GRAVELY®

500/5000 SERIES
CONVERTIBLE TRACTORS
SERVICE MANUAL

FORM NO. 16409 (6-79)

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INTRODUCTION

This manual is designed to provide an indepth service procedure for the 500/5000 series convertible tractors.

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

To continue its program of quality and design improvements, the manufacturer reserves the right to change specifications, designs and prices without notice and incurring obligation.

1 Gravely Lane
Clemmons, North Carolina 27012

Contents

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
A. Hard Starting or Loss of Power **(Check First for Dirty Air Cleaner!)**	1. Faulty Ignition. 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. a. Gasoline not getting to carburetor. 1. Dirt or gum in fuel line. 2. Fuel pump faulty. b. Dirt in carburetor. c. Carburetor improperly adjusted.
B. Overheating	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.
C. Backfiring	1. Fuel mixture too lean. 2. Improper timing. 3. Valve "sticking"
D. Occasional "Skip" at High Speed	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.
E. Operating Erratically	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.
F. Engine Will Not Idle	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.

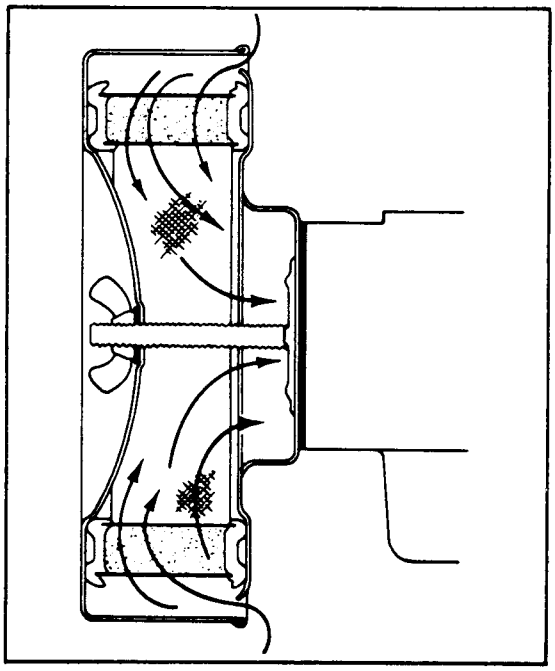


Figure 1 Dry type Air Cleaner

LUBRICATION

TRANSMISSION

Capacity: 5 U.S. Quarts
Grade: GL-6 (API service class)
Viscosity: Summer: SAE 30W or SAE 10W-30
Winter: (32°F or below) SAE 10W or SAE 10W-30

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

Engine
Oil capacity 8 horsepower: 2½ pints
Oil capacity 10 and 12 horsepower: 4 U.S. pints
Recommended oil (all models):
Summer — SAE 30W or SAE 10W-30
Winter — (0°F or below) SAE 5W-20

Check oil level daily. Maintain at full mark, do not overfill. Regular draining of the oil in the transmission is not necessary. The transmission oil drain is the bottom bolt in the left axle housing on all models.

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.

CONDITION	POSSIBLE CAUSE/PROBABLE REMEDY
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 value 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 values.

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 throughly. 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.

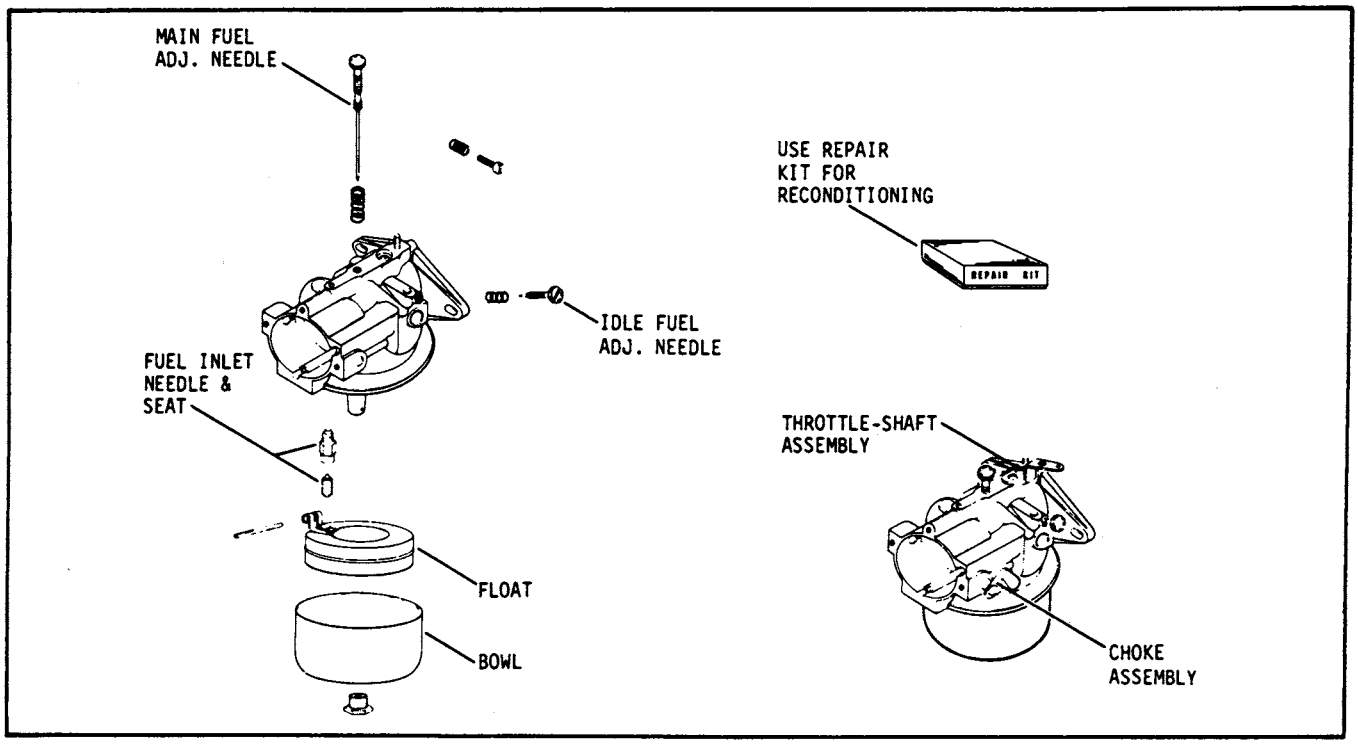


Figure 2 Side Draft Carburetor

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 11/64'' plus or minus 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.

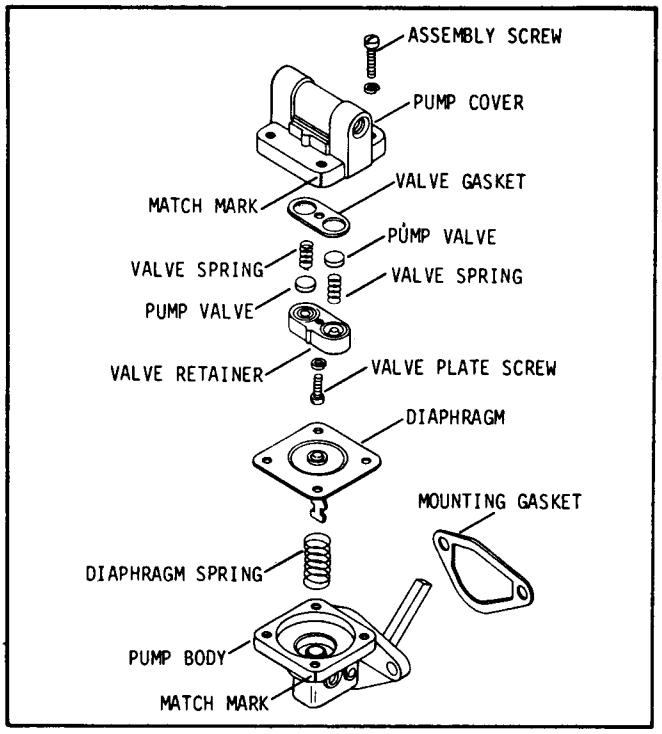


Figure 3 — Fuel Pump

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, noting their position. Discard valve springs, valves and valve retainer 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 Kohler Single Cylinder Engines are equipped with centrigugal 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.

Governed speed may be at a fixed point as on constant speed type settings or variable as determined by the throttle lever on variable speed type governor settings.

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.

While the internal mechanism is basically the same on all engines, the external arrangement is different on the Model K241, K301, K181. Be sure to follow adjustment procedure for the model and for the type of governor setting used.

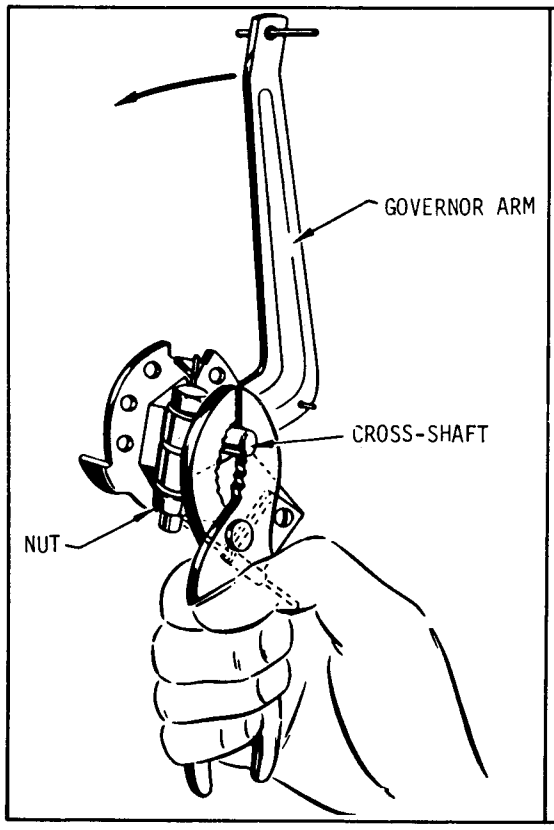


FIGURE 4 — INITIAL ADJUSTMENT
K181

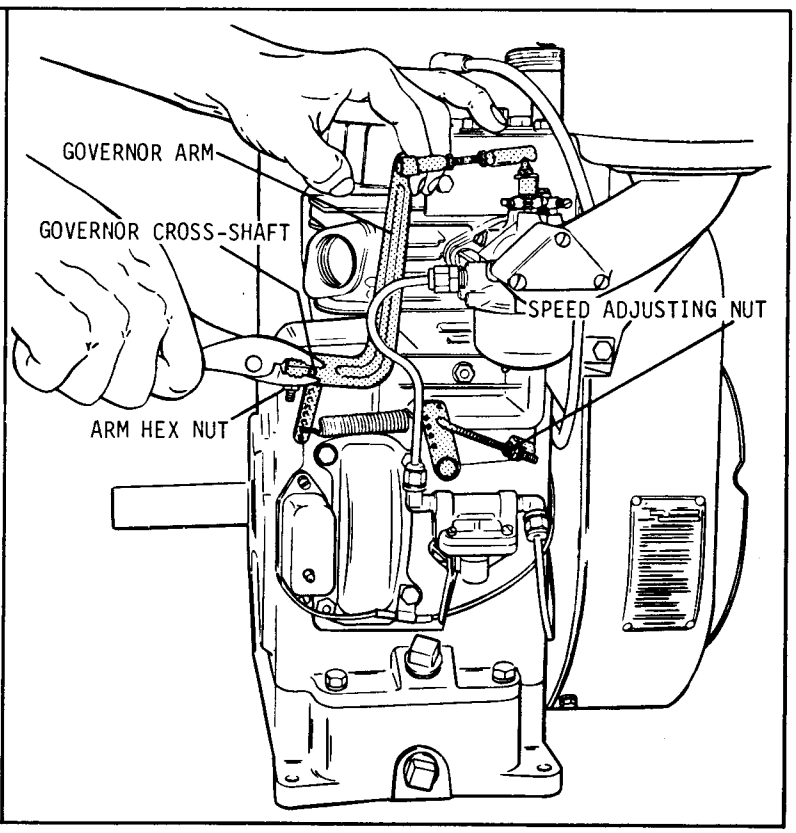


FIGURE 5 — INITIAL ADJUSTMENT
K241, K301

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 away 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.

SPEED ADJUSTMENT — K181

After making initial adjustment and connecting throttle wire on variable speed applications, start engine and check maximum operating speed with hand tachometer. If adjustment is necessary to bring speed within correct operating range, use the following procedure for both Constant and Variable Speed settings.

STEP 1: Loosen bushing nut slightly.

STEP 2: Move throttle bracket in counterclockwise direction to increase engine speed or move throttle bracket in clockwise direction to decrease engine speed. Caution: Do not allow engine to operate at speeds above maximum. Maximum permissible speed is 3600 RPM

STEP 3: With speed in proper range, retighten bushing nut to lock throttle bracket in position. Caution: Do not apply excessive pressure on bushing nut as this could cause binding or collapsed threads.

SPEED ADJUSTMENT — K241, K301,

Loosen capscrew and move high speed stop bracket until correct speed is attained then retighten capscrew.

SENSITIVITY ADJUSTMENT — K241, K301

On the K241, K301 and K321, 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.

