consist of a dimple on the camshaft and a chisel mark on the crankshaft gear (Fig. 7-19). On most antifriction bearing engines, the crankshaft web is dimpled to match the larger dimple on the camshaft gear (Fig. 7-20). On models 300400 and 320400, the crankshaft reference is on the inner web (Fig. 7-21).

The 30 and 32 cubic inch engines pose a small problem during assembly because the crankshaft gear masks the mark during assembly. One way around this is to mark the relevant gear tooth with chalk. Another way is to forget about the timing marks entirely and time by the rock position. Install the crankshaft and cam. Turn the crankshaft to top dead center. Both valves should be closed; if they are not, extract the cam and experiment until it drops into place without raising the lifters. The engine is now at top dead center on the compression stroke. Rock the crankshaft a few degrees each direction. When the engine is timed properly, one valve should crack open before top dead center, the other immediately after top dead center. This is the rock position, a characteristic of all original equipment camshafts.

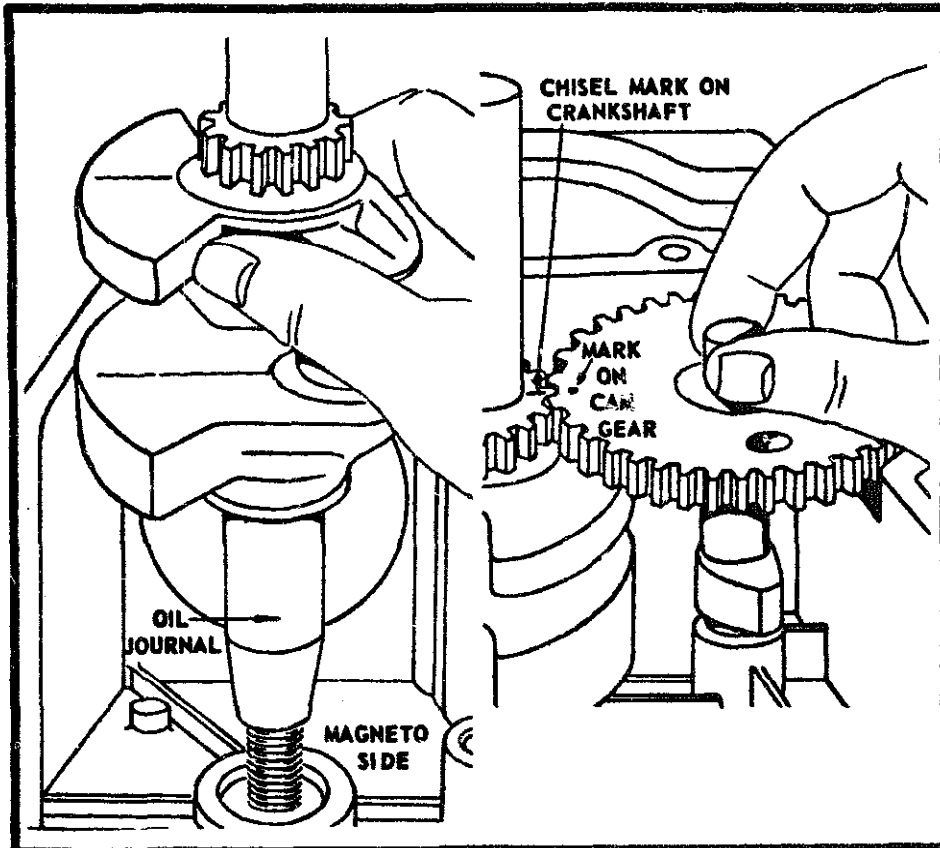


Fig. 7-19. Timing marks are stamped adjacent to gear teeth on plain bearing engines. (Courtesy Briggs & Stratton Corp.)

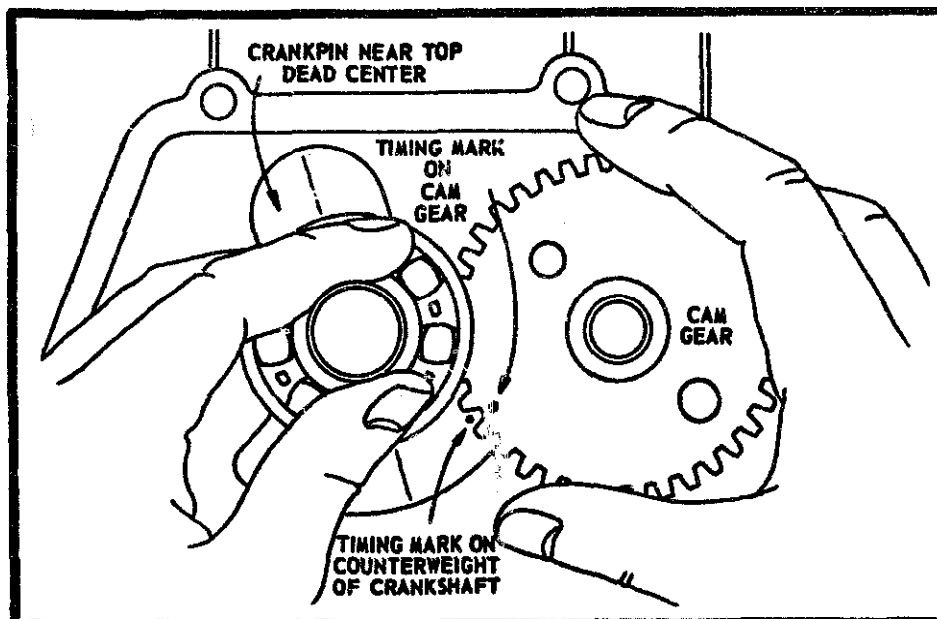


Fig. 7-20. One timing mark is on the crankshaft counterweight on engines with ball bearing mains. (Courtesy Briggs & Stratton Corp.)

Timing has carried us ahead of the story, and it is necessary to backtrack. Aluminum block camshafts are moored in the block bearing and lift out when the valves are both closed. At this position, the timing marks are aligned. Cast-iron block cams are hollow and ride on a shaft that spans the block. To remove the cam on smaller engines, drive the shaft out with a hammer and punch, working from the power takeoff side. The shaft, together with an expansion plug, will be forced out the magneto side. The big 300400 and 320400 models employ a similar arrangement, except that the shaft is bolted into place and manipulated from the power takeoff side.

These 30 and 32 cubic inch engines are unique in another respect—the camshaft rides in a replaceable bearing on the magneto side. This bearing is secured by two capscrews to the outside of the block and can be shimmed to adjust camshaft end play. The end play specification is 0.002-0.008 of an inch, or the same as for the universal crankshaft specification.

| Part Number | Shim Thickness |
|-------------|----------------|
| 270518      | 0.005 inch     |
| 270517      | 0.007 inch     |
| 270516      | 0.009 inch     |

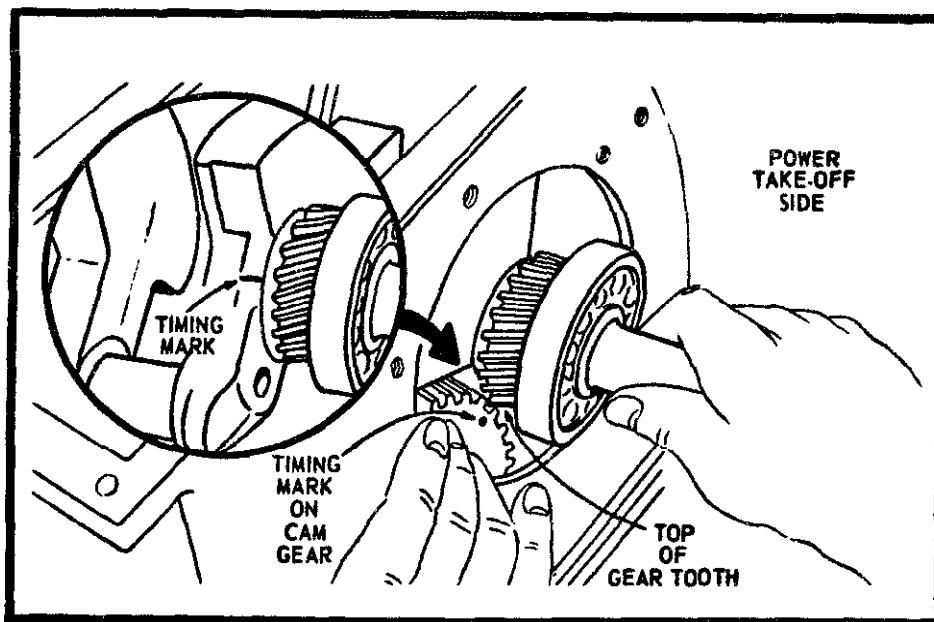


Fig. 7-21. Briggs & Stratton models 300400 and 320400 have the crankshaft mark on the inner web.



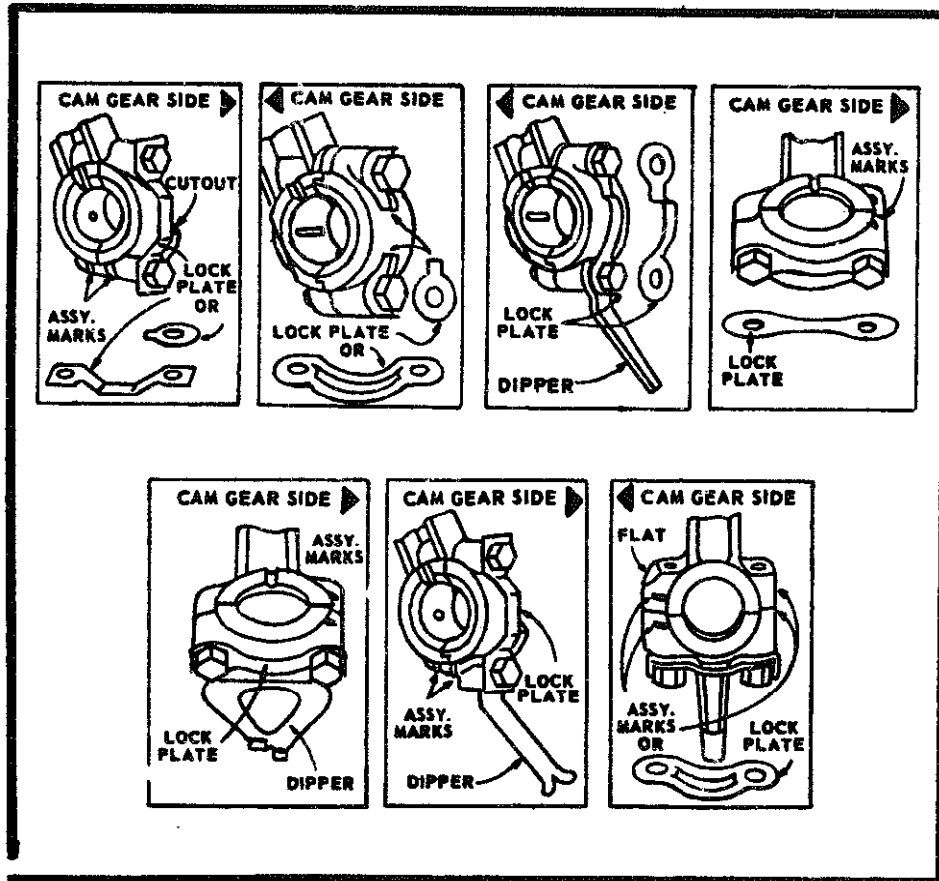


Fig. 7-22. Briggs & Stratton connecting rods.

