



▲ SAFETY MESSAGE ▲

The product for which you have requested information or replacement parts is not a current product. The replacement models incorporate product designs, safety features, safety instruction or warnings which represent the latest "State Of The Art" developments. For your safety and those around you please contact your nearest Ariens/Gravelly Dealer for a demonstration of the current product safety provisions and features.

CONVERTIBLE 10, 10A and 12 SERVICE MANUAL

INTRODUCTION

This manual is designed to provide an indepth service procedure for the Convertible 10, Convertible 10-A and Convertible 12 tractors.

We recommend that the procedure outlined in this manual be followed to provide an ease of repair.

This manual is set up using the current recommended service procedures and operations. However, recommendations are subject to change without notice or incurring obligation on the part of Gravely Corporation.



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SAFETY PRECAUTIONS

IT IS TOO LATE TO REMEMBER WHAT SHOULD HAVE BEEN DONE AFTER THE ACCIDENT HAS HAPPENED.

Many hours of lost time and much suffering can be caused by the failure to practice simple safety rules.

1. Make sure the work area is clear of objects that might be picked up and thrown.
2. Do not wear loose fitting clothing that might get caught in moving parts.
3. Disengage all clutches prior to starting the engine.
4. Do not add fuel to the tractor when it is hot, while it is running, or while you are smoking.
5. Never run the engine in a closed garage or shed without adequate ventilation.
6. Do not try to oil or grease the tractor or its attachments while in operation.
7. Adequate ventilation must be provided when batteries are being recharged. In addition, sparks, open flames and smoking should be avoided since hydrogen gas is produced which, if ignited, can cause an internal explosion that can shatter the battery. This gas is produced in quantity only while the battery receives high rate of charge but can linger for several hours in a poorly ventilated area.
8. Prevent AC leads from alternator from touching or shorting.
9. Disconnect all leads at rectifier regulator before welding on tractor or an attachment mounted on the tractor.

TROUBLE SHOOTING

(engine)

CONDITION	POSSIBLE CAUSE
<p>A. <u>Hard Starting or Loss of Power</u></p> <p>(Check First for Dirty Air Cleaner!)</p>	<ol style="list-style-type: none"> 1. Faulty Ignition. <ol style="list-style-type: none"> a. Loose or grounded high tension or breaker point leads. b. Improper breaker point gap and timing. c. Defective breaker points. d. Faulty spark plug or improper gap. e. Faulty condenser or coil. 2. Faulty Fuel System. <ol style="list-style-type: none"> a. Gasoline not getting to carburetor. <ol style="list-style-type: none"> 1. Dirt or gum in fuel line. 2. Fuel pump faulty. b. Dirt in carburetor. c. Carburetor improperly adjusted.
<p>B. <u>Overheating</u></p>	<ol style="list-style-type: none"> 1. Insufficient available cool air. 2. Dirty air intake screen, shroud or cooling fins. 3. Improper fuel. 4. Fuel mixture too lean. 5. Improper ignition timing. 6. Engine overloaded. 7. Tight tappet clearance.
<p>C. <u>Backfiring</u></p>	<ol style="list-style-type: none"> 1. Fuel mixture too lean. 2. Improper timing. 3. Valve "sticking".
<p>D. <u>Occasional "Skip" at High Speed</u></p>	<ol style="list-style-type: none"> 1. Spark plug gap too wide. 2. Improper carburetor setting or lack of fuel. 3. Wrong type spark plug. Use recommended spark plug. 4. Improper timing.
<p>E. <u>Operating Erratically</u></p>	<ol style="list-style-type: none"> 1. Vent in gas cap plugged 2. Loose ignition connections. 3. Faulty choke control. 4. Improper fuel mixture. 5. Water in fuel. 6. Air leaks in manifold or carburetor connections. 7. Clogged fuel line. 8. Fuel pump faulty.
<p>F. <u>Engine Will Not Idle</u></p>	<ol style="list-style-type: none"> 1. Improper carburetor idling adjustment. 2. Carburetor clogged. 3. Spark plug gap set too close. 4. Leaking carburetor or manifold gaskets.

AIR INTAKE SYSTEM

(all models)

The importance of maintaining an air cleaner in proper condition can not be overemphasized! Dirt induced through improperly installed, improperly serviced or inadequate elements, wears out more engines than does long hours of operation. Even a small amount of dirt will wear out a set of piston rings in a few hours. Furthermore, operating with a clogged element causes a richer fuel mixture which can lead to formation of harmful sludge deposits. Always cover carburetor or air horn when air cleaner is removed for servicing.

Dry type air cleaner elements should be replaced after 100 to 200 hours if engine is normally operated under good clean air conditions -- service and replace element more frequently under dusty or dirty conditions.

Dry type elements should be cleaned after each 100 hours of operation or more often under dusty conditions -- remove element and tap lightly on a flat surface to remove loose surface dirt. Replace element if dirt does not drop off easily. Do not wash dry elements in any liquid or attempt to blow dirt off with air hose as this will puncture the filter element.

Carefully handle new element -- do not use if gasket surfaces are bent or twisted. Not only must the right filter element be used but it must be properly installed to prevent unfiltered air from entering engine. Check the following when installing new element.

1. Back plate must be securely tightened to carburetor. Replace back plate if bent or cracked.
2. Gasket surfaces of element must be flat against back plate and cover to seal effectively.
3. Washer must be in place between cover and wing nut to seal and prevent unfiltered air from entering through hole in cover. If washer is not used, make sure wing nut (special) properly seals area around cover hole.
4. Wing nut must be finger tight.

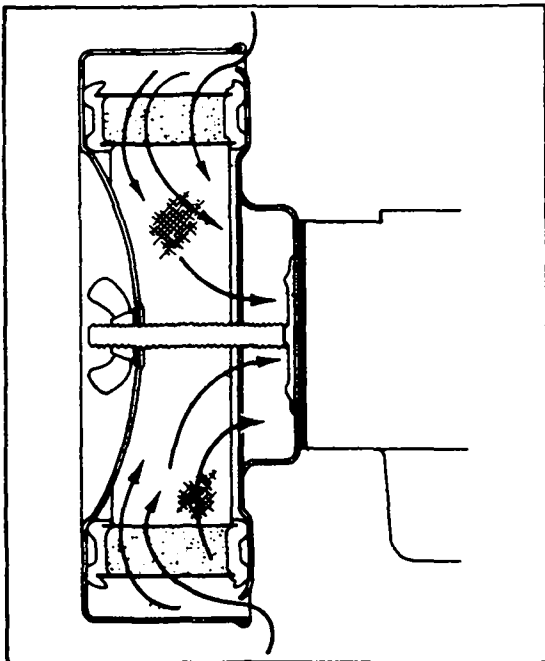


Figure 1 Dry Type Air Cleaner

LUBRICATION

TRANSMISSION

Capacity: 5 U.S. Quarts
Grade: GL-6 (API service class)
Viscosity: 90W (SAE standards)

Change: after first 40 hours of operation. Drain plug is lowest bolt on L.H. axle housing.

ENGINE

Capacity: 2 U.S. Quarts
Grade: SE (API service class)
Viscosity: (SAE standards)
below 0°F) 5W20
average 10W30
above 85°F) 10W40

Change: 25 hours use or 3 months whichever occurs first.

FUEL SYSTEM

(all models)

CARBURETOR

Carburetors are adjusted in the factory and under normal conditions require no further adjustment. If, however, one of the following conditions exist, readjustment of the carburetor may be needed.

<u>CONDITION</u>	<u>POSSIBLE CAUSE/PROBABLE REMEDY</u>
A. Black, sooty exhaust smoke, engine sluggish.	A. Mixture too rich - readjust main fuel needle.
B. Engine misses and backfires at high speed.	B. Mixture too lean - readjust main fuel needle.
C. Engine starts, sputters and dies under cold weather starting.	C. Mixture too lean - turn main fuel adjustment 1/4 turn counterclockwise.
D. Engine runs rough or stalls at idle speed.	D. Improper idle adjustment - readjust idle fuel needle.

Maximum power and efficiency are possible only with proper carburetion. Improper carburetor adjustment can lead to overheating, fouled spark plug, excessive valve wear and other problems. Do not neglect carburetor if any of the above problems persist. The following adjustment procedure is for the standard side draft carburetors.

STEP 1 - Stop engine and carefully turn Main Fuel and Idle Fuel Needle adjusting screws all the way in (clockwise direction) until they bottom - DO NOT FORCE SCREWS as this will damage needle valves.

STEP 2 - For preliminary adjustment, turn Main Fuel screw 2 turns in counterclockwise direction, turn Idle Fuel screw 1 - 1/4 turns in counterclockwise direction.

STEP 3 - Start engine and operate at normal speed until normal operating temperatures are reached.

STEP 4 - Main Fuel Adjustment - With engine operating at full throttle and full load, turn Main Fuel Needle in (clockwise) until engine slows down (lean), note position of screw, then turn needle out (counterclockwise) until engine regains speed and then again slows down (overrich). Turn needle back in until it is positioned halfway between lean and overrich settings. If adjusted properly, the engine should accelerate smoothly and operate with steady governor action.

STEP 5 - Idle Fuel Adjustment - Operate engine at idle speed of about 1000 RPM (adjust Idle Speed screw until this speed is attained - check with tachometer). Turn Idle Fuel Needle in (clockwise) until engine slows down and idles rough then turn screw out until engine speeds up and idles smoothly at the desired idle speed.

STEP 6 - Final Adjustment - Since main fuel and idle fuel adjustment have some affect on each other, recheck engine and make final adjustments as necessary to achieve smoothest operation.

NOTE: If the preceding steps do not remedy problems attributed to carburetor, carburetor reconditioning may be necessary.

Carburetor Reconditioning

Service difficulties with fuel systems usually originate from improper carburetor adjustments or dirt, gum or varnish in components. It will be necessary to completely disassemble carburetor to clean thoroughly. Normally only pre-season cleaning will be required; however, the frequency of cleaning will depend upon use and operating conditions.

All parts should be cleaned in a solvent. Gum is easily removed with an alcohol or acetone solvent. Be sure any carbon deposits are removed from bore, especially where throttle plate seats in casting. Blow out all passages with compressed air. Replace all worn and damaged parts. Always use new gaskets. Carburetor repair kits are available for most carburetors. They include the bowl nut gasket, bowl ring gasket, float pin, bowl baffle gasket and fuel inlet needle and seat.

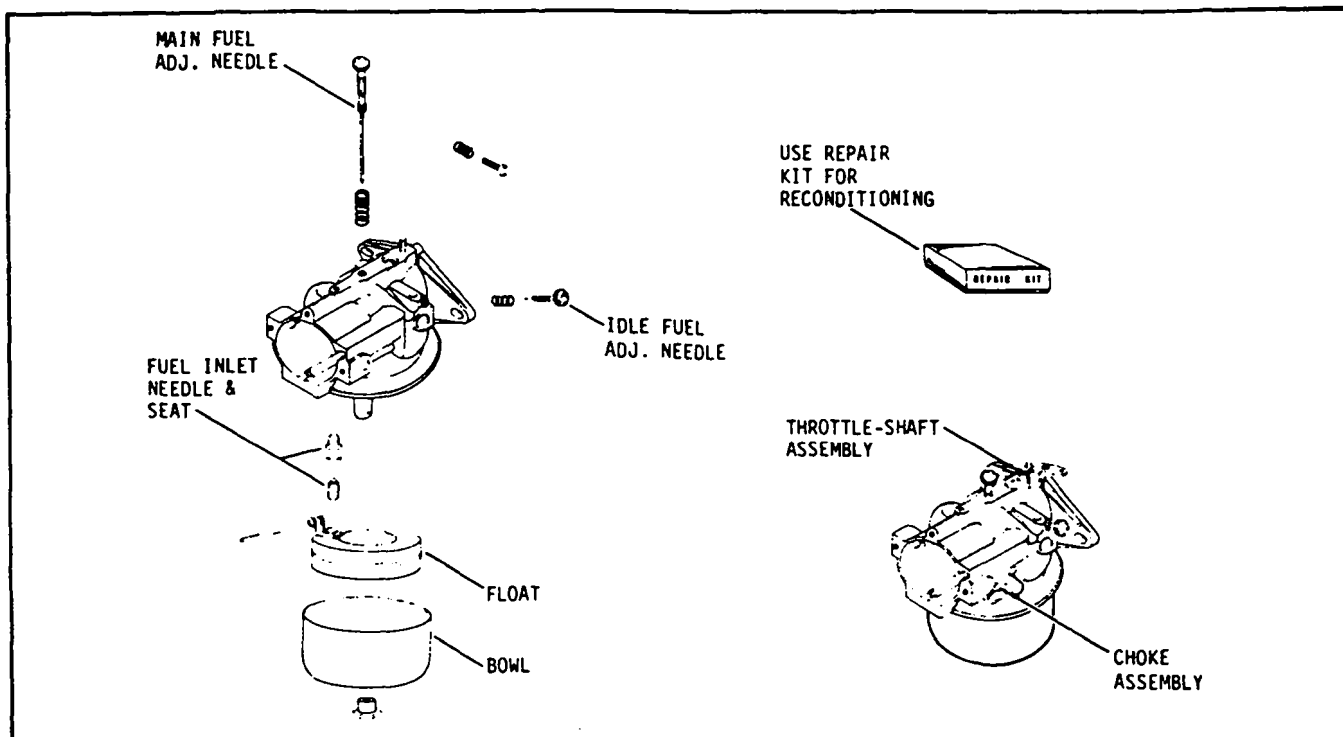


Figure 3 Side Draft Carburetor

Disassembly of Carburetor

1. Remove carburetor from engine.
2. Remove bowl nut, gasket and bowl. When carburetor has bowl drain, remove drain spring, spacer (when used), plug and gasket from inside of bowl.
3. Remove float pin, float, needle and needle seat. Check float for dents, leaks and wear on float lip or in float pin holes.
4. Remove bowl ring gasket.
5. Remove idle fuel adjusting needle, main fuel adjusting needle and springs.
6. Do not remove choke and throttle plates and shafts. If these parts are worn, replace carburetor assembly.

Assembly of Carburetor

1. Install needle seat, needle, float and float pin.
2. Set float level. With carburetor casting inverted and float resting lightly against needle in its seat, there should be $1\frac{1}{64}$ " plus or minus $\frac{1}{32}$ of an inch clearance between machined surface of casting and free end of float (side opposite needle seat).
3. Adjust by bending lip of float with small screwdriver.
4. Install new bowl ring gasket, new bowl nut gasket and bowl nut. Tighten securely after making sure bowl is centered on gasket.
5. Install main fuel adjustment needle. Turn in until needle seats in nozzle and back out two turns.
6. Install idle fuel adjustment needle. Back out approximately 1-1/2 turn after seating lightly against jet.
CAUTION: DO NOT USE FORCE ON ADJUSTMENT NEEDLES.

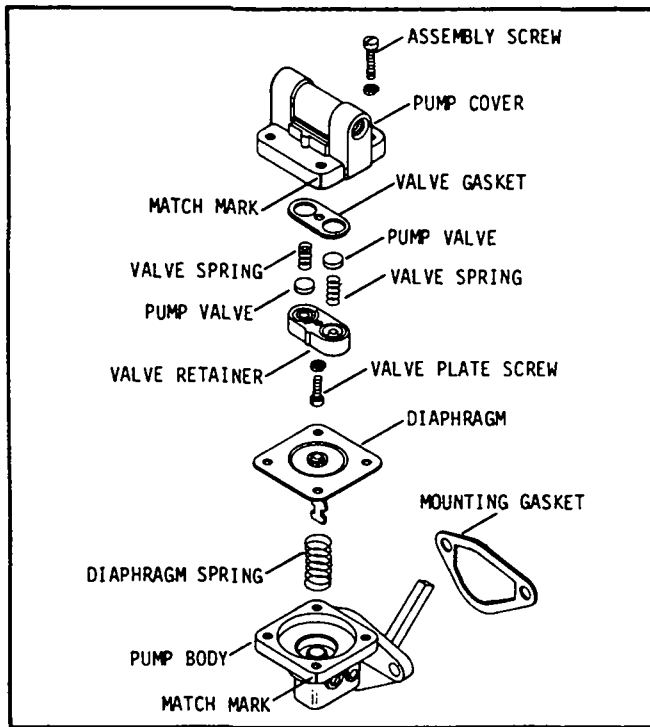


Figure 4 Fuel Pump

FUEL PUMP

The mechanical pump operates off a cam on the camshaft. The fuel pump lever rides on the cam and transmits this mechanical action to a diaphragm within the pump body.

Reconditioning Procedure:

1. Remove fuel lines and mounting screws holding pump to engine.
2. With a file, make an indicating mark across a point at the union of fuel pump body and cover. This is a positive marking to assure proper reassembly. Remove assembly screws and remove cover.
3. Turn cover over and remove valve plate screw and washer. Remove valve retainer, valves, valve springs and valve gasket.
4. Clean fuel head thoroughly with solvent and a fine wire brush.
5. Holding pump cover with diaphragm surface up, place new valve gasket into the cavity. Now assemble the valve spring and valves into the cavity and reassemble valve retainer and lock in position by inserting and tightening fuel pump valve retainer screw.
6. Place pump cover assembly in a clean place and rebuild the lower diaphragm section.
7. Holding mounting bracket, press down on the diaphragm to compress spring under it, then turn bracket 90° to unhook diaphragm so it can be removed.
8. Clean mounting bracket with a solvent and a fine wire brush.
9. Replace the diaphragm operating spring, stand new spring in casting, position diaphragm and press down on diaphragm to compress spring and turn 90° to reconnect diaphragm.
10. Hold mounting bracket, then place the pump cover on it (make sure that indicating marks are in line) and insert the four screws. **DO NOT TIGHTEN.** With the hand on the mounting bracket only, push the pump lever to the limit of its travel and hold in this position while tightening the four screws. This is important to prevent stretching the diaphragm.
11. Mount the fuel pump on engine, using the new mounting gaskets. Connect the fuel lines.

GOVERNOR SYSTEM (all models)

All Kohler Single Cylinder Engines are equipped with centrifugal flyweight mechanical type governors. The governor gear – flyweight mechanism is mounted within the crankcase and driven off a gear on the camshaft.

OPERATION: In operation, centrifugal force causes the flyweights to move outward with increase in speed and inward with decreasing speed. As the flyweights move outward, they force the rod portion of the assembly to push outward. Tension of the governor spring pulls the flyweights back inward with decrease in engine speed. The rod, in turn, contacts a tab on the governor cross shaft causing it to rotate with changing speed. One end of the cross shaft protrudes through the side of the crankcase. Through external linkage the action of the cross

shaft is transmitted to the throttle (or butterfly) valve in the carburetor. When the engine is at rest, the tension of the governor spring should hold the throttle valve in open position.

When a normal load is applied and engine (and governor) speed tends to decrease, the resulting rotation of the cross shaft acts against the governor spring to open the throttle valve wider which, in turn, admits more fuel and restores engine speed. With governor properly adjusted, this action takes place so rapidly that a reduction in speed is hardly noticed. As speed again reaches governed setting, the shaft rotates to either open or close the throttle valve to maintain speed at a relatively constant level.

ADJUSTMENT: Governors are adjusted at the factory and further adjustment should not be necessary unless governor arm or linkage works loose and becomes disconnected. Governor readjustment may be indicated if engine speed surges or hunts with changing load or if speed drops considerably when normal load is applied.

Initial Adjustment: The following procedure can be used on all models for the initial setting. Make this setting with engine stopped.

STEP 1: Loosen (do not remove) nut which holds governor arm to the governor cross shaft.

STEP 2: Grasp end of cross shaft with pliers and turn in counterclockwise direction as far as possible (tab on cross shaft will stop against rod on governor gear assembly).

STEP 3: Pull governor arm all the way from carburetor then retighten nut holding governor arm to shaft. With updraft type carburetor, lift arm as far as it will go then retighten arm nut.

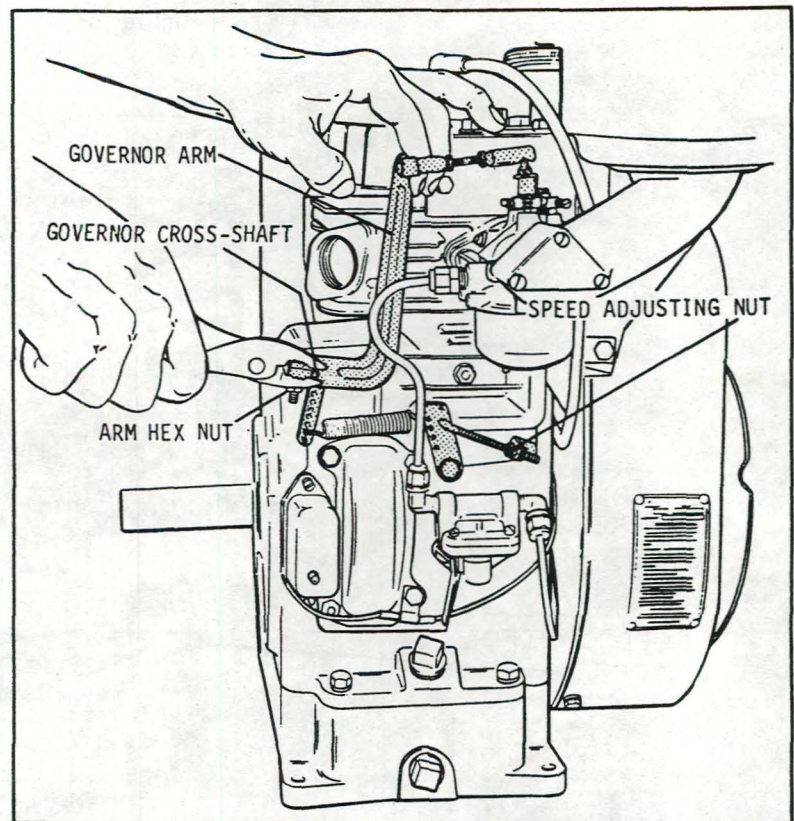


Figure 5 Initial Adjustment
K241, K301

SPEED ADJUSTMENT - K241, K301

After making initial adjustment and hooking up throttle wire on variable speed applications, start engine and check operating speed with hand tachometer. Maximum allowable speed for K241 and K301 models is 3600 RPM. Do not exceed this speed.

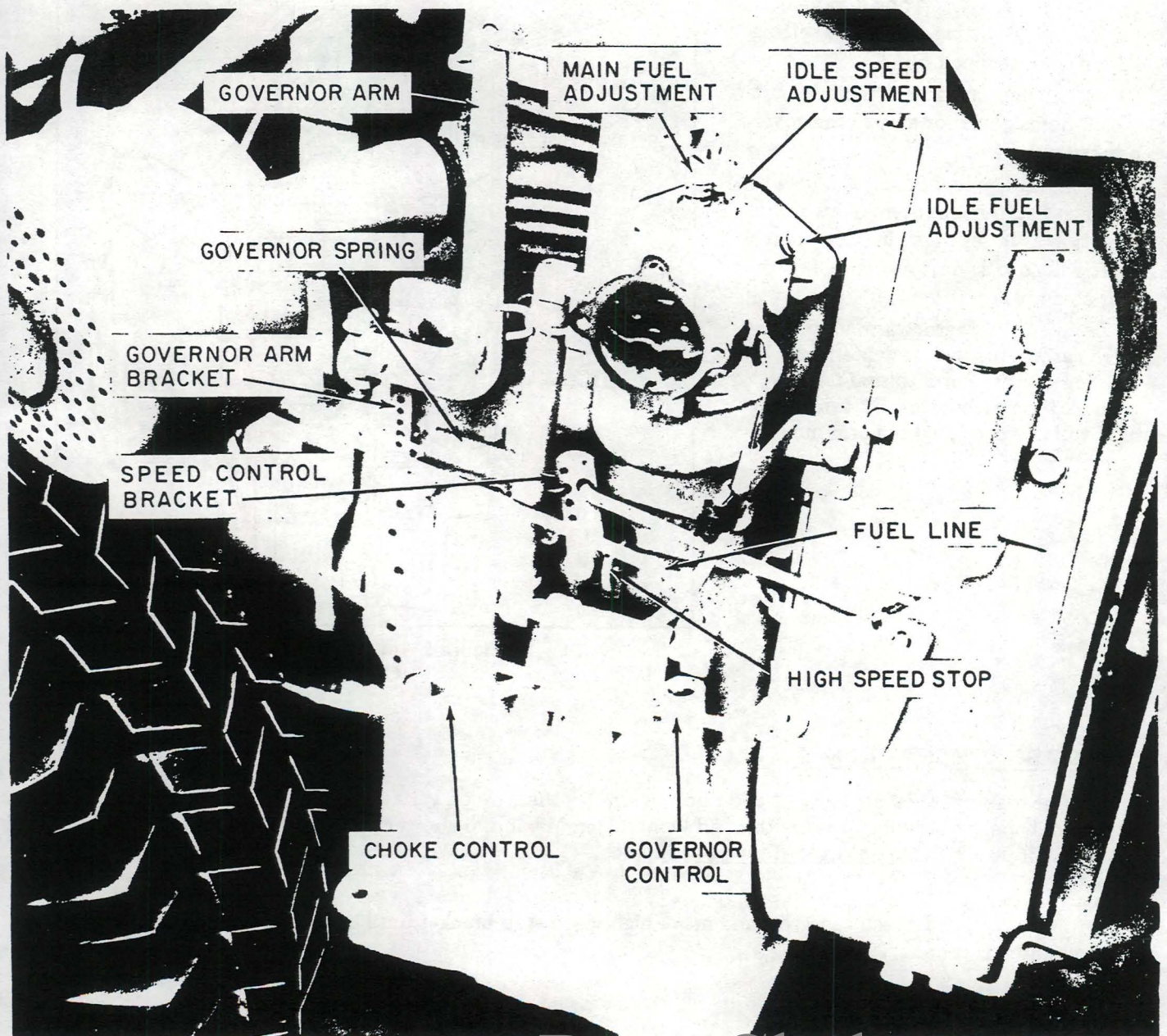
Loosen capscrew and move high speed stop bracket until correct speed is attained then retighten capscrew. (See Figure 6).