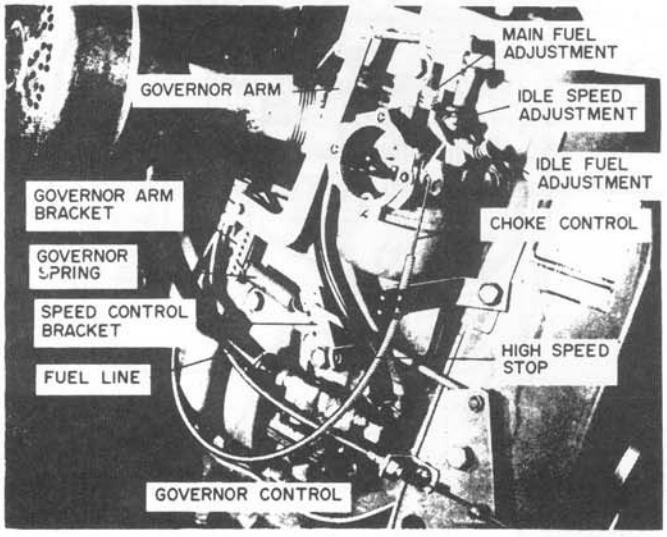


Figure 6

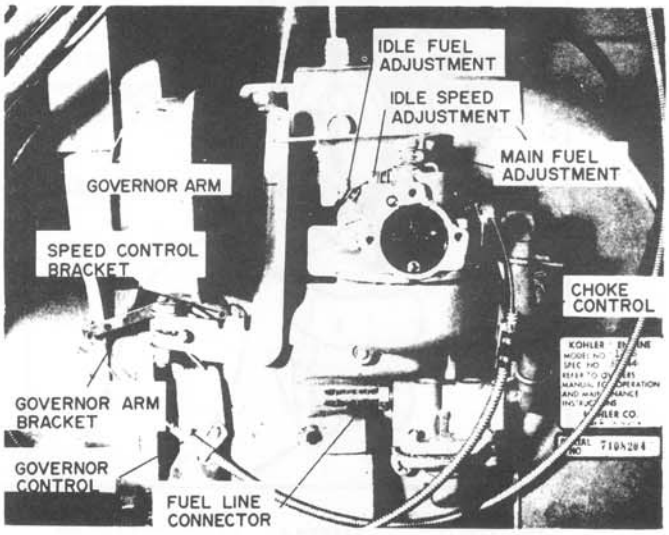


Figure 7

IGNITION SYSTEM

When checking out an ignition system, start with the components that require frequent service or adjustment. Hard starting, roughness, low power and erratic operation are often attribured to faulty ignition. All components must be in top condtion 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.

COMMON CAUSES — POOR OR NO IGNITION

NO IGNITION SPARK

1. Switch turned off
2. Leads disconnected or broken
3. Bad plug
4. Ignition switch faulty
5. Breaker points oxidized
6. Breaker points stuck
7. Condenser faulty
8. Ignition coil faulty

POOR IGNITION

1. Plug wet
2. Plug gap incorrect
3. Plug carbon fouled
4. Wrong plug
5. Breaker points dirty or bad condition
6. Point gap wrong
7. Condenser weak
8. Push rod sticking or worn
9. Cam lobe worn

SPARK PLUG SERVICE

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 TEST: Remove plug, set gap to specifications, place plug with side electrode against cylinder head then crank engine at speed sufficient to produce a good spark — if a sharp snappy spark is noted between the electrodes, this eliminates the ignition components as the fault — wrong timing could however be causing problems.

Spark Plug Service: Every 100 hours remove plug, check condition and reset gap. Good operating conditions are indicated if plug has light coating of 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. Do not sandblast, wire brush, scrape or otherwise service plug in poor condition — best results are obtained with new plug. Set spark gap at .025" for gasoline, .020" on shielded plugs. Tighten plug to 18 to 22 foot lbs. with a torque wrench.

SPARK PLUG SPECIFICATIONS

ENGINE MODEL	PLUG SIZE	HEX. SIZE	PLUG REACH	STANDARD PLUGS		RESISTOR PLUGS	
				SOLID POST	KNURLED NUT	NON-SHIELDED	SHIELDED
K181	14mm	13/16"	3/8"	J-8 270321-S	J-8 220040-S	XJ-8 232604-S	XEJ-8 220258-S
K241	14mm	13/16"	7/16"	H-10 235040-S	Not Available	XH-10 235041-S	XEH-10 235259-S
K301	14mm	13/16"	7/16"	H-10 235040-S	Not Available	XH-10 235041-S	XEH-10 235259-S
Gap Setting — Gasoline .025" (Shielded .020") Tightening Torque — All plugs 18 to 22 foot lbs. (Champion plugs listed — use Champion or equivalent plus.)							

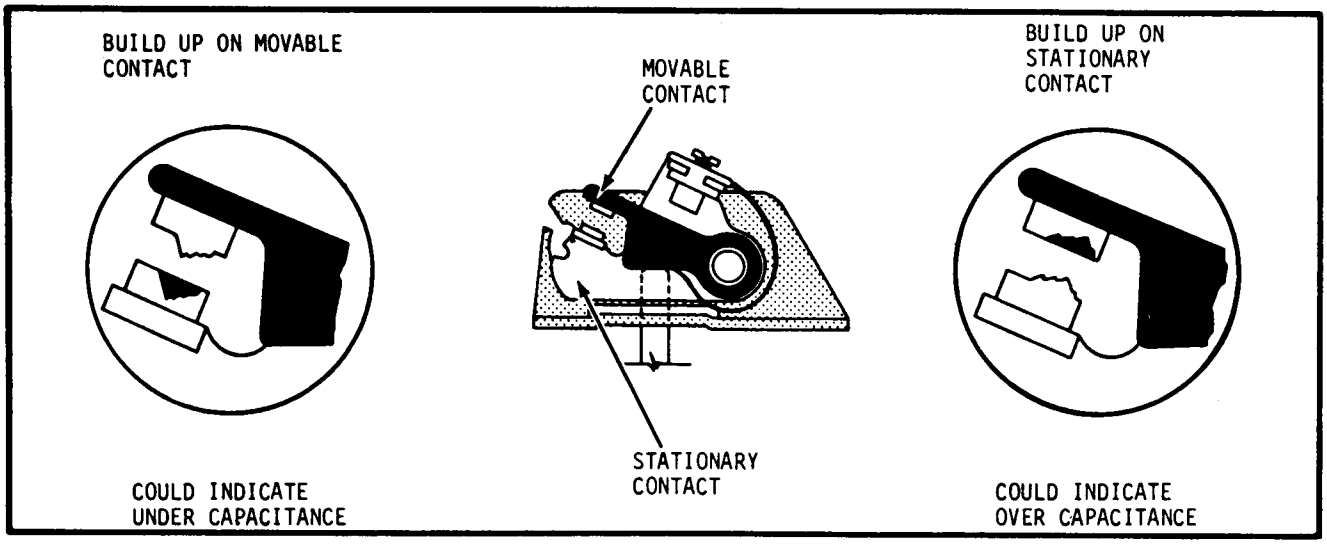


Figure 8 — Metal Transfer Indicators on Breaker Point

BREAKER POINT SERVICE

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. Adjusting breaker point gap affects the time that the contacts are opened and closed. If the points are adjusted to a wider gap they will open earlier and close later in terms of cam movement. A definite time is required for the magnetic field within the ignition coil to build up to sufficient value. If the contact points are closed for too short a time, a weak spark will be produced by the coil. If points are set too wide, they will open before the primary current reaches the maximum value and on the other hand if set too close, they will open after the primary current has passed its maximum value.

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 capacitiance, 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 teminals — 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.

MAGNETO IGNITION SYSTEMS

On all magneto ignition systems, high strength permanent magnets provide the source energy for ignition. With rotor type systems, the magnet is pressed onto the crankshaft and is rotated inside the coil-core assembly on the bearing plate. On the other systems, a permanent magnet ring on the inside of the flywheel revolves a round the stator (coil-core) assembly. Movement of the magnets past the stator magnetically induces current flow in the ignition coil windings and the alternator or lighting coils when finished. The magnets are placed with alternate North and South poles so that the direction of magnetic flux changes direction which induces an alternating current in the coil windings — this effect is shown in the magneto cycle illustration. Current flow reaches maximum in the ignition coil at the instant the magnetic flux reverses direction — the ignition must be timed to occur when this energy is highest for the best spark. The ignition coil has a low tension primary winding and a high tension secondary winding. The secondary winding has up to 100 more turns than the primary and is of relatively thin wire to step up the voltage. Current flows in the primary only while the breaker points are closed. Current flowing in the primary creates, magnetically, a difference in electrical potential between it and the secondary winding. When ignition is required, the breaker points open to break the primary circuit — this results in a sudden collapse of the magnetic field which, in turn, induces sufficient energy in the secondary to bridge the spark gap and ignite the fuel-air mixture in the combustion chamber. The collapsing magnetic field also induces energy in the primary; however, this energy is quickly absorbed by the condenser which prevents the energy from arcing across the air gap between the breaker points. Energy in the primary can go as high as 250 volts while in the secondary this could reach 25,000 volts (250 volts × 100 turns = 25,000 volts); however, the secondary energy increases only to a high enough value to bridge the spark gap which is usually somewhere between 6,000 to 20,000 volts — the actual value is determined by such variables as engine speed, compression, spark gap and condition of the spark plug. Timing of the ignition spark is established by setting of the spark gap — if the gap is set wider this causes ignition to occur earlier while reducing the gap causes it to occur later.

BATTERY IGNITION SYSTEMS

The battery ignition systems function in the same way as the magneto ignition systems, except that the energy source for the ignition coil is the battery. On these systems, battery charge is maintained by a 15 amp flywheel-alternator. With the alternator systems, a permanent magnet ring on an inside rim of the flywheel revolves around the alternator stator on the bearing plate. This produces Alternating Current but is changed to Direct Current in the rectifier-regulator unit to charge the battery.

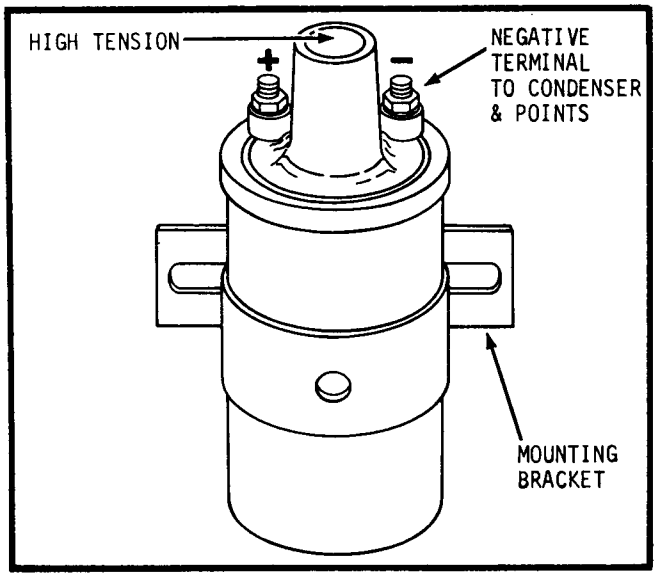


Figure 9 — Typical Battery Ignition Coil

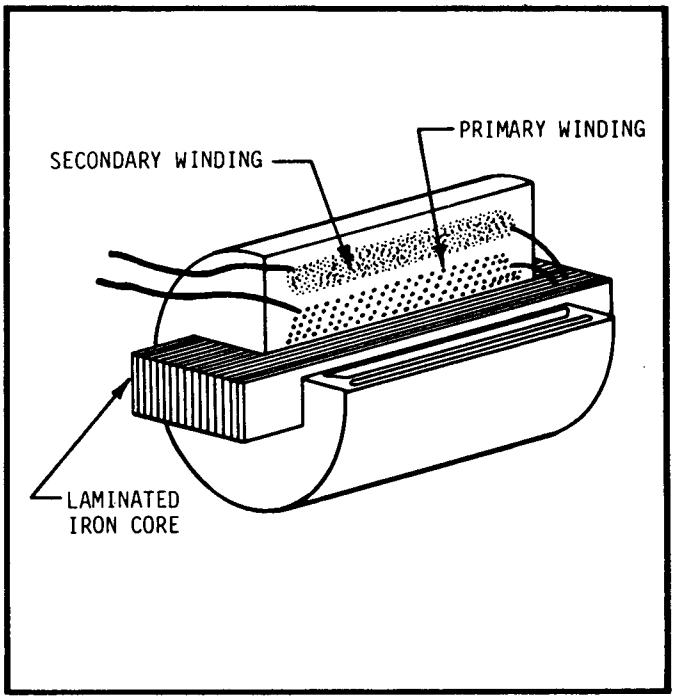
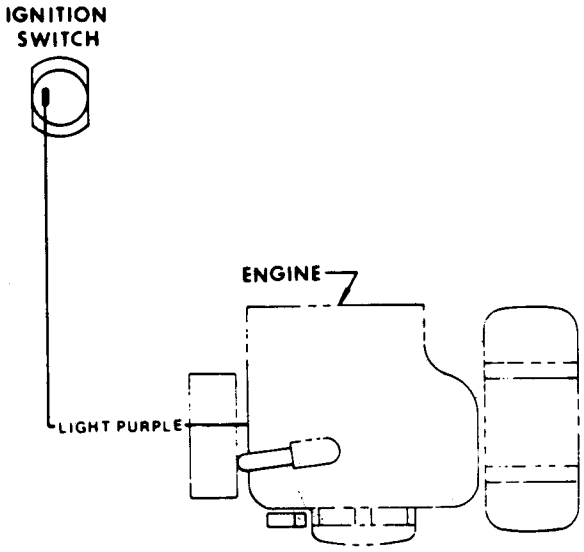


Figure 10 — Typical Magneto Ignition Coil

NOTE
The 10 and 12 hp elect start engines are equipped with an automotive ignition system that consist of points, condenser and external mounted coil with built in resistor.

WIRING DIAGRAM
(FOR 500 SERIES MANUAL START TRACTORS)



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, however, a storage battery will have to be used per timing light manufacture's instructions.

Figure 11 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.
(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.

ELECTRICAL STARTING-CHARGING SYSTEMS

ALTERNATOR SYSTEM*

CHARGING CIRCUIT

1. Battery (12 volt)
2. Rectifier-Regulator
3. Alternator 15 AMP System

CRANKING CIRCUIT

1. Compact Starting Motor

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

Storage batteries used are of the lead-acid type. Lead is used in the construction of the cellplates 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.