If end play is more than 0.008 of an inch, use bearing kit number 299706.

Inspect the camshaft for evidence of wear—the inspection can be quite cursory, since a failure of the case hardening quickly leads to a “bald” camshaft.

Reground camshafts are indispensable for serious attempts at modification, but pose a problem because they open the valves sooner, and keep them open longer, than the factory product. The best of them are made from billets, giving the designer complete freedom in selection of lobe profiles, and allowing the valves to open wider. The purpose of the exercise is to give improved volumetric efficiency so that the engine does not gasp for air or suffocate on its own fumes at high speed. The operative term in the last sentence is “high speed.” Racing camshaft grinds produce little torque at low throttle angles and, depending upon how soon the intake valve opens, may burble back through the carburetor at idle.

Another difficulty, or at least a potential difficulty, involves the "phantom" spark generated by a flywheel magneto. This superfluous spark occurs near top dead center on the exhaust stroke, 360 crankshaft degrees past the ignition spark. With stock valve timing, the intake valve is closed, and the worst the phantom can do is to add fireworks to the exhaust. But a reground cam opens the intake valve early, during the period of phantom spark. As a result, a carburetor fire is possible, particularly during starting.

### CONNECTING ROD

Figure 7-22 shows the various Briggs & Stratton connecting rods. In each case, rod bolts are secured by a lock strap, and the lower half of the rod, the cap, is indexed to the shank by means of a rabbet joint, or with match marks. The match marks are embossed on the rod and must be aligned if the rod bearing is to be round.

To avoid confusion, mark which side of the rod shank is near the camshaft. Reversed installation can starve the rod bearing for oil and may, depending upon the engine model, send the dipper crashing against the camshaft.

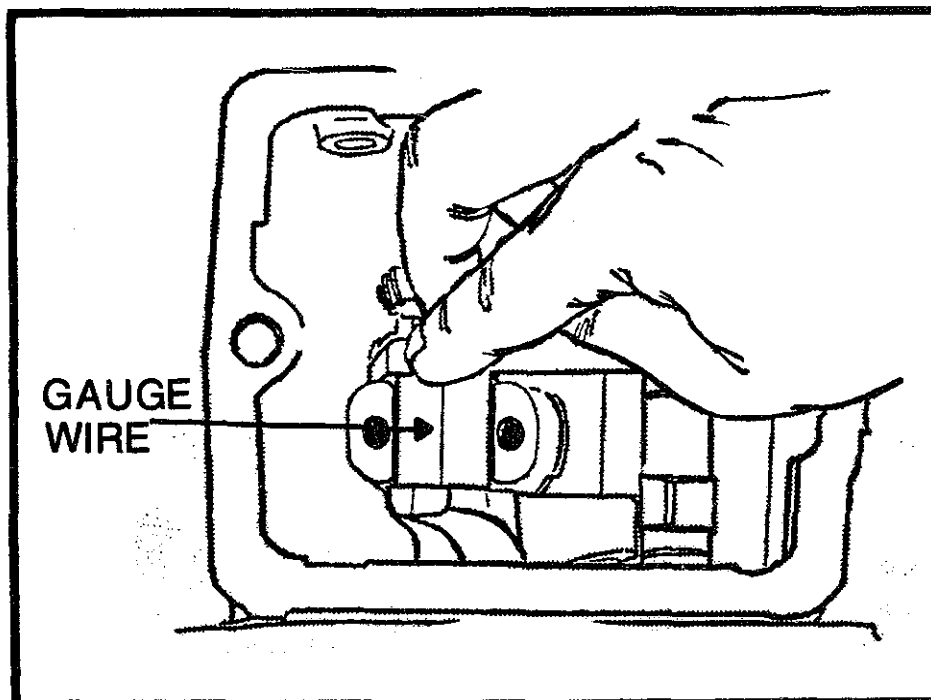


Fig. 7-23. Plastic gauge wire placed for running clearance. (Courtesy Clinton Engines Corp.)

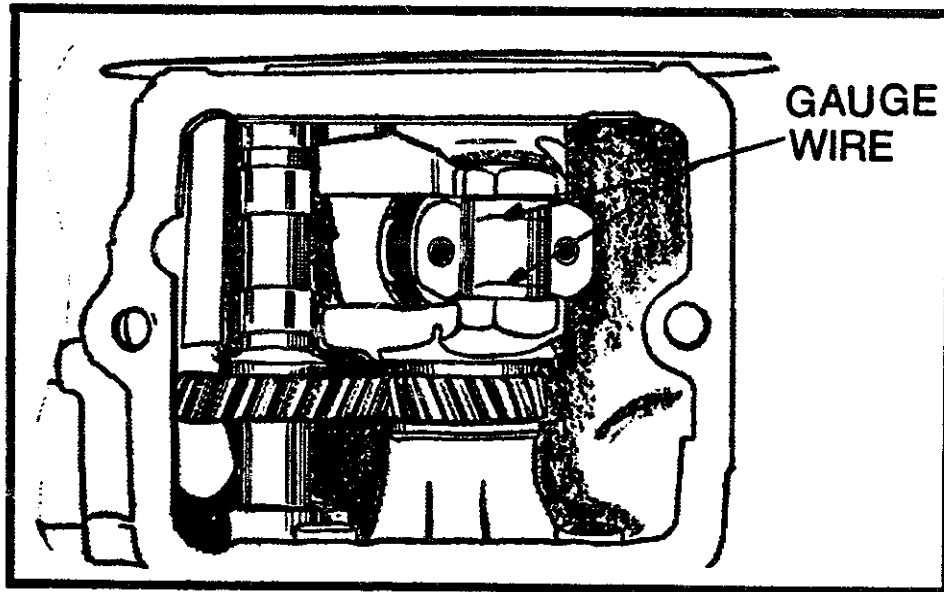


Fig. 7-24. Plastic gauge wire placed for taper. (Courtesy Clinton Engines Corp.)

Remove the rod nuts, straightening the lock-strap tabs with a chisel. Inspect the bearing surface for scores and discoloration. If the rod and crankpin appear sound, wipe the oil off these parts and lay a piece of plastic gauge wire (available from auto parts houses) along the length of the crankpin (Fig. 7-23). Without turning the crankshaft, the torque the rod cap to the specification in Table 7-2.

Table 7-2. Connecting Rod Bolt Torque Limits.

| Model                          | Torque (in-lbs) |
|--------------------------------|-----------------|
| 5, 6, N, 8                     |                 |
| 6B, 60000, 8B, 80000,          |                 |
| 82000, 92000, 110900,          |                 |
| 100000, 130000                 | 100             |
| 140000, 170000, 190000         | 170             |
| 251000                         | 185             |
| 9                              | 140             |
| 14, 19, 190000, 200000, 23,    |                 |
| 230000, 240000, 300000, 320000 | 190             |

Remove the cap and read the bearing clearance in thousandths by comparing the width of the gauge wire to the scale printed on the package. The greater the clearance, the less the wire flattens. Scrape off the remnants of the wire and repeat the operation, this time using two pieces of wire, positioned athwart the crankpin (Fig. 7-24). Differences in width between the two wires show crankpin taper; variations in width of the same wire shows out-of-round. Briggs & Stratton supplies crankpin and big end bearing specs as wear limits, not as clearance data. Without inside and outside micrometers, wear limits are well nigh useless.

The bearing clearance should fall between 0.015 and 0.03 of an inch. Less than 0.015 of an inch makes lubrication marginal; more than 0.03 of an inch pounds the life out of the rod and crankshaft, particularly at high speed or under heavy load. Racing engines are traditionally set up loose, in the three tenths range, to leave room for rod and crankshaft expansion at elevated temperatures. But synthetic oils are more tolerant of heat than petroleum based lubricants, and hence allow racing mechanics to close down the clearances in their engines without danger of seizure.

Crankshaft taper is a touchy subject. Some mechanics would reject a crank that showed any measureable taper. The objection to taper is that it throws the piston askew in the bore and can, if severe enough, plough the piston pin past the retainer and into the cylinder wall. In practice, one can live with 0.005 of an inch of taper if the retainer appears sound and the piston skirt shows a normal wear pattern.

An unusual wear pattern should alert you to the possibility of conn rod or crankshaft distortion. A bent connecting rod tilts the piston, leaving a signature that looks like an hour glass (Fig. 7-25). A twisted connecting rod rocks the piston, concentrating wear above and below the piston pin bores (Fig. 7-26). While connecting rod twist cannot be verified without an expensive jig, it is possible to detect bends at right angles to the rod bearings. Figure 7-27 shows how this is done using a bar with the same diameter as the piston pin and the block as references. The conn rod is passed or rejected on the basis of these inspections. No repairs are possible.