SENSITIVITY ADJUSTMENT -- K241, K301

On the K241, K301 governor sensitivity can be adjusted by repositioning the governor spring in the holes on the governor arm and speed control brackets. If set too sensitive, speed surging will occur with change of load. If a big drop in speed occurs when normal load is applied, the governor should be set for greater sensitivity.

Normally, the governor spring is placed in the third hole from bottom on the governor arm bracket and in the second hole from top on speed control bracket. To make governor control more sensitive, increase tension on spring by moving spring into holes spaced further apart. Conversely decreasing spring tension allows broader governor control but less sensitivity.

Figure 6



IGNITION SYSTEM

When checking out an ignition system, start with the components that require most frequent service or adjustment. Hard starting, roughness, low power and erratic operation are often attributed to faulty ignition. All components must be in top condition and the ignition spark must be properly timed to maintain good performance. If performance indicates that ignition is faulty, the first thing to do is to determine if this system is actually at fault. A simple operational test will help determine this.

OPERATIONAL TEST (except Solid State Ignition Models)

Remove high tension lead at the spark plug and hold end terminal about 1/16" to 1/8" away from the cylinder head while cranking the engine. Make sure the engine is cranked fast enough to produce a good spark. If a sharp snappy spark occurs, the trouble is apparently not in the ignition coil, condenser or breaker points although it still could be attributed to poor condition of spark plug. If no spark or a very weak spark occurs, ignition trouble is indicated.

SPARK PLUG

Engine misfire or generally poor operation is often caused by spark plugs in poor condition or with improper gap setting. Always clean area around spark plug before removing to prevent dirt from falling into engine. The first thing to do after removing a spark plug is to carefully note its condition as this is often an indicator of the ignition trouble. Plugs fail for various reasons. Often the porcelain insulator cracks or becomes coated with oil, carbon or other deposits. This can cause the high voltage ignition impulse to pass from the center electrode to ground without jumping the spark gap. As an engine operates, the electrodes are gradually burned or worn away. In time, the gap becomes so wide that the available ignition voltage cannot jump the gap and the engine misses.

Spark Plug Service: Every 100 hours remove plug, check condition and reset gap. Good operating conditions are indicated if plug has light coating or gray or tan deposit. A dead white, blistered coating could indicate overheating. A black (carbon) coating may indicate an "overrich" fuel mixture caused by clogged air cleaner or improper carburetor adjustment. Set spark gap at .025". Tighten plug to 27 ft. lbs. torque when installing.

BREAKER POINTS

Engine operation is greatly affected by breaker point condition and adjustment of the gap. If points are burned or badly oxidized, little or no current will pass and as a result the engine may not operate at all, or if it does run it is likely to miss particularly at full throttle.

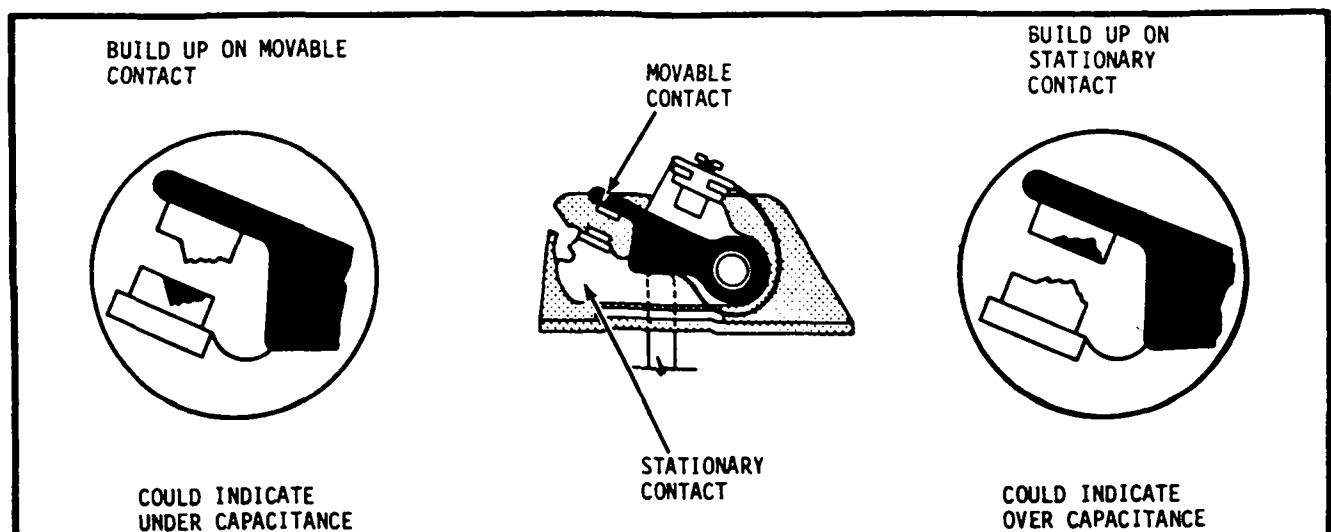


Figure 7 Metal Transfer -- Breaker Points

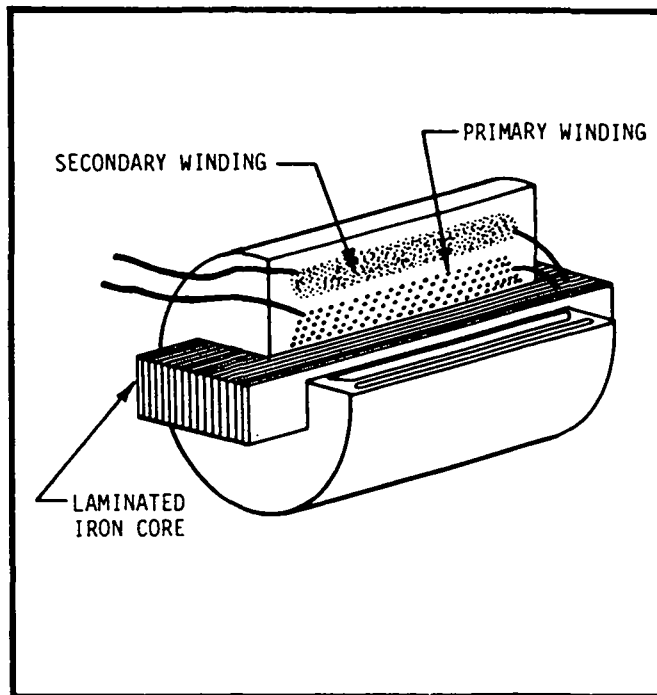


Figure 8 Typical Magneto Ignition Coil

Always replace badly burned or pitted breaker points. A certain amount of build up or metal transfer occurs under normal operating conditions; however, if this occurs too frequently and becomes excessive, the condenser may be at fault -- see Condenser Service for details. Slightly pitted points can be dressed down with a point file, although this should be done only as a temporary field fix. Replace points at first opportunity after filing. If the points are oxidized, rub a piece of coarse cloth between the surfaces. Dirty or oily points can be cleaned with cloth but make sure no particles of lint are left between surfaces.

CONDENSER

If the condenser shorts out, the coil will be unable to release output voltage. On the other hand, if it opens or decreases in capacitance, the ignition points will burn excessively. If badly burned breaker points occur too frequently, the condition of the condenser should be suspected. If condenser has too small capacitance, metal will transfer from the stationary contact to the movable contact. If its capacitance is too large, the metal will build up on the stationary contact.

The condenser can be tested with an ohmmeter or a commercial condenser tester. To check with the ohmmeter, remove the condenser then connect leads between the condenser lead and a good ground on the engine. At first, a low resistance should be indicated; however, this should very quickly rise to a high value. If low resistance is indicated continuously, the condenser is definitely faulty and must be replaced. When using a commercial condenser tester, follow instructions given by the tester manufacturer.

IGNITION COIL

Ignition coils do not require servicing on a regular basis, however, the coil should be kept in clean condition and the terminals and connections must be tight to provide good electrical contact. The rubber nipple on the high tension terminal must be in good condition to prevent leakage of current across exposed surfaces. The coil must be hooked up properly.

TESTING: Special test instruments are required to accurately test ignition coils. When using such equipment, carefully follow instructions stated by the tester manufacturer. A coil can be checked for opens with a simple test lamp. To test for an open primary winding, connect the two test points to the primary terminals -- the lamp will not light if the circuit is open.

To check the secondary circuit, connect one test point to the high tension terminal and the other point to either of the primary terminals. In this case, the lamp will not light but tiny sparks should be noted as the test points are rubbed across the terminals. If the secondary is opened, no sparks will occur. If the tests show that the primary or secondary is open, replace coil or test further with the coil tester.

PERMANENT MAGNETS

if the strength of a permanent magnet is suspected as the cause of magneto trouble, a simple rough test will indicate if its field strength is sufficient. With the flywheel removed, place the blade of a screwdriver (non-magnetized) within one inch of the permanent magnet. If the field strength is sufficient, the blade will be quickly pulled to the magnet.

IGNITION TIMING PROCEDURE

Engines are equipped with a timing sight hole in either the bearing plate or in the blower housing. A snap button is used to cover the hole. The button is easily pried loose with a screwdriver so that the timing marks can be observed. Two timing marks are stamped on the flywheel -- the T mark indicates Top Dead Center (TDC) while the S or SP mark indicates the spark or Spark Run point which is 20° before top dead center.

Two methods can be used for timing -- the timing light method is the more precise way of achieving exact timing. The timing light can be used with magneto ignition systems.

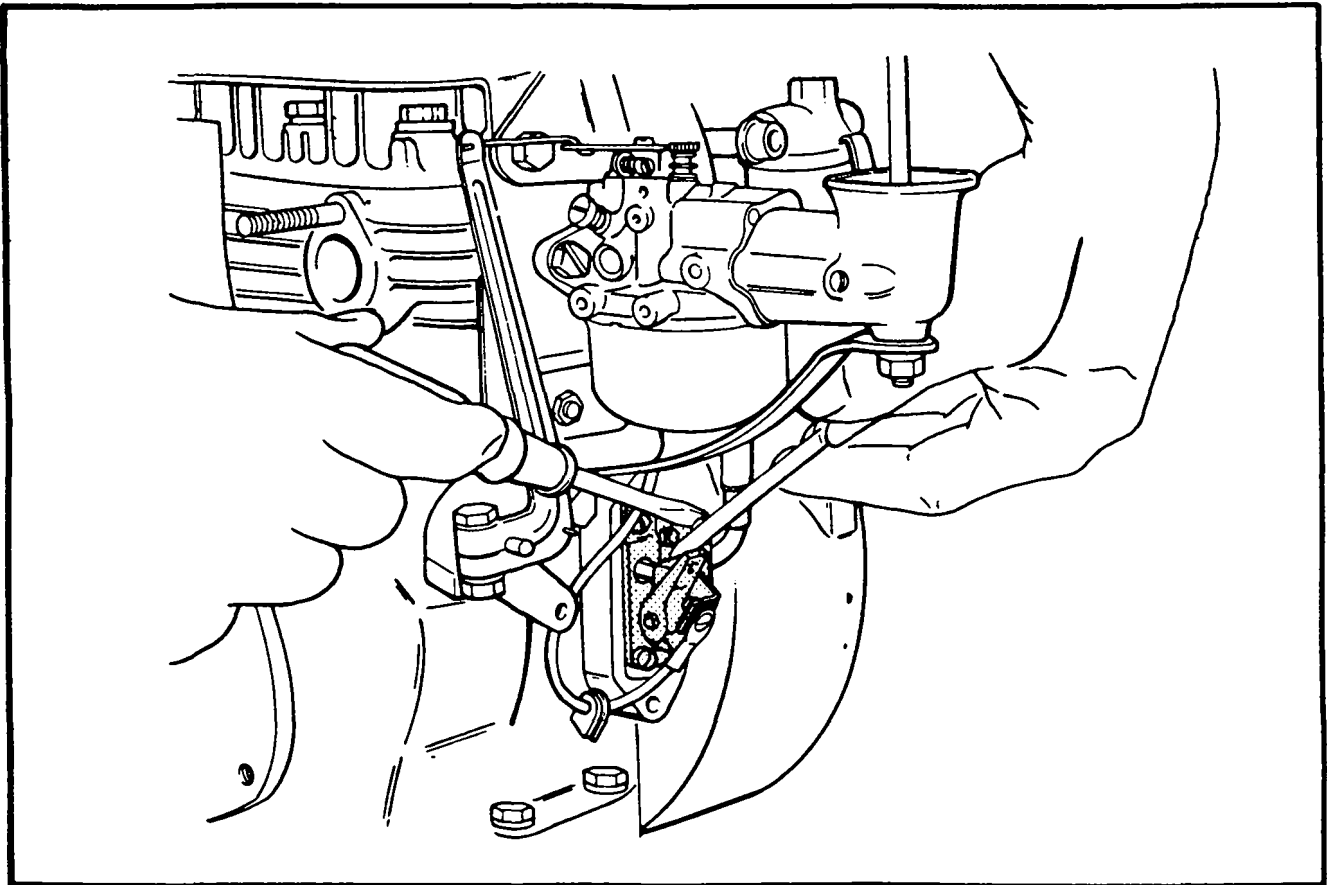


Figure 9 Adjusting Breaker Point Gap

METHOD 1 - STATIC TIMING: Remove breaker point cover and remove spark plug lead to prevent unintentional starting. Rotate engine by hand in direction of normal rotation (clockwise when viewed flywheel end). Points should just begin to break as the S or SP mark appears in the center of the timing sight hole. Continue rotating engine until points reach maximum opening. Measure gap with feeler gauge -- gap should be .020" fully open. If necessary, loosen point gap adjustment screw and readjust gap to .020" full open. Maximum gap setting can vary a few thousandths (.018 - .022") to achieve smoothest running. Securely tighten adjusting screw after timing. This provides a method of timing in order to start the engine after replacing the points. Precise timing with a timing light is required.

METHOD 2 - TIMING LIGHT: Several different types of timing lights are available -- follow manufacturer's instructions for type used. The following timing procedure can be used with most timing lights:

- A. Remove high tension lead at spark plug -- wrap one end of a short piece of fine wire around spark plug terminal. Reconnect lead to terminal -- free end of wire must protrude from under boot.

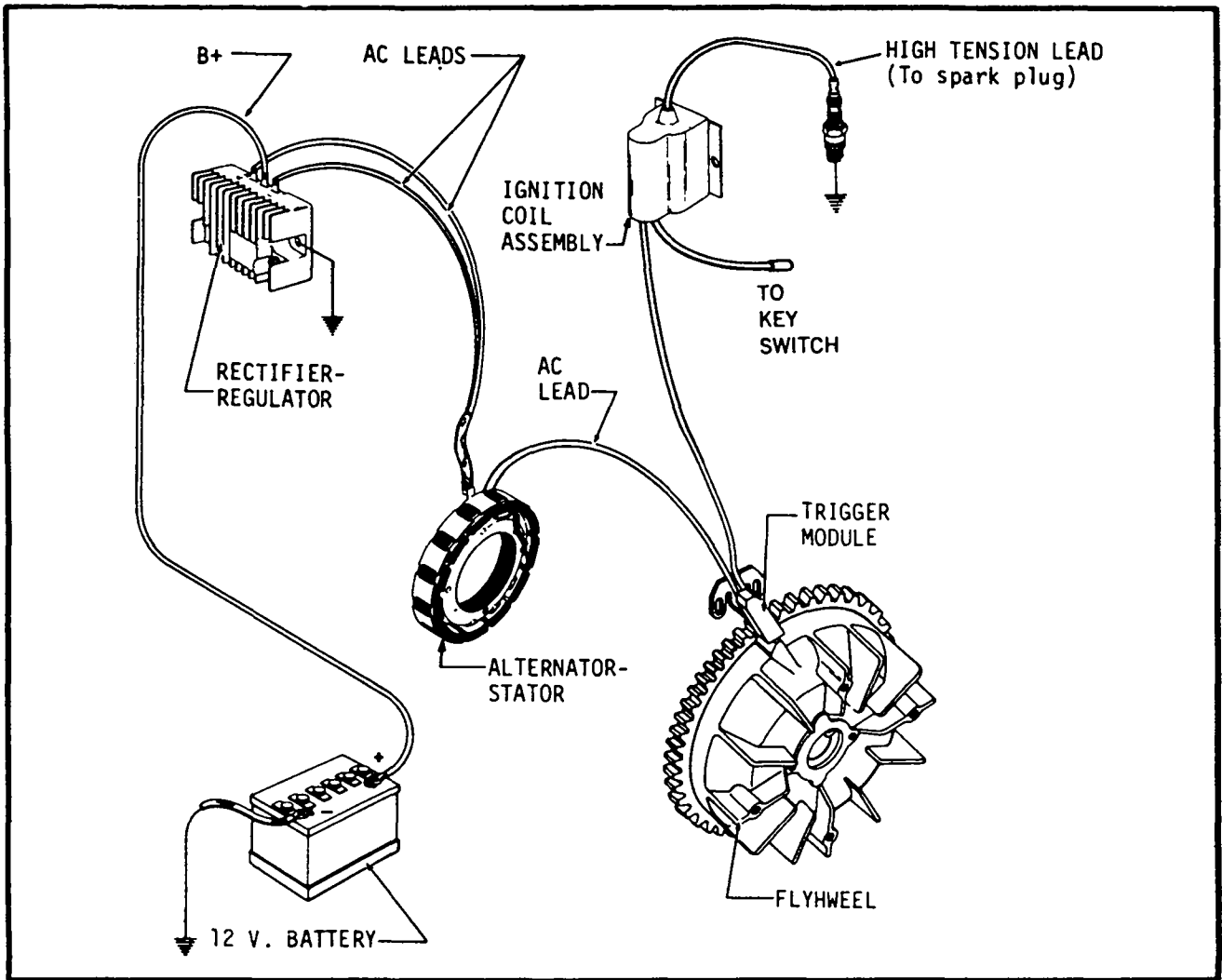


Figure 10 Typical Breakerless - Alternator System (Schematic)

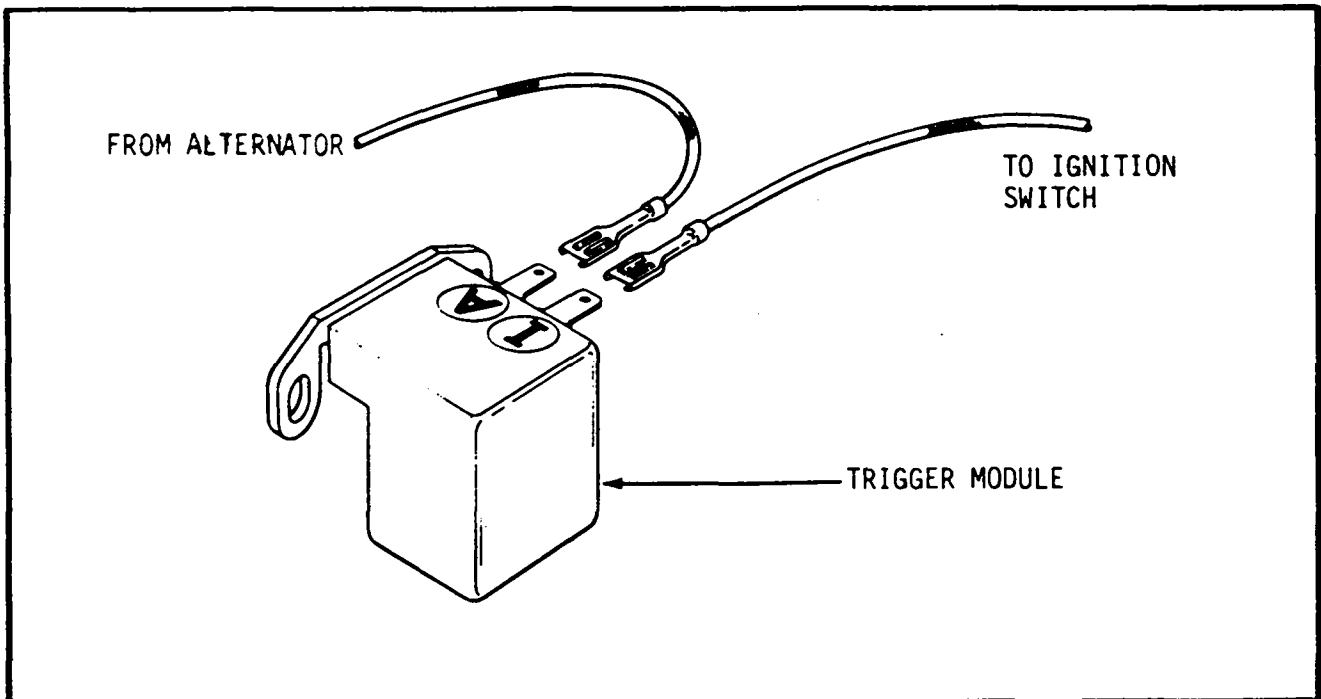


Figure 11 Wiring Connection Detail on Trigger Module

(Note: Step A for timing lights with alligator clips -- some lights have sharp prongs on spark lead -- on these simply push prong thru boot until it contacts metal connector.)

- B. Connect one timing light lead to the wire that has just been wrapped around spark plug terminal.
- C. Connect second timing light lead to hot (ungrounded) side of battery -- see timing light instructions for battery size, wiring, etc.
- D. Connect third timing light lead to ground.
- E. Remove snap button, rotate (by hand) engine until S mark visible -- chalk S line for easy reading.
- F. Start engine, run at 1200 - 1800 RPM, aim timing light into sight hole -- light should flash just as S mark is centered in sight hole or even with center mark on bearing plate or blower housing.
- G. If timing is off -- remove breaker point cover, loosen gap adjusting screw, shift breaker plate until S mark is exactly centered. Retighten adjusting screw before replacing breaker point cover.

BREAKERLESS -- ALTERNATOR IGNITION

The Kohler Breakerless-Alternator Ignition system uses solid state devices which eliminate the need for mechanically operated breaker points. With the breakerless ignition, timing is permanently set for the lifetime of the engine. Except for the spark plug, the entire system is virtually service-free. The system provides an instantaneous, high energy spark which makes spark gap and even condition of the plug less critical.

The breakerless ignition system includes four major components which are: ignition winding (on alternator stator), trigger module, ignition coil assembly and special flywheel with trigger projection. The system also includes the conventional spark plug and lead, plus an ignition switch. The ignition winding is separate from the other AC windings on the alternator stator -- the other windings are used for battery charging and other purposes (Discussed in the Electrical System Section).

The trigger module includes three diodes, a resistor, a sensing coil and magnet, plus an electronic switch called an SCR. The trigger module has two clip-on type terminals. The terminal marked A must be connected to the alternator while the I terminal is connected to the ignition coil -- improper hook-up will cause damage to the electronic devices.

The ignition coil assembly includes the capacitor and a pulse transformer arrangement similar to the conventional high tension coil with primary and secondary windings. The flywheel has a special projection for triggering the ignition.

AIR GAP: The air gap between trigger assembly and projection on the flywheel is usually set at about .015" ($\pm .005$). Although the actual gap setting is not critical to operation at normal speeds, decreasing the gap to .010" may promote faster starting under certain conditions. If a closer gap is desired, rotate flywheel until projection is adjacent to the trigger assembly. To adjust, loosen capscrews on trigger bracket and move trigger closer to projection until .010" gap is measured on feeler gauge. Do not set closer than .010", and make sure flat surfaces on trigger and projection are parallel to each other. Retighten capscrews after gap is readjusted.

TROUBLE ANALYSIS: In case of ignition trouble, make the following tests in the sequence listed until the faulty part is located. Use an ohmmeter or flashlight type continuity tester to perform the Ignition Coil and Trigger Module tests.

Spark Plug Test: Remove plug from head, leave high tension lead connected to plug, ground plug on engine then crank engine fast enough to produce spark -- if spark does not appear between electrodes, use new plug and repeat test. If spark is still not evident, proceed with further tests.

Ignition Coil Assembly Tests: (A) -- Remove high tension lead from terminal on coil. Insert one tester lead in coil terminal and the other to the coil mounting bracket. Continuity through the coil should be indicated. (B) -- Connect one tester lead to the coil mounting bracket and the other to the ignition switch wire. Continuity should not be indicated here. Replace ignition coil assembly if wrong results are obtained from either of these tests.

Trigger Module Tests: (A) -- Connect one tester lead to the AC inlet lead on trigger module and other to lead on trigger side of ignition switch. This should show continuity in one direction but not in the other -- reverse leads to check this. (B) -- Connect one tester lead to the trigger module mounting bracket and the

other to the AC inlet lead to the module. Continuity should be indicated in one direction but not in the opposite – reverse leads to check this. (C) – Connect positive lead of tester to outlet (coil side) wire on ignition switch, connect other lead to the trigger module mounting bracket. Crank engine -- when trigger projection on flywheel passes the trigger module, the flashlight tester should turn on, or if an ohmmeter is used, a 5 to 10 ohm resistance should be indicated. Before being triggered, an open circuit should be indicated. Replace the trigger module if wrong results are obtained from any of these tests.

AC Leads and Winding: If ignition trouble persists after the system checks out in each of the foregoing tests, the AC leads or ignition windings are probably faulty. Replace stator assembly in this event.