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 on the equipment powered by the engine. The 15 amp rectifier-regulator has different solid-state components and therefore cannot be used with any other charging system.

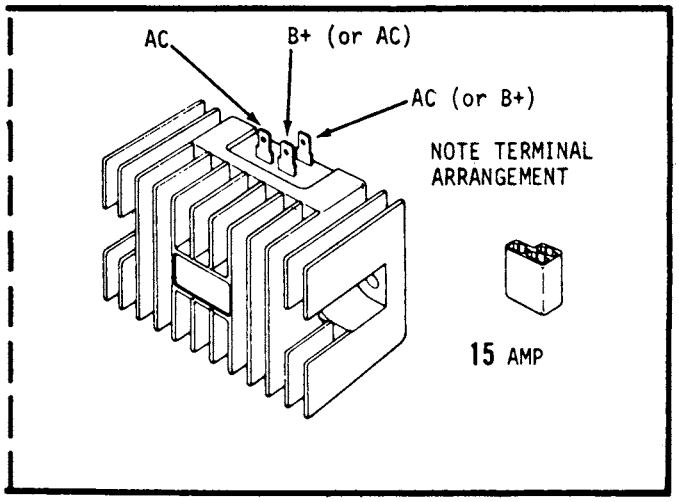
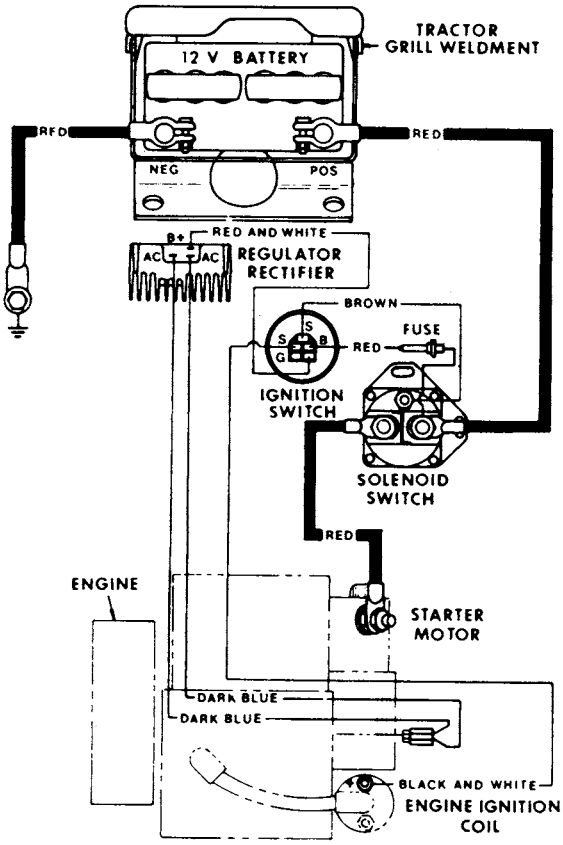


Figure 12 — 15 Amp System

WIRING DIAGRAM
(FOR 500 SERIES ELECTRIC START TRACTORS)



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 magnet.

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.

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
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: A-1 — If charge rate increases. A-2 — If charge rate does not increase.	A-1 — Indicates alternator system OK, battery was fully charged. A-2 — Check for defective stator or rectifier-regulator (TEST B).
TEST B — Unplug leads at rectifier-regulator, connect VOM (multimeter) across AC leads, check AC voltage: B-1 — If less than 28 volts. B-2 — If more than 28 volts.	B-1 — Defective stator, replace with new assembly. B-2 — Defective rectifier-regulator, replace with new unit.
CONDITION: BATTERY CONTINUOUSLY CHARGES AT HIGH RATE	POSSIBLE FAULT/REMEDY
TEST C — Check B+ to ground with DC Voltmeter: C-1 — If over 14.7 volts. C-2 — If under 14.7 volts.	C-1 — Rectifier-regulator not functioning properly. Replace with new unit. C-2 — Alternator system OK. Battery unable to hold charge. Check specific gravity of battery. Replace if necessary

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

PERMANENT MAGNET TYPE STARTING MOTORS

The permanent Magnet (PM) starting motors, now used on the 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.

CONDITION	POSSIBLE FAULT AND CORRECTION
A. STARTER FAILS TO ENERGIZE	A-1 Wiring: Check for badly corroded or loose connections, also broken or frayed insulation. Clean and tighten connections, replace wires in poor condition. A-2 Starting Switch or Solenoid: Bypass the switch or solenoid with jumper wire — if starter cranks normally, replace defective part. A-3 Battery: Check specific gravity of battery — if low, recharge or replace battery as necessary.
B. STARTER ENERGIZES BUT TURNS TOO SLOWLY	B-1 Battery: Check condition of battery (See A-3). 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.

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 antispring 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 diassembled for servicing. Service is not required at any specific hourly basis — it should be done only when performance indicates a need for such service.

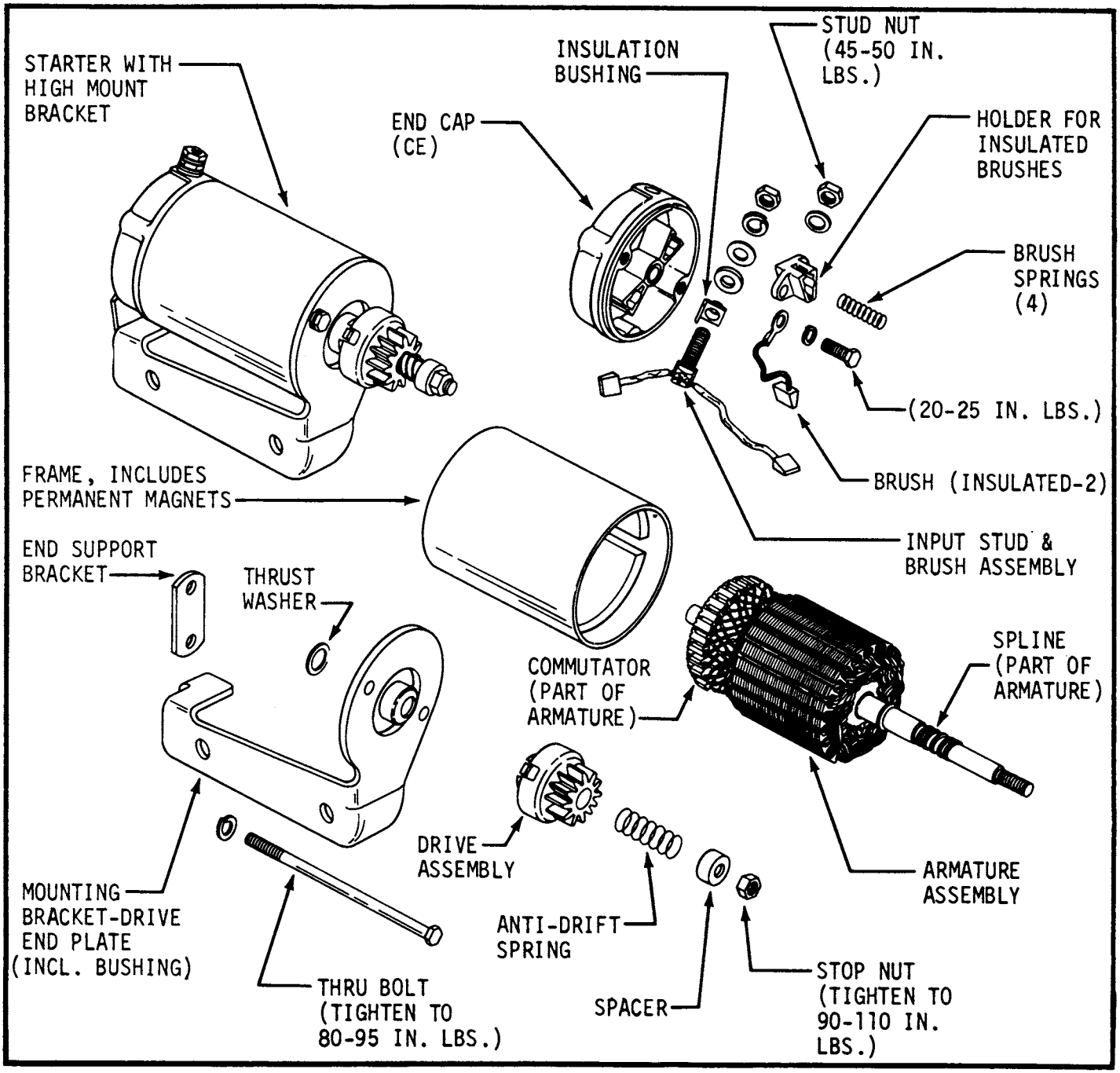


Figure 13

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 ot 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 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 valves 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.

RETRACTABLE STARTERS K181 ONLY

Eaton retractable starters are pre-lubricated during assembly and should require no further service unless disassembled to replace starting rope or rewind spring. The Eaton starter is mounted on the blower housing of the engine with 5 mounting screws. When the starting rope is pulled, pawls or dogs engage in a drive cup which is secured to the end of the crankshaft. As soon as tension on the rope is released, the pawls retract to disengage from the drive cup. If rope or spring replacement or other repairs become necessary, remove the 5 mounting screws and move the starter to bench for disassembly. CAUTION: Use extreme care when removing, handling and installing rewind springs.

Disassembly

STEP 1: Remove screw (and washers) on dog retainer and slip retainer off small spring fastened over post on outside face of pulley — carefully slip retainer off to avoid damaging spring.

STEP 2: Relieve rewind spring tension as follows:

a. Pull rope handle out about 8 inches — tie knot in rope to prevent rope from being pulled into housing.
b. Insert screwdriver blade under rope retainer on handle, slip rope out of retainer and untie knot at handle.
c. Hold pulley — sheave with thumb to prevent rewind spring from unwinding rapidly, then untie other knot and slowly allow spring to unwind.

STEP 3: Pulley Sheave Removal: Carefully slip pulley-shreave assembly out of housing — CAUTION: Inside loop of rewind spring fits into inner hub of assembly — spring can unwind violently unless it is held in housing while the assembly is removed.

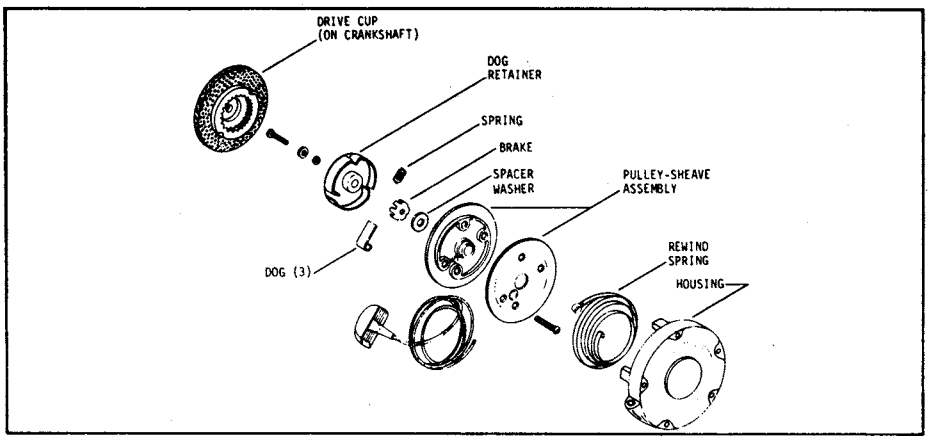


Figure 14 — Retractable Starter

STEP 4: Starting Rope Replacement (omit Step 4 if rope replacement unnecessary) Remove 4 screws on sheave side of pulley-sheave assembly, disassemble sheave from pulley, remove old rope and replace with new — tie double knot end of rope then reassemble pulley to sheave. Rewind rope on pulley assembly.

STEP 5: Rewind Spring Replacement (omit Step 5 if rewind spring replacement unnecessary)

a. Carefully remove rewind spring — start on inside loop, pull one loop out at a time.
b. Place new spring in housing, then, after blocking spring to prevent lateral movement, carefully remove retaining clip and tape if used — tape must be cut and removed in segments — do not peel from spring.

Reassembly

STEP 1: Housing-Sheave-Pulley Assembly: a. Bend piece of wire to form hook — hook inside loops of rewind spring, pull out to allow hub on inside of pulley to slip into inside of spring. b. Slide pulley-sheave into position with hub inside spring. Remove wire, then fully seat and turn pulley until spring engages in slot on hub.

STEP 2: Dog Retainer: Reinstall dogs in pulley, place spacer washer and hook spring over pulley shaft, then install retainer and secure with screw (with washer(s).

STEP 3: Pre-Tension Rewind Spring: a. Insert end of rope thru bushing in housing, pull rope out until notch in pulley is aligned with bushing. b. Hold pulley and slack up on rope. Place rope in notch, then, after blocking housing to prevent it from turning, pre-tension spring by rotating pulley and pull slack rope thru bushing — temporarily tie knot in rope to hold tension while installing handle.

STEP 4: Replace Handle and Test: a. Thread end of rope thru handle then thru rope retainer. Tie permanent knot in end of rope, reinstall retainer in handle. b. Untie temporary knot in rope, pull rope to fully extended position and release. If properly pre-tensioned, rope will fully rewind until handle hits housing.

ROPE REPLACEMENT — ALIGNMENT

While retractable starters do not require servicing, they should be checked occasionally to make sure they are secure and also that the rope is in good condition. If the rope is frayed, replace it immediately. It's a relatively simple job to replace the rope before it breaks, but if it does break, the pulley is free to unwind violently which can result in a broken spring or other damage calling for rebuilding of the starter. After removing starter from engine, replace the rope as follows — make sure starter is realigned with the drive cup when it is reinstalled on the engine.