The only insurance a modified engine has, the only durability advantage of it over the factory product, is an aftermarket connect-

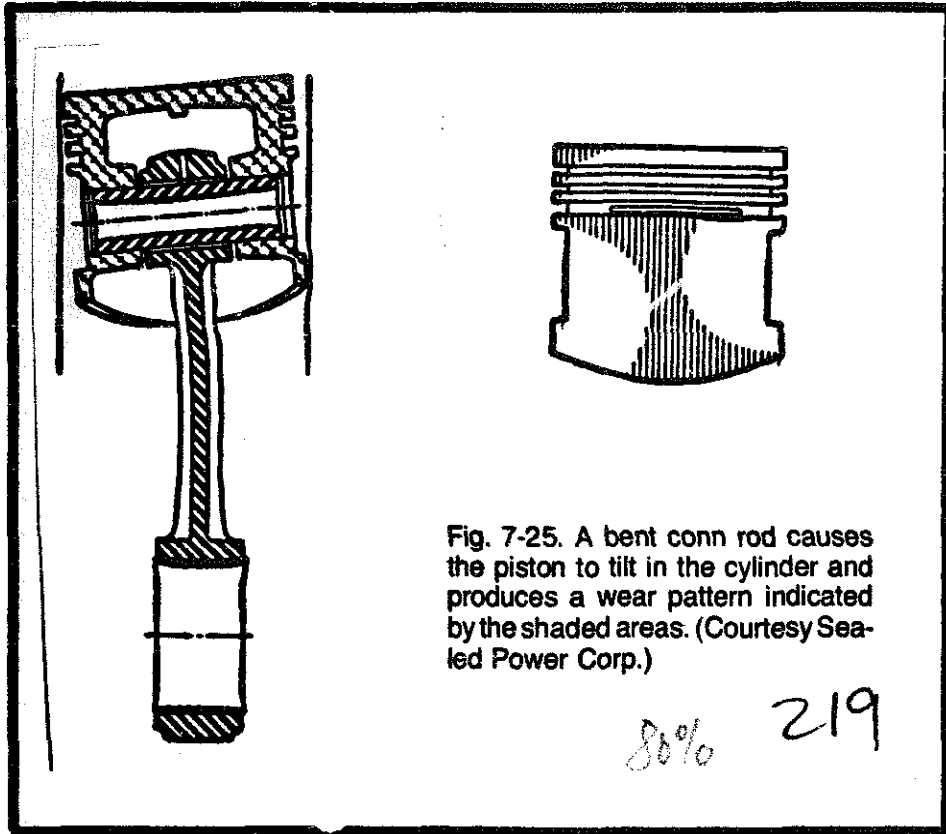


Fig. 7-25. A bent conn rod causes the piston to tilt in the cylinder and produces a wear pattern indicated by the shaded areas. (Courtesy Sealed Power Corp.)

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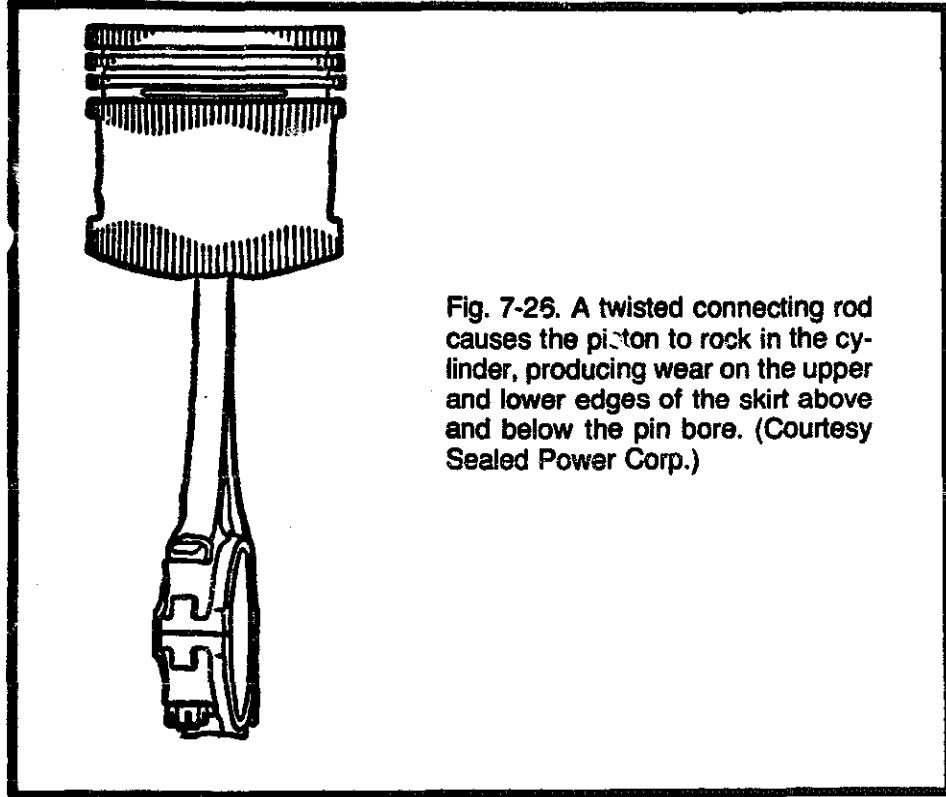


Fig. 7-26. A twisted connecting rod causes the piston to rock in the cylinder, producing wear on the upper and lower edges of the skirt above and below the pin bore. (Courtesy Sealed Power Corp.)

ing rod. The best of these rods are lighter than the Briggs & Stratton product, and shift the burden of fragility to the crankshaft. If you go so far as to defeat the governor—something not recommended here—you *must* invest in one of these connecting rods. Otherwise the engine will self-destruct in a matter of minutes.

## PISTON

The piston has four functions:

- To react against combustion pressure, converting chemical energy into mechanical motion
- To hold the rings square in the bore
- To pass surplus heat out of the chamber and into the cooling fins
- To isolate the crankcase from the violence of combustion.

The thrust faces—the contact areas on either side of the piston pin and roughly parallel with it—should be lightly burnished. A matted finish, as if the piston had been lapped, means that abrasive particles have accelerated wear. Usually these abrasives are pre-

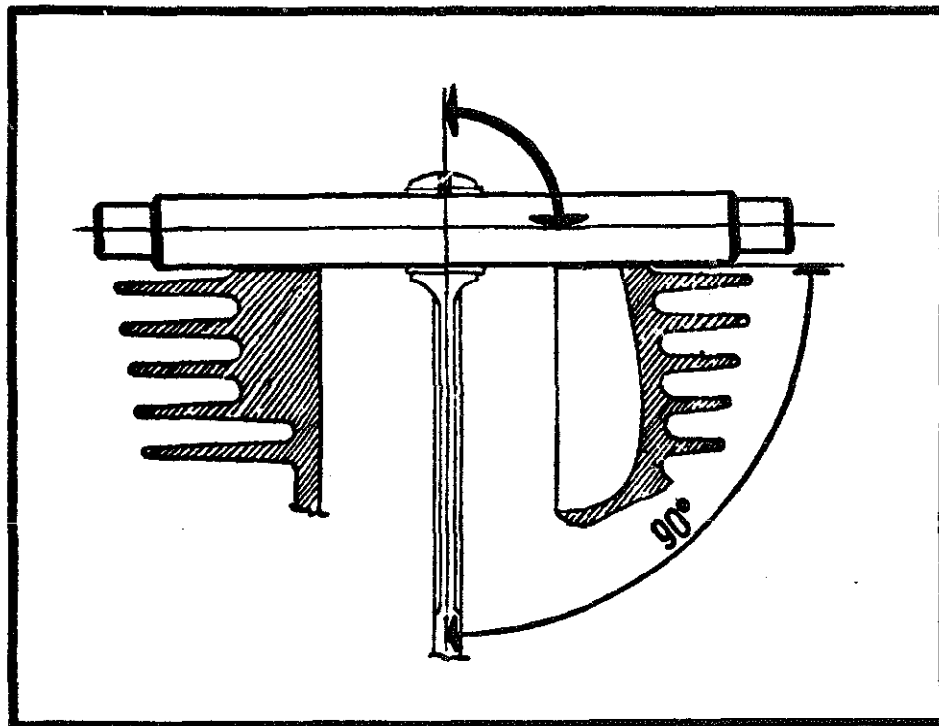


Fig. 7-27. Assuming the firedeck is true, a connecting rod gauge will detect a bent rod. (Courtesy CZ.)

sent in the oil, although a failed air cleaner can contribute to the problem. Deep scratches usually mean mean lubrication failure compounded by overheating. In the most severe cases, the piston melds itself to the bore, depositing splashes of aluminum on the cylinder. A piston with this sort of damage cannot, of course, be reused.

Once the carbon is removed, the piston crown should be smooth and regular, its surface broken only by a suggestion of tool marks. A wavy or flaked piston crown is prima facie evidence of detonation, preignition, or a combination of both. Once the surface is compromised, the metal under it no longer has the heat strength to withstand combustion.

It's rare, but not unknown, to find a broken Briggs & Stratton piston. The piston may crack at the skirt, in which case it has been loose in the bore and pounded itself to death, or it may crack on the underside at the piston pin bosses. In either event, discard the piston.

The piston rings change direction twice each revolution. Because the rate of deceleration is more abrupt at top dead center, the upper side of the ring groove suffers most. It may appear to be stepped, each step like growth rings on a tree testifying to the increased age of the ring. For as the ring wears, it moves further out in the groove. The upper groove wears four or five times as fast as the second groove. For practical purposes, the third groove, the oil ring groove, does not wear at all.

Remove the rings from the piston, handling them with great care. The edges are razor sharp. Pry one of the upper rings apart, much like you would break a wishbone. The ring should snap cleanly. Secure one of the broken pieces in a file holder and use it as a scraper to remove carbon from the ring grooves. It may be necessary to dull the broken end with a few file strokes to prevent gouging.

Position a new ring in the upper groove and insert a feeler gauge under it as shown in Fig. 7-28. If a 0.006 of an inch leaf can be bottomed on the base of the groove, the piston should be replaced. The new rings will flutter, fatigue, and break.