ELECTRICAL SYSTEM

Two basic types of electrical systems are in use on Kohler Single Cylinder Engines. One system involves the use of a motor-generator unit which functions as a starting motor and also as a DC generator for charging the storage battery. The other system, the Magneto-Alternator System (also Breakerless-Alternator) uses solid state electronic devices for converting Alternating Current to Direct Current for charging. The charging and cranking circuit of the breakerless-alternator system is almost identical to that of the magneto-alternator system -- the only difference is in the ignition coil or winding on the stator. A small compact starter is used with the alternator systems. The major components of each system are:

MOTOR-GENERATOR SYSTEM

CHARGING CIRCUIT

1. Battery (12 volt)
2. Voltage (& Current) Regulator
3. Motor-Generator

CRANKING CIRCUIT

1. Motor-Generator

MAGNETO-ALTERNATOR SYSTEM *

CHARGING CIRCUIT

1. Battery (12 volt)
2. Rectifier-Regulator
3. Alternator

CRANKING CIRCUIT

1. Compact Starting Motor

* Also Breakerless-Alternator System

A 12 volt storage battery is used with both systems and can therefore be discussed separately. The remainder of the components will have to be grouped according to the electrical system type.

BATTERY (All Models)

Storage batteries used are of the lead-acid type. Lead is used in the construction of the cell plates and sulfuric acid serves as the electrolyte. "Wet" batteries are filled with electrolyte and are stored ready to use if satisfactory charge has been maintained. With "dry charged" batteries, the plates are charged but an electrolyte of specific grade must be added just before using. Both types function in the same general way.

All Kohler Engines use negative ground systems in which the negative (-) terminal of the battery is connected in common ground to the engine while the positive (+) terminal is the "live" terminal. When disconnecting battery always remove ground (-) terminal first.

Voltage Test: With a battery in good condition, each cell contributes approximately 1.95 to 2.08 volts. If less than 0.05 volt difference is noted between the highest and lowest cells, the battery may be recharged. If the difference is more than .05 volts, this could indicate a cracked plate or other damage which could call for replacement of the battery.

Specific Gravity Test: As a battery discharges and the energy is not replenished, sulfuric acid is chemically withdrawn from the electrolyte and lead sulfate deposits continue to build up on the plates. This results in a diminishing specific gravity of the electrolyte. If the specific gravity drops below 1.240, the battery must be recharged. In fully charged condition, the specific gravity will be in the 1.260 - 1.280 range. Hydrometer readings must be corrected for variation in temperature of electrolyte. Add .004 to the reading for every 10° above 80°F. and subtract .004 for every 10° below 80°F.

As a battery is recharged, a reverse chemical reaction takes place which causes the lead sulfate deposits to be changed back to lead, lead dioxide and sulfuric acid. In effect, this reverses the discharge reaction and restores materials to active condition. If sulfate deposits become too great or if the level of the electrolyte is not maintained above the level of the plates, the battery may be permanently damaged.

Safety Percautions: Adequate ventilation must be provided when batteries are being recharged. Also, sparks, open flames and smoking should be avoided since hydrogen gas is produced which, if ignited, can cause an internal explosion that can shatter the battery. This gas is produced in quantity only while the battery receives high rate of charge but can linger for several hours in a poorly ventilated area.

Service: To maintain battery in top condition perform services at frequent intervals:

1. Regularly check level of electrolyte – add water as necessary to maintain level above plates – do not overfill as this can cause poor performance or early failure due to loss of electrolyte.
2. Keep terminals and top of battery clean. Wash with baking soda and rinse with clear water. Do not allow soda solution to enter cells.
3. Check other electrical components if battery repeatedly becomes discharged.

MOTOR – GENERATOR (C-10 only)

A motor-generator is a single unit combining characteristics of both a motor and a generator. As a motor, it functions to convert electrical energy into mechanical energy to crank an engine for starting. As a generator, it functions to convert mechanical energy into electrical energy to recharge the battery. The motor-generator is coupled to the engine through a Vee belt-pulley drive arrangement.

These units feature both series (cranking and shunt) generating windings. The cranking winding, which is in series with the armature, consists of heavy gauge, low resistant wire to carry as high a current as possible. When cranking the current from the battery is allowed to flow through this circuit thus creating a high density magnetic field which interacts with the armature windings and forces the armature to rotate. The shunt field also contributes during starting. After the engine starts and the starting switch opens to break the cranking circuit, the unit functions as a conventional generator with the shunt field producing energy for recharging.

Motor generators mounted at front (flywheel) end of engine rotate in clockwise direction -- units mounted at rear (PTO) end rotate in the reverse or counterclockwise direction when viewed from pulley end.

CAUTION: Never operate the motor-generator during cranking for more than 30 seconds at a time without pausing to allow it to cool for at least 2 minutes. Overheating, caused by excessively long cranking periods, may seriously damage motor-generator.

SERVICE: At periodic intervals, units should be inspected to determine condition. Operating the unit in excessive dust or dirt, at high temperatures or continuously at full output are factors which increase bearing, commutator and brush wear. Frequent cranking due to numerous starts and stops, excessively long cranking periods caused by hard-starting engine conditions, excessively dirty or moist operating conditions or heavy vibration makes servicing necessary at frequent intervals. Service should include checking motor operation, check of the mounting, wiring and connections – all should be tight and in good condition.

If commutator is glazed or dirty, it can be cleaned by placing armature in a lathe. While armature is rotating, hold a strip of No. 00 sandpaper lightly against commutator, moving sandpaper back and forth. Blow out all dust after sanding. If commutator is rough, out of round, has high mica or is extremely dirty, it should be turned down on a lathe and the mica should also be undercut between the bars. Start undercut with 3 cornered file and finish with straight edge file (or hacksaw blade) – make sure no mica remains on the inside edges of the commutator segments.

Belt should be checked to be sure it is in good condition and has correct tension. Low belt tension will permit belt slippage and result in rapid belt wear and either low or erratic generator output. Excessive belt tension will also cause rapid belt wear. Tension should be adjusted so that belt can be depressed 1/2” below tops of both pulleys at the approximate center of the upper span as shown in the accompanying illustration. To adjust, loosen capscrew holding motor-generator unit to upper bracket then shift position of unit until proper tension is obtained. Retighten capscrew after adjustment.

Brushes should be checked about every 200 hours – inspection can be made by removing the two thru bolts and CE frame. Brushes must be at the proper angle and in good firm contact on the commutator. Excessive spring tension will cause rapid brush and commutator wear. Insufficient tension will result in arcing and burning of the brushes and commutator. Correction in tension can be made by bending the brush spring as required. If brush spring shows evidence of overheating (blued or burned), a new spring should be installed. If brushes are worn down to 1/2 their original length, they should be replaced.

LUBRICATION: The hinged cap oilers on earlier units should be filled with 8 to 10 drops of light engine oil every 100 hours of motor-generator operation. Some ball bearings are greaseless and are lubricated by an oil-saturated felt pad. Upon disassembly of the unit, the felt pad should be resaturated with light grade engine oil. Do not pack this type ball bearing with grease. All other ball bearings (without felt pad) should

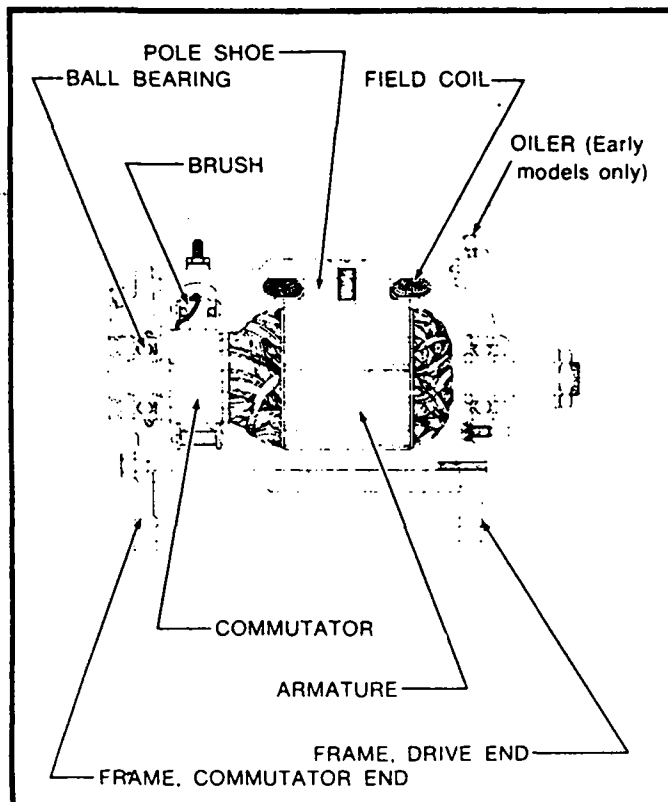


Figure 12 Motor - Generator, Cutaway View

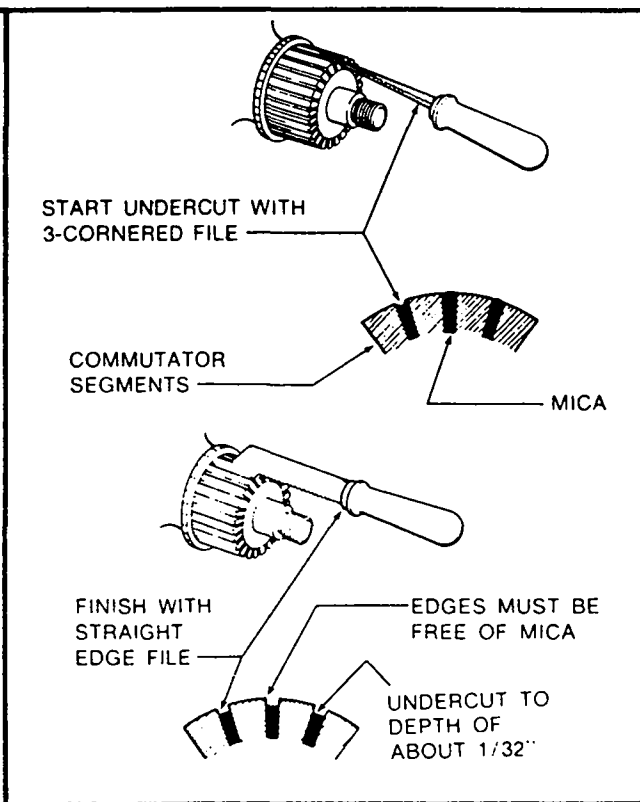


Figure 13 Undercutting Mica On Commutator

be cleaned and repacked with ball bearing grease upon disassembly of the motor-generator. The armature shaft should be wiped clean and coated with a light grade engine oil.

MOTOR TESTS: If unit fails to crank properly, inspect entire cranking circuit for loose or badly corroded connections and damaged wiring. Check battery to determine condition. When battery is satisfactory and wiring and connections are in good condition, close starting switch. If unit fails to crank, wire around motor switch with a heavy jumper lead. If motor-generator operates, the switch is defective and should be replaced. If unit fails to operate, the trouble can be attributed to the engine or to the motor-generator. Excessive friction in the engine from tight bearings or pistons or from too heavy oil causes hard cranking. If unit fails to crank properly when engine is known to be in good operating condition and the rest of the cranking circuit is found to be satisfactory, the motor-generator should be removed for further checking. With the motor-generator removed from the engine, the armature should be checked for freedom of operation by turning the shaft. Tight, dirty or worn bearings, a bent armature shaft or loose pole shoe screws may cause the armature to drag and fail to turn freely. If armature does not turn freely, the motor must be disassembled.

GENERATOR TESTS: If generator output is zero, check the commutator, brushes and internal connections. Sticking brushes, a dirty or gummy commutator or poor connections may prevent the generator from producing any output. Solder thrown from the commutator riser bars indicates that the generator has been overheated from excessive output. Often this leads to an open circuit and burned commutator bars and, consequently, no output. If the brushes are satisfactorily seated and making good contact with the commutator and the cause of trouble is not apparent, the unit should be disassembled and tested according to manufacturer's specifications. Special test equipment will usually be needed for further analysis.

DISASSEMBLY: Noise emanating from a generator may be caused by a loose mounting or drive pulley. It can also be caused by worn or dirty bearings or improperly seated brushes. Dirty bearings may sometimes be saved by cleaning and relubrication, but worn bearings should be replaced. Excessive noise may result if the brush holder is bent resulting in improper seating of the brush. Such a brush holder should be replaced. The end frames, bearings and armatures can be removed or replaced without disturbing any electrical connections. The brush holder assemblies are mounted individually on the walls of the field frame. To disassemble motor-generator, use the following procedure:

1. Unscrew thru bolts and remove commutator end frame from the field frame.
2. Place armature in a vise with soft jaws and remove shaft nut, pulley and the drive end frame.
3. Remove brush holders if new ones are to be installed, by drilling out the rivets holding them to the field frame. Install new holders, securing them to frame with new rivet or screws, nuts and washers.

4. The armature or field coils must not be cleaned in degreasing tank or with degreasing compounds since insulation damage might occur. Ball bearings should be thoroughly cleaned and repacked with high melting point ball bearing grease. Other parts should be cleaned and carefully inspected for wear or other damage. Any defective part should be repaired or replaced. On reassembly, all soldered electric connections should be made with rosin flux. Acid must not be used on electrical connections.

VOLTAGE REGULATOR (C-10 only)

The current-voltage regulator is automatic in its control of current and voltage to battery. A grounding strap is used to connect case of voltage regulator in common ground with engine. If this becomes loose and makes poor electrical connection, poor regulation can result. Make sure regulator is properly grounded at all times. Many cases of regulator trouble can be eliminated by a simple cleaning of the contact points plus possible readjustment. The flat point always develops a slight cavity and is the point that requires most attention. It is not necessary to have a perfectly flat surface on this point, but cleaning the surface down to pure metal with a fine cut riffl file will insure long periods of service. The file should not be allowed to become greasy and should not be used on other metals. After filing, wipe point with lintless cloth, saturated in trichloroethylene to insure clean surfaces. The flat point is in the armature. Clean by loosening the upper contact support and moving it to one side. CAUTION: NEVER USE EMERY CLOTH OR SANDPAPER TO CLEAN CONTACT POINTS.

Run engine for at least 20 minutes before making voltage adjustments as this will allow temperature of regulator to stabilize. Use same battery and generator that will be used on engine for correct settings.

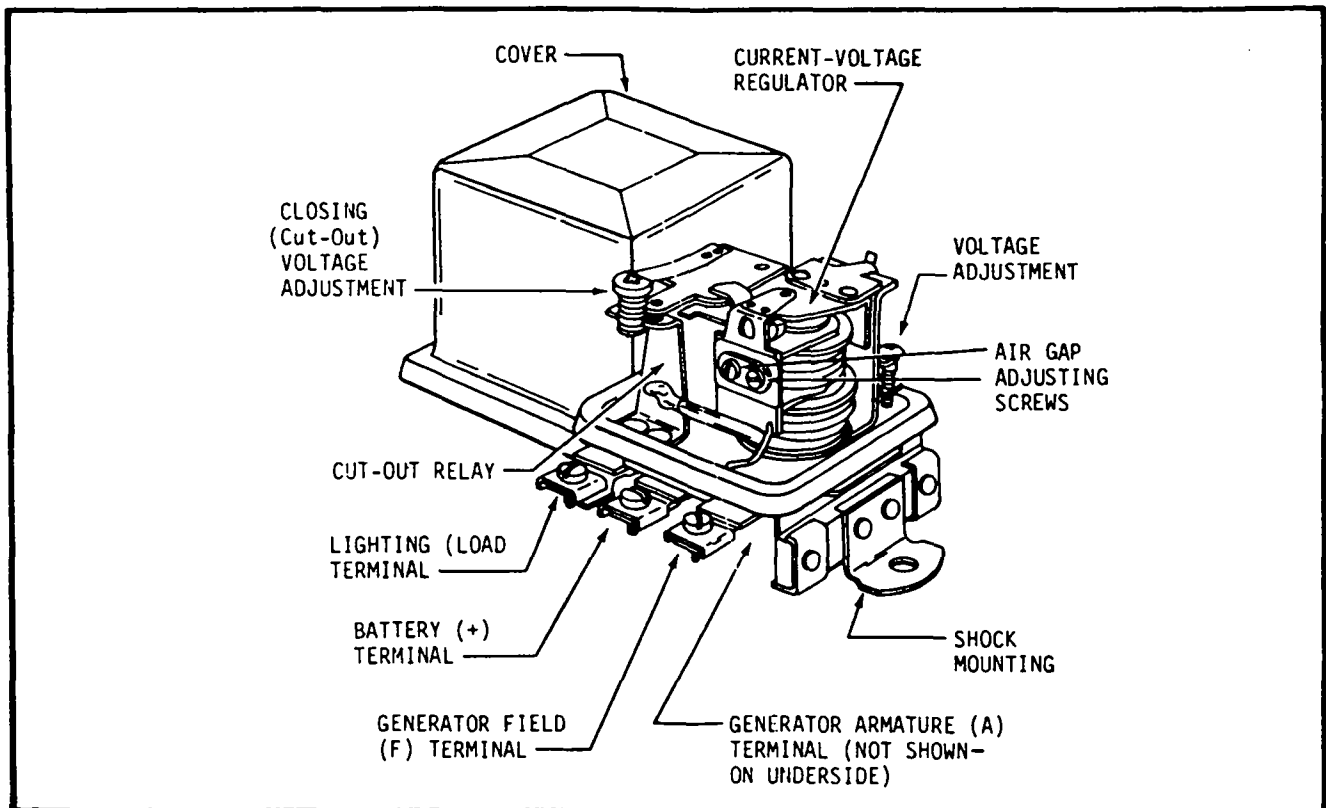


Figure 14 Typical Voltage Regulator

Cutout Relay Unit: This requires three checks and adjustments: air gap, point opening and closing voltage. The air gap and point opening adjustments must be made with the battery disconnected!

1. **Air Gap:** Place fingers on the armature directly above the core and press armature down until the points just close, then measure the air gap between the armature and the center of the core. Gap should be .020". Adjust by raising or lowering armature at its hinge mounting. Retighten screws after adjustment.
2. **Point Opening:** Adjust point opening by bending the armature stop. Opening should be .020".
3. **Closing Voltage:** Adjust closing voltage by turning screw clockwise to increase spring tension

and voltage, counterclockwise to decrease spring tension and closing voltage. Be sure that closing voltage adjustment is at least 0.5 volt less than the current voltage regulator unit setting. This should be 12.8 volts.

Current-Voltage Regulator Unit: This requires two inspections and adjustments: The armature air gap and the voltage setting. Disconnect battery before making these adjustments.

1. **Armature Air Gap:** To check air gap, push the armature down until contact points are still just touching, then measure air gap. This should be .075". Adjust by loosening contact mounting screws and raising or lowering the contact bracket as required. Be sure points are lined up and screws are retightened after adjustment and before resetting voltage setting.
2. **Voltage Setting:** Adjust the voltage setting by turning adjusting screw – clockwise to increase the voltage setting and counterclockwise to decrease the voltage setting. After each adjustment, replace cover and allow ample running time to again stabilize voltage and temperature before rechecking the voltage setting.

CAUTION: If adjusting screw is turned down (clockwise) beyond normal range required for adjustment, the spring support may fail to return when pressure is relieved. If this happens, turn screw counterclockwise until enough clearance develops between the screw head and spring support. Then bend spring support upward carefully with a small pliers until contact is made with the screw head. The final setting should always be approached by increasing spring tension. In other words, if setting is too high, unit should be adjusted below the required value then raised to the exact setting by increasing spring tension. Be sure screw is exerting force on hanger.

Spring Replacement: When current voltage unit is badly out of adjustment or requires spring replacement, use following procedure: Replacing regulator spring requires care to prevent bending or distorting spring support or the armature hinge. Preferably spring should be hooked at lower end first then stretched up with a screwdriver blade or other suitable tool, inserted between the turns until the upper end of the spring can be hooked.

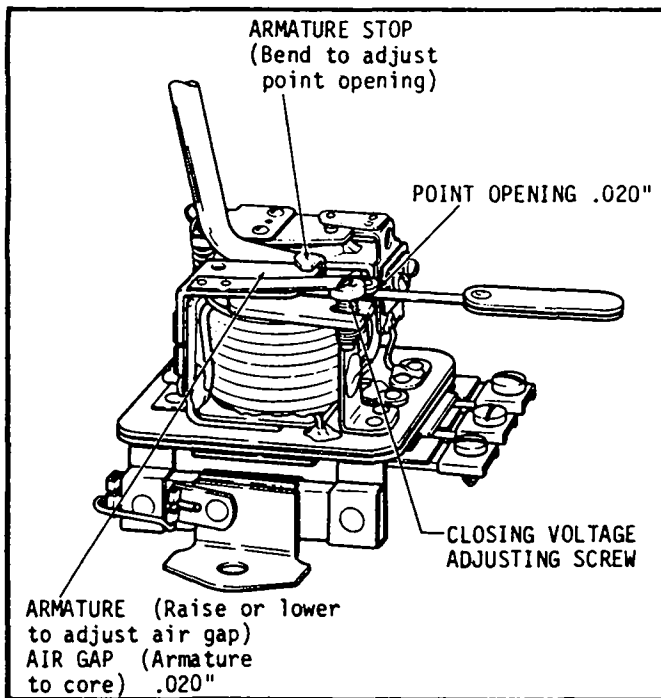


Figure 15 Cutout Relay Adjustments

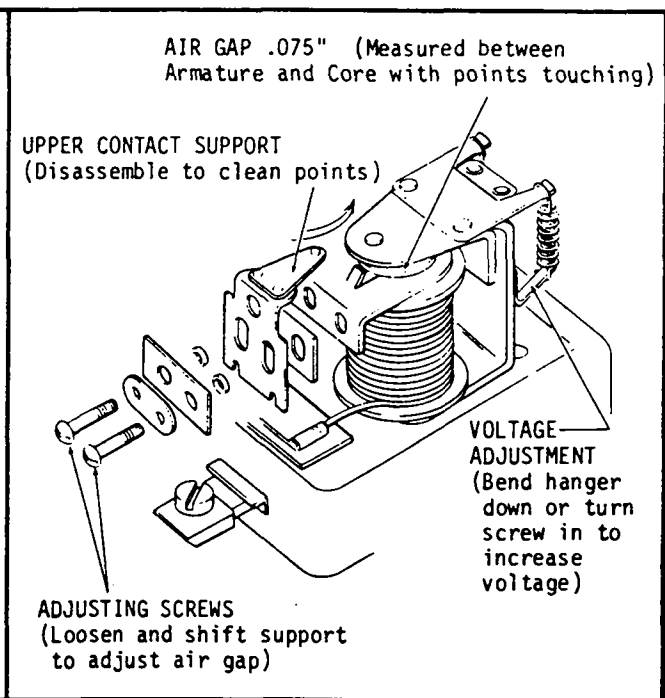


Figure 16 Current - Voltage Adjustments

MAGNETO-ALTERNATOR SYSTEMS (C-10A and C-12)

The 10 Amp Magneto-Alternator System consists of a magneto ignition circuit and a battery charging or alternator circuit. This system should not be confused with other magneto-alternator systems which provide energy for ignition and lighting but do not have battery charging capabilities.

The alternator system consists of three major components: a permanent magnet ring bolted to the inside rim of the flywheel, an alternator stator assembly which is affixed to the engine bearing plate and a rectifier-regulator unit which is externally mounted on the tractor. Identification of engines with this system can be made through the rectifier-regulator unit as shown on the accompanying illustration.

Operation: As the magnet ring is rotated around the stator, an Alternating Current is generated in the stator winding. The AC thus produced is rectified to Direct Current in the rectifier-regulator unit. This is accomplished through the use of solid state (no moving parts) electronic devices which are arranged to form a full wave bridge rectifier. Regulation is also provided by electronic devices which "sense" the counter-voltage created by the battery to control or limit the charging rate. Since heat is generated in operation of certain of these electronic devices, cooling fins are provided on the rectifier-regulator to help dissipate the heat. The unit should be mounted with the fins in a vertical position and preferably in a well ventilated area.

Service: The same service procedure used for the conventional magneto-ignition system also applies to this magneto circuit. The magneto coil is secured to a stator post by a tab which is wedged between the post and the inside of the coil. If coil replacement becomes necessary, the flywheel must first be removed to gain access to the stator. The retaining tab must be pulled out of the slot before the faulty coil can be removed from the stator post. When installing new coil, position tab with clip in hole on stator, then slip coil over tab and stator post. After the coil is in place, bend protruding end of tab over to prevent interference with magnet ring.

No adjustments are possible on the alternator system and field service on this system is not recommended. The faulty part should be replaced by a new part. Repair of the rectifier-regulator, which is a sealed unit, requires the use of special test equipment available only at the place of manufacture. Stator repairs must also be performed with special equipment. The accompanying Trouble Analysis Chart can be used to pinpoint the faulty part.

Precautions

1. Battery polarity must be correct. Negative ground systems are used.
2. Prevent alternator leads (AC) from touching or shorting. This could permanently damage the stator.
3. Disconnect leads at rectifier-regulator before electric welding is done on equipment in common ground with engine.