ROPE REPLACEMENT: If the rope has not broken, simply pull the rope to its full extended position, secure the pulley in this position (block it to prevent it from rewinding), cut the knot off and remove the old rope. Install the handle on a rope, slip the other end in thru the bushing in housing and the hole in the pulley, install the rope retainer washer, then tie a knot in rope — carefully burn end slightly to fuse it, making it a permanent knot. Slowly release the pulley — brake it so that the rope winds slowly around the pulley until it is fully retracted. Realign starter to drive cup per the instructions below. If rope was broken, it will be necessary to return the starter unit to an authorized service center for repair — don't attempt to disassemble these starters as the rewind spring can unwind violently if improperly handled.

ALIGNMENT: Whenever retractable starter has been removed or has worked loose on engine, it must be realigned. If this is not done, teeth in drive cup will be damaged. Use the following procedure to align starter.

1. Attach starter to engine with retaining capscrews but do not tighten capscrews all the way.
2. Pull starter handle out about 8" so that starter centers as dogs engage in the drive cup then hold rope in this position while tightening starter mounting capscrews to complete installation.

ENGINE — GENERAL SERVICE
(all models)

COOLING

Air is drawn into the cooling shroud by fins proyided 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.

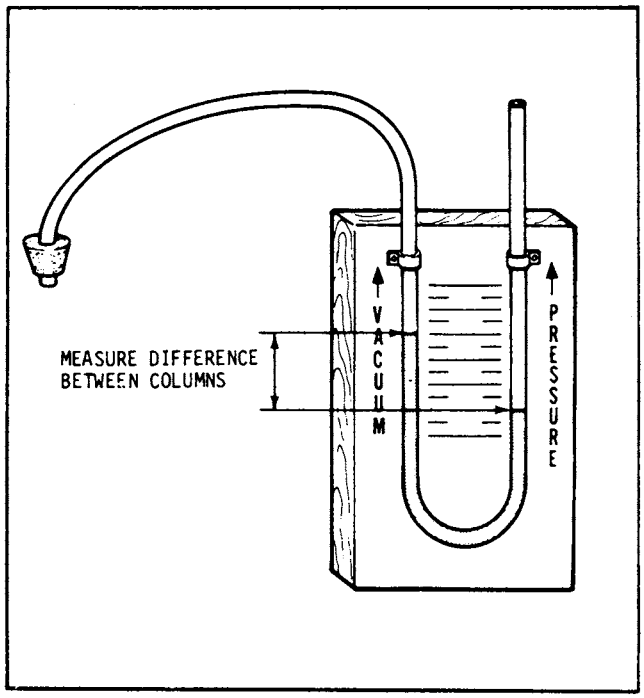


Figure 15 "U" Tube Manometer

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 in 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 dissembling 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-produce 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.

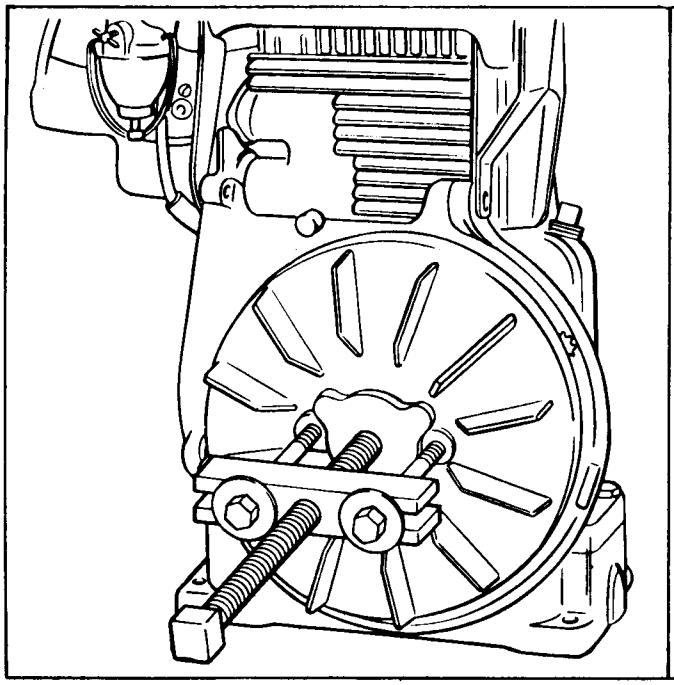


Figure 16 Remove Flywheel With Puller

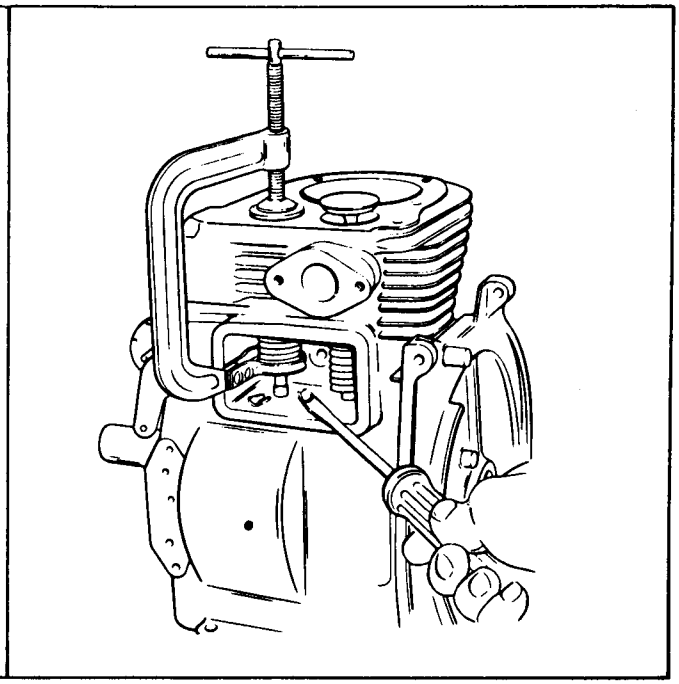


Figure 17 Using Valve Compressor.

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 preignited 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.

DISASSEMBLY 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.
   - 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.

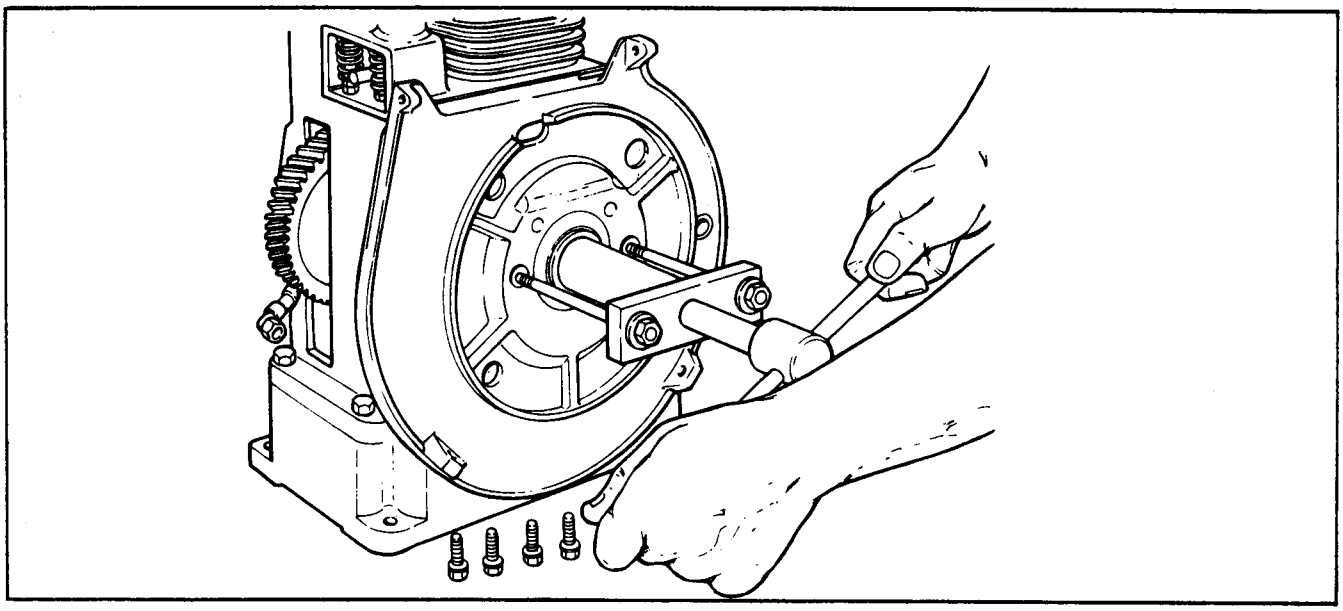


Figure 18 Pulling Bearing Plate

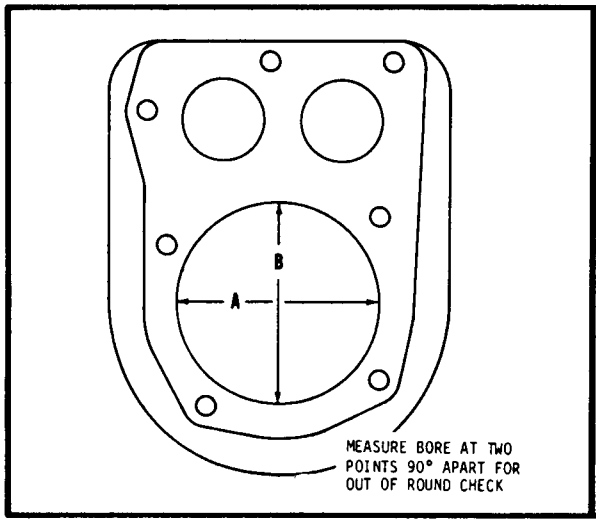


Figure 19 Measuring Cylinder Bore

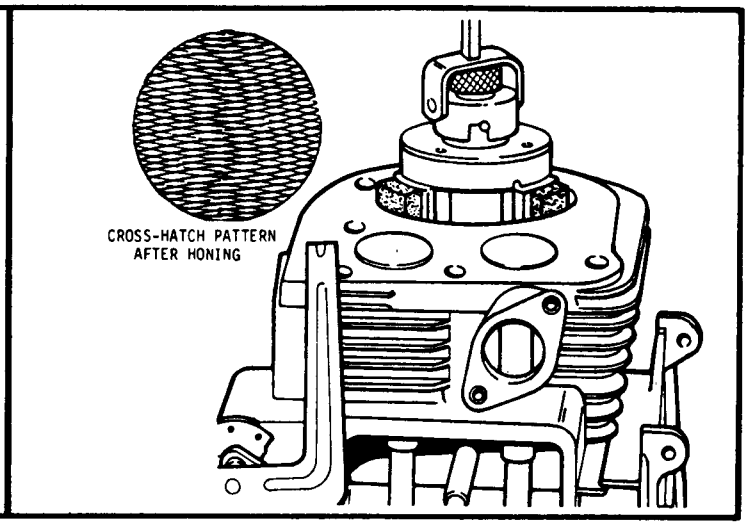


Figure 20 Honing Cylinder Walls

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 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.