Small engine mechanics rarely measure piston clearance, but depend upon the "wobble test" instead. The piston should have a barely perceptible side-to-side play at top dead center (the region of the bore that suffers most). Consideration should be given to replac-

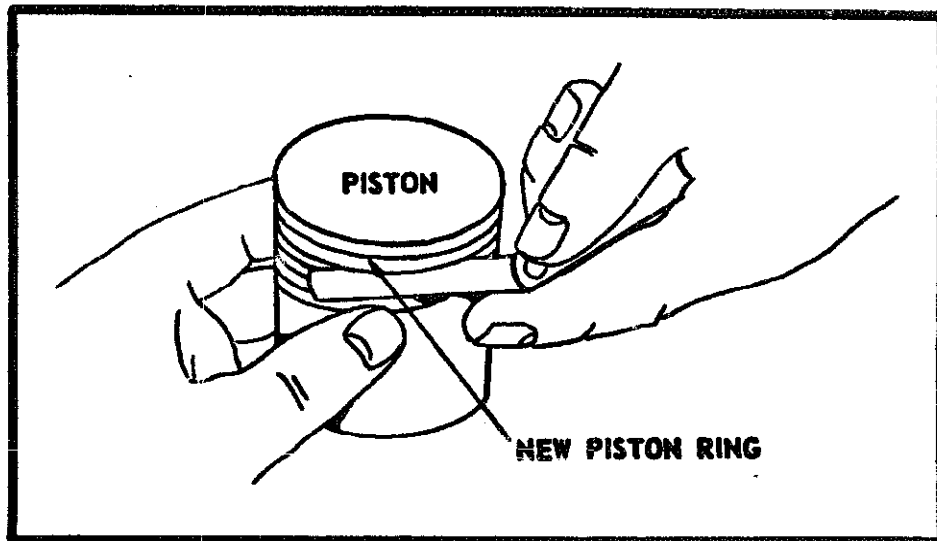


Fig. 7-28. Checking piston ring groove width. (Courtesy International Harvester Corp.)

ing the piston if the play is estimated at 0.004 of an inch, more than 0.005 of an inch calls for a rebore to the next oversize.

In the past, pistons for modified engines have been fitted loose, with clearances on the order of 0.006 of an inch to allow for heat expansion. Better lubricating oils, the high price of replacement parts, and the impact of studies generated in Japan have tended to discourage this practice. It has been shown that a loose piston is much more liable to seize than one with reasonable clearances. If the piston wanders in the bore, only small areas are in contact, and those areas are likely to starve for oil. A clearance of 0.0025 of an inch between either thrust face and the bore is a good compromise.

A word about replacement pistons. Those used in chromed Kool-Bore cylinders are themselves chrome plated; those intended for iron bores are tin plated and are further identified by the expander band behind the oil ring and the letter *L* stamped on the crown. The tin plated piston cannot tolerate a chromed bore, nor can the chrome plated piston live in the iron bore.

Since chromed cylinders cannot be replated in the field, oversizing the bores is impractical, and oversized pistons are not available. Iron bore pistons are available in oversizes of 0.010, 0.020, and 0.030 of an inch. The oversize is stamped on the crown.

Before separating the piston from the connecting rod, note any reference marks on the piston. Some pistons have the letter *F*



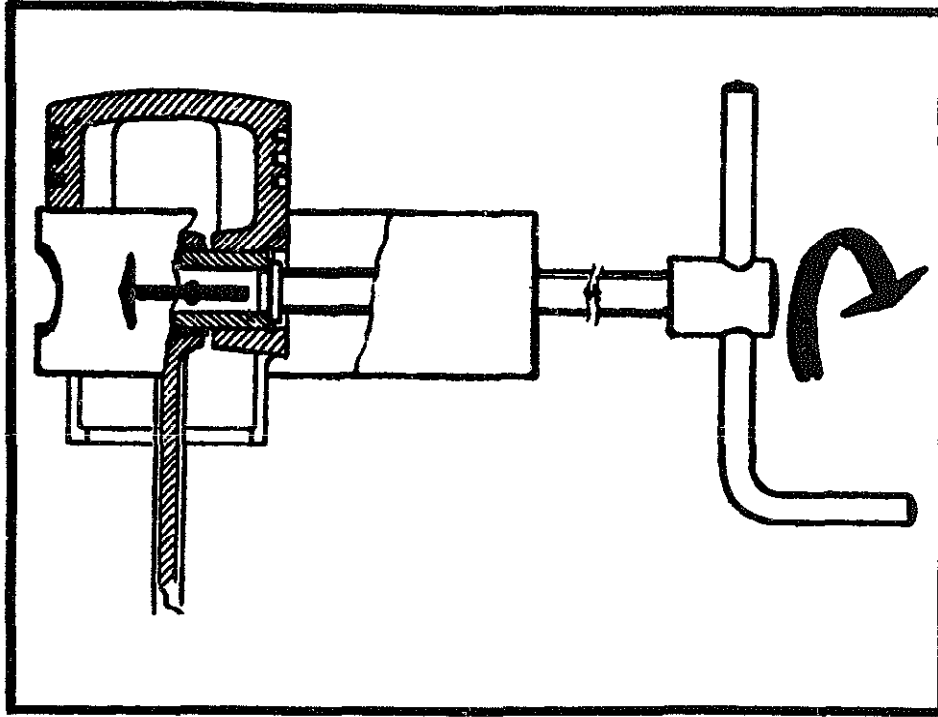


Fig. 7-29. A piston pin press. (Courtesy CZ.)

embossed on the skirt. Others have notched crowns. These reference marks should be on the flywheel side. Make note of the connecting rod match marks, referencing them to the camshaft or some other prominent feature. Otherwise it is possible to reassemble the shank wrong. Solid piston pins have a recess on one side and should be assembled as found originally.

Using long nosed pliers, remove both piston pin retainer clips and discard them. Retainers are too important to be trusted a second time around. Remove the piston pin. Figure 7-29 shows a tool of the type supplied by motorcycle and snowmobile manufacturers. Another method is to heat the piston by wrapping it in rags soaked with hot oil, or by placing the piston crown down on an electric hot plate. Yet another method is to support the piston in a wood V-block and drive the pin out with a punch. Be sure to keep the punch against the pin, because if it wanders into the bearings, the piston will be ruined.

While there is no substitute for an aftermarket piston cast in high silicon alloy for heat strength and domed to increase the compression ratio, these pistons are expensive. For moderate power increases, a carefully fitted and polished stock piston is adequate.

Confine the polishing to the crown, being careful not to remove any material, even carbon accumulations, from the flanks.

### Piston Rings

Counting from the top, the purpose of the first and second ring is to seal compression and combustion pressure; in addition to its primary function, the second ring scrapes surplus oil from the bore, and is sometimes called the scraper ring to distinguish it from the uppermost, or compression ring. The bottom, or oil control ring, lubricates the cylinder.

A piston ring is a pressure compensating seal. When there is no pressure in the cylinder, the ring lies dormant, exerting only a few ounces of residual spring tension against the bore. As pressure above the ring rises, some of this pressure bleeds over the upper edge of the ring and, acting from behind it, cams the ring hard against the bore. The greater the pressure, the stronger the camming action, and the more tightly the ring hugs the bore.

The ring must have some residual tension, otherwise the pressure escapes past the ring face. Severely worn rings, or rings that have been overheated cannot develop the initial tension. By the same token, the ring must be free to move in the bore. Carbon and

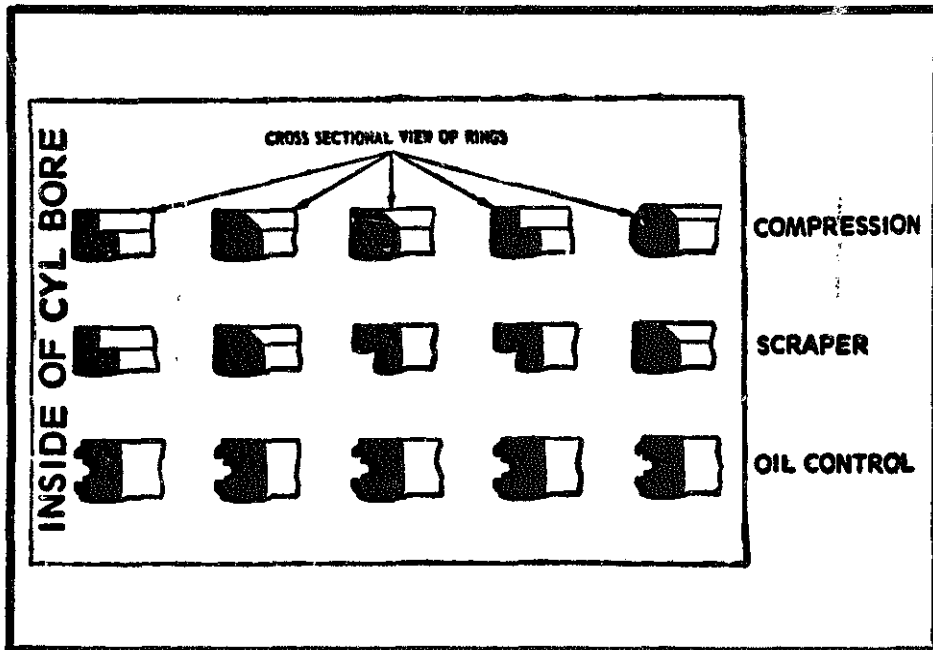


Fig. 7-30. Briggs & Stratton ring profiles.

varnish bound rings have ceased to function; whatever compression the engine has is developed by the piston.

Figure 7-30 illustrates four "factory" ring sets. Note that the compression and scraper rings have a definite top and bottom; installing these rings upside down costs compression and, in the case of the scraper, increases oil consumption. Oil control rings and expanders (not shown) are symmetrical, and can be installed either side up. The upper side is identified by the words "*top or up.*"

Briggs & Stratton also supplies "engineered" ring sets for use in severely worn iron or chrome bores. These rings tolerate 0.005 of an inch of cylinder wear and seat themselves without the need for honing.

The ring gap—the installed distance between the ring ends—is primarily a measure of ring wear (Fig. 7-31). The more the ring faces have eroded, the wider the gap. In this context, the wear limit is 0.035 of an inch on both compression rings and 0.045 of an inch for the oil control ring for aluminum Kool-Bore applications. Iron sleeved engines are set up a little tighter, with ring wear limits of 0.030 of an inch for the compression rings and 0.035 of an inch for the oil control ring.