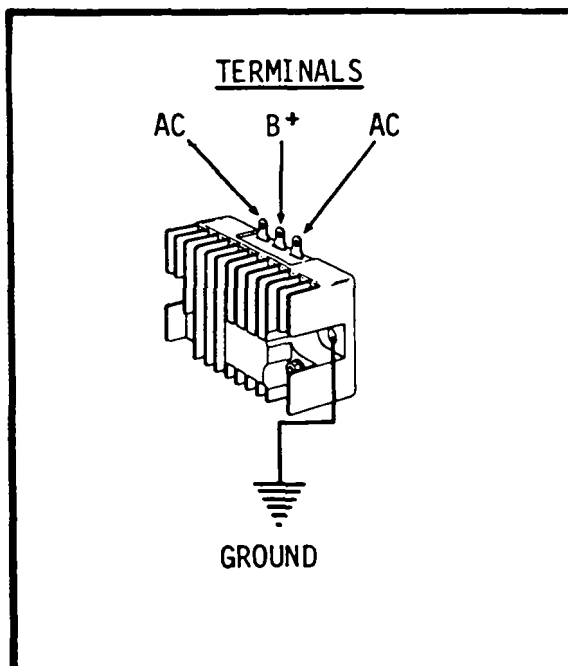


Figure 17 Rectifier - Regulator Assembly

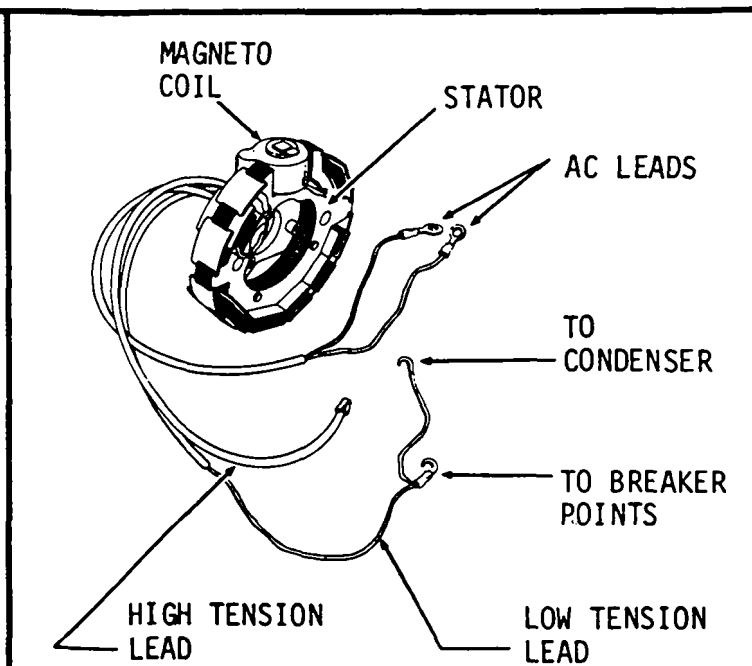
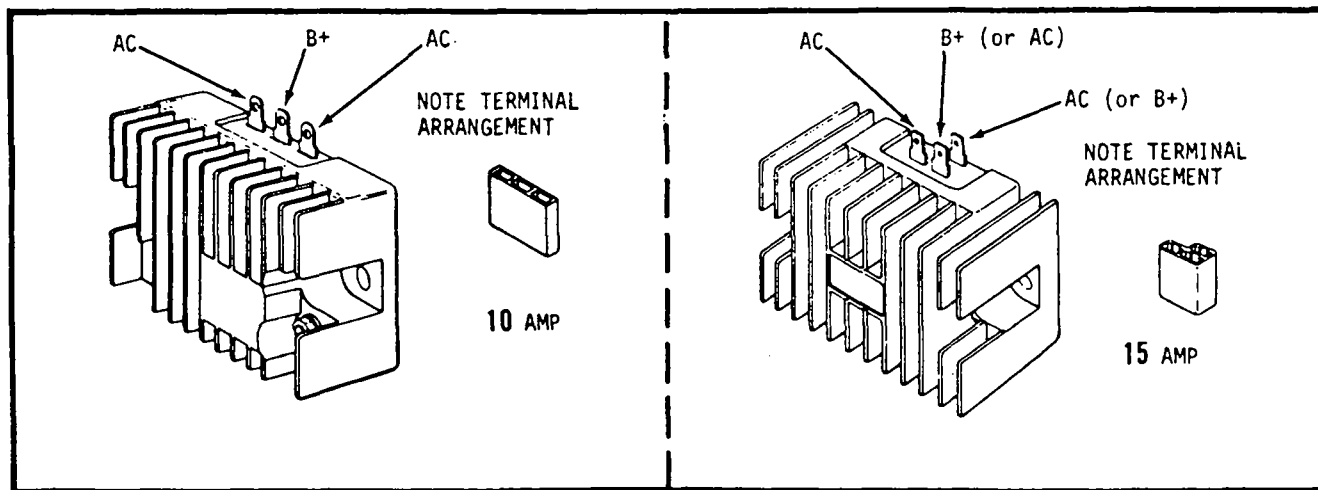


Figure 18 Alternator Stator Assembly

TROUBLE ANALYSIS
10 AMP MAGNETO - ALTERNATOR

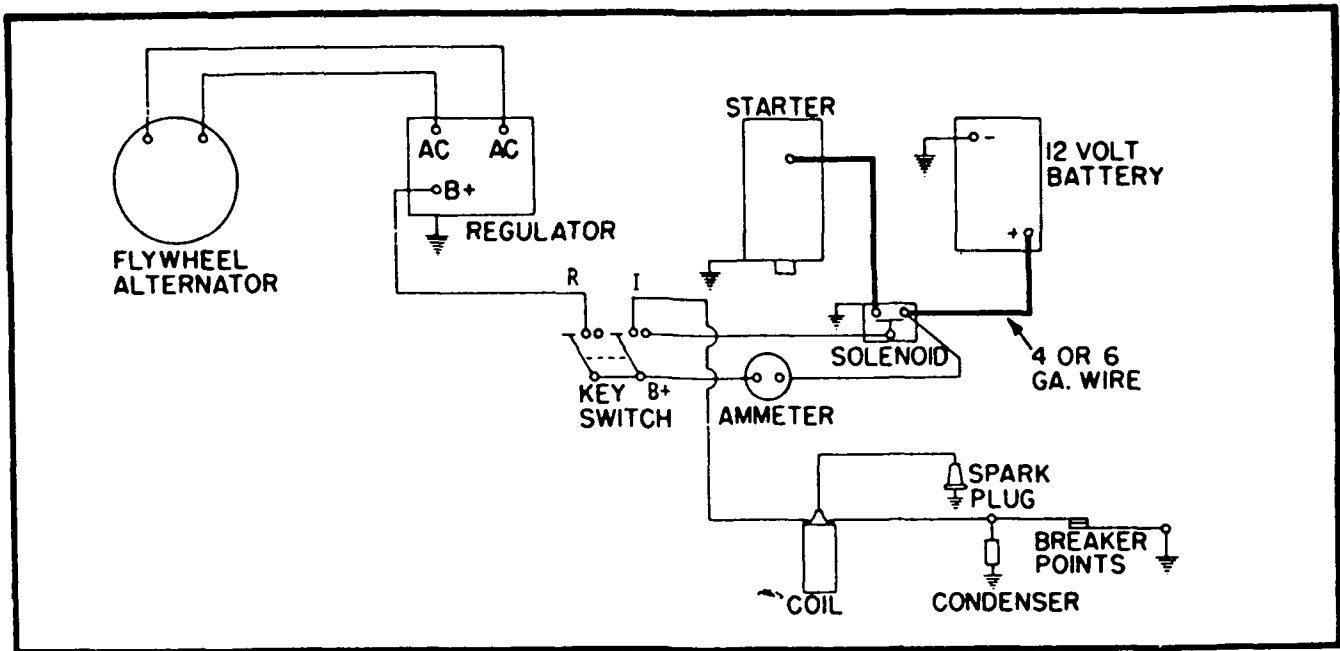
CONDITION: NO CHARGE TO BATTERY	POSSIBLE FAULT/REMEDY
<p>TEST A - Disconnect B+ cable at positive (+) terminal of battery. Connect DC Voltmeter between B+ cable and ground. With engine running at full speed (no load), check DC voltage:</p> <p>A-1 - If above 14 volts.</p> <p>A-2 - If less than 14 volts (but above 0 volts).</p> <p>A-3 - If 0 volts.</p>	<p>A-1 - Alternator system OK - ammeter may be giving false reading. Repair or replace ammeter.</p> <p>A-2 - Check for defective rectifier - regulator (TEST C)</p> <p>A-3 - Check for defective stator or rectifier - regulator (TEST C).</p>
<p>TEST B - With B+ cable reconnected, check B+ (at terminal on rectifier - regulator) to ground with DC Voltmeter. If 13.8 volts or higher, place load (lights) on battery to reduce voltage below 13.6 volts:</p> <p>B-1 - If charge rate increases.</p> <p>B-2 - If charge rate does not increase.</p>	<p>B-1 - Indicates alternator system OK, battery was fully charged.</p> <p>B-2 - Check for defective stator or rectifier - regulator (TEST C).</p>
<p>TEST C - Unplug AC leads at rectifier - regulator, connect AC Voltmeter across AC leads, check voltage with engine running at full speed (no load):</p> <p>C-1 - If less than 20 volts.</p> <p>C-2 - If more than 20 volts.</p>	<p>C-1 - Defective stator, replace with new assembly.</p> <p>C-2 - Defective rectifier - regulator, replace with new unit.</p>
CONDITION: BATTERY CONTINUOUSLY CHARGES AT HIGH RATE	POSSIBLE FAULT/REMEDY
<p>TEST D - Check B+ to ground with DC Voltmeter:</p> <p>D-1 - If over 14.7 volts.</p> <p>D-2 - If under 14.7 volts.</p>	<p>D-1 - Rectifier - regulator not functioning properly. Replace with new unit.</p> <p>D-2 - Alternator system OK. Battery unable to hold charge. Check specific gravity of battery. Replace if necessary.</p>



RECTIFIER-REGULATOR UNITS--10 AND 15 AMP SYSTEMS

15 AMP ALTERNATOR

The 15 amp alternator circuit includes three major components which are: a ceramic magnet ring which is permanently affixed to an inner rim of the flywheel, the alternator stator mounted on the bearing plate of the engine and a rectifier-regulator unit which is mounted either on the engine or on equipment powered by the engine. Terminals on the 15 amp rectifier-regulator are positioned in a different pattern than those on the 10 amp rectifier-regulator to prevent the two systems from being hooked up in error. The 15 amp rectifier-regulator has different solid-state components and therefore cannot be used with any other charging

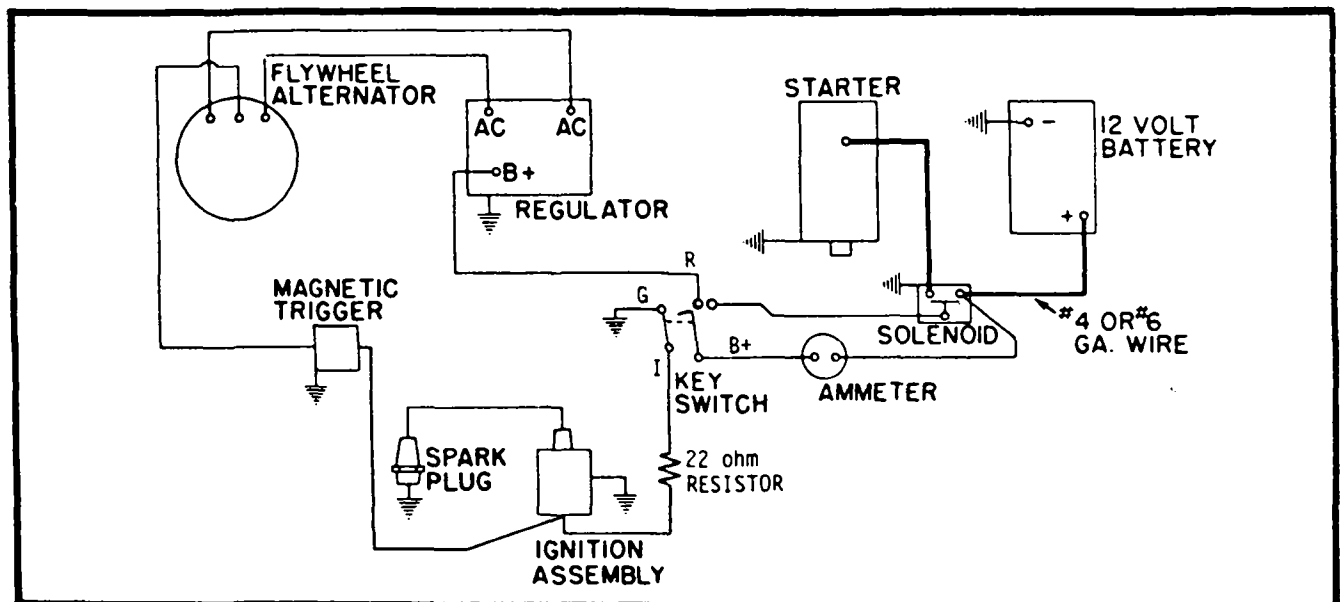


ALTERNATOR CHARGING-BATTERY IGNITION SYSTEM (15 AMP SHOWN)

system. The 15 amp unit is slightly larger, physically, than the 10 amp unit. Other main differences are found in the ceramic magnet ring and the alternator stator with more posts and windings which accounts for the higher output than the 10 amp system.

The ceramic ring is permanently assembled with roll pins and compression locking pins on the flywheel first and is then charged magnetically. Because of this and the fact that special tools are required to install the ring, it cannot be ordered or serviced as a separate item. The ceramic material allows better and more complete alignment of magnetic poles of the electrons which thus produces an extremely high strength magnetic field. While ceramic magnets are very strong, the material is brittle and can crack or break if struck with a hard object or when dropped. If the magnets are badly damaged, a new flywheel, complete with new ceramic ring is required — the replacement flywheel must be charged on special equipment at the factory just prior to shipment. When working on engines with this system, avoid any metallic chips or objects that could be attracted to and stick on the magnets.

Two different types of ignition circuits are used in conjunction with the 15 amp battery charging systems. They are the battery ignition and breakerless ignition circuits. Magneto type ignition is not available with 15 amp systems. The ignition circuits are described in the foregoing section. The stator used with the battery type ignition circuit has 18 posts but only 16 are wound. On breakerless ignition circuits, these two extra



ALTERNATOR CHARGING-BREAKERLESS IGNITION SYSTEM (15 AMP SHOWN)

posts are wound to provide energy for ignition. The ignition winding on the breakerless circuits are of very thin wire which is covered by an epoxy — be careful when installing the flywheel not to touch the sharp edges against the wires as they can be easily cut in spite of the protective covering.

SERVICE: No adjustments are possible on the alternator system and field service is not recommended. The faulty part should be replaced by a new part. The Trouble Analysis Chart can be used to pinpoint the faulty part on a 15 amp system.

TESTS: There are only a few tests that can be applied to the charging circuit. If the battery is not being charged, check out the battery first for cracked cells, etc., — if the battery proves to be in good condition, that is, the tests reveal it is able to hold charge, the trouble is either in a faulty rectifier-regulator or in the stator windings. Check stator per test procedures outlined in the accompanying trouble shooting chart.

The ignition circuit functions the same as previously described breakerless and/or battery ignition circuits and should be tested or serviced the same way.

Since the rectifier-regulator will not work (SCR's cannot turn on) without a battery in the system, there are no actual tests that can be performed on this unit with equipment in the field — it will either regulate as required or it will not function at all. If it is not working, check to make sure that a good ground contact is made between rectifier and vehicle or engine — often paint causes poor electrical path here.

PRECAUTIONS — 15 AMP SYSTEMS

1. Battery polarity must be correct. Negative ground systems are used with Kohler Engines.
2. Prevent alternator leads (AC) from touching or shorting. This could permanently damage the stator.
3. Disconnect leads at rectifier-regulator before electric welding is done on equipment in common ground with engine.
4. Do not operate for any length of time without a battery in the system.

PRE-SERVICE PROCEDURE

1. Check to make sure that a good ground is provided between the rectifier-regulator unit and the equipment. This must be in common ground with the engine and battery. (See wiring diagrams)
2. Check for and correct poor connections or broken wires.

TROUBLE SHOOTING - 15 AMP SYSTEM

TEST WITH ENGINE RUNNING AT 3600 RPM - NO LOAD

CONDITION: NO CHARGE TO BATTERY	POSSIBLE FAULT/REMEDY
<p>TEST A -- With B+ cable connected, check B+ (at terminal on rectifier-regulator) to ground with DC Voltmeter. If 13.8 volts or higher, place minimum load of 5* amps on battery to reduce voltage:</p> <p>A-1 -- If charge rate increases.</p> <p>A-2 -- If charge rate does not increase.</p>	<p>A-1 -- Indicates alternator system OK, battery was fully charged.</p> <p>A-2 -- Check for defective stator or rectifier-regulator (TEST B).</p>
<p>TEST B -- Unplug leads at rectifier-regulator, connect VOM (multimeter) across AC leads, check AC voltage:</p> <p>B-1 -- If less than 28 volts.</p> <p>B-2 -- If more than 28 volts.</p>	<p>B-1 -- Defective stator, replace with new assembly.</p> <p>B-2 -- Defective rectifier-regulator, replace with new unit.</p>
CONDITION: BATTERY CONTINUOUSLY CHARGES AT HIGH RATE	POSSIBLE FAULT/REMEDY
<p>TEST C -- Check B+ to ground with DC Voltmeter:</p> <p>C-1 -- If over 14.7 volts.</p> <p>C-2 -- If under 14.7 volts.</p>	<p>C-1 -- Rectifier-regulator not functioning properly. Replace with new unit.</p> <p>C-2 -- Alternator system OK. Battery unable to hold charge. Check specific gravity of battery. Replace if necessary.</p>

*Turn lights on if 60 watts or more or simulate load by placing a 2.5 ohm 100 watt resistor across battery terminals.

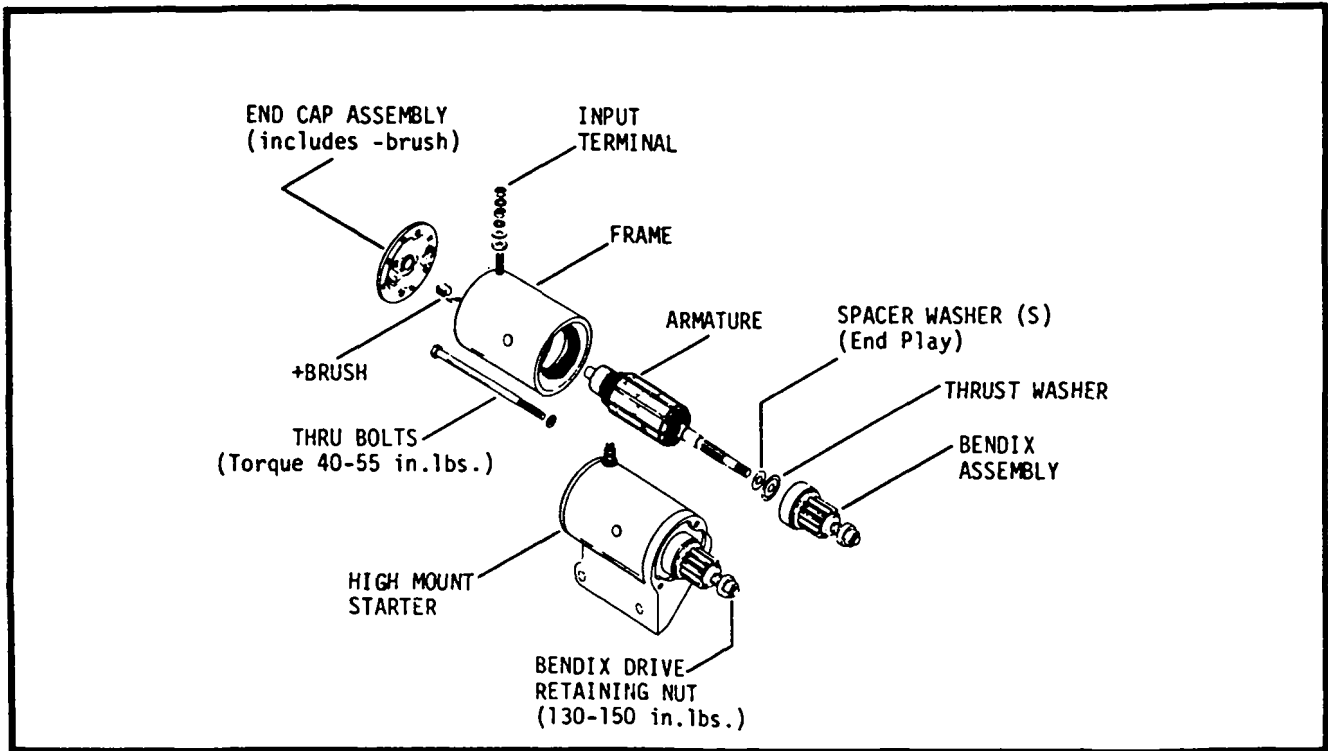


Figure 19 Compact Starting Motor

COMPACT STARTING MOTOR (C-10A and C-12)

The compact starting motors used with magneto-alternator (ignition and battery charging) systems, use Bendix type drives to engage and disengage from the engine.

OPERATION: When the starting circuit is closed and the armature starts to rotate, the Bendix drive pinion moves laterally on a splined sleeve into mesh with the flywheel ring gear. When the pinion butts against a stop washer at the end of the armature shaft, the pinion rotates along with the armature to crank the engine. The armature and pinion remain in positive engagement until the engine fires and attains the speed where the flywheel begins overriding the armature. At this instant, the greater momentum of the flywheel throws the pinion out of mesh and back into the retracted or disengaged position. After the starting circuit is opened and as the armature coasts to a stop, a small spring holds the pinion in the retracted position.

PRECAUTIONS: In the event of a "false start", that is, if the engine gets up sufficient speed to disengage the starter but fails to continue running, the engine must be allowed to come to a complete halt before a restart attempt is made. If the flywheel is still rotating when the starter is engaged, the pinion and ring gear will clash and almost certainly be damaged.

Also, as with all starting motors, the cranking time must be limited to prevent overheating of the starter. On these compact starters, the maximum time allowed for cranking is 60 seconds followed by a 30 second cooling period. The cranking limit is not unreasonable for if an engine fails to start after this length of time, ignition or carburetion troubles are indicated and these should be corrected before the engine is placed in operation.

SERVICE: These starters are pre-lubricated during assembly and further lubrication is not normally needed until the starter is partially disassembled for brush or commutator servicing. These services are not required at any specific hourly basis -- they should be performed only after starter performance indicates the need of such service. Instructions for brush, commutator and lubrication service follow the Trouble Analysis Chart.

The end cap assembly must be removed to inspect and service the brushes and commutator.

Remove the two thru bolts then carefully slip end cap off end of armature. Lift spring and remove positive brush from holder if complete removal of end cap is necessary.

Brush-Commutator Service: Use a coarse cloth to clean brushes and commutator. If commutator is grooved or extremely dirty, use a commutator stone or fine sandpaper to polish -- do not use emery cloth. Brushes should be replaced if unevenly worn or worn to less than 5/16" in length. Brush replacement is made with a new Brush Kit. The rivet must be drilled out and the new brush riveted in its place. Make sure good mechanical and electrical contacts are made. Positive brush is affixed to field winding. Peel back insulating material, remove old brush. Solder or clip new brush to same spot rewrap insulating material around new joint.

End Cap Installation: Before reassembling new or serviced end cap assembly, lightly coat bushing and end of the armature shaft with SAE No. 10 oil -- make sure there is no excess of oil to splatter from these parts. Insert positive brush in a holder. Hold positive brush spring away with a needle nose pliers, then carefully guide end cap into position -- release brush spring after brushes are started on commutator. Secure end cap to frame with two thru bolts. Tighten bolts to 40 - 55 inch lb. torque value.

Bendix Drive Assembly: To inspect and service the Bendix drive, remove starter from engine (remove two mounting bolts). If drive pinion or splined sleeve is damaged, replace Bendix drive assembly. If Bendix is in good condition, wipe clean -- do not lubricate -- leave completely dry.

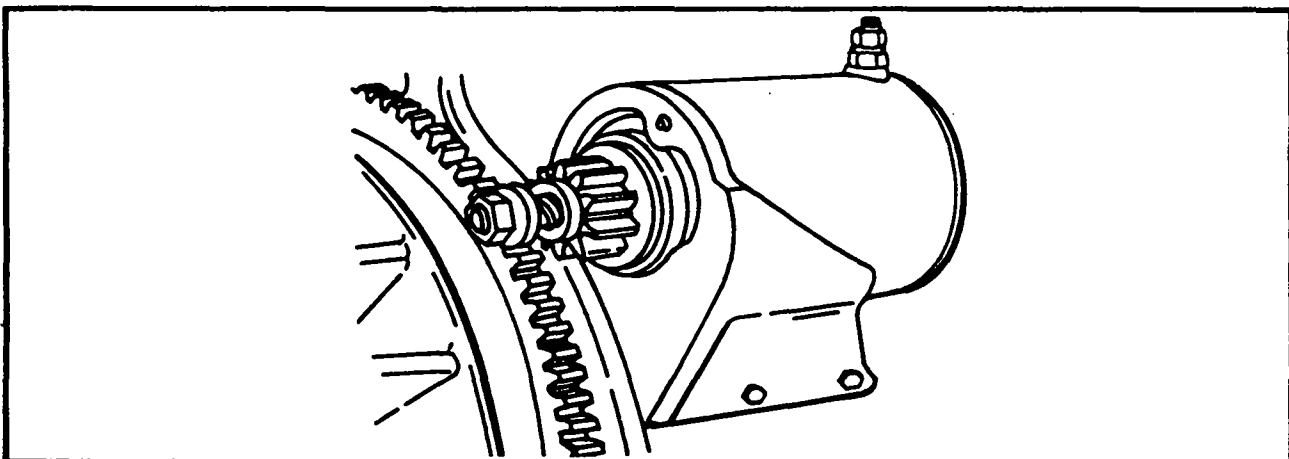


Figure 20 Bendix Drive - Ring Gear Engagement

MOUNTING-ALIGNMENT: Make sure the special mounting bolts (and lock washers) are used when installing starter. In addition to securing the starter to the machined surface on the crankcase, these special bolts provide proper alignment of the Bendix drive gear to the ring gear on the engine. Use of ordinary bolts will allow the starter to shift which could result in clashing and damage to the gears.

Trouble Analysis: Problems that can occur during normal usage are listed in the accompanying chart. The symptom, possible cause and the suggested remedy are stated. If these steps do not solve the problem, the starting motor should be replaced. Replacement of the end cap assembly, which includes the negative brush and spring, is the only recommended field service that requires partial disassembly of the motor – complete disassembly must not be attempted in the field.