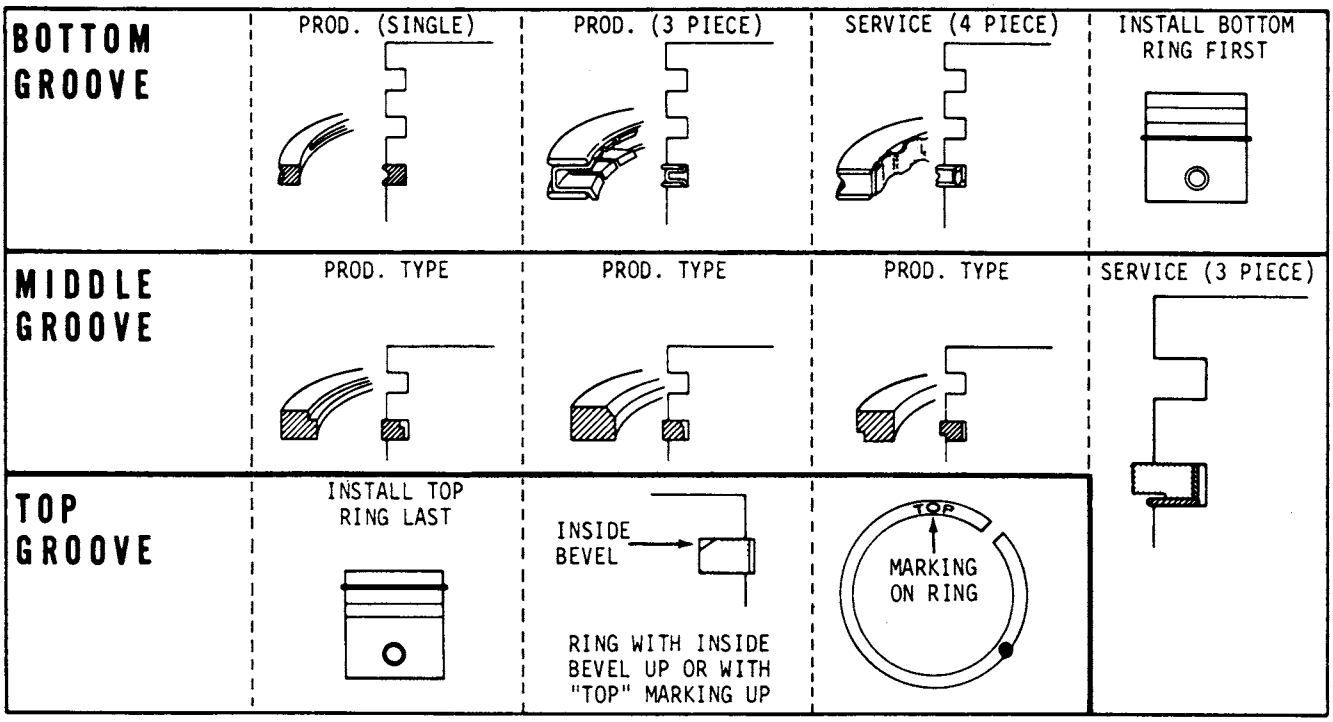


Figure 21 Production Type And Service Type Rings

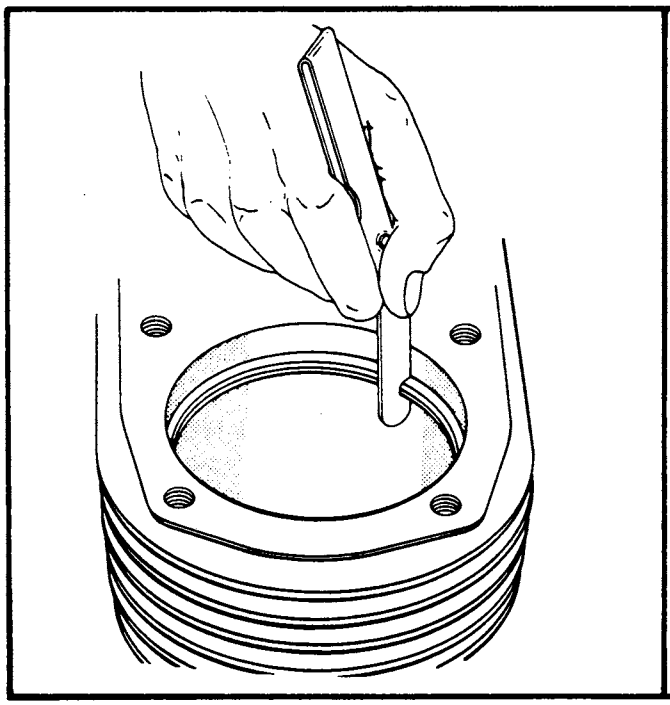


Figure 22 Measuring Piston Ring End Gap

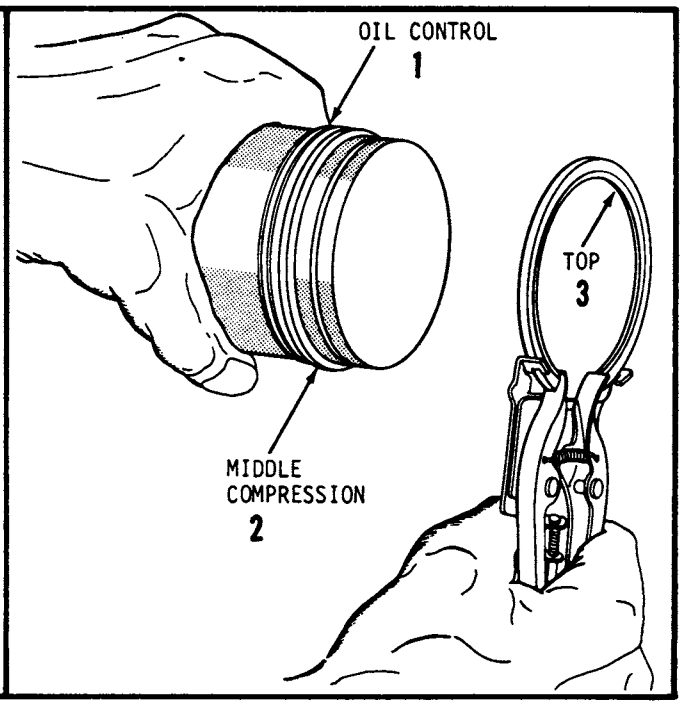


Figure 23 Ring Installation Sequence

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 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 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 interferance 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 K181, K241 and K301 engines . Loosen the locking nut, turn adjusting nut in or out until proper clearance is attained then securely tighten locknut.

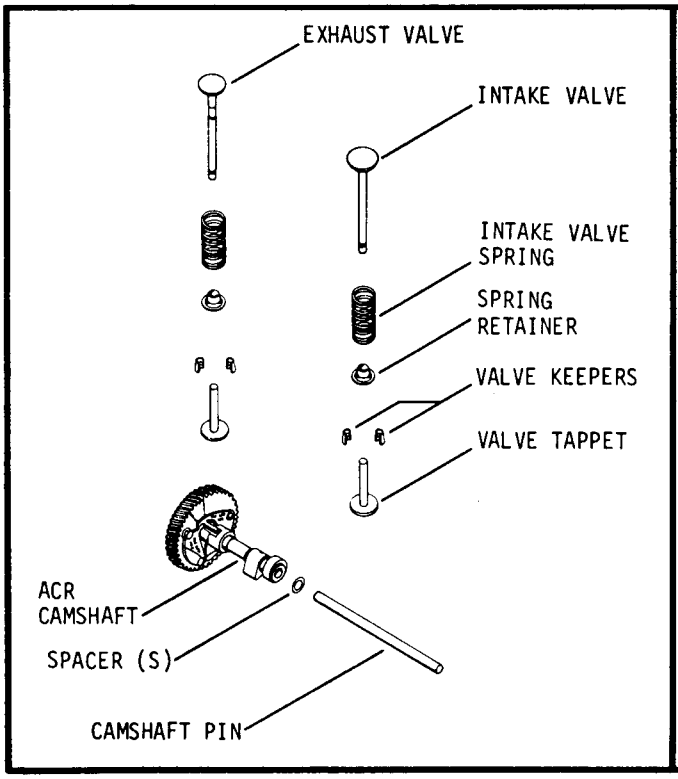


Figure 24 Valve — Tappet Clearance

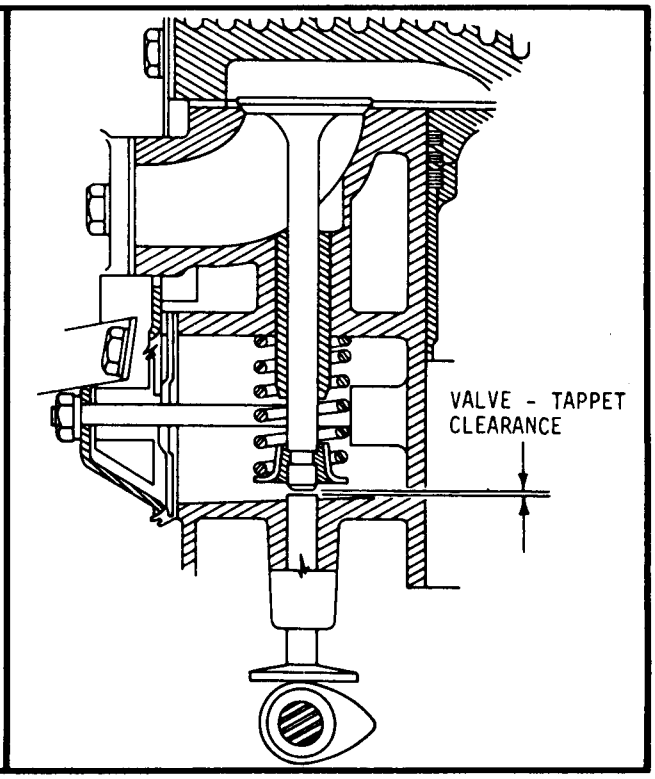


Figure 25 Camshaft and Valve Mechanism

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.

RING GEAR K181, K241 and K301

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.
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.

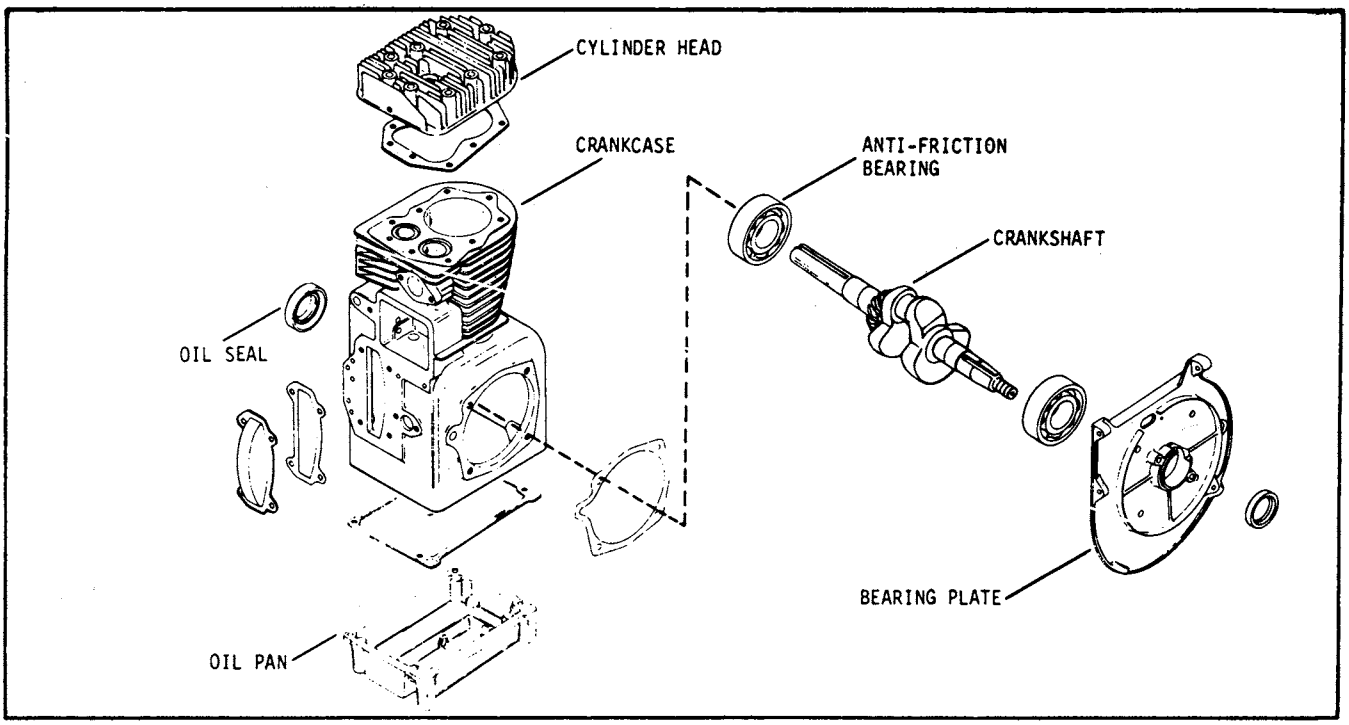


Figure 26 Exploded View, Major Components Of Typical Engine

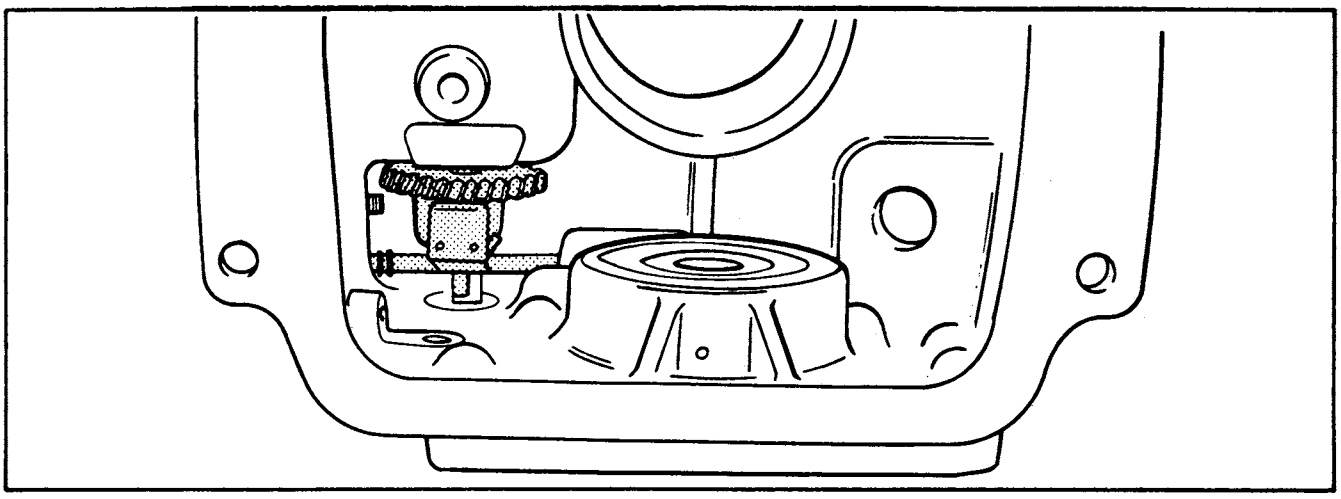


Figure 27 Governor Gear Assembly In Crankcase

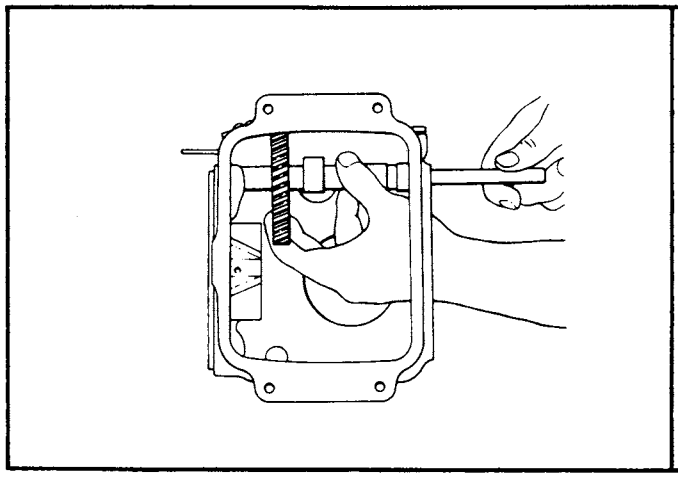


Figure 28 Installing Camshaft

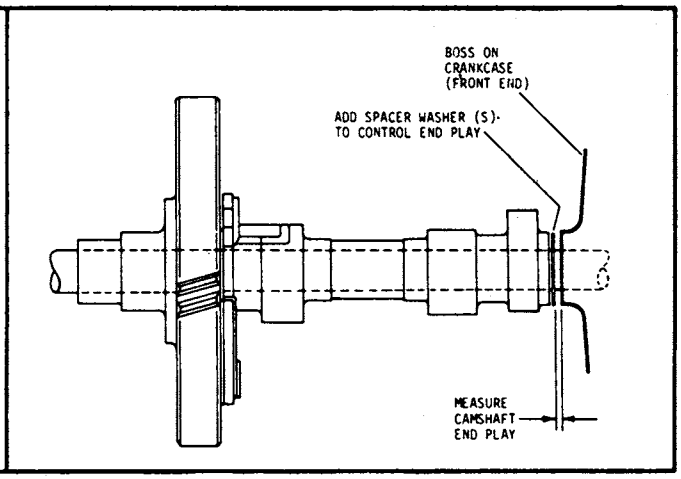


Figure 29 Camshaft End Play

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 30.