The variation in ring gap at different positions in the bore is a poor man's micrometer. Establish the gap at the base of the bore in the region below ring travel. This gap represents zero bore wear. Each increase in gap above this null point translates as cylinder wear, and/or eccentricity. The change from the bottom to the zone just under the ridge is the cylinder taper. When making these measurements, use a piston as a ram to keep the ring square.

Ring gap is also a way to detect manufacturer's mistakes. It is unusual, but by no means spectacularly rare, for rings to be mislabeled. Determine the gap of each new ring. This gap should be considerably less than the wear limit, certainly no more than 0.0015 of an inch per inch of bore diameter.

The big problem with rings is hardly mentioned in the literature, and rarely acknowledged by mechanics. Rings have a tendency to break *after* overhaul, within a few hours of startup.

No one is surprised to find broken rings in a worn engine; indeed, the fact that one or more rings has shattered justifies the mechanic's work. But replacement rings should be immune to

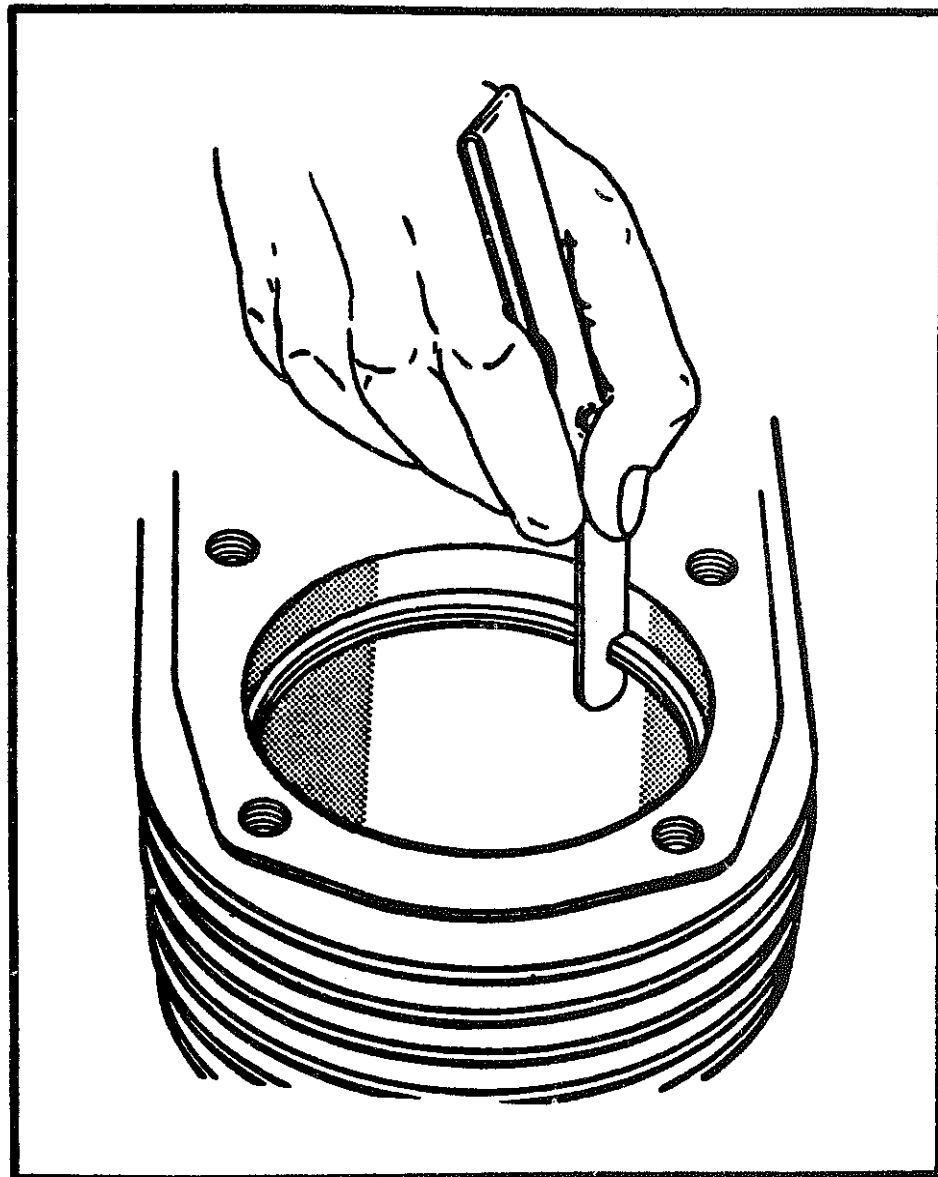


Fig. 7-31. Determining ring end gap. (Courtesy Kohler of Kohler.)

breakage. In some cases, particularly those involving the upper compression ring, an overly wide ring groove is the culprit. But post-overhaul breakage occurs about as often when rings are fitted on a new piston, a piston that should have correctly sized grooves. Break in stresses can hardly be blamed, since factory new engines seem immune to early ring failure.

The reason must be in the way the mechanic handles the rings while they are in his charge. He performs two operations—expanding the rings to slide over the piston, and compressing them

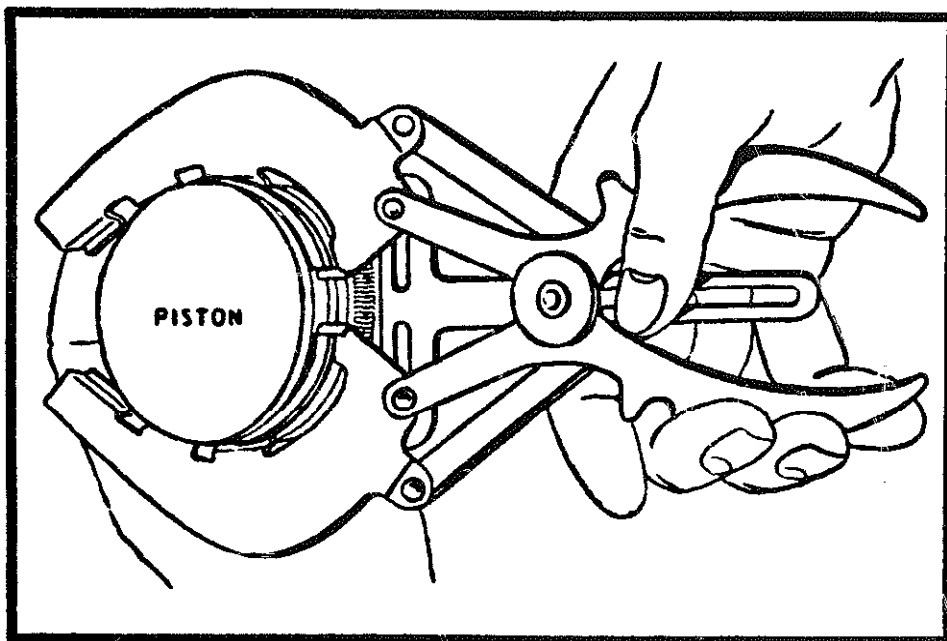


Fig. 7-32. Using a piston ring expander. (Courtesy Briggs & Stratton Corp.)

to enter the cylinder bore. If done incorrectly, either of these operations can weaken the rings.

Purchase or rent an expander like the one shown in Fig. 7-32. This tool pries the ring open while holding the ends in the same plane. Install the oil control ring first, then the scraper, and finally the compression ring. Check that the upper two have their correct sides up and rotate each ring 120 degrees from the others. If the gaps were to be in line, the rings might "freeze" in that position, leaking compression and exhaust gases on each upward stroke. Staggered, the rings are free to rotate, discouraging groove sticking, and are extremely unlikely to align their gaps again.

Lubricate the rings, piston pin, and piston skirt with high grade motor oil. The old method, now in disfavor because of the spark plug fouling it caused, at least was thorough. The mechanic simply immersed the piston, crown down and pin deep, in a bucket of oil.

Ring compressors for small engines are available from K-D Manufacturing, Whitney, and of course, from Briggs & Stratton and its competitors. Mount the piston assembly in a vise with blocks of hardwood between the jaws to protect the connecting rod. Tighten the compressor over the rings, exerting just enough pressure to overcome residual ring tension. It is not necessary to bear down hard on the compressor. Place the assembly over the bore, aligning

any index marks on the piston or rod, and push the piston out of the tool and into the cylinder (Fig. 7-33). Thumb pressure should be adequate. Do not force the issue. If the piston hangs, a ring has escaped the confines of the compressor, or the rod is jammed against the crankshaft. Withdraw the assembly and start over.

Once the piston is in the cylinder, torque up the rod and turn the crankshaft a few revolutions. The piston should move without protest, slowing a bit as it transverses the middle of the stroke, where piston movement is greater per degree of crankshaft rotation than at the dead centers.

### Cylinder Bore

One of the mechanic's responsibilities is to gauge the cylinder bore at three places along its length; at the upper limit, center, and

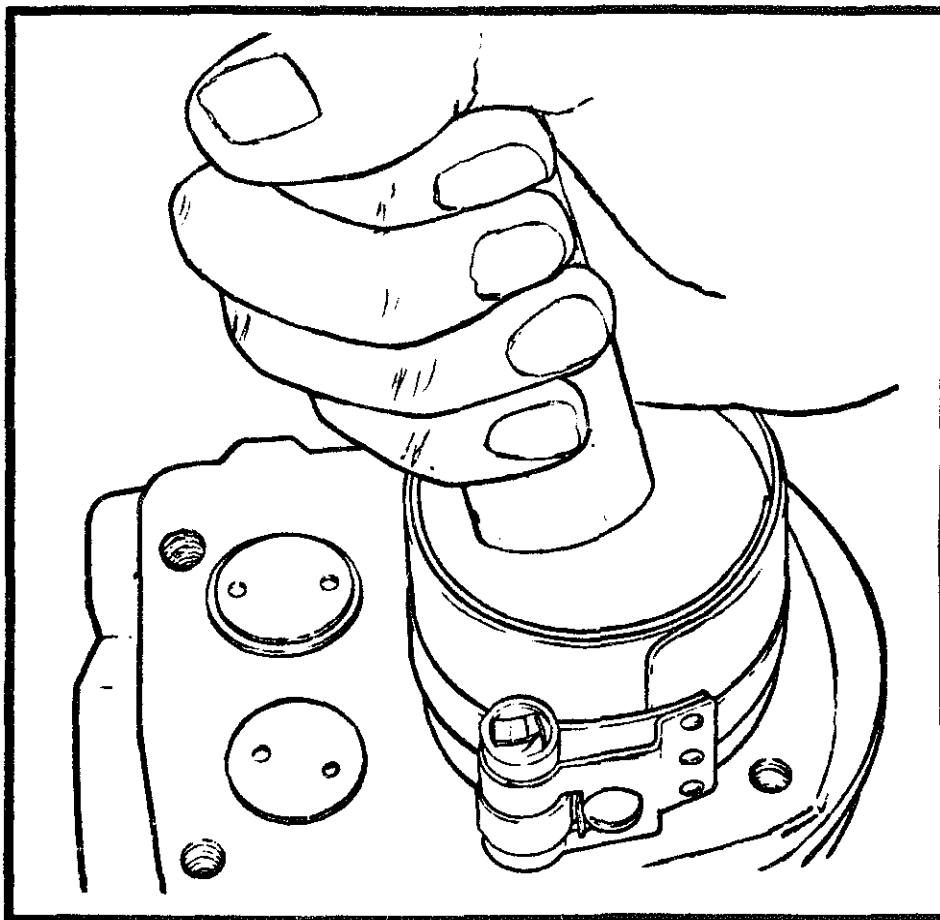


Fig. 7-33. Installing the piston with a ring compressor. (Courtesy Kohler of Kohler.)