TEST PROCEDURE - STARTER ON ENGINE	
CONDITION	POSSIBLE FAULT AND CORRECTION
A. STARTER FAILS TO ENERGIZE	<p>A-1 Wiring: Check for badly corroded or loose connections, also broken or frayed insulation. Clean and tighten connections, replace wires in poor condition.</p> <p>A-2 Starting Switch or Solenoid: Bypass the switch or solenoid with jumper wire - if starter cranks normally, replace defective part.</p> <p>A-3 Battery: Check specific gravity of battery - if low, recharge or replace battery as necessary.</p>
B. STARTER ENERGIZES BUT TURNS TOO SLOWLY	<p>B-1 Battery: Check condition of battery (See A-3).</p> <p>B-2 Brushes: Remove end cap, check for unevenly worn or dirty brushes and commutator. Use a coarse cloth (not emery paper) to clean. Replace brushes if excessively or unevenly worn. See brush replacement procedure.</p>

PERMANENT MAGNET TYPE STARTING MOTORS (Late C-10A and Late C-12)

The permanent Magnet (PM) starting motors, now used on the 10, and 12 HP engines, weigh less than conventional starters and require less current to operate. The PM starters weigh less due to the fact that field coils are eliminated. On conventional starters, a relatively heavy current is directed thru the field coils to build up the strong magnetic field necessary to start the armature turning. On PM starters, the permanent magnets provide this strong field, and only a small current is needed in the armature to start it turning.

DRIVE UNIT

The PM starters use a drive very similar in appearance and function to a Bendix drive arrangement. There are, however, design differences which excluded it from being classified as a Bendix drive. On the PM starter drive, for example, the inertia absorbing cushion is part of the pinion, not separate, as on the Bendix drives. With the one piece unit, the greater mass provides more inertia for positive engagement plus it permits use of a heavier duty anti-drift spring for quicker, cleaner disengagement. When the armature starts to turn, the drive pinion moves laterally on the splined portion of the armature shaft into mesh with the ring gear on the flywheel of the engine. As the pinion butts against the stop or spacer, it locks in positive engagement with the armature to turn the engine. When the engine fires and attains the speed where the flywheel begins to "override" the armature, the greater momentum of the flywheel throws the pinion out of mesh. The anti-spring holds the pinion in the retracted position as the armature coasts to a halt.

PRECAUTIONS

In the event of a "false start", that is, if the engine gets up sufficient speed to disengage the starter but then fails to continue running, the engine must be allowed to come to a complete halt before a restart attempt is made. If the flywheel is still rotating when the starter is engaged, the pinion and ring gear may clash and damage the teeth.

Even with PM starters which can crank for long periods without overheating, the cranking time should be limited to 60 seconds. If an engine fails to start after this length of time, there is probably something wrong with the engine or it may be out of fuel, flooded, or there may be poor ignition or some other condition preventing it from starting.

Make sure the special shouldered capscrews (and lock washers) are used when installing starter. In addition to securing the starter to the machined surface on the crankcase, these special capscrews properly align the pinion to the ring gear on the engine. Use of ordinary capscrews will allow the starter to shift which could result in clashing of the gears.

The PM starters are pre-lubricated during assembly and further lubrication is not required unless the starter is disassembled for servicing. Service is not required at any specific hourly basis -- it should be done only when performance indicates a need for such service.

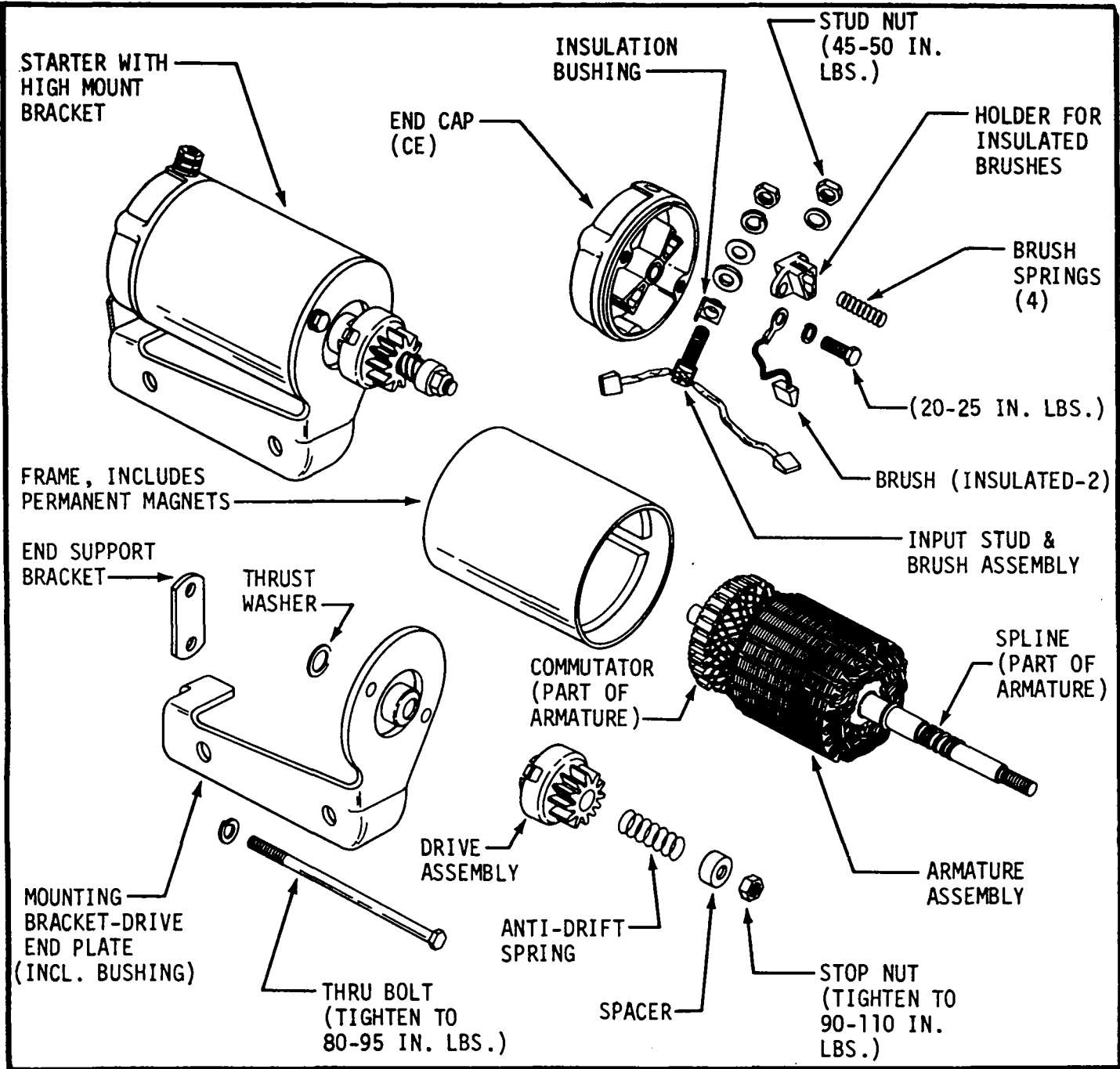


Figure 21

STARTER SERVICE

If starting problems develop that cannot be attributed to poor connections, low battery, faulty switches, etc., remove starter from engine for inspection and reconditioning.

DRIVE ASSEMBLY: If pinion is badly worn or has broken teeth, replace drive as a unit. To do this, hold armature shaft and remove stop nut, spacer, anti-drift spring, then slip drive unit off over spline and armature shaft. Leave new drive unit off if further disassembly of starter is required -- drive unit is the last part to be reinstalled. Reverse procedure to reinstall drive unit -- tighten stop nut to 90 - 110 inch lbs. Do not lubricate spline as dust may build up here and cause sticking.

BRUSH COMMUTATOR SERVICE: The starter must be completely disassembled to service brushes and commutator; however, disassembly can be done quickly and easily. Proceed as follows:

1. Remove drive unit.

2. Remove thru bolts.
3. Remove end bracket capscrew from end cap, then turn bracket so that it will not interfere with removal of mounting bracket.
4. Slip mounting bracket and frame off over drive end of armature.
5. Separate end cap from armature -- NOTE -- Brush springs will probably fall out when brushes pull free of the commutator.
6. Clean up commutator with a coarse, lint-free cloth -- if badly worn or grooved, turn down on lathe.
7. Replace brushes as follows: The input brushes are part of the terminal stud assembly. To replace, remove nuts, and pull stud out thru inside of end cap. Insert new stud terminal-brush unit after transferring insulation bushing from old unit. To replace, remove nuts, and pull stud out thru inside of end cap. Insert new stud terminal-brush unit after transferring insulation bushing from old unit. To replace insulated brushes, simply remove capscrew and lockwasher. Always use new brushes and springs. Assemble brushes with chamfered side away from springs. Keep brush leads away from contact with metal of end cap.
8. To keep brushes in position so that they will fit over the commutator as the end cap is reinstalled, wrap rubber bands over brushes and end cap -- cut and remove the rubber bands after brushes are started on the commutator.
9. Reverse procedure to reassemble reconditioned starter -- make sure bolts, etc., are tightened to the torque values specified on the accompanying illustration. Apply a light film of oil to the shaft where it contacts the bearings -- do not lubricate spline on armature shaft.

ENGINE - GENERAL SERVICE

(all models)

COOLING

Air is drawn into the cooling shroud by fins provided on the flywheel. The rotating air screen and the cooling fins on the block and cylinder head must be kept clean and unobstructed at all times. Never operate engine with blower housing or cooling shrouds removed. These direct air flow past cooling fins. Removal results in improper air circulation.

EXTERNAL SURFACES

External surfaces must be maintained in clean condition free of any oil and dirt accumulation. This is done not only for safety and appearance but because poor cooling efficiency results from dirty external surfaces.

ENGINE STORAGE

If engine is to be out of service for a considerable length of time, the following steps are recommended:

- a. Drain oil from crankcase while engine is still hot and flush with clean, light oil. Refill crankcase.
- b. Drain fuel tank and carburetor.
- c. Clean exterior of engine.
- d. Spread a light film of oil over any exposed surfaces of engine subject to corrosion.
- e. Pour tablespoon of oil into spark plug hole, crank engine slowly by hand and replace spark plug.
- f. Store in dry place.

ENGINE TESTS

Crankcase Vacuum Test: A partial vacuum should be present in the crankcase when engine is operating at normal temperatures. An engine in good condition will have crankcase vacuum of 5 to 10" water column as read on "U" tube water manometer or 1/2 to 1" Hg. as calibrated on mercury vacuum gauge. Crankcase vacuum check is best accomplished with the "U" tube manometer. If vacuum is not in the specified range, this could be attributed to one or more of the following factors -- the condition easiest to remedy should be checked first:

- A. Clogged Crankcase Breather can cause positive pressures to build up in the crankcase. Disassemble breather assembly, thoroughly clean, then recheck pressure after re-installing.
- B. Worn oil seals can cause lack of vacuum. Oil leakage is usually evident around worn oil seals. (See Oil Seal Replacement Instructions).

- C. **Blowby, leaky valves** can also cause positive pressures. These conditions can be confirmed by making compression test on engine.

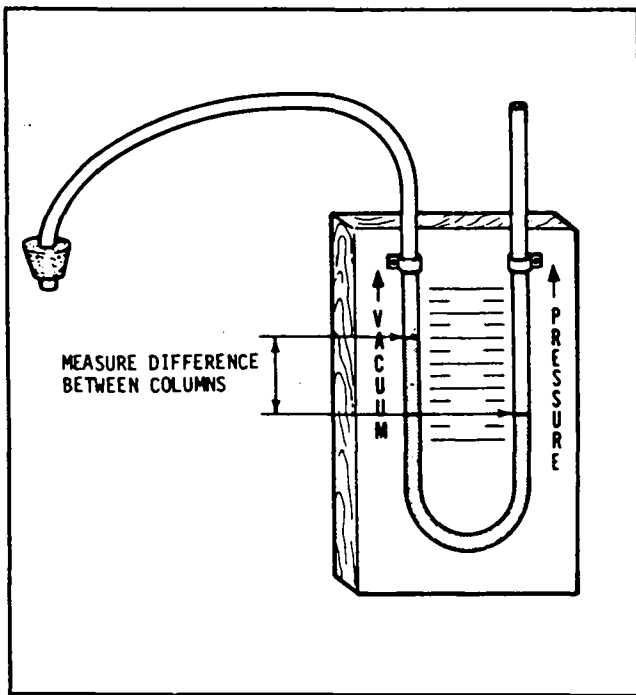


Figure 22 "U" Tube Manometer

Construction - "U" Tube Manometer

Vacuum gauges, mercury and water manometers are available commercially. A water "U" tube manometer is simple to construct if limited usage does not warrant purchase of commercial product. To construct water manometer, proceed as follows:

- (a) Procure length of clear plastic tubing. Bend tube to form "U" and mount on board as shown in accompanying illustration. Make gradual, rather than sharp bend in tube.
- (b) Measure inside, straight section of tube and mark inch increment from 0 to 12".
- (c) Procure cork having outside diameter which will be a snug fit in the oil fill hole. Drill hole in center of cork to receive one end of tube.
- (d) Pour water (colored for easier reading) into tube until level reaches the approximate halfway mark on scale.

When using manometer, place cork end into oil fill hole (other end open to atmosphere) and measure difference between columns. If water column is higher in tube connected to engine, vacuum or negative pressure is indicated. If the higher column is on the atmospheric side of manometer, positive pressure is present.

Compression Test: The results of a compression check can be used to determine if an engine is in good operating condition or if reconditioning is needed. Low readings can indicate several conditions or a combination of the following conditions:

LOW COMPRESSION	
POSSIBLE CAUSE	REMEDY
A. Cylinder head gasket blown.	A. Remove head, replace gasket, reinstall head, recheck compression.
B. Cylinder head warped or loose.	B. Remove head, check for flatness (see cylinder head service), reinstall and secure in proper sequence to specified torque value.
C. Piston rings worn - blowby occurring.	C. Recondition engine.
D. Valves leaking.	D. Recondition engine.

Higher than normal compression can indicate that excessive carbon deposits have built up in the combustion chamber.

A simple "feel" test can be used as a "spot check" if poor compression is suspected as the reason for hard starting and lack of power. If results of test point to poor compression -- this test should be followed up with the more precise and accurate test method using a compression gauge.

METHOD 1 - SPOT CHECK (WITHOUT GAUGE)

- A. Remove high tension lead from the spark plug.

On all engines, rotate flywheel backwards (counterclockwise direction) against power stroke - if little or no resistance is felt, check with compression gauge.

METHOD 2 - COMPRESSION GAUGE TEST

- A. Remove spark plug and insert compression gauge in hole.
- B. Engine will have to be motored to a speed of about 1000 RPM. Hold throttle wide open and take several compression readings. Consistant readings of 110 to 120 psi indicate good compression.

INSPECTION-DISASSEMBLY

When disassembling an engine, carefully inspect and note the physical appearance of each of the components. Often the appearance of parts will indicate operation under other than ideal conditions. In observing these indicators, you may be able to suggest improved service and operating techniques which will result in prolonged engine service life. Some of the things to look for are:

1. Excessive sludge and varnish formation.
2. Scoring of the cylinder walls.
3. Severe piston damage.
4. Evidence of external oil leakage.

Sludge is a natural by-product of combustion and a small accumulation is normal. Excessive sludge formation could indicate several things. The most common cause is perhaps too infrequent oil and oil filter changes. It can also indicate operation with improper ignition timing or overrich carburetor adjustment or a poorly serviced clogged air cleaner which restricts air intake and also results in an overrich mixture.

Scoring of the Cylinder Wall

Unburnt fuel not only adds to sludge formation but can, in severe cases, cause scuffing and scoring of the cylinder walls. As raw fuel seeps down the cylinder walls, it washes the necessary lubricating oils off the piston and cylinder walls so that the piston rings make metal to metal contact with the walls. Scoring of the cylinder walls can also be caused by localized hot spots resulting from blocked cooling fins or from inadequate or contaminated lubrication.

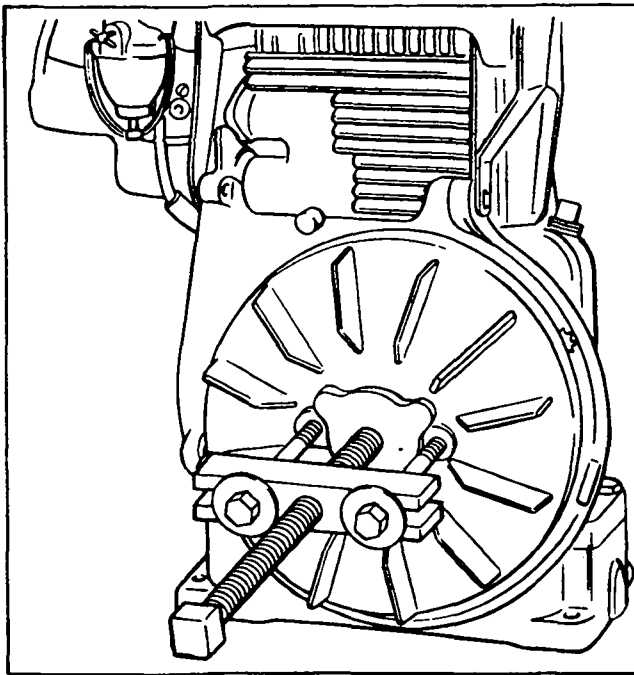


Figure 23 Remove Flywheel With Puller

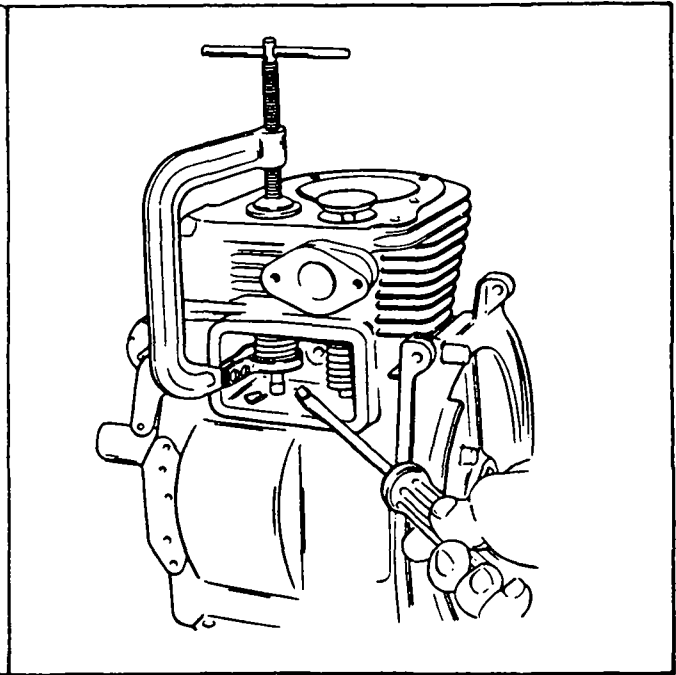


Figure 24 Using Valve Compressor

Severe Piston Damage

Major damage to pistons and rings can take various forms. The top of the piston ring may be burned through or the top groove may be excessively worn and the ring broken or stuck in the groove. This can be attributed to abnormal combustion. If ignition timing is overadvanced, ignition will occur while the piston still has a long distance to travel on its compression stroke. As a result, the combined heat of compression plus the heat of pre-ignited fuel raises temperatures to values comparable to that of an acetylene torch. This, of course, acts mainly on the top land and top ring of the piston and results in early failure.

Evidence of External Oil Leakage

If excessive oil leakage is evident, this may indicate improperly serviced breather systems. Normally, an engine operates internally at pressures under atmospheric or, in other words, with a negative crankcase pressure. If positive pressures build up within the crankcase from a clogged breather or from piston blow-by, oil will be forced out of an engine at oil seals, gaskets or any other available spot.

These are just a few of the more common indicators. Numerous others exist and are obvious to the experienced mechanic. Often the cause will become apparent in view of the particular condition of the part. Always look for these signs when disassembling an engine prior to reconditioning.

DIASSEMBLY PROCEDURE

The following is intended as a guide to disassembly of the standard engine models – the sequence may have to be varied slightly to facilitate removal of special equipment or accessory items such as motor - generators, starters, instrument panels, etc.

1. Disconnect lead and remove spark plug.
2. Close valve, remove fuel line at carburetor.
3. Remove air cleaner from carburetor intake.
4. Remove carburetor.
5. Remove motor generator if so equipped.
6. Remove blower housing, cylinder baffle and head baffle.
7. Remove rotating screen and starter pulley.
8. Flywheel is mounted on tapered portion of the crankshaft. Use of a puller is recommended for removing flywheel.
9. Remove breaker point cover, breaker point lead, breaker assembly and push rod if so equipped.
10. Remove magneto assembly.
11. Remove valve cover and breather assembly.
12. Remove cylinder head.
13. Raise valve springs with a spring compressor and push valve keepers off valve stems. Remove valve spring retainers, springs and valves.
14. Remove oil base and unscrew connecting rod cap. Remove piston assembly from cylinder block.
15. Remove crankshaft, oil seals and, if necessary antifriction bearings. It may be necessary to press crankshaft out of cylinder block. Bearing plate should be removed first if this is done.
16. Turn cylinder block upside down and, using a small punch, drive camshaft pin out from power-take-off side of engine. Pin will slide out easily after it is driven free of block.
17. Remove camshaft and valve tappets.
18. Loosen and remove governor arm from governor shaft.
19. Unscrew governor bushing nut and remove governor shaft from inside of cylinder block.
20. Loosen (do not remove) screw located to lower right of governor bushing nut until governor gear is free to slide off stub shaft.

ENGINE RECONDITIONING

All parts should be thoroughly cleaned – dirty parts cannot be accurately gauged or inspected properly for wear or damage. There are many commercially available cleaners that quickly remove grease, oil and grime accumulation from engine parts. If such a cleaner is used, make sure that all trace of the cleaner is removed before the engine is reassembled and placed in operation. Even small amounts of these cleaners quickly break down the lubricating properties of engine oils.

1. INSPECTION

- A. Gasket surfaces - Check all surfaces to make sure that they are free of gasket fragments and sealer materials. Surfaces must also be free of deep scratches or nicks.
- B. Bearings - (Crankshaft) - One bearing is pressed into the cylinder block – the other is located in the bearing plate. Do not remove bearings unless they show signs of damage and are to be replaced. (See Reconditioning - Cylinder Block.) If the bearings turn easily and noiselessly and there is no evidence of scoring or grooving on the races, the bearings can be reused.

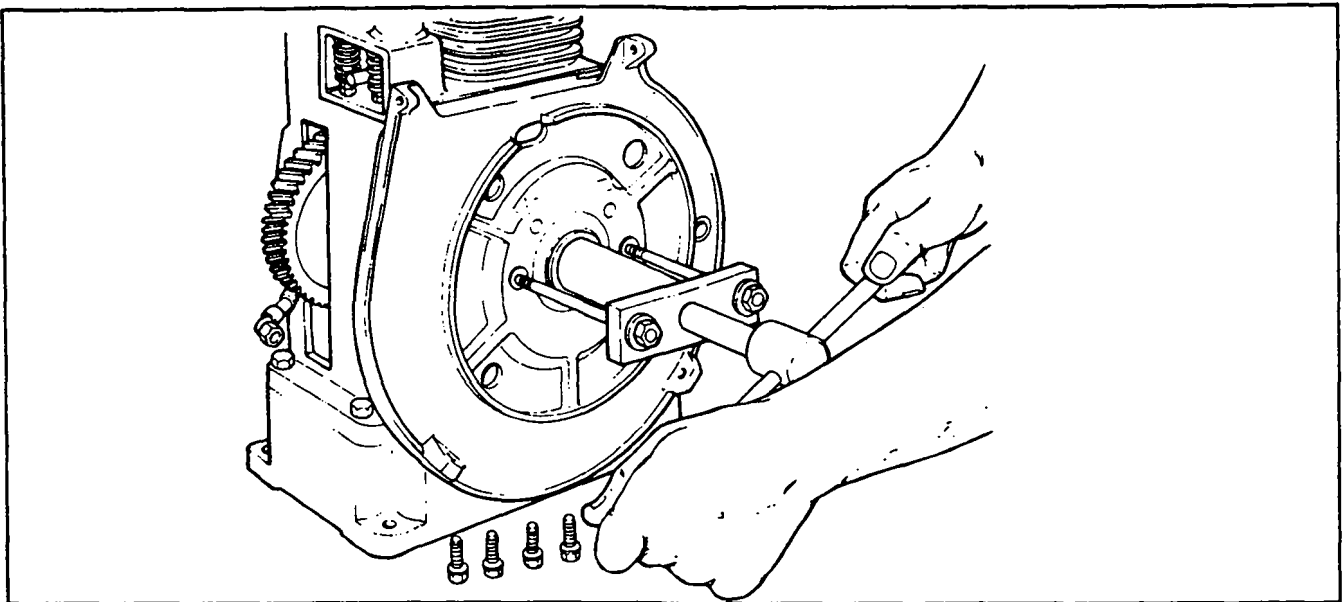


Figure 25 Pulling Bearing Plate

- C. Cylinder bore - If badly scored, excessively worn or tapered or out of round more than .005, reboring if necessary. Use an inside micrometer to determine amount of wear (See Fits and Clearance Section). If cylinder bore is not damaged and is within tolerances, only light deglazing may be necessary.

2. RECONDITIONING - CYLINDER BLOCK

- A. Remove old oil seal from block but do not install new seal until after crankshaft is reinstalled.
- B. Reboring procedure - See Clearance Section for original cylinder bore size. Use an inside micrometer to measure wear then select nearest suitable oversize of either .010, .020 or .030". Reboring to one of these oversizes will allow usage of the available oversize piston and ring assemblies. While most commercially available cylinder bores can be used with either portable drills or drill presses, the use of a low speed drill press is preferred as it facilitates more accurate alignment of the bore in relation to the crankshaft crossbore. Reboring is best accomplished at drill speed of about 600 RPM. After installing coarse stones in hone, proceed as follows:
- B1 - Lower hone into bore and after centering, adjust so that stones are in contact with walls. Diesel fuel oil or kerosene can be applied to the stones as a cutting-cooling agent.
- B2 - With the lower edge of each stone positioned even with the lowest edge of the bore, start drill and honing process. Move hone up and down while reboring to prevent formation of cutting ridges. Check size frequently.
- B3 - When bore is within .0025 of desired size, remove coarse stones and replace with burnishing stones. Continue with burnishing stones until within .0005 of desired size then use finish stones and polish to final size.
- B4 - After reboring, carefully clean cylinder wall with soap and water, then after drying thoroughly, apply light coat of oil to prevent rust.