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 in installed — directions stated in Step 6.

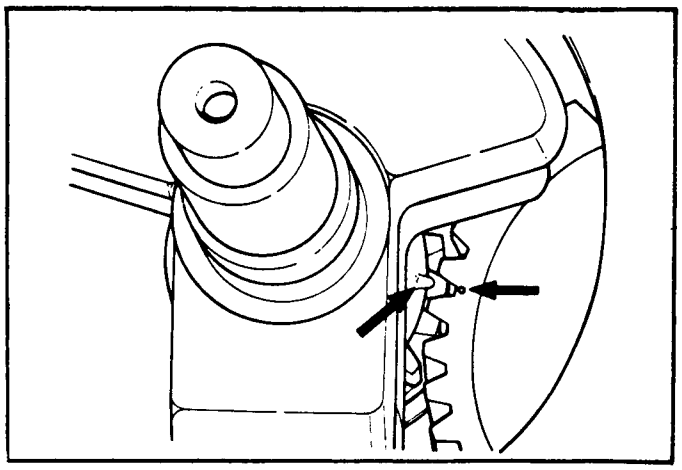


Figure 30 Timing Marks On Crankshaft and Camshaft

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 effected.

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.O. end) and shoulder on crankshaft. If end play is not within tolerance as stated in Clearance Section, remove bearing plate and add or subtract gaskets to avhieve proper clearance.

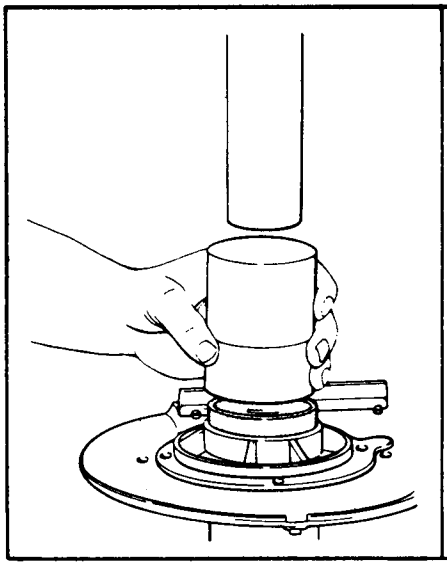


Figure 31 Pressing Bearing In Bearing Plate

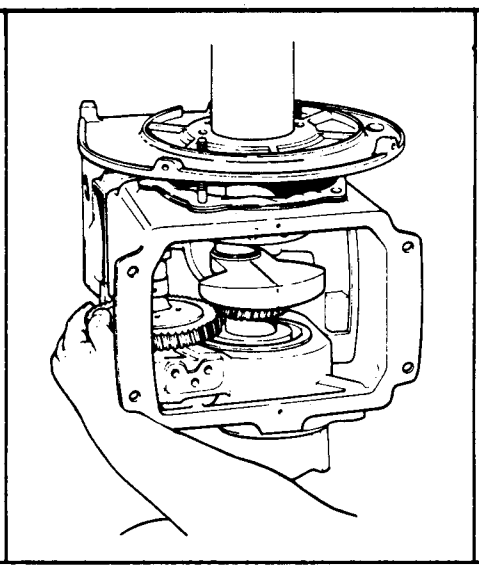


Figure 32 Installing Bearing Plate

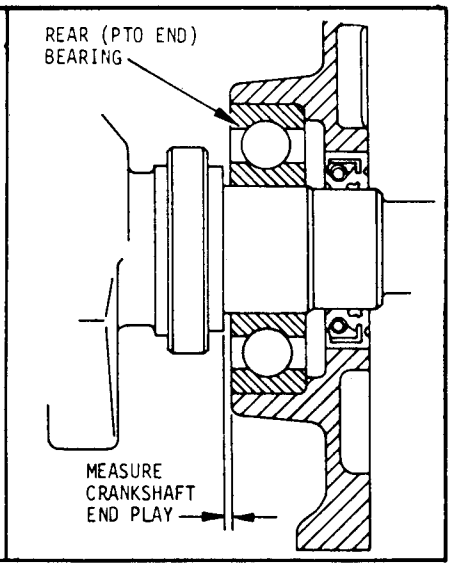


Figure 33 Crankshaft End Clearance

7. Piston and Rod Assembly

a. 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.

b. After making sure rings are in proper position in correct grooves, oil complete assembly, staggering 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.

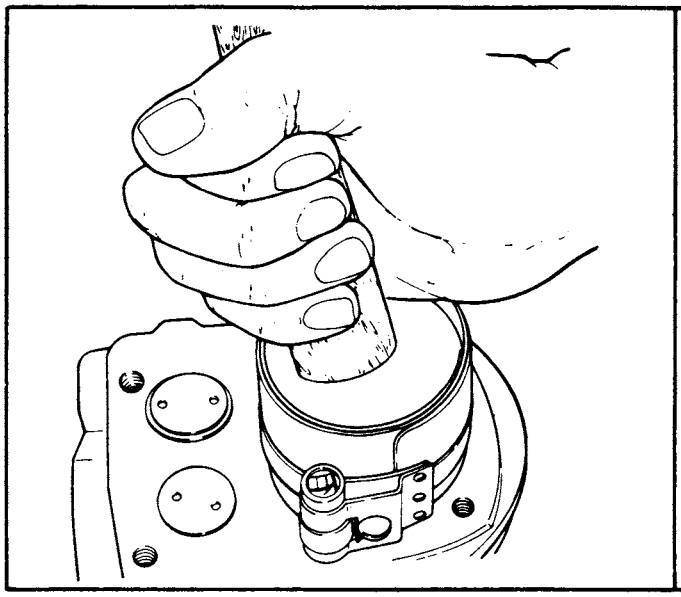


Figure 34 Installing Piston — Ring Assembly

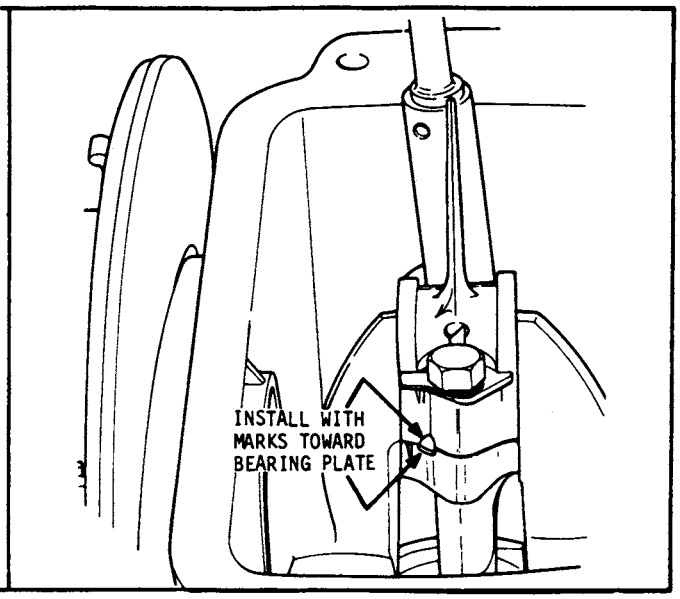


Figure 35 Installing Connecting Rod Cap Screw

8. Attaching Rod to Crankshaft
   a. After piston assembly is installed, place block on end and oil connecting rod and crank pin.
   b. It is important that marks on connecting rod and cap line up and face flywheel end of engine. (See Figure 35)
   c. 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.
   d. If locking tabs are used, bend tabs to lock cap screws.
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 36)
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.

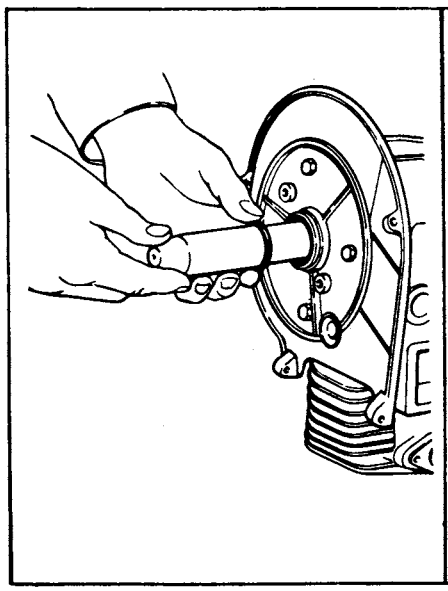


Figure 36 Installing Oil Seals

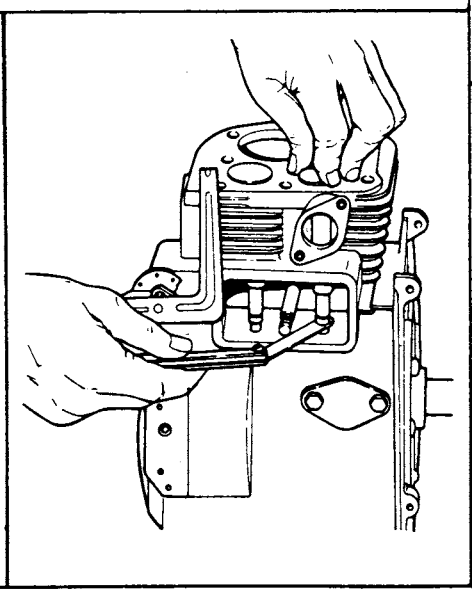


Figure 37 Checking Valve — Tappet Clearance

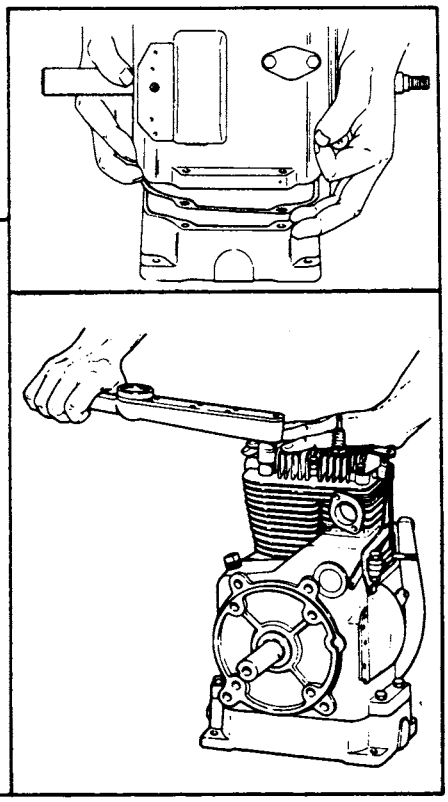


Figure 38 Tightening Cylinder Head Capscrews

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 K181, 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.

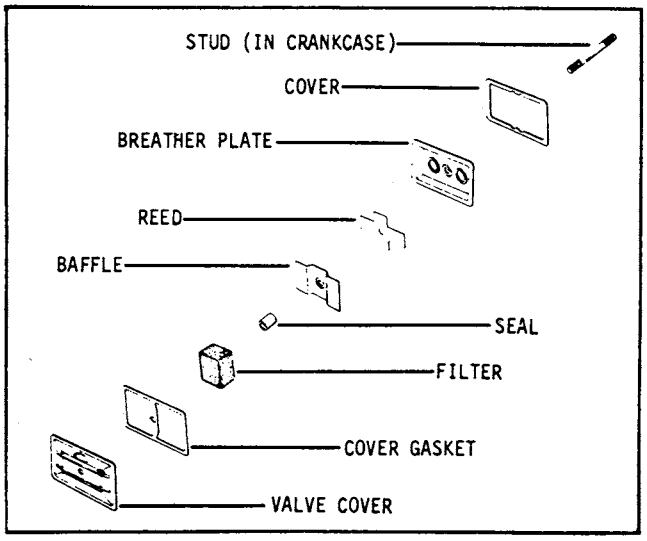


Figure 39 Typical Crankcase Breather

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.