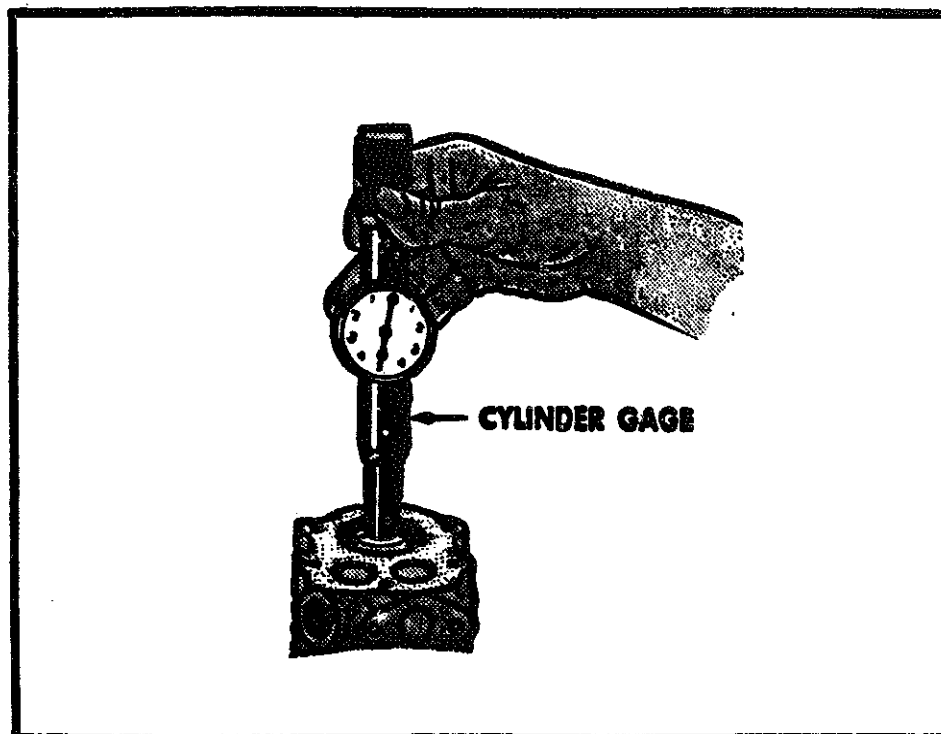


Fig. 7-34. The best way to determine cylinder bore wear is with a direct reading gauge. (Courtesy Clinton Engines Corp.)

lower limit of ring travel. Make two measurements at each station, one in line with the piston pin axis, and one at right angles to it.

Figure 7-34 shows a direct reading cylinder gauge in use. At least some of the cost of this tool is justified by its convenience. Very little skill is required to obtain consistent results. An inside micrometer is somewhat less expensive, but requires practice to master. Most small engine mechanics estimate bore wear with the wobble test and the fortitude of their convictions. The wear limits of the cylinder bore are:

|  |                          |
|--|--------------------------|
| all models.....  | 0.0035 inch oversize     |
| cast-iron blocks.....                                    | 0.0015 inch out of round |
| aluminum blocks (iron sleeved or<br>chrome plated) ..... | 0.0015 inch out-of-round |

**Boring.** Cast iron blocks and aluminum blocks with iron sleeves can be bored 0.010, 0.020, and 0.030 of an inch past stock diameters. Cast-iron blocks will accept larger overbores, engines on

record having been taken out to 0.090 of an inch. Finding a suitable piston, however, is the hardest part of the job.

There are three ways to bore the block. Assuming first rate tooling and reasonable competency on the part of the machinist, the best method is to use a vertical boring machine of the type illustrated in Fig. 7-35. The next best choice is to cut the bore in a lathe. The least desirable method is to hone the cylinder oversize (Fig. 7-36).

Since machine tools are expensive and few customers come in for major engine work, most shops use a hone. An adjustable hone, such as the one illustrated, gives better accuracy than the conventional, spring loaded type. Select the stone from the hone manufacturer's recommendation, remembering that grit size (the number of abrasive particles per square inch) and hone code numbers are not always identical. For example, code number a 500 stone is equivalent to 280 grit.

Some mechanics prefer to run the hone dry, but once the stones are wetted, they must continue to be lubricated. Kerosene and other petroleum oils dissolve the adhesive that binds the parti-

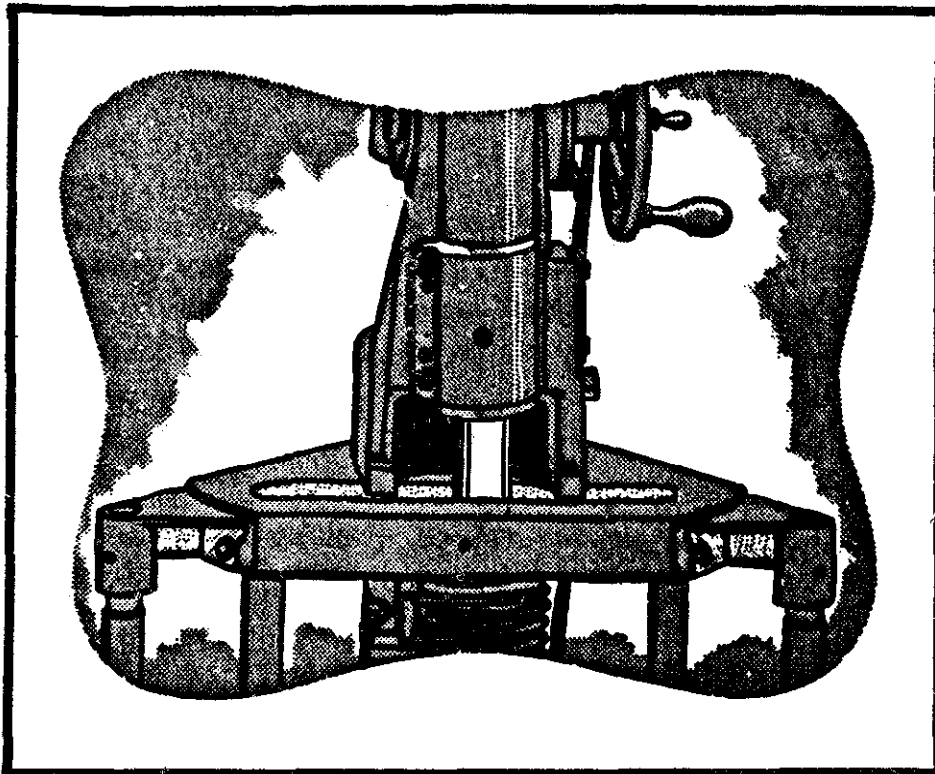


Fig. 7-35. Cylinders should be machined oversize with a boring bar. (Courtesy Clinton Engines Corp.)



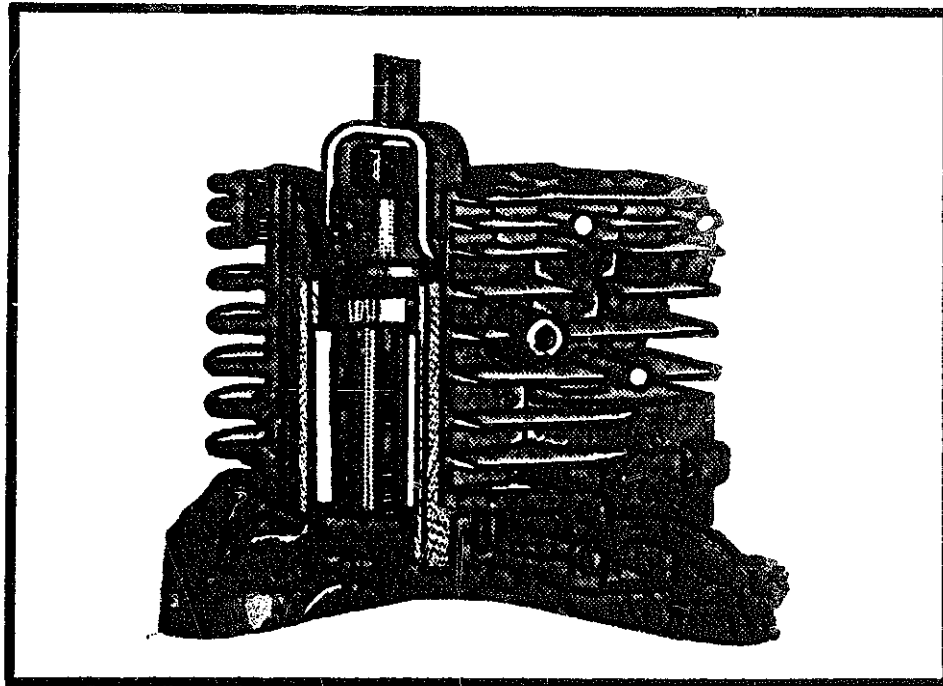


Fig. 7-36. Most cylinders are honed oversize. (Courtesy Clinton Engines Corp.)

cles in the stone and cause rapid wear without a corresponding increase in cutting speed. Use a commercial honing oil, animal fat, or vegetable oil such as Crisco.