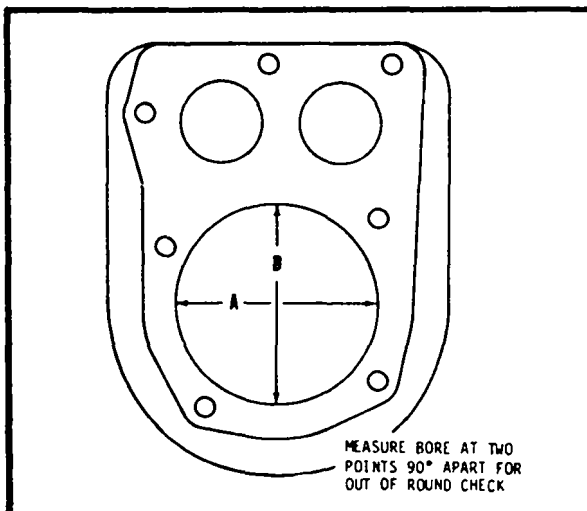


Figure 27 Honing Cylinder Walls

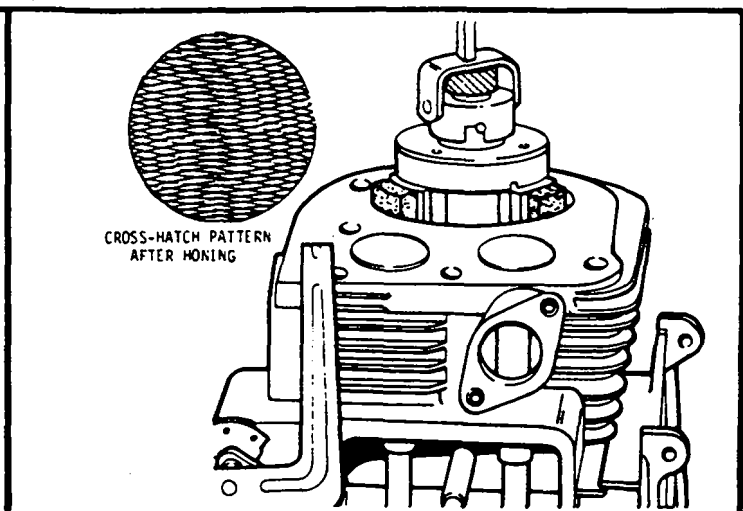


Figure 26 Measuring Cylinder Bore

CRANKSHAFT

1. **Keyways -- Gears** - If keyways for flywheel are badly worn or chipped, replacement of the crankshaft may be necessary. Broken or badly worn gear teeth will also necessitate replacement of shaft.
2. **Crankpin** - Inspect crankpin for score marks or metallic pickup. Slight score marks can be cleaned with crocus cloth soaked in oil. If wear limits, as stated in Clearance Section, are exceeded by more than .002", it will be necessary to either replace crankshaft or regrind the crankpin to .010 undersize.

CONNECTING ROD

1. Check bearing area (big end) for excessive wear, score marks, running and side clearance. Replace rod and cap if worn beyond limits stated.
2. Connecting rods with bearing area .010 undersize are available for use with reground crankpin.

PISTON - PISTON RINGS

Production type and service ring replacement sets are available in the standard size plus .010", .020" and .030" oversize sets. Cylinder bore must be deglazed before service ring sets are used. Chrome plated rings, when used, should be installed in the top groove.

1. If the cylinder block does not need reboring and if the old piston is within wear limits and free of score or scuff marks, it may be reused. **Never** reuse old rings, however.
2. Remove old rings and clean up grooves.
3. Before installing new rings on piston, place each ring in turn in its running area in cylinder bore and check end clearance.
4. Rings must be installed according to markings on rings. Generally compression rings must be installed with groove or bevel up when this is on inside diameter of ring. The chrome ring, when used, must be installed in

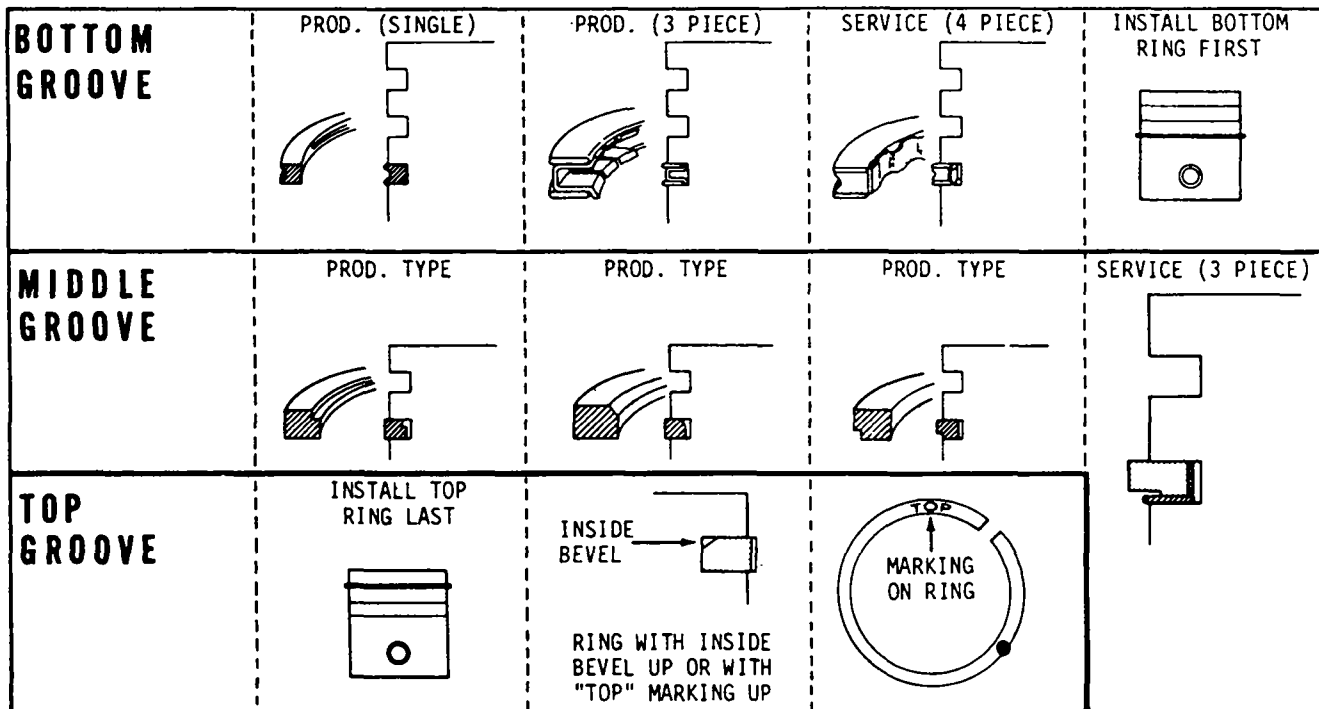


Figure 28 Production Type And Service Type Rings

the top groove. When bevel is on outside of ring, install in down position or toward skirt. Ring installation instructions are usually included with new ring sets. Follow instructions carefully. Use ring expander to install rings and check side clearance of each ring after installation.

PISTON - ROD ASSEMBLY

Normally very little wear takes place in the piston boss-piston pin area. If the original piston and connecting rod can be reused after reconditioning, the pin will usually not have to be replaced. If the piston boss or

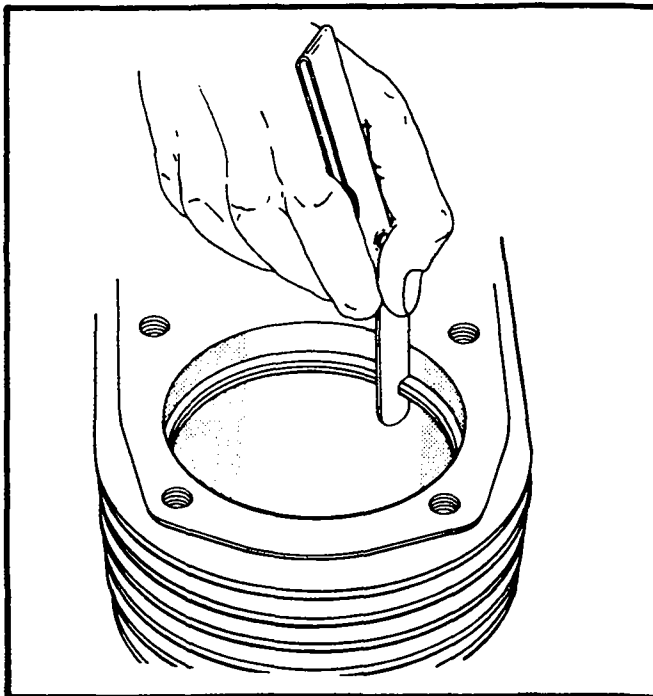


Figure 29 Measuring Piston Ring End Gap

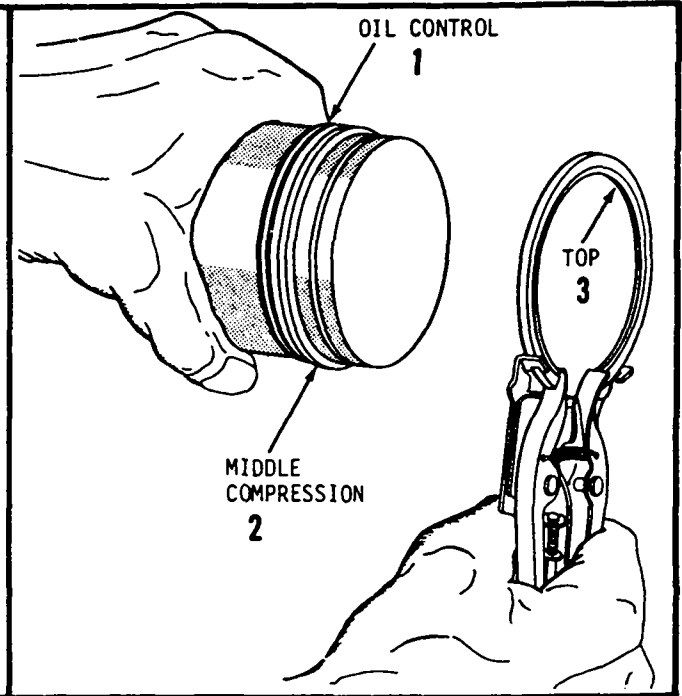


Figure 30 Ring Installation Sequence

connecting rod small end are worn beyond limits, they can be reworked to receive the available .005 or .010 oversize piston pins. In many cases, it may be more advantageous to use a new piston-rod assembly rather than to rework the old piston boss and connecting rod. A new piston pin should be used when a new connecting rod is used with the original piston. After checking pin, rod and piston boss to make sure proper clearances are available, assemble piston to rod with pin (light interference to loose fit) and lock pin with new retainers -- make sure retainers are fully engaged in grooves.

VALVES — VALVE MECHANISM

Carefully inspect valve mechanism parts. Check valves and valve seat area or inserts for evidence of deep pitting, cracks or distortion. Check clearance of valve stems in guides.

Guides: To remove, drive guides down into valve chamber and carefully break protruding end until guide is completely removed. Be careful not to damage block when removing old guide. Use an arbor press to install new guides --- press to depth stated in Clearance Section.

Valves and Valve Seats: Consult parts manual for correct valve numbers when replacing valves. Some applications require special hard-faced valves for both intake and exhaust valves. Exhaust valves are always hard faced. Intake valve seats are usually machined into block although inserts are used in certain applications. Exhaust valves seat on special hardened inserts. Seating surfaces should be held as close as possible to 1/32" width. Seats with more than 1/16" must be reconditioned with 45° and 15° cutters to obtain proper width. Reground or new valves must be lapped in to provide proper fit. Use a hand valve grinder with suction cup for final lapping. Lightly coat valve face with "fine" grade of grinding compound then rotate valve on seat with grinder. Continue grinding until smooth surface is obtained on seat and on valve face.

Valve Clearance: Valve clearance must be checked after resurfacing and lapping in. Install valves in guides, rotate camshaft to position where cam has no effect on tappet -- hold valve firmly on seat and check clearance between valve stem and tappet (See Clearance Section).

Adjustable tappets are used on the K241 and K301 engines. Loosen the locking nut, turn adjusting nut in or out until proper clearance is attained then securely tighten locknut.

CYLINDER HEAD

Blocked cooling fins often cause localized "hot spots" which can result in "blown" cylinder head gaskets. If gasket fails in area surrounding one of the retaining capscrews, high temperature combustion bases can burn away portions of aluminum alloy head. If no evidence of this is found, head should be checked for flatness. A slightly warped head can be resurfaced by simply rubbing it on a piece of sandpaper positioned on a flat surface. Carefully clean carbon deposits from cylinder head if it is to be reused -- use putty knife or similar blade to scrape deposits. Be careful not to nick or scratch aluminum, especially in gasket seat area.

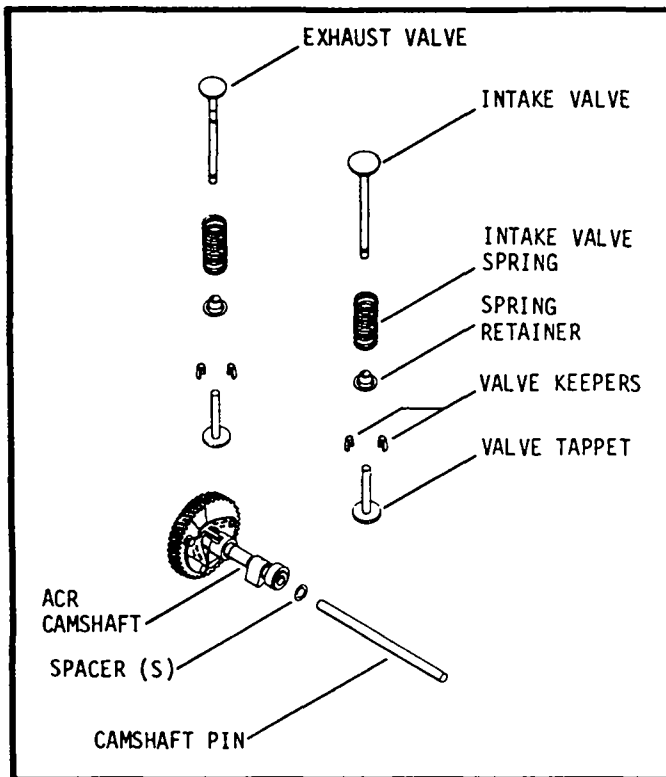


Figure 31 Camshaft And Valve Mechanism

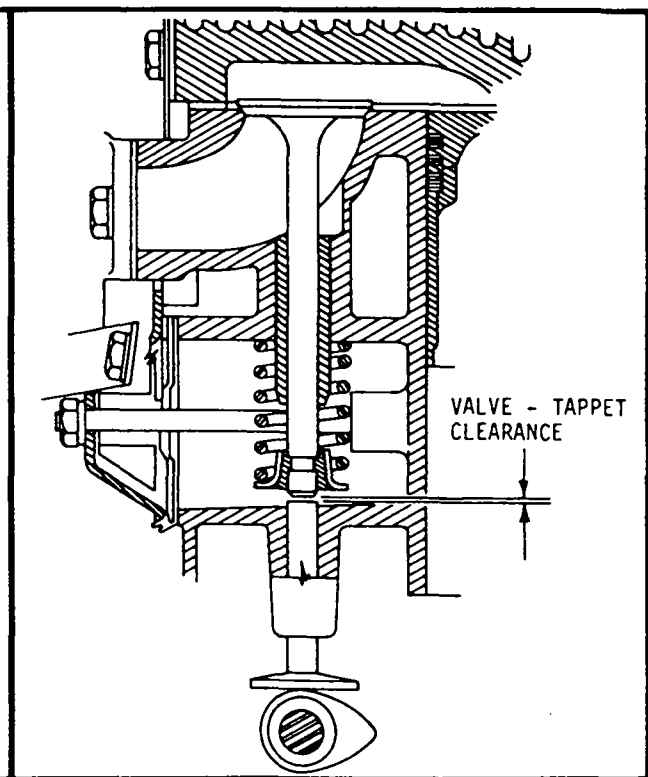


Figure 32 Valve - Tappet Clearance

RING GEAR (C-10A and C-12)

If inspection of the ring gear reveals broken, excessively worn or otherwise damaged teeth, the ring gear must be replaced. The ring gear is press fitted into a recess on the outer perimeter of the flywheel. The flywheel must be off the engine for ring gear replacement.

Several methods may be used to remove the damaged ring gear. One method is to break the gear with a cold chisel and/or a hack saw. Another way is to heat the ring gear with a torch, then drive the gear off the flywheel. If the latter method is used, the flywheel will also absorb some heat and it must be allowed to cool before the new ring gear can be installed.

The new gear must be expanded with heat before installation. This can be done by submerging the gear in hot oil or heating in oven to about 400 to 450°F. Position the heated gear on the flywheel, then after making sure it is not cocked, either press the gear on with an arbor press or drive it on with a soft-head hammer. As the gear cools, it will contract to form a tight press fit on the flywheel. Be sure to tighten the flywheel retaining nut to the proper torque value after reinstalling the flywheel on the engine.

ASSEMBLY (all models)

1. Rear Main Bearing
 - a. Install rear main bearing by pressing it into cylinder block with shielded side facing to inside of block.
2. Governor Shaft
 - a. Most engines have a cross shaft with an extension riveted in place to line up with governor gear. A needle bearing is provided (in block) to hold cross shaft in alignment.
3. To Install Governor
 - a. Place cylinder block on its side. Slide governor shaft into place from inside of block.
 - b. The governor shaft can be adjusted for end clearance by moving needle bearing in block. Set bearing to allow a slight back-and-forth movement of the shaft.
 - c. Place space washer on stub shaft and slide governor gear assembly into place.

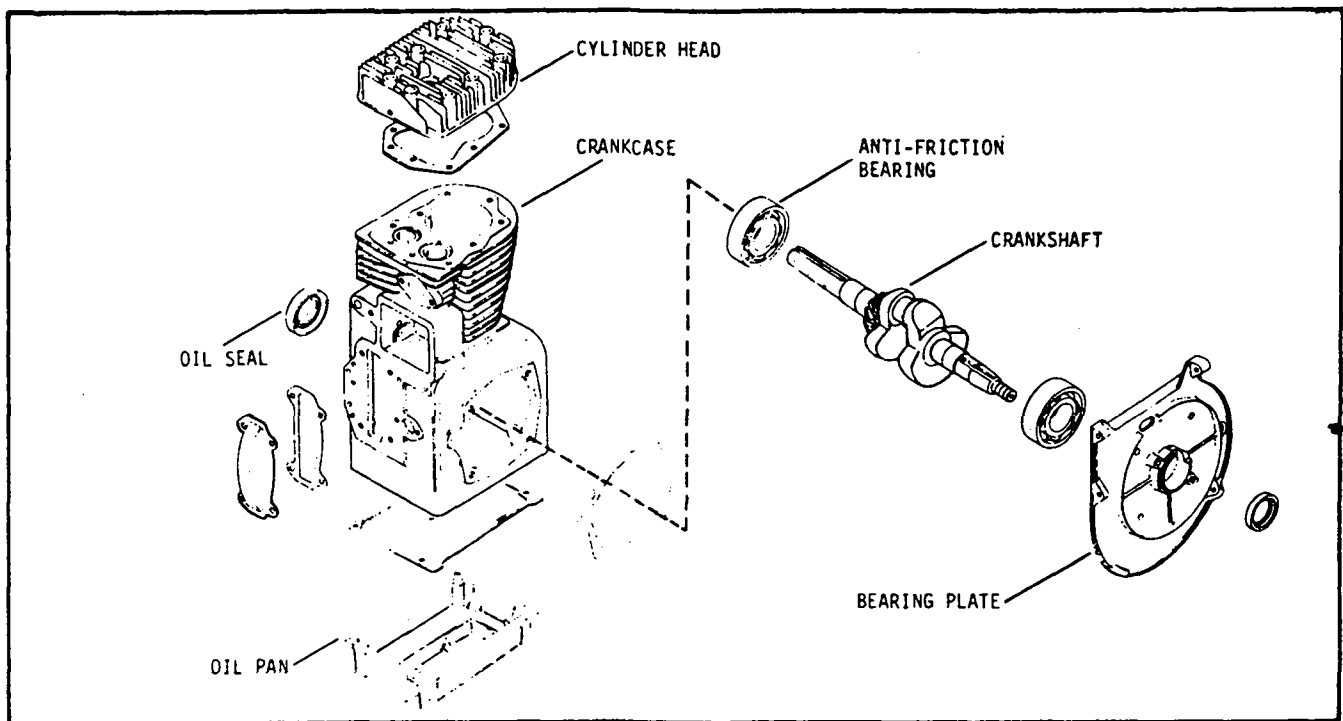


Figure 34 Governor Gear Assembly In Crankcase

- d. Tighten holding screw from outside of cylinder block. Screw prevents governor gear from sliding off stub shaft during assembly.
- e. Rotate governor gear assembly to be sure holding screw does not contact weight section of gear.

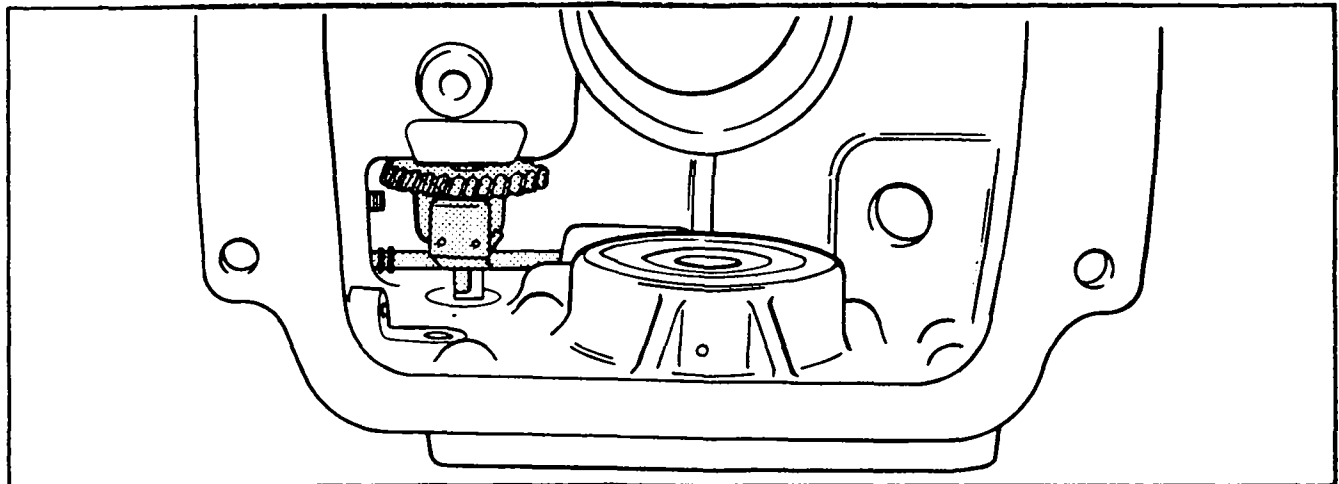


Figure 33 Exploded View, Major Components Of Typical Engine

4. Camshaft Installation

- a. Turn cylinder block upside down.
- b. Tappets must be installed before camshaft is placed. Insert tappets in valve guides. Exhaust tappets are interchangeable.
- c. Position camshaft inside block.
- d. Lubricate rod then insert into block (bearing plate side). Before pushing rod through camshaft, slip one .005" washer (end play) between end of camshaft (opposite gear end) and block. Push rod through camshaft and tap lightly until rod just starts into bore at P. T. O. end of block. Check end play with feeler gauge -- if within tolerance press rod into final position or remove rod and add (or subtract) .005 and .010" thick washers as necessary to attain proper end play (See Fits and Clearance Section).
- e. While rod is a tight press fit at P. T. O. end of block, a light to loose fit is necessary at the bearing plate end. New bearing plate gaskets have notch to allow any oil that may leak past to drain back into block.

If gasket is not notched, apply gasket sealer around end of rod (outside block) to seal when bearing plate and gaskets are installed.

5. Crankshaft Installation

- a. Place block on base of arbor press and carefully insert tapered end of crankshaft through inner race of antifriction bearing.
- b. Turn crankshaft and camshaft until timing mark on shoulder of crankshaft lines up with mark (dot) on cam gear as shown in Figure 37.
- c. When marks are aligned, press crankshaft into bearing – make sure gears mesh as shaft is pressed into bearing. After shoulder bottoms against inner race, recheck timing mark to make sure they are still aligned.
- d. Crankshaft end play is controlled by the thickness of gaskets used between the bearing plate and block. End play must be checked after bearing plate is installed -- directions stated in Step 6.