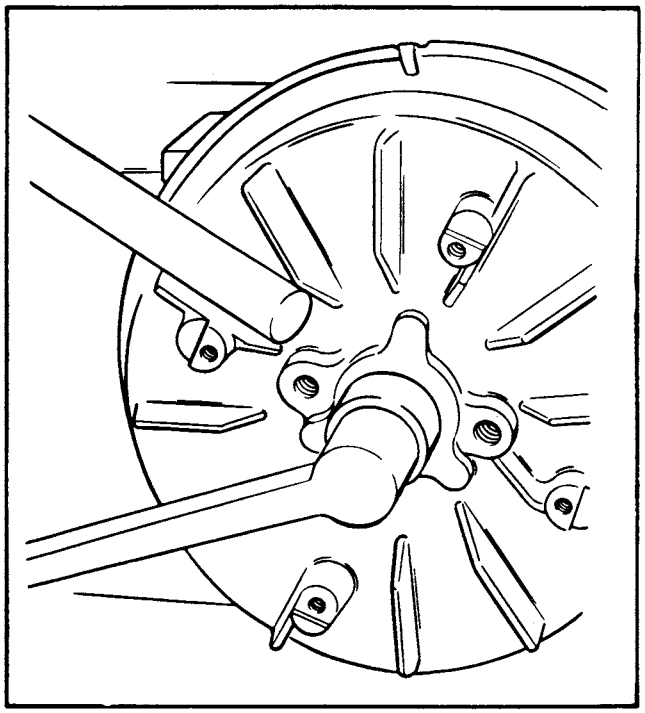


Figure 40 Installing Flywheel

    d. Set breaker gap at .020 full open. For ignitior 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:

DESCRIPTION	SIZE	DESCRIPTION	SIZE
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 ox.	Valve Spring Compressor	
Feeler Gauge	25 Blade	Needle Nose Pliers	
Drift Punch	5/16"	Timing Light	
Ratchet	3/8" Drive	Tachometer	
8" Extenstion	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.

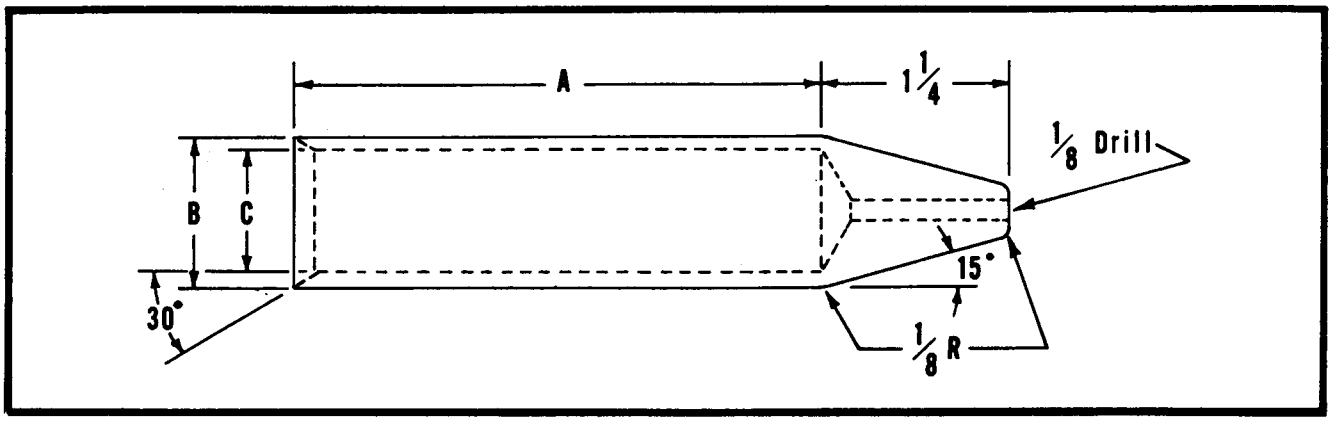


Figure 41 — Dimensional Diagram — Seal Sleeve

SEAL SLEEVE DIMENSION (FIG. 41)	K241, K301	K181
A	7-5/16"	4-3/4"
B	1.245/1.250" 1.495/1.500"	1.125/1.120"
C*	1.002/1.003' 1.252/1.253"	1.002/1.003"

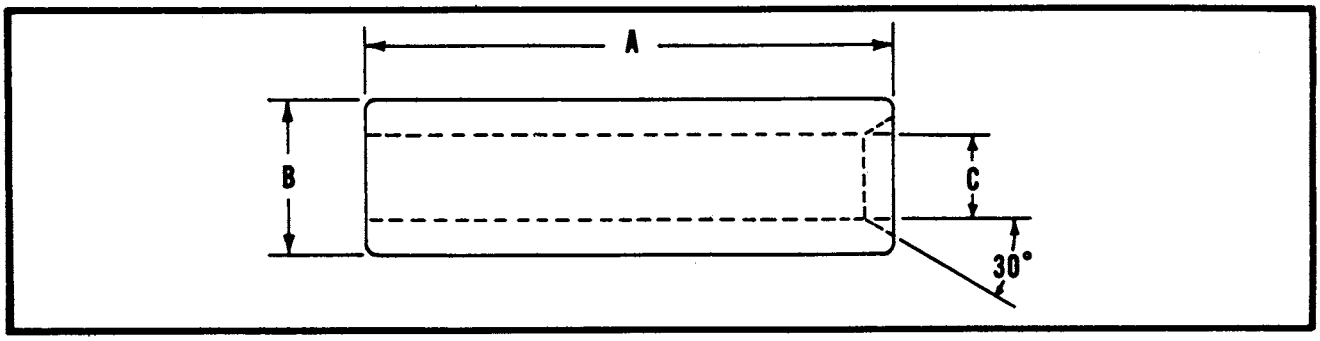


Figure 42 — Dimensional Diagram — Seal Driver

SEAL DRIVER DIMENSION (FIG. 42)	K241, K301	K181
A	8-13/16"	6-1/4"
B	1-11/16"	2"
C	1.248/1.253" 1.498/1.503"	1.123/1.128"

TORQUE VALUES — STANDARD HARDWARE ITEMS

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

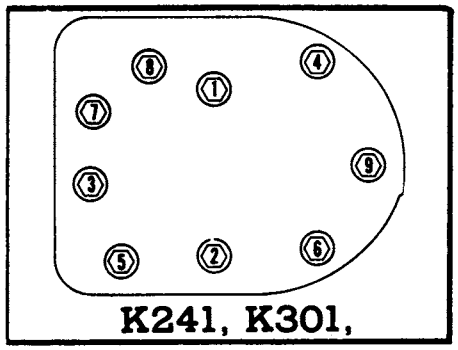


Figure 43 — Head Bolt Tightening Sequence

TORQUE VALUES — MAJOR ITEMS	ENGINE MODEL		
	K241	K301	K181
GOVERNOR ARM LOCKING SCREW	-----	-----	35 in. lbs.
CYLINDER CAPSCREW*	420 in. lbs.	420 in. lbs.	200 in. lbs.
CONNECTING ROD CAPSCREW*	300 in. lbs.	300 in. lbs.	200 in. lbs.
FLYWHEEL RETAINING NUT**	60 ft. lbs.		60 ft. lbs.
SPARK PLUG	27 ft. lbs.	27 ft. lbs.	27 ft. lbs.

* Lubricate with grease at assembly.

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.

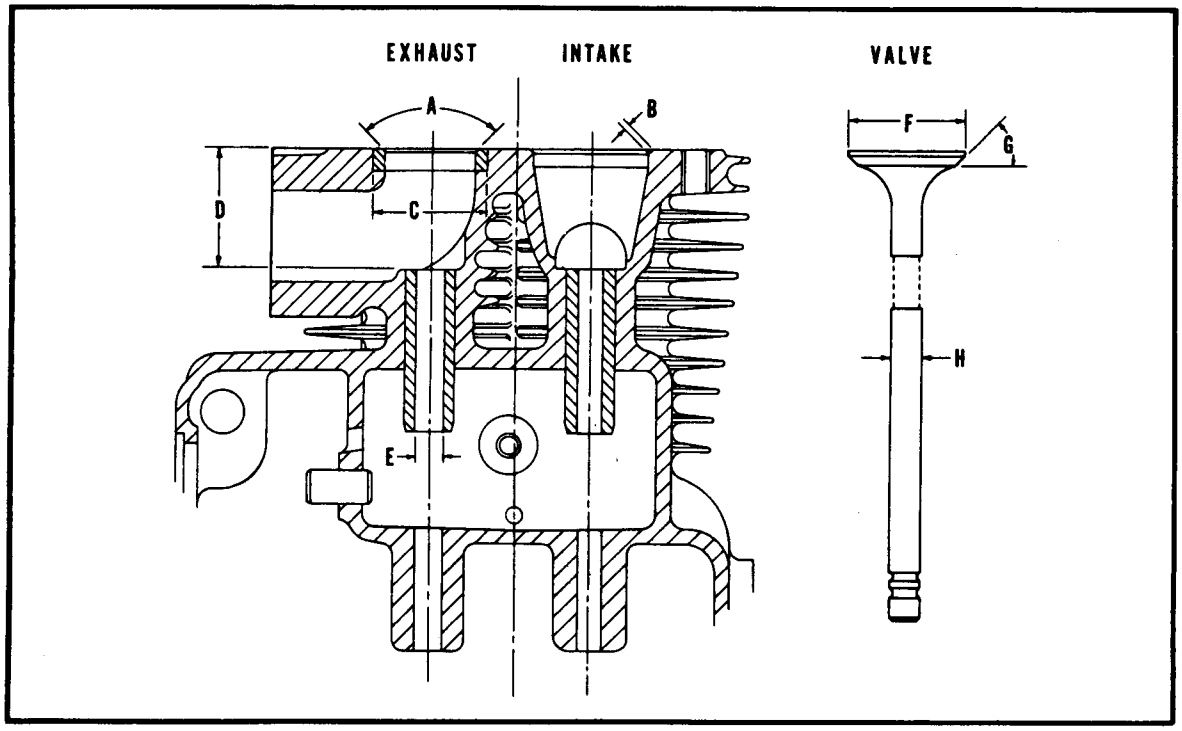


Figure 44 Valve Detail Drawing — Location

VALVE DETAILS

DIMENSION	MODEL K241, K301,		K181	
	INTAKE	EXHAUST	INTAKE	EXHAUST
A SEAT ANGLE	89°	89°	89°	89°
B SEAT WIDTH	.037/.045	.037/.045	.37/.045	.037/.045
C INSERT O.D.	-----	1.2535/1.2545	-----	1.2535/1.2545
D GUIDE DEPTH	1-15/32	1-15/32	1-5/16	1-5/16
E GUIDE I.D.	.312/.313	.312/.313	.312/.313	.312/313
F VALVE HEAD DIAMETER	1.370/1.380	1.120/1.130	1-3/8	1-1/8
G VALVE FACE ANGLE	45°	45°	45°	45°
H VALVE STEM DIAMETER	.3105/3110	.3090/.3095	.3105/.3110	.3090/.3095

FITS & CLEARANCES

SPECIFICATION	ENGINE MODEL		
	K181	K241	K301
Bore and stroke	2-15/16x2-3/4	3-1/4x2-7/8	3-3/8x3-1/4
Bore diameter, new	2.9375	3.250	3.375
Crankshaft end play	.002/.023	.003/.020	.003/020
Crankshaft - conn. rod journal size	1.1860/1.1855	1.5000/1.4995	1.5000/1.4995
Crankpin - conn. rod side clearance	.005/.016	.007/.016	.007/.016
Crankpin length	1.125	1.187	1.180
Journal diameter, new	1.181	1.575	1.575
Connecting rod to crankpin running clearance	.001/.002	.001/.002	.001/.002
Connecting rod to wrist pin clearance	.0006/.0011	.0003/.0008	.0003/0003
Wrist pin to piston boss	.0001 Int. to .0003 Loose	.0000/0003 Select Fit	One Thumb Push Fit
Piston to cylinder bore (thrust face)	.0045/.0070	.003/.004	.003/004
Piston to cylinder bore (top of skirt)	.006/.008	.0075/.0085	.0065/.0095
		.85975	.85975
Piston pin diameter	.625	.86	.86
Ring side clearance, top ring	.0025/.0040	.002/.004	.002/.004
Ring side clearance, middle ring	.0025/.0040	.002/.004	.002/.004
Ring side clearance, oil ring	.001/.0025	.001/.003	.001/.003
Ring end gap	.007/.017	.010/.020	.010/.020
Ring width, inches, top ring	.093	.093	.093
Ring width, inches, middle ring	.093	.093	.093
Ring width, inches, oil ring	.187	.187	.187

Camshaft pin to camshaft clearance	.0010/.0035	.001/.0035	.001/.0035
Camshaft pin to block (Bearing plate end)	.0005/.0020	.0005/.002	.0005/.0020
Camshaft pin to block /P.T.O.E.) (Int.)	.0015/.003	.0015/.0030	.0015/.0030
Camshaft pin to breaker cam	.0010/.0035	.0010/.0025	.0010/.0025
Camshaft end play	.005/.010	.005/.010	.005/.010
Valve stem clearance in guide, intake	.0010/.0025	.0010/.0025	.0010/.0025
Valve stem clearance in guide, exhaust	.0025/.0040	.0025/.0040	.0025/.0040
Valve guide in block (Interference)	.0005/.0020	.0005/.0020	.0005/.0020
Valve seat in block (exhaust) (Interference)	.002/.004	.003/.005	.003/.005
Valve clearance, intake (cold)	.006/.008	.008/.010	.008/.610
Valve clearance, exhaust (cold)	.015/.017	.017/.020	.017/.020
Valve seat angle	44.5	44.5	44.5
Valve face angle	45	45	45
Valve seat width	.037/.045	.037/.045	.037/.045
Valve tappet clearance in block	.0005/.002	.0008/.0023	.0008/0023
Governor bushing to gov. cross shaft clear.	.0005/.002	.001/.0025	.0010/.0025
Governor gear to governor shaft	.0025/.0055	.0005/.0020	.0005/0020
Ball bearing to cylinder block (Interference)	.0014/.0029	.0006/.0022	.0006/.0022
Ball bearing to bearing plate (Interference)	.0014/.0029	.0012/.0028	.0012/.0028
Ball bearing to crankshaft (Int. to loose)	.0005/.0002	.0004/.0005	.0004/.0005