Although cylinders have been bored with a quarter inch drill motor, a drill press is the better choice. Loosely bolt the block to the work table so that the block will tend to center itself on the hone. Adjust the spindle stops to limit hone travel to  $\frac{3}{4}$  of an inch past either end of the bore, and gear the machine down to 400 rpm. Reciprocate the hone about seventy strokes a minute. If you use a spring loading hone, concentrate on the lower part of the bore and slowly increase the length of the strokes to include the whole bore. Sweep the whole bore with an adjustable hone, opening the stones until the cut is uniform from top to bottom.

Briggs & Stratton piston oversizes are based on the diameter of the original piston, and not on bore diameter. In other words, a piston marked 0.010 is ten thousandths of an inch larger than the factory standard piston. If the cylinder bore is enlarged 0.010 of an inch, this piston will have the correct running clearance. A machinist might be confused on this point since other manufacturers base piston size on bore. In this system, a piston that is marked 0.010 is

exactly ten thousandths of an inch larger than the original bore. The bore must be cut out further for piston clearance.

Whether the bore is machined or honed, the last 0.0015 of an inch or so should be finish honed with a fairly light stone. Otherwise the rings are slow to seat and may never give adequate oil control. Cast-iron rings seat best with a code number (not grit number) 200 stone; chrome rings need a 300 stone; and stainless steel rings require the almost polished finish given by a 500 stone.

Abrasive particles must be removed from the bore if the honing process is not to continue over the life of the engine. Petroleum based solvents merely float the abrasive deeper into the pores of the metal. The only way to clean a honed bore is with hot water, detergent, and a sturdy brush. Scrub the bore thoroughly and wipe it down with paper towels. If the towels discolor, abrasive is still present and more scrubbing is required. Once the bore is completely free of abrasive, oil it to prevent rust.

**Deglazing.** Cast-iron is an amazing material, used in its heyday for everything from lampposts to structural beams. The Crystal Palace, symbol of Victoria's reign and British industrialism, was frames in cast-iron.

One of this metal's unique properties is the way it forms a glaze when subject to rubbing friction. The working surface flows and compresses into a smooth, hard skin that is almost impervious to further wear. Without the formation of glaze, it would be impossible to run cast-iron rings in iron bores.

Glaze is beneficial to an older engine, and indeed makes it possible to run cast-iron rings in iron bores, but it is a nuisance when the engine has been overhauled and the rings are replaced. Its imperviousness to wear means that the rings do not break in properly. Break in is a mutual honing process, a period of accelerated ring and bore wear until the parts accommodate themselves to each other.

Deglazing, or "glaze busting," is no more than light honing for the purpose of roughening the metal and giving it tooth. Done correctly, the cylinder wall takes on a dull, matted appearance. Upon microscopic examination, the surface is characterized by diamond shaped peaks and valleys. The peaks are in rubbing contact with the piston rings, while the valleys become oil channels to cool the rings and to float away the debris.

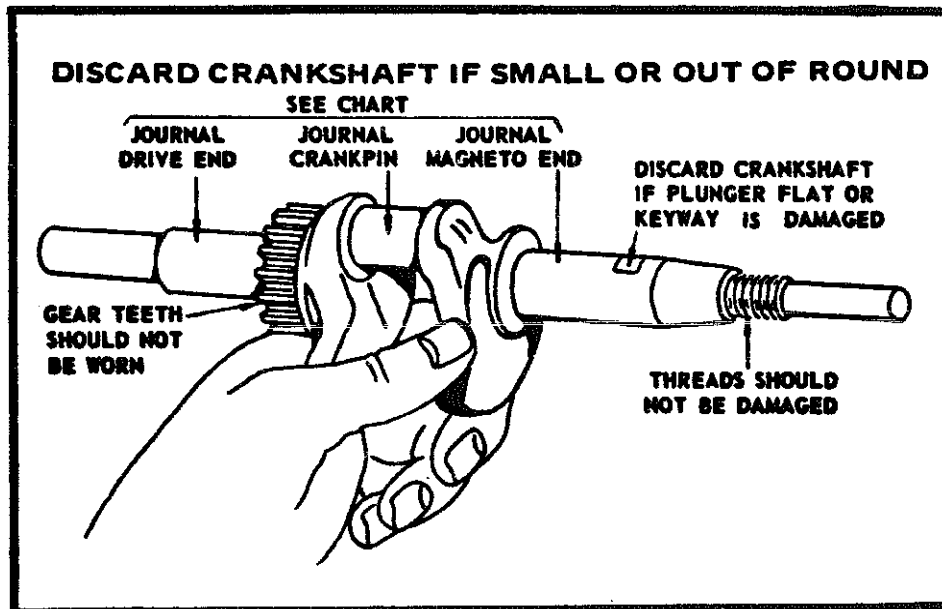


Fig. 7-37. Crankshaft inspection points. (Courtesy Briggs & Stratton Corp.)

Use the appropriate finishing stone for the ring material as described under "Boring," and turn the hone no more than 400 rpm. Reciprocate it at approximately seventy strokes a minute. The cylinder may be said to be deglazed when the surface is entirely honed, although some discretion should be used in the matter. The hone will skip in an eccentric, or egg shaped, cylinder. Cylinders with severe eccentricity should either be overbored to the next size, or left alone. Taking out the oval costs more metal than it is worth.

Deglazing is inappropriate for chromed bores that do not develop a "skin" and for cast-iron bores fitted with the Briggs & Stratton engineered ring set.

## CRANKSHAFT

The crankshaft is the fundamental part upon which all else depends. Because it is a passive element, having nothing directly to do with performance, mechanics sometimes take the crankshaft for granted. But flaws in the crankshaft mean that the engine will not live, and all of the polishing and fitting amounts to nought.

Begin the inspection with the flywheel threads (Fig. 7-37). Pulled or crossed threads mean that the wheel can break free. The keyway must be square and sized to fit the key, otherwise the magneto will jump time and starting will become problematic. The

indentation on crankshafts with flywheel magnetos must be square for the points to break. Bearing surfaces should be reasonably close to specification, and smooth (small imperfections can be polished out, but deep, nail hanging ridges mean the crankshaft must be replaced. Without a micrometer, you can get some idea of main journal wear by moving the crankshaft side-to-side in the bearings. There should be no, or almost no play. The crankpin can be checked with a new connecting rod and plastic wire gauge. The crankshaft should be straight to within 0.001 of an inch, a determination that is made with a dial indicator and a set of precision V-blocks.

Almost any crankshaft repair, even welding, is technically feasible, but economic considerations limit repairs to straightening and rebuilding the crankpin bearing. Straightening involves precision V-blocks, a hydraulic press, tandem dial indicators, and the patience to match or exceed factory tolerances. Once the crank is straightened, it must be inspected for cracks by the magnetic particle method. The cost of this work should be no more than a third of the price of a new crankshaft. Crankpin bearing work is more expensive. The pin is ground undersize, built up with vaporized metal, and ground to dimension. Sometimes the repair holds; sometimes it doesn't. Grinding the crankpin off center increases the stroke, a technique favored by go-cart racers.

### **Main Bearings**

Depending upon the model, Briggs & Stratton engines use plain or ball main bearings. When ball bearings are specified, the inner race makes a press fit with the crankshaft, and the outer race is pinned to the bearing carrier which, in turn, is bolted to the block. Plain bearings take the form of a bushing on cast-iron engines, and are integral on aluminum blocks.

Ball bearing clearances cannot be gauged; the condition of the bearing is judged by how it looks and sounds. Soak the bearing in solvent to remove all lubricant and allow it to air dry. If you use compressed air, the source must be fitted with a water trap, since antifriction bearings have zero tolerance for moisture. Turn the bearing by hand: it should roll without catches and without the cracks and pops associated with Brineled races and pitted balls. Some outer

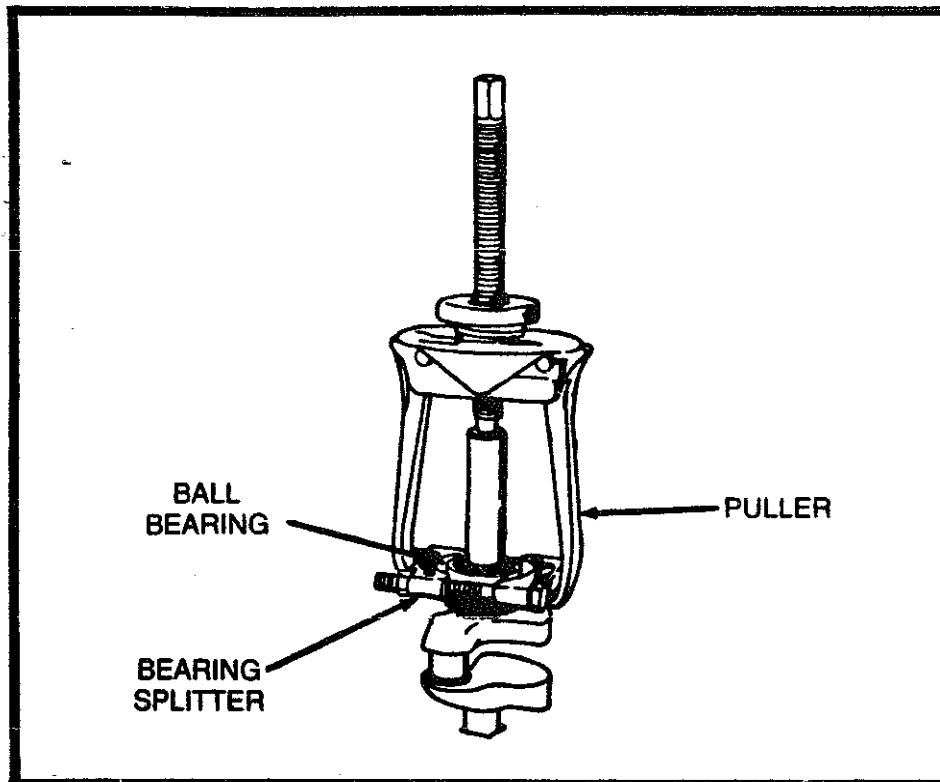


Fig. 7-38. Ball bearings can be pulled with a bearing splitter. (Courtesy Tecumseh Products Co.)

race play is allowable, although it should be limited to a few thousandths of an inch.