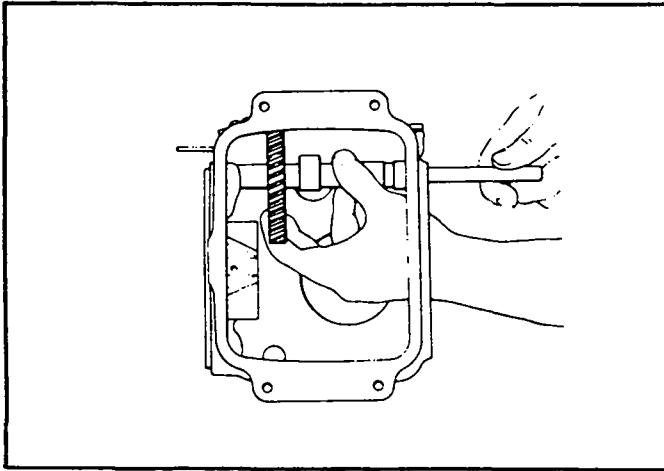


Figure 35 Installing Camshaft

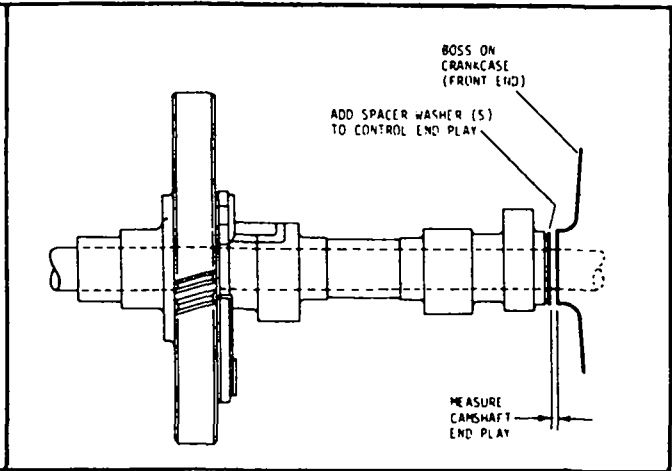


Figure 36 Camshaft End Play

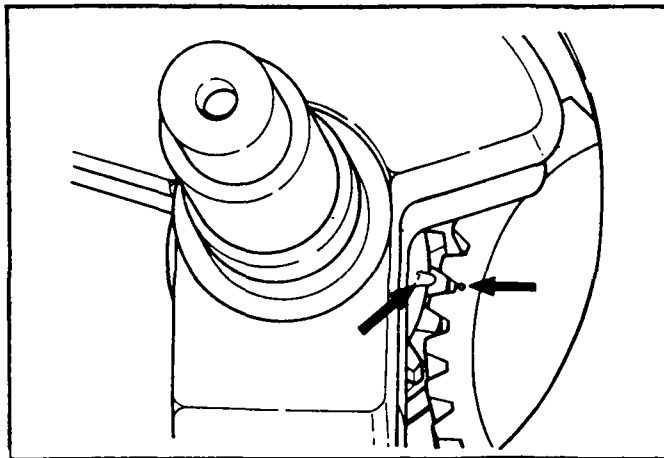


Figure 37 Timing Marks On Crankshaft and Camshaft

6. Bearing Plate

- a. Press front main bearing (shielded side up) into bearing plate. Make sure bearing is straight and true in bore and bottomed properly. If cocked, crankshaft end play will be adversely affected.
- b. Crankshaft end play is determined by thickness of gaskets used between block and bearing plate. Initial use of one .020" and one .010" gasket should bring end play within limits -- this must be checked after bearing plate is installed.
- c. Install gaskets with thicker gasket next to block, place bearing plate on crankshaft and carefully press plate onto shaft and into position on block. Install cap screws with copper washers and secure bearing plate to block. Draw screws up evenly to avoid distortion of bearing plate.
- d. Crankshaft end play is measured (with feeler gauge) between inner race of rear bearing (P.T.Q. end) and shoulder on crankshaft. If end play is not within tolerance as stated in Clearance Section, remove bear-

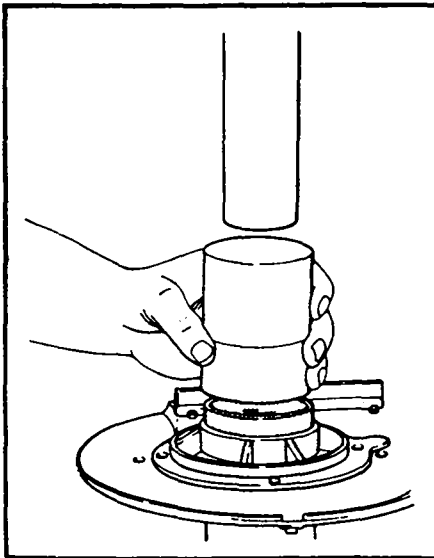


Figure 38 Pressing Bearing In Bearing Plate

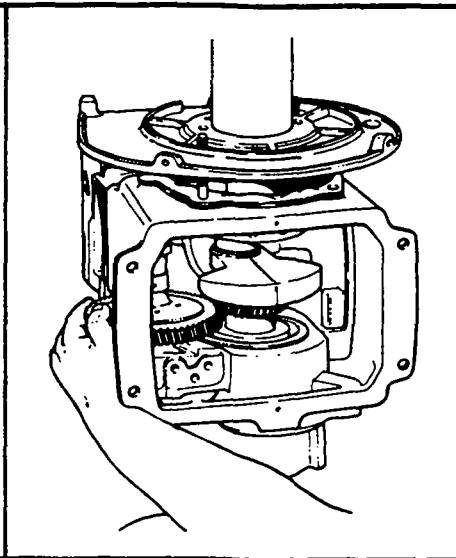


Figure 39 Installing Bearing Plate

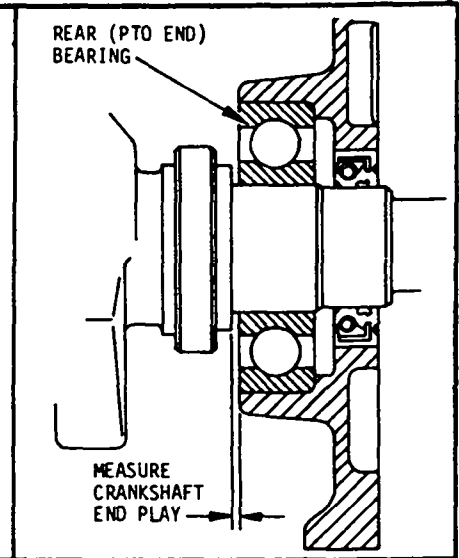


Figure 40 Crankshaft End Clearance

ing plate and add or subtract gaskets to achieve proper clearance.

7. Piston and Rod Assembly

- Assemble piston to connecting rod and secure piston pin with retainer rings. Always use new retainer rings. Be sure retainer rings are fully engaged in grooves in piston bosses.
- After making sure rings are in proper position in correct grooves, oil complete assembly, stagger ring gaps so they are not in line and insert complete assembly into cylinder bore. Be sure connecting rod marking is toward flywheel side of engine. Use a ring compressor to prevent ring breakage during installation. Gently push piston into bore with hammer handle -- do not pound.

8. Attaching Rod to Crankshaft

- After piston assembly is installed, place block on end and oil connecting rod and crank pin.
- It is important that marks on connecting rod and cap line up and face flywheel end of engine. (See Figure 42)
- Rod cap, lock or lock washers and cap screws are then attached to connecting rod. Use a torque wrench to tighten cap screws to proper torque value as stated in Clearance Section.
- If locking tabs are used, bend tabs to lock cap screws.

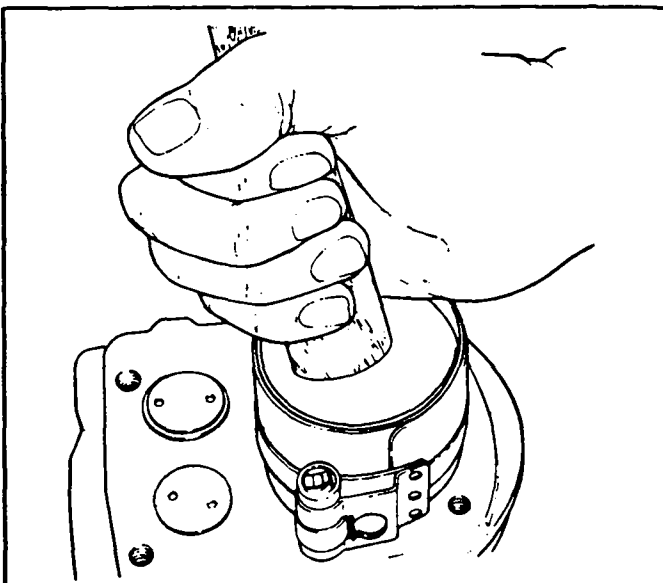


Figure 41 Installing Piston - Ring Assembly

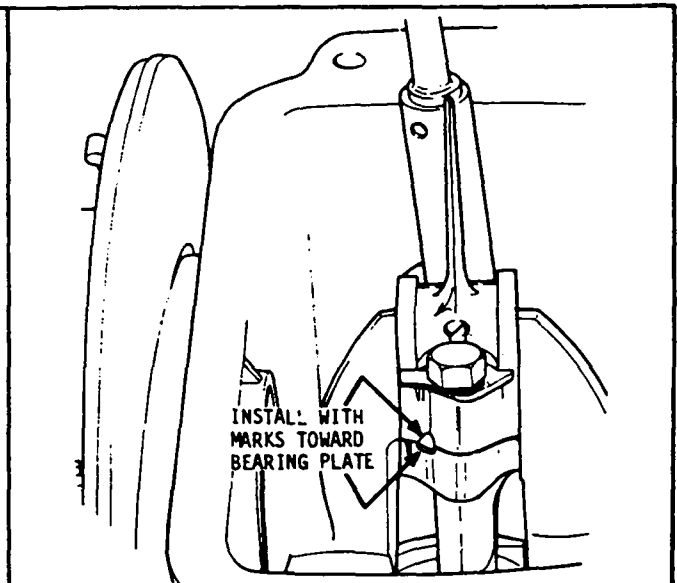


Figure 42 Installing Connecting Rod Cap Screw

9. Installation of Oil Seals on Crankshaft

- a. Guide oil seals into position on crankshaft without damaging lips of seals. Any foreign matter on knife-like edge or any bending of seal may cause damage and an oil leak can result.
- b. After oil seals are started on shaft, place block on its side. The oil seals may now be driven squarely into bearing plate and cylinder block. (See Figure 43)

10. Oil Base

- a. Use pilot studs to align cylinder block, gasket and oil base.
- b. A new gasket must be used to prevent oil leakage.
- c. Assemble oil base to block with four screws.
- d. Torque pan bolts.

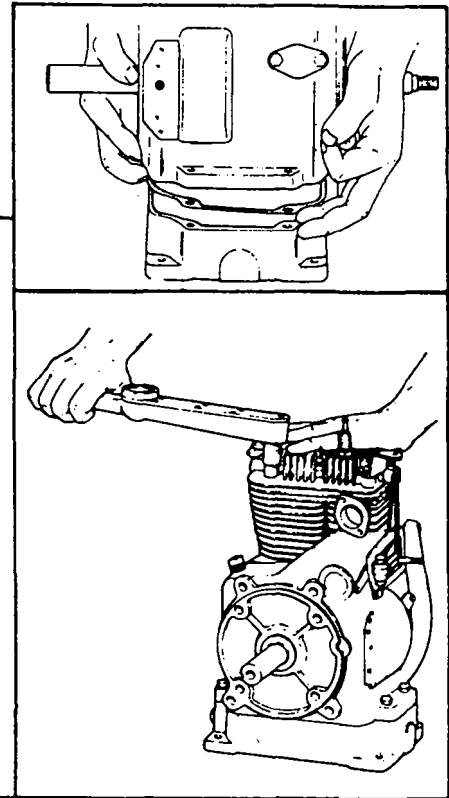
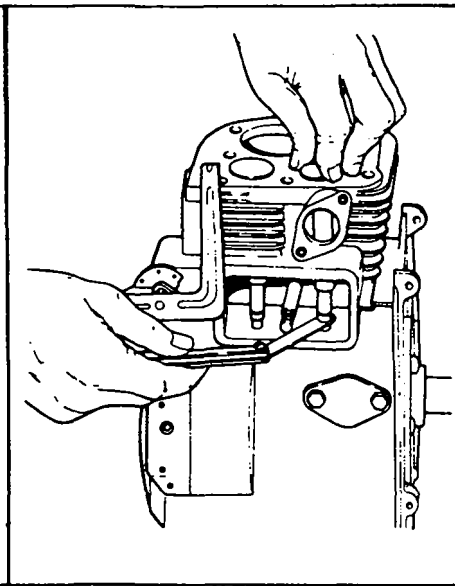
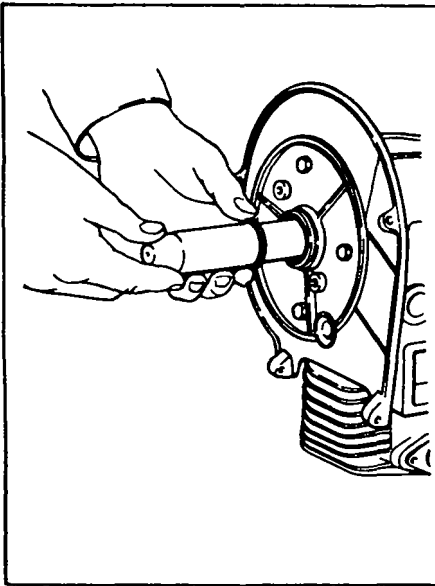


Figure 43 Installing Oil Seals Figure 44 Checking Valve - Tappet Clearance Figure 45 Tightening Cylinder Head Capscrews

11. Installing and Setting Valves

- a. Valves, valve seats and ports should be thoroughly cleaned. Valves should be ground and lapped-in to obtain a good valve seat. Keep valve seat from 1/32" to 1/16" in width.
- b. Valve clearance should be checked cold. On K241 and K301 adjust tappets to correct clearance.
- c. After correct clearance is obtained, remove valves and install valve springs and retainers and rotators if used. Replace valves, compress springs and place locking keys in grooves of valve stems.

12. Cylinder Head

- a. Always use a new gasket when head has been removed for service work.
- b. Check cylinder head on face plate to be sure gasket surfaces make good contact at all points.
- c. It is important that head cap screws be tightened evenly and in steps until proper torque is reached.
- d. Install new spark plug and tighten to specified torque. Spark plug gap should be .025.

13. Breather Assembly

Reed type breathers are used to maintain slight vacuum in crankcase. All parts must be clean and in good condition. Use new gaskets, reed and filter for reconditioned engine.

14. Magneto

- a. On all magneto ignition systems the magneto coil - core assembly is secured in stationary position on the bearing plate. On the magneto - alternator system the coil is part of the stator assembly which is also

secured to the bearing plate. Permanent magnets are affixed to the inside rim of the flywheel.

- b. After installing magneto components, run all leads out through hole provided (in 11 o'clock position) on bearing plate.

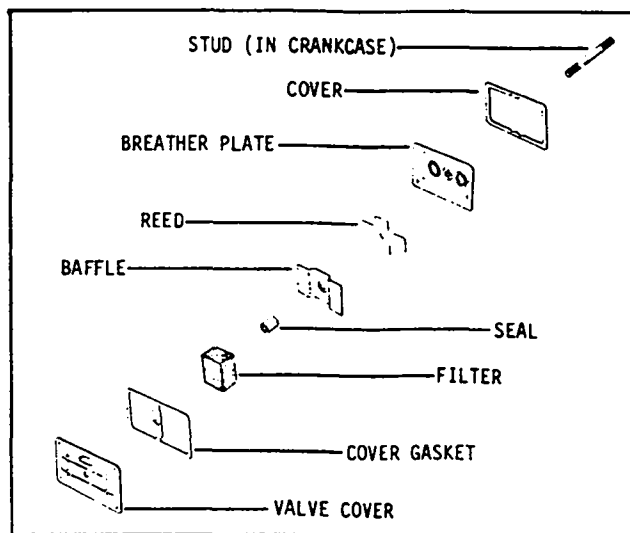


Figure 46 Typical Crankcase Breather

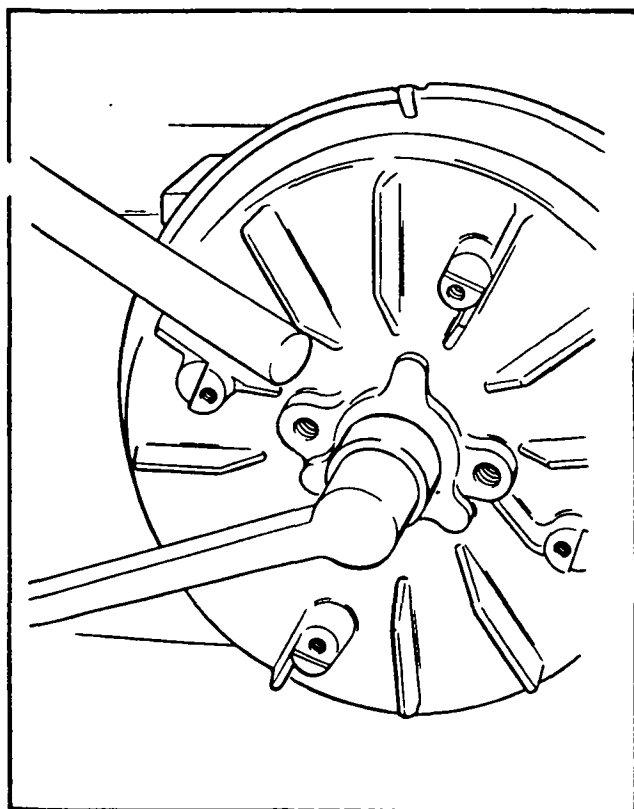


Figure 47 Installing Flywheel

15. Flywheel

- a. Place wave washer on crankshaft and place flywheel in position. The square key holds flywheel on shaft.
- b. Install starter pulley, lock washer and holding nut. Insert a bar between flywheel fins and tighten holding nut to torque value specified in Clearance Section.
- c. The rotating screen is fastened to starter pulley with screws and spacers.

16. Breaker Points

- a. Install push rod.
- b. Fasten breaker in place with two screws.
- c. Place cover gasket in position and attach magneto lead.
- d. Set breaker gap at .020 full open. For ignitor setting, refer to Ignition System Service.
- e. Make preliminary adjustments before installing breaker point cover. Be sure breaker lead grommet is in place.

17. Carburetor

- a. Insert a new gasket and assemble carburetor to intake port with two screws.
- b. Refer to Service Section on carburetor adjustment procedure.

18. Governor Arm and Linkage

- a. Insert carburetor linkage in throttle arm.
- b. Connect governor arm to carburetor linkage and slide governor arm onto governor shaft.
- c. Before tightening clamp bolt, turn shaft counterclockwise as far as possible with a pair of pliers, pull arm as far as possible to left (away from carburetor), tighten nut and check for freedom of movement.

19. Blower Housing and Fuel Tank

- a. The engine is now ready for (1) head baffle, (2) cylinder baffle, and (3) blower housing – assembled in sequence stated. These parts are fastened to engine by cap screws which attach to cylinder head and bearing plate. Caution: Shorter screws go into lower portion of blower housing.
- b. Connect fuel line between pump and carburetor.

FINAL ADJUSTMENTS

Follow instructions in Service Procedure Section for final adjustment of engine.

RUN-IN PROCEDURES (RECONDITIONED ENGINES)

After an engine has been reconditioned and reassembled, it must be “run-in” on API class “SB” oil and under load for a period of about 5 hours. This should be sufficient time to seat the piston rings.

After the initial run-in period, drain the “run-in” type oil and refill with API Service SE oil of proper viscosity. Do not continue using “run-in” oil after the first 5 hours of operation.

TOOL LIST

Common Tools

Following is a list of tools that are used in servicing Kohler Engines:

<u>DESCRIPTION</u>	<u>SIZE</u>	<u>DESCRIPTION</u>	<u>SIZE</u>
Combination Wrench	3/8”	3/8” Socket	7/16” Hex. Standard
Combination Wrench	7/16”	3/8” Socket	1/2” Hex. Standard
Combination Wrench	1/2”	3/8” Socket	1/2” Deep
Combination Wrench	9/16”	3/8” Socket	9/16” Deep
Combination Wrench	5/8”	3/8” Socket	13/16” Deep
Screw Driver	5/16” x 6”	Ft. Lb. Torque Wrench	
Screw Driver	3/8” x 10”	In. Lb. Torque Wrench	
Screw Driver	No. 1 Phillips x 3”	Ring Compressor	
Pliers	6”	Ring Expander	
Ball Peen Hammer	12 oz.	Valve Spring Compressor	
Feeler Gauge	25 Blade	Needle Nose Pliers	
Drift Punch	5/16”	Timing Light	
Ratchet	3/8” Drive	Tachometer	
3” Extension	3/8” Drive		

Special Tools

Oil seal sleeves and drivers aid assembly and insure seal protection during assembly. Use following drawings and dimensions for making oil seal sleeves and drivers. All dimensions are in inches.

<u>SEAL SLEEVE DIMENSION (FIG. 48)</u>	<u>K241, K301</u>
A	7-5/16”
B	1.245/1.250” 1.495/1.500”
C*	1.002/1.003’ 1.252/1.253”

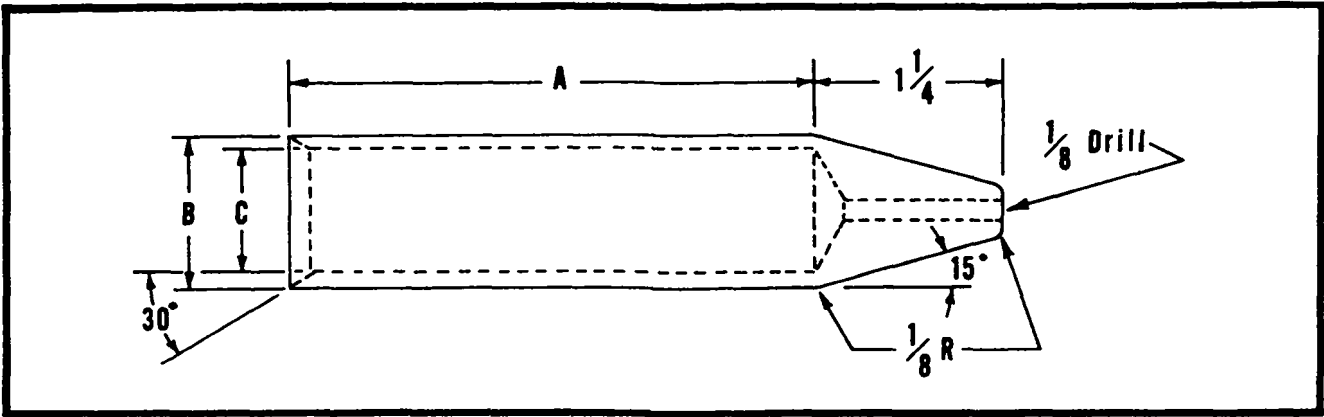


Figure 48 Dimensional Diagram -- Seal Sleeve

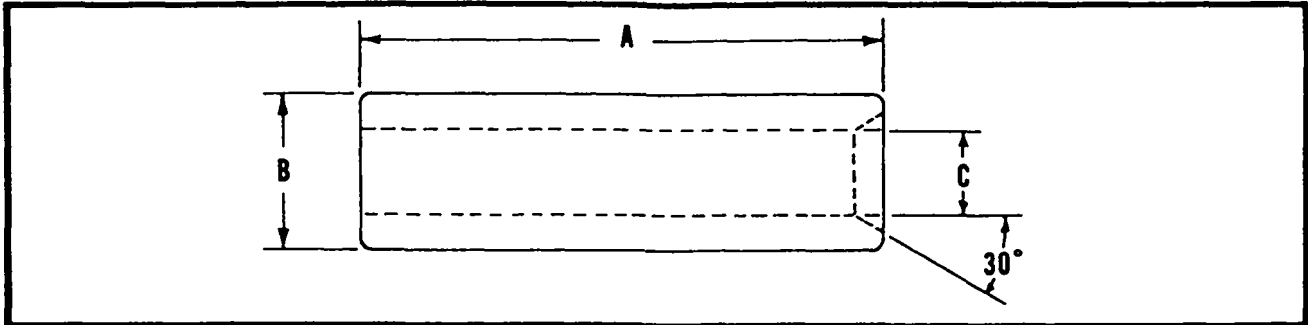


Figure 49 Dimensional Diagram -- Seal Driver

SEAL DRIVER DIMENSION (FIG. 49)	K241, K301
A	8-13/16"
B	1-11/16"
C	1.248/1.253" 1.498/1.503"

TORQUE VALUES - MAJOR ITEMS	ENGINE MODEL	
	K241	K301
GOVERNOR ARM LOCKING SCREW	---	---
CYLINDER CAPSCREW*	420 in. lbs.	420 in. lbs.
CONNECTING ROD CAPSCREW*	300 in. lbs.	300 in. lbs.
FLYWHEEL RETAINING NUT **	60 ft. lbs.	
SPARK PLUG	27 ft. lbs.	27 ft. lbs.

TORQUE VALUES -- STANDARD HARDWARE ITEMS

<u>SIZE</u>	<u>TORQUE</u>	<u>SIZE</u>	<u>TORQUE</u>
1/4 - 20	70 in. lbs.	1/2 - 13	50 ft. lbs.
1/4 - 28	85 in. lbs.	1/2 - 20	70 ft. lbs.
5/16 - 18	150 in. lbs.	9/16 - 12	75 ft. lbs.
5/16 - 24	165 in. lbs.	9/16 - 18	100 ft. lbs.
3/8 - 16	260 in. lbs.	5/8 - 11	110 ft. lbs.
3/8 - 24	300 in. lbs.	5/8 - 18	140 ft. lbs.
7/16 - 14	35 ft. lbs.	3/4 - 10	150 ft. lbs.
7/16 - 20	45 ft. lbs.	3/4 - 16	200 ft. lbs.

CONVERSION TABLE (INCH LBS. TO FOOT LBS.)										
FOOT LBS.	5	10	15	20	25	30	35	40	45	50
INCH LBS.	60	120	180	240	300	360	420	480	540	600

Divide inch lbs. by 12 for foot pound values.

Multiply foot lbs. by 12 for inch pound values.