FITS & CLEARANCES

SPECIFICATION	ENGINE MODEL		
	K181	K241	K301
Bore and stroke	2-15/16x2-3/4	3-1/4x2-7/8	3-3/8x3-1/4
Bore diameter, new	2.9375	3.250	3.375
Crankshaft end play	.002/.023	.003/.020	.003/020
Crankshaft - conn. rod journal size	1.1860/1.1855	1.5000/1.4995	1.5000/1.4995
Crankpin - conn. rod side clearance	.005/.016	.007/.016	.007/.016
Crankpin length	1.125	1.187	1.180
Journal diameter, new	1.181	1.575	1.575
Connecting rod to crankpin running clearance	.001/.002	.001/.002	.001/.002
Connecting rod to wrist pin clearance	.0006/.0011	.0003/.0008	.0003/0003
Wrist pin to piston boss	.0001 Int. to .0003 Loose	.0000/0003 Select Fit	One Thumb Push Fit
Piston to cylinder bore (thrust face)	.0045/.0070	.003/.004	.003/004
Piston to cylinder bore (top of skirt)	.006/.008	.0075/.0085	.0065/.0095
		.85975	.85975
Piston pin diameter	.625	.86	.86
Ring side clearance, top ring	.0025/.0040	.002/.004	.002/.004
Ring side clearance, middle ring	.0025/.0040	.002/.004	.002/.004
Ring side clearance, oil ring	.001/.0025	.001/.003	.001/.003
Ring end gap	.007/.017	.010/.020	.010/.020
Ring width, inches, top ring	.093	.093	.093
Ring width, inches, middle ring	.093	.093	.093
Ring width, inches, oil ring	.187	.187	.187

Camshaft pin to camshaft clearance	.0010/.0035	.001/.0035	.001/.0035
Camshaft pin to block (Bearing plate end)	.0005/.0020	.0005/.002	.0005/.0020
Camshaft pin to block /P.T.O.E.) (Int.)	.0015/.003	.0015/.0030	.0015/.0030
Camshaft pin to breaker cam	.0010/.0035	.0010/.0025	.0010/.0025
Camshaft end play	.005/.010	.005/.010	.005/.010
Valve stem clearance in guide, intake	.0010/.0025	.0010/.0025	.0010/.0025
Valve stem clearance in guide, exhaust	.0025/.0040	.0025/.0040	.0025/.0040
Valve guide in block (Interference)	.0005/.0020	.0005/.0020	.0005/.0020
Valve seat in block (exhaust) (Interference)	.002/.004	.003/.005	.003/.005
Valve clearance, intake (cold)	.006/.008	.008/.010	.008/.610
Valve clearance, exhaust (cold)	.015/.017	.017/.020	.017/.020
Valve seat angle	44.5	44.5	44.5
Valve face angle	45	45	45
Valve seat width	.037/.045	.037/.045	.037/.045
Valve tappet clearance in block	.0005/.002	.0008/.0023	.0008/0023
Governor bushing to gov. cross shaft clear.	.0005/.002	.001/.0025	.0010/.0025
Governor gear to governor shaft	.0025/.0055	.0005/.0020	.0005/0020
Ball bearing to cylinder block (Interference)	.0014/.0029	.0006/.0022	.0006/.0022
Ball bearing to bearing plate (Interference)	.0014/.0029	.0012/.0028	.0012/.0028
Ball bearing to crankshaft (Int. to loose)	.0005/.0002	.0004/.0005	.0004/.0005

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.

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

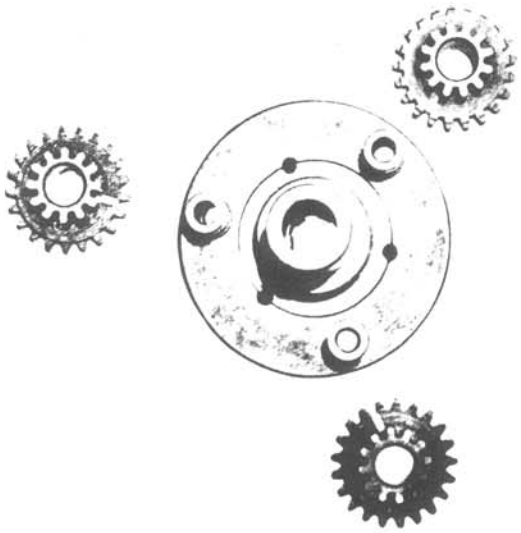


Figure 48

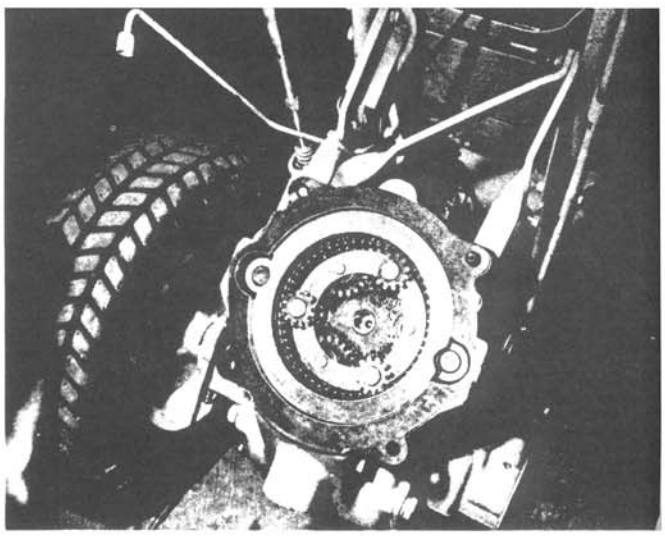


Figure 47

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 bears and pins.

c. Check internal gear teeth for wear.

d. If friction surface, or bond, of clutch cup is worn or damaged, replace cup.

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.

d. Mesh the three gears with Sun pinion so that the timing marks form an equal sided triangle. Timing marks (A, Figure 48) 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 51) to accept the assembly.

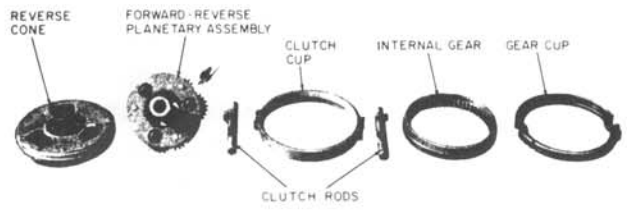


Figure 47

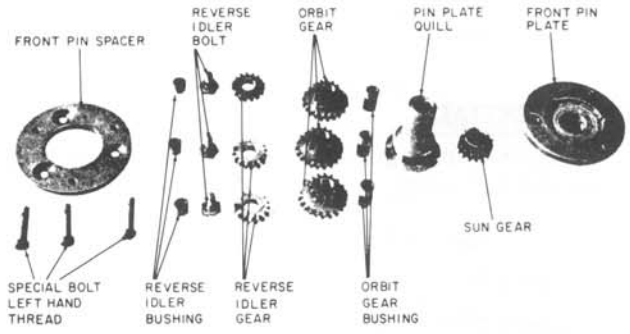


Figure 48

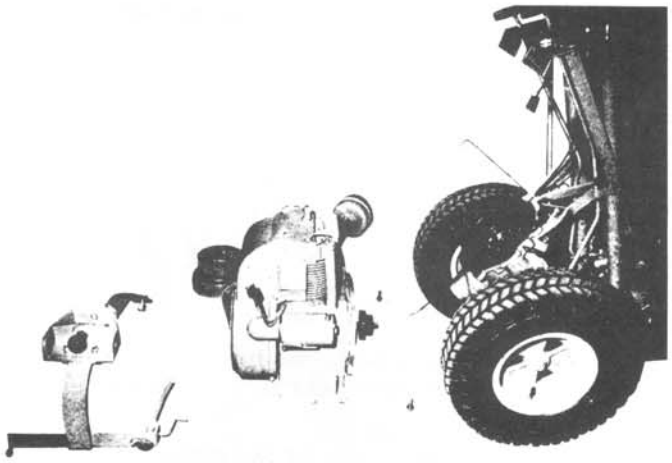


Figure 45

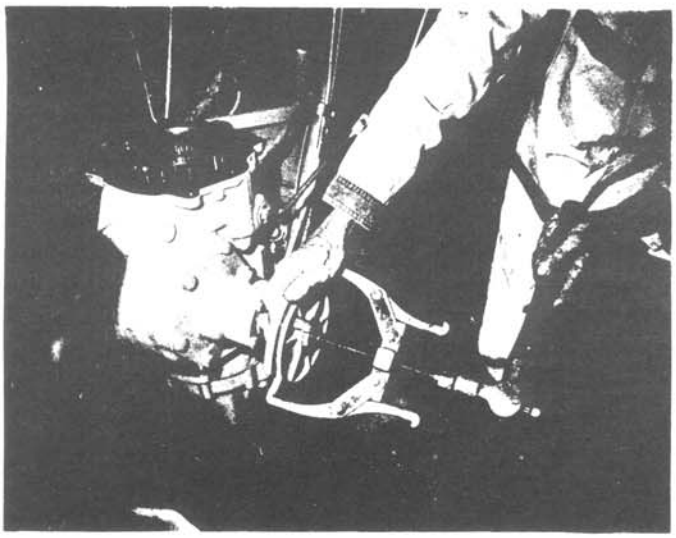


Figure 46

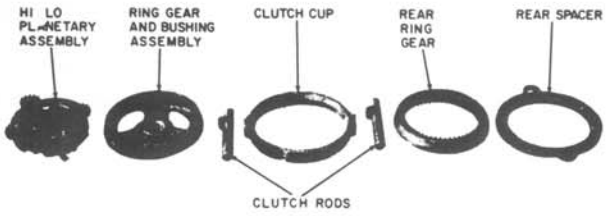


Figure 51

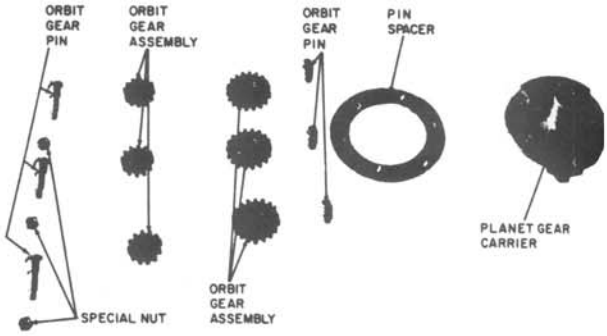


Figure 52

FIRST-SECOND GEAR, CLUTCH AND PLANETARY

To examine the first-second clutch and planetary, remove engine as described on page 38 and release unit by turning the actuating shaft.

To avoid damage to the rear pin plate bushing, it is not recommended that Planetary System be further diassembled 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.
11. Using wire cutters, remove wire securing bolts on each side of worm gear. Secure differential assembly upright in vise.
12. Remove bolts securing clutch housing to worm gear. Remove clutch housing, gears, and shims.
13. Turn worm gear over and remove pinned housing and gears.
14. Tilt differential mechanism and remove from worm gear. The mechanism does not ride on the inside surface of the gear.
15. 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.
16. 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.
17. Tilt the differential mechanism and install it in the worm gear.
18. 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.
19. 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 18.
20. Check end play of shifting gear .00 — .010 maximum. Remove clutch housing and adjust shims as necessary. Torque bolts to 20 ft. lbs.
21. Insert wire through one bolt head, cross and insert through other, then twist ends together securely. Trim twist to 1/2 inch length. Repeat, securing other bolts on other side of gear.
22. 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.
23. 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.
24. 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.
25. Remove the engine and high-low planetary or the advance casting and the forward-reverse planetary.
26. Using a screwdriver or similar too, 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.
27. Adjust axles for .008 — .012 end play. Add or remove shims behind the bearing cap.

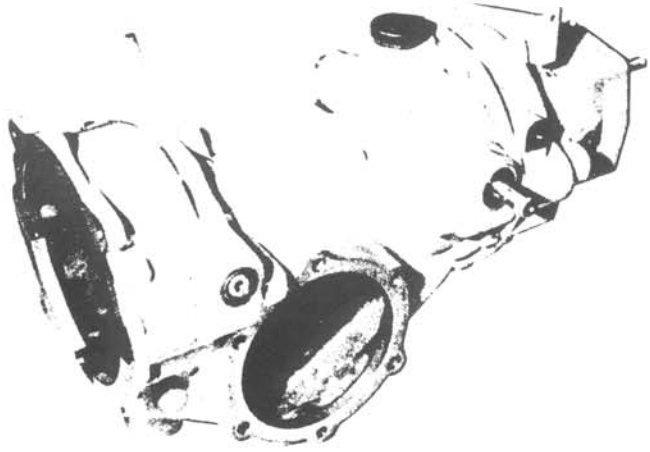


Figure 53

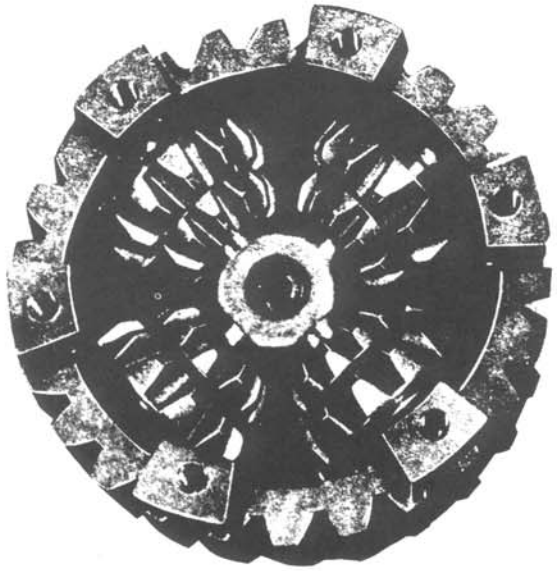


Figure 54

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 or damage.

e. Check for bearing failures.

f. Examine pinion shaft for twisting.

g. Replace worn or damaged parts.

NOTES