If the bearings have failed, remove them from the crankshaft with an arbor press or a bearing splitter (Fig. 7-38). Driving new bearings home with a length of pipe, sized to match the diameter of the *inner* race (Fig. 7-31). A more refined method is to warm the replacement bearings in a container of oil. Maximum allowable oil temperature is 325 degrees Fahrenheit, and the bearings must be held clear of the bottom and sides of the container. Once warmed, the inner races will expand enough to slip over the crankshaft. The shielded sides of the balls are inside, toward the crankpin.

Magneto side plain bearings can be renewed on all engines. Sump side bearings can be renewed except on models 9, 14, 19, 20, and 23 in the cast-iron series, 8B-HA, 80590, 81590, 82590, 80790, 81790, 82990, 92590, and 92990 in the aluminum series. Power take off side reamers are not available for these engines, and the new oil sumps or bearing covers must be purchased.

Replacing plain bearings requires a set of factory reamers and guide blocks (Fig. 7-39). It is one of those jobs that the amateur should avoid, since the tools cost several times more than a dealer would charge to do the work. The process begins with the magneto side bearing. On cast-iron blocks, the old bushing is knocked out, a new one pressed home, and, with the tool centered on the flange bearing and magneto side oil seal groove, the bushing is reamed. On aluminum block engines, there is no bushing and the bearing web must be rough reamed to accept one. The new bushing is installed, staked into place to prevent rotation, and line reamed as before. Once the magneto side bushing is true, it is used as a center for the sump side bushing.

### Oil Seals

Oil seals should be replaced each time the engine is opened, if only for the insurance value. Figure 7-40 illustrates the technique. Install the seal with the steep side of the lip inward, toward the oil, and the numbered side outward, toward the tool. Seal drivers are available, although most mechanics use a length of two by four. The seal must be pressed home dead flat and to the depth of the original. If the crankshaft is grooved, the seal can be repositioned a fraction of an inch to compensate. However, the back of the seal must make good contact with the recess and must not invade the oil port.

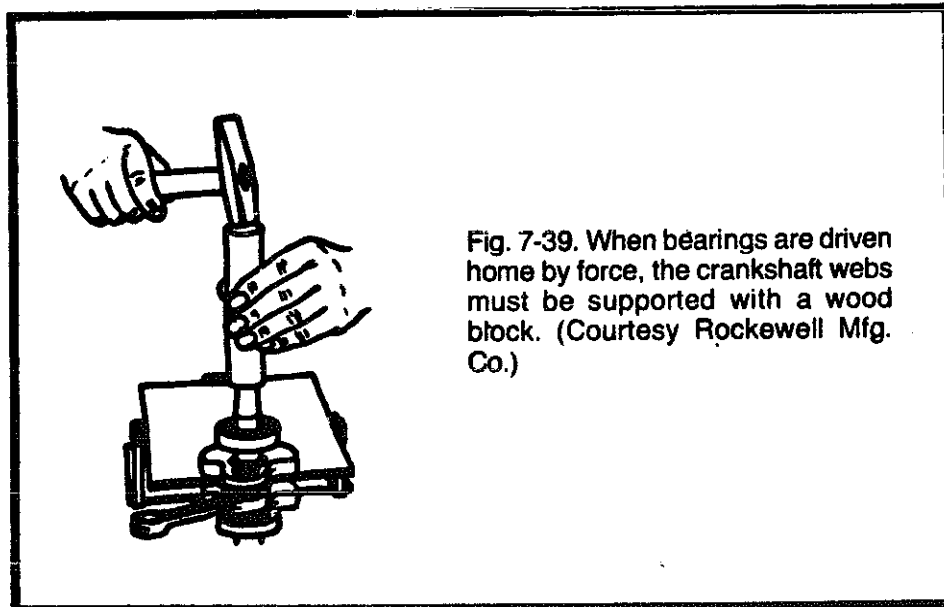


Fig. 7-39. When bearings are driven home by force, the crankshaft webs must be supported with a wood block. (Courtesy Rockwell Mfg. Co.)

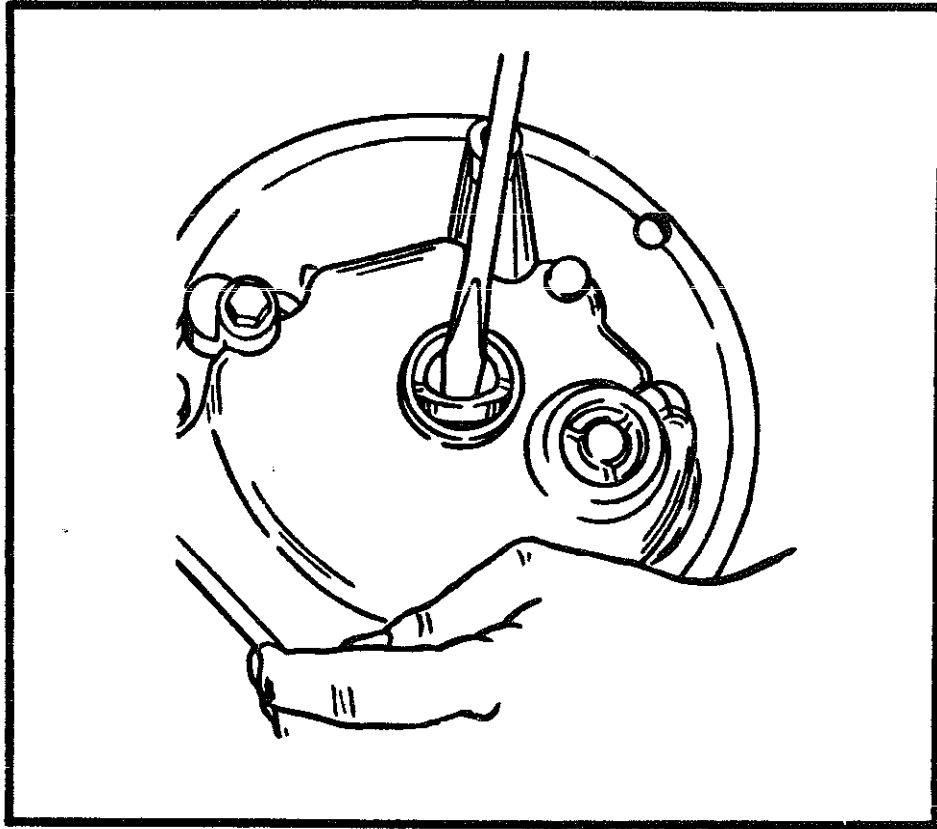


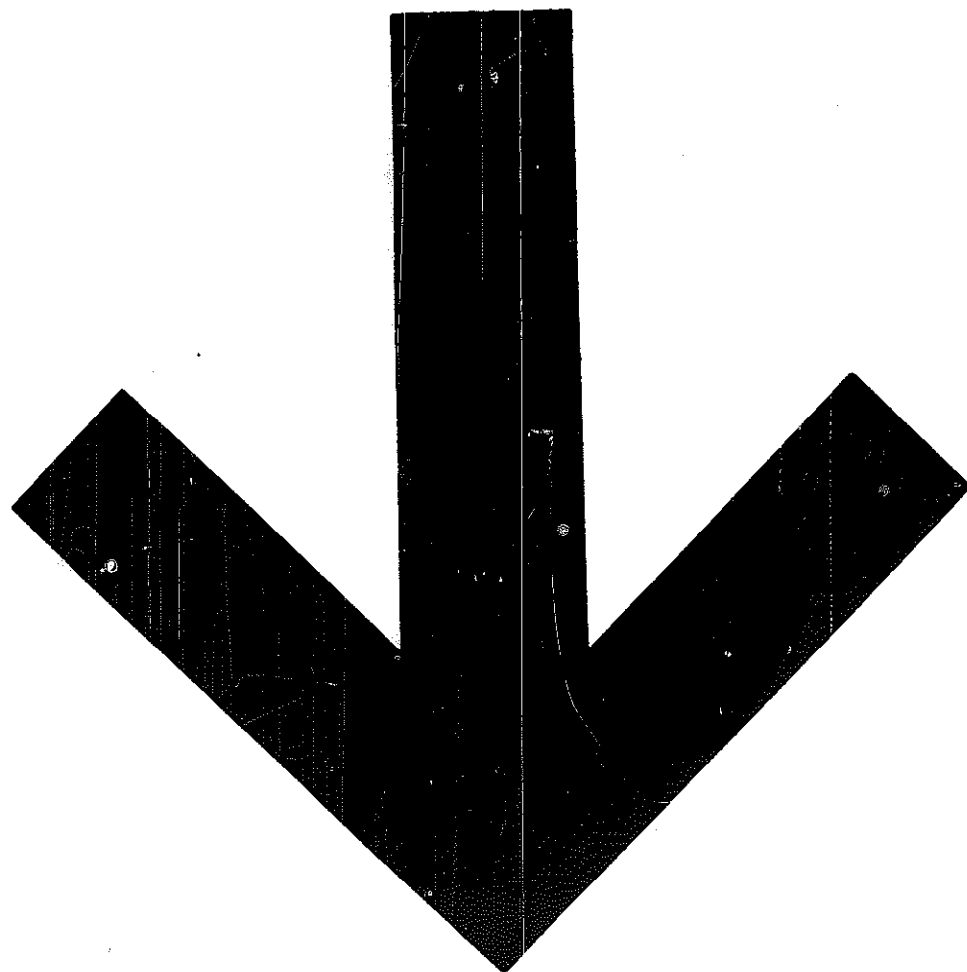
Fig. 7-40. Oil seals can be pryed loose with a large screwdriver. (Courtesy Tecumseh Products Co.)

New seals are often damaged during engine assembly. The seal lips should be greased to aid break in and the crankshaft should be lightly polished. Cover keyways with masking tape.

In passing, it should be mentioned that it is not necessary to disassemble the engine to remove and install an oil seal. Deform and tear the old seal with a punch, being careful not to damage the seal cavity or the crankshaft. Once the seal has relaxed, withdraw it with a pair of side cutting pliers. Install the new seal with a length of pipe whose outside diameter closely matches that of the seal.

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