Figure 50 Head Bolt Tightening Sequence

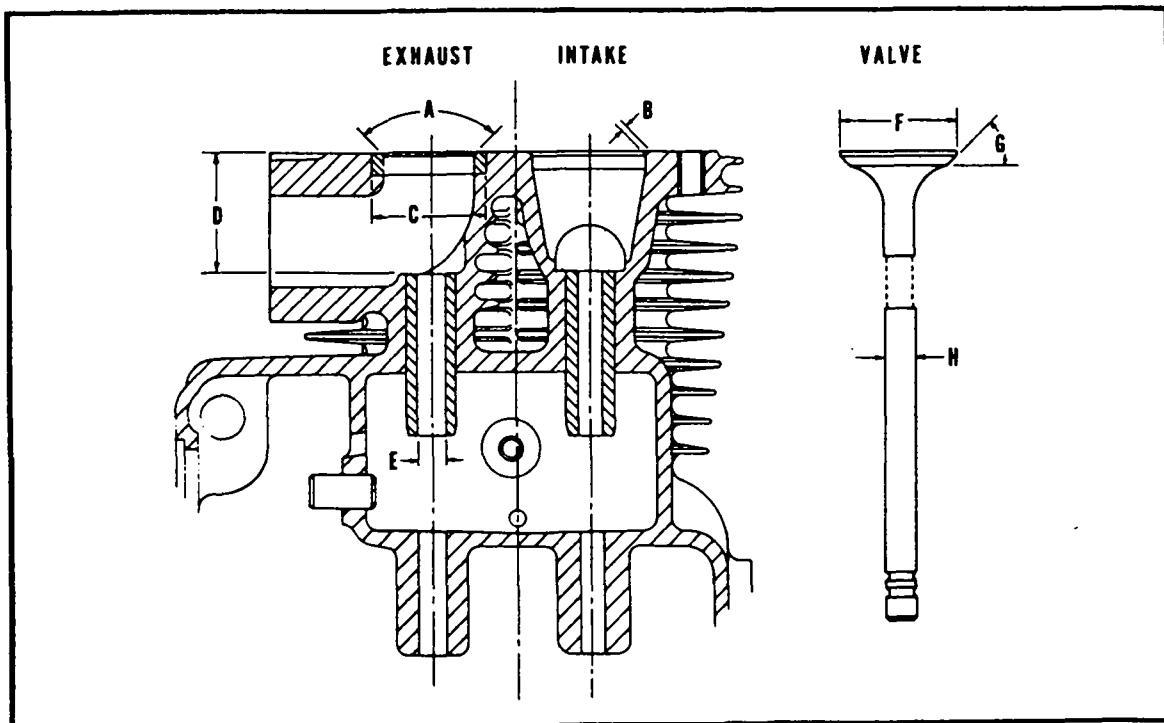
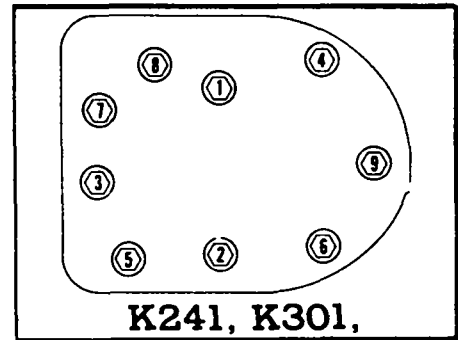


Figure 51 Valve Detail Drawing -- Location

SPECIFICATION		
	K241	K301
Bore and stroke	3-1/4x2-7/8	3-3/8x3-1/4
Bore diameter, new	3.250	3.375
Crankshaft end play	.003/.020	.003/.020
Crankshaft - conn. rod journal size	1.5000/1.4995	1.5000/1.4995
Crankpin - conn. rod side clearance	.007/.016	.007/.016
Crankpin length	1.187	1.180
Journal diameter, new	1.575	1.575
Connecting rod to crankpin running clearance	.001/.002	.001/.002
Connecting rod to wrist pin clearance	.0003/.0008	.0003/.0008
Wrist pin to piston boss	.0000/.0003 Select Fit	One Thumb Push Fit
Piston to cylinder bore (thrust face)	.003/.004	.003/.004
Piston to cylinder bore (top of skirt)	.0075/.0085	.0065/.0095
Piston pin bore size	.85975	.85975
Piston pin diameter	.86	.86
Ring side clearance, top ring	.002/.004	.002/.004
Ring side clearance, middle ring	.002/.004	.002/.004
Ring side clearance, oil ring	.001/.003	.001/.003
Ring end gap	.010/.020	.010/.020
Ring width, inches, top ring	.093	.093
Ring width, inches, middle ring	.093	.093
Ring width, inches, oil ring	.187	.187

Camshaft pin to camshaft clearance	.001/.0035	.001/.0035
Camshaft pin to block (Bearing plate end)	.0005/.002	.0005/.0020
Camshaft pin to block (P.T.O.E.) (Int.)	.0015/.0030	.0015/.0030
Camshaft pin to breaker cam	.0010/.0025	.0010/.0025
Camshaft end play	.005/.010	.005/.010
Valve stem clearance in guide, intake	.0010/.0025	.0010/.0025
Valve stem clearance in guide, exhaust	.0025/.0040	.0025/.0040
Valve guide in block (Interference)	.0005/.0020	.0005/.0020
Valve seat in block (exhaust) (Interference)	.003/.005	.003/.005
Valve clearance, intake (cold)	.008/.010	.008/.010
Valve clearance, exhaust (cold)	.017/.020	.017/.020
Valve seat angle	44.5	44.5
Valve face angle	45	45
Valve seat width	.037/.045	.037/.045
Valve tappet clearance in block	.0008/.0023	.0008/.0023
Governor bushing to gov. cross shaft clear.	.001/.0025	.0010/.0025
Governor gear to governor shaft	.0005/.0020	.0005/.0020
Ball bearing to cylinder block (Interference)	.0006/.0022	.0006/.0022
Ball bearing to bearing plate (Interference)	.0012/.0028	.0012/.0028
Ball bearing to crankshaft (Int. to loose)	.0004/.0005	.0004/.0005

FITS & CLEARANCES

VALVE DETAILS

DIMENSION	MODEL K241, K301, K321	
	INTAKE	EXHAUST
A SEAT ANGLE	89°	89°
B SEAT WIDTH	.037/.045	.037/.045
C INSERT O. D.	-----	1.2535/1.2545
D GUIDE DEPTH	1-15/32	1-15/32
E GUIDE I. D.	.312/.313	.312/.313
F VALVE HEAD DIAMETER	1.370/1.380	1.120/1.130
G VALVE FACE ANGLE	45°	45°
H VALVE STEM DIAMETER	.3105/.3110	.3090/.3095

TRANSMISSION TROUBLE ANALYSIS

TROUBLE	CAUSE	DETERMINATION	SOLUTION
Clutches engaged Tractor drive wheels will not turn.	Bound linkage, missing clevis pins. Bent clutch rods, bent or broken actuating shaft levers.		Repair linkage.
	Sheared keys in one or both actuating shaft levers.		Replace sheared keys.
	Broken drive pinion shaft.	Engage P.T.O. and hi-lo planetary, P.T.O. does not turn.	Replace parts as required.
	Hi-Lo planetary gears - broken, broken or worn clutch.	Engage P.T.O. and hi-lo planetary, P.T.O. does not turn, pinion shaft could be tight indicating broken parts in planetary.	Replace parts as required.
	Forward-Reverse planetary, worn or broken clutches, broken gears.	Engage P.T.O. and hi-lo planetary, P.T.O. turns. Check differential action by raising wheels off the ground, turning one wheel by hand other wheel should turn freely in opposite direction.	Replace parts as required.
	Differential problems.	Tight or no differential action. Free wheeling tractor or tractor wheels won't turn.	Replace parts as required.
Transmission seems to be loading engine, even to stall point when Hi-Lo engaged. Ground speed about three times as fast as normal speed when Forward-Reverse is engaged.	Frozen Hi-Lo planetary.		Replace parts as required.
P.T.O. will not shift in or out of gear or will not stay in gear.	Bending of external linkage.		Repair external linkage.
	Broken or worn internal P.T.O. shifting mechanism.		Replace parts as required.

SHIFTING LINKAGE

Before assuming that internal transmission problems exist, check all external linkage. Inspect the shifting linkage beginning with the control lever and work towards the transmission. Check for binding. Look for broken or missing cotter pins and sheared keys.

CLUTCH ADJUSTMENT

Clutch adjustment is necessary anytime clutch slippage occurs.

Clutch rods when engaged should just completely compress the springs on the clutch actuating lever when fully engaged.

To adjust, tighten the jam nuts until proper adjustment is obtained.

If external adjustments do not correct problems, internal examination may be necessary.

ENGINE REMOVAL

1. Remove ground cable from battery.
2. Drain Transmission oil.
3. Turn off fuel at fuel tank. Remove fuel line from fuel pump.
4. Remove the choke cable from carburetor.
5. Remove the throttle cable from the linkage.
6. Separate wiring harness at connector.
7. Remove cable from starter motor.
8. Remove rear hitch from tractor.
9. Remove 2 lower bolts securing engine to the chassis casting.
10. Remove the 2 upper bolts from the engine but leave in place the casting to support the braces.
11. Remove engine from tractor.

TRANSMISSION REMOVAL

1. Remove engine from tractor.
2. Remove battery.
3. Remove capscrews holding the handles, fuel tank, and battery box assembly to the chassis, and lift assembly off chassis.
4. Remove wheels and wheel hubs

FORWARD-REVERSE CLUTCH AND PLANETARY SYSTEM

To gain access to the forward-reverse clutch and planetary system, remove advance housing and rotate actuating rod with the lever until entire planetary system is released. All components of the forward-reverse clutch assembly are now ready for inspection.

- a. Examine all parts for excessive wear or play.
- b. Pay particular attention to the orbit gears and the orbit gear pins. If the bores of the gears are scored or out-of-round, replace gears and pins.
- c. Check internal gear teeth for wear.
- d. If friction surface, or bond, of clutch cup is worn or damaged, replace cup.

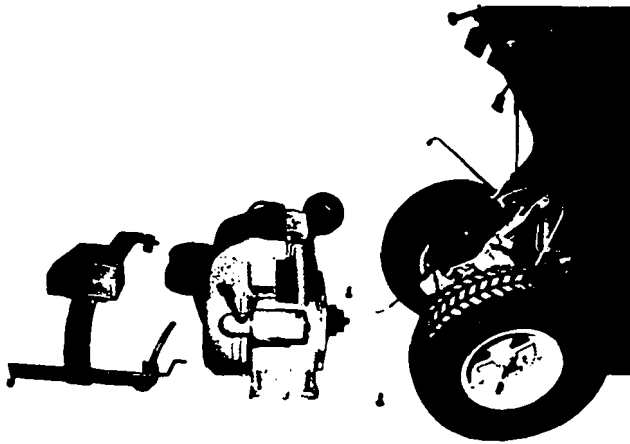


Figure 52



Figure 53

e. Check the friction surfaces of the reverse cone and internal gear for scoring. If surfaces are damaged, replace parts to prevent rapid wear of a new clutch.

When replacing the Forward-Reverse Clutch unit, the planetary gears must be timed.

Time Planetary gears as follows:

- a. Place Sun pinion in bore of front pin plate.
- b. Secure pin-plate quill to the pin plate with three (3) quill-securing bolts.
- c. Place the orbit gear pins in orbit gears.

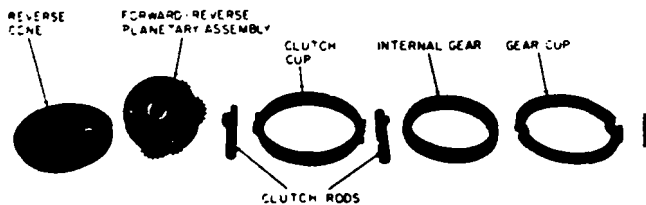


Figure 54

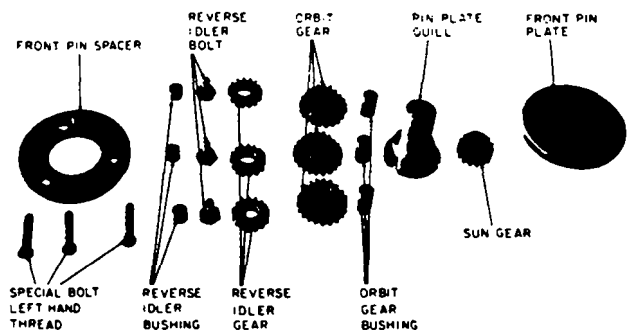


Figure 55

d. Mesh the three gears with Sun pinion so that the timing marks form an equal sided triangle. Timing marks (A, Figure 57) are small punches on the opposite side of gears.

When replacing this unit in the transmission it is necessary to mesh the teeth on the actuating rod and the clutch slide rods (See Figure 58) to accept the assembly.

FIRST-SECOND GEAR, CLUTCH AND PLANETARY

To examine the first-second clutch and planetary, remove engine as described on page 44 and release unit by turning the actuating shaft.

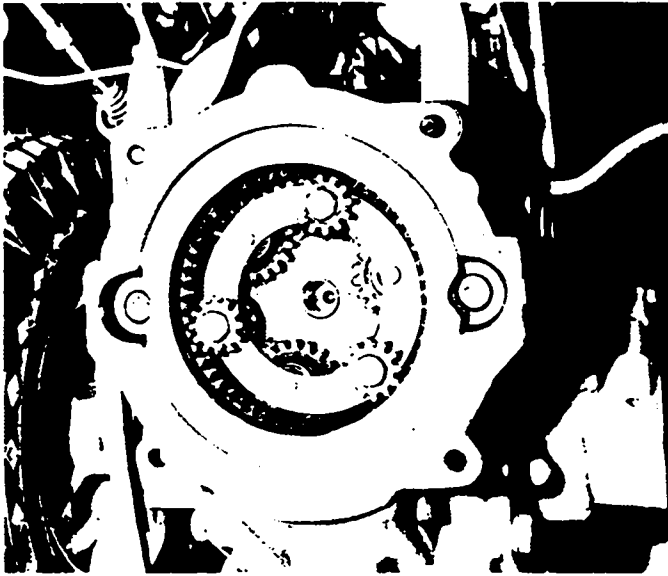


Figure 56

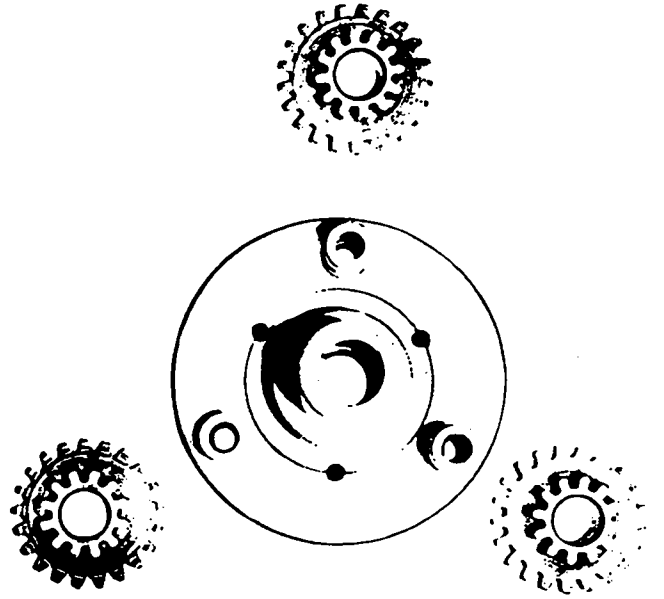


Figure 57

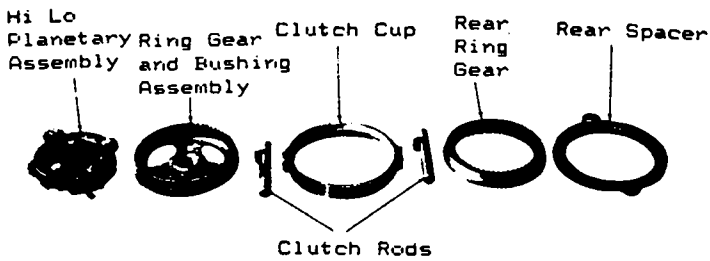


Figure 58

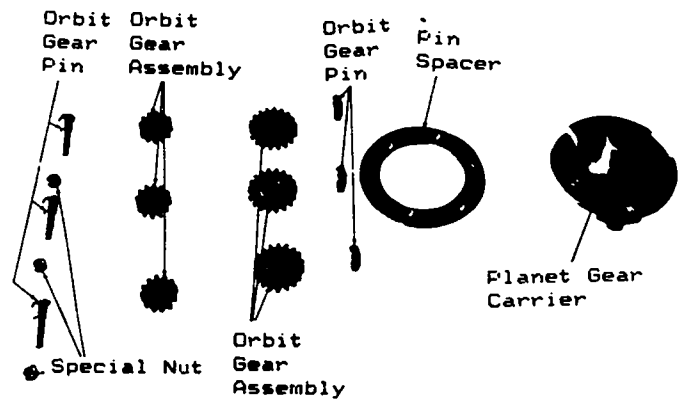


Figure 59

To avoid damage to the rear pin plate bushing, it is not recommended that Planetary System be further disassembled unless definite problems exist.

If an unreasonable amount of play is noticed in the system:

- a. Inspect orbit gear pins and bushings for wear.
- b. Inspect the orbit gear carrier bushing for wear.
- c. Check for worn or damaged gearing.
- d. See forward-reverse clutch and planetary system procedure, items d and e for clutch inspection routine.

DIFFERENTIAL

Before assuming internal swiftamatic difficulties, inspect the external linkage and parts for binding. Carefully check the following:

1. Check linkage for binding, sheared spring pin, loose nuts or debris build up.
2. Check to see that the shifter arm is not binding on the stationary pivot.
3. Check to see that the clutch sliding pivot is free.
4. Check to see that the extension spring is in place.
5. Check stationary clutch bolt. Be sure it is not sheared.
6. Raise tractor wheels. Turn one wheel by hand. The other wheel should turn in the opposite direction. Check for tightness and rough spots while turning.

DIFFERENTIAL REMOVAL

1. Drain oil from transmission.
2. Raise tractor and remove wheels.
3. Remove right hand wheel hub.
4. Disconnect swiftamatic shift linkage.
5. Remove right hand axle housing with axle.
6. Carefully examine the shifting yoke, shifting clutch, stationary clutch and clutch housing. Particular attention should be given to see that the stationary clutch is properly secured against rotation. Also make sure the shifting clutch slides freely on the shifting gear.
7. If no discrepancies have been found at this point or if the failure is obviously a part of the differential assembly remove the differential assembly.
8. Remove left hand wheel hub.
9. Remove left hand axle housing with axle.
10. Remove the differential assembly from the tractor.

Note: The following steps (11 through 21) refer to tractor prior to serial number J-65504. Refer to steps 22 through 32 for tractor serial number above J-65504. Steps 33 through 38 apply to all tractors.

11. Secure the differential assembly upright in a vise.
12. Bend down locking plates and remove six (6) bolts securing clutch housing to worm gear.
13. Lift off clutch housing. Remove shims.
14. Remove internal parts of differential. Carefully check all parts for damage or abnormal wear.

Abnormal conditions include:

1. Scoring of thrust washers.
 2. Scoring of spider pin arms.
 3. Scoring of bore of gears.
 4. Scoring on the back of gears.
 5. Chipped teeth.
 6. Heavy wear on gear teeth.
15. Examine internal surfaces of the worm gear. An even wear pattern is normal, however it should not exceed .010 inch. If the gear is pitted in spots or has small gouges, polish these areas.

16. Reassemble the differential mechanism. Use new needle thrust bearings if any other part have been replaced. Assemble on two opposite spider arms in this sequence: spider gear, shifting train pinion, needle thrust bearing, needle thrust race, shims, spider thrust washer. On the two remaining spider arms, assemble in this sequence, spider gear and thrust spacer. Install in bronze gear.
 17. Using a differential gear, check shimming of spider gears. Adjust shims so that gear sits solid on all four spider gears.
 18. Install shims, differential gear, shifting gear and clutch housing on worm gear. Use new drilled bolts; clean bolts and apply a stud locking preparation to the bolt threads. Torque bolts to 17-20 ft. lbs.
 19. Check end play of shifting gear - .0— .010 maximum. If necessary, remove clutch housing and adjust shims accordingly. Reinstall clutch housing and bolts. Torque to 20 ft. lbs.
 20. Insert wire through one bolt head, cross and insert through another, then twist ends securely. Trim twist to ½ inch length. Repeat, securing other bolts.
 21. Turn differential assembly over and remove bolts. Replace with new bolts as in steps 18 & 20.
-
22. Using wire cutters, remove wire securing bolts on each side of worm gear. Secure differential assembly upright in vise.
 23. Remove bolts securing clutch housing to worm gear. Remove clutch housing, gears, and shims.
 24. Turn worm gear over and remove pinned housing and gears.
 25. Tilt differential mechanism and remove from worm gear. The mechanism does not ride on the inside surface of the gear.
 26. Disassemble the differential mechanism---carefully check the bore of the gears and the spider arms for scoring, check the backs of the shifting train pinions.
 7. Reassemble the differential mechanism using new thrust needle bearings if any other parts were replaced. On the two spider arms with snap ring grooves at the end, assemble in this sequence: spider gear, shifting train pinion, bearing, spacer and snap ring. On the other two arms assemble in this sequence: spider gear, race, bearing, spacer and snap ring.
 28. Tilt the differential mechanism and install it in the worm gear.
 29. Install the pinned gear and differential gear on the pinned housing and install it on the worm gear. Use new drilled bolts; clean bolts and apply a stud locking preparation to the bolt threads. Torque bolts to 17-20 ft. lbs.
 30. Turn worm gear over and install the clutch housing, with differential gear, shifting gear and shims on the worm gear. Torque bolts to 20 ft. lbs. Replace with new bolts as in step 29.
 31. Check end play of shifting gear .00— .010 maximum. Remove clutch housing and adjust shims as necessary. Torque bolts to 20 ft. lbs.
 32. Insert wire through one bolt head, cross and insert through other, then twist ends together securely. Trim twist to ½ inch length. Repeat, securing other bolts on other side of gear.
-
33. Install differential on L.H. axle in L.H. axle housing. (Pinned housing side of differential assembly in axle housing.)
Be sure thrust pin is in place in the differential assembly so it will be between the axles.
 34. Place equal amount of shims and a shellacked gasket on each axle housing. Install L.H. axle housing and differential assembly in tractor. Secure axle housing to tractor.
 35. Install R.H. axle housing on tractor, being sure the shifting clutch fits on the shifting gear. Secure axle housing to tractor. Torque bolts to 45 ft. lbs.
 36. Remove the engine and high-low planetary or the advance casting and the forward-reverse planetary.
 37. Using a screwdriver or similar tool, check the differential assembly for play. Running clearance should be .008—.012. Adjust by adding or removing an equal amount of shims from each axle housing.
 38. Adjust axles for .008—.012 end play. Add or remove shims behind the bearing cap.

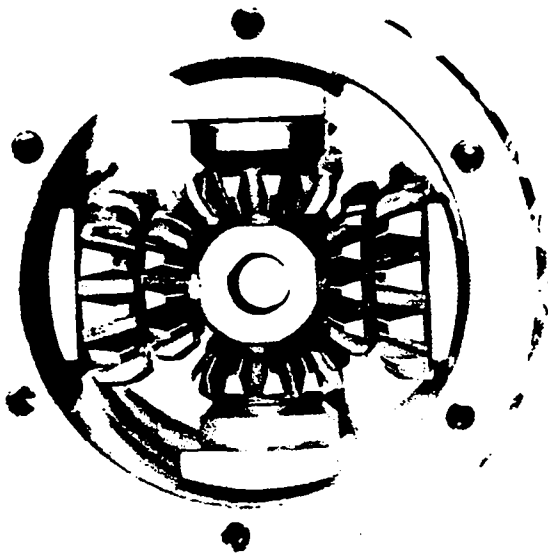


Figure 60



Figure 61



Figure 62

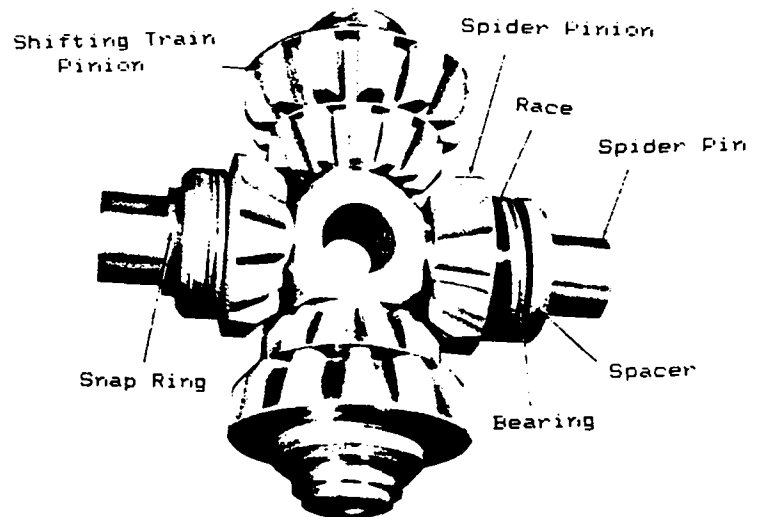


Figure 63

POWER TAKE OFF (PTO)

If it becomes difficult to shift the power takeoff in and out of gear, check external linkage for binding.

To examine the PTO, remove attachment-boss plate on the front of advance casting. At this point the dog gear and shifting eccentrics are exposed. Proceed as follows:

- a. Check the dog block for wear.
- b. Examine shifter shaft for wear.
- c. For closer inspection of the shifter assembly, remove the assembly by removing jam nut inside of advance casting and then removing the shoulder bolt.
- d. Inspect shifter body and its components for damage.
- e. Check for bearing failures.
- f. Examine pinion shaft for twisting.
- g. Replace worn or damaged parts.