

®

GRAVELLY

**SERVICE
MANUAL**

424

430

432

450

 **GRAVELLY**
CORPORATION

© 2010 Gravelly Corporation

INTRODUCTION

This manual is designed to aid servicemen in maintenance and repair of the 424, 430, 432 and 450 tractors.

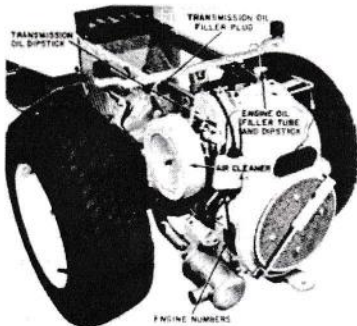
R. H. refers to Right Hand; L. H. refers to Left Hand. All directions are given with reference to the operator's position, as you sit on the tractor.

The 424 and 430 are equipped with either a Kohler or Onan engine. See Photo A and B. Kohler service instructions are included in this manual for the Kohler engines. Onan engine service instructions are contained in a separate book.

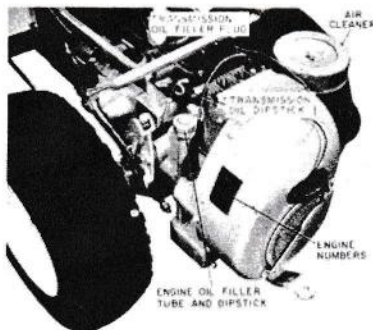
The 432 is equipped with a Kohler engine. See Photo A. Engine service instructions are contained in this manual.

The 450 is equipped with an Onan engine. See Photo C. Engine service instructions are contained in a separate book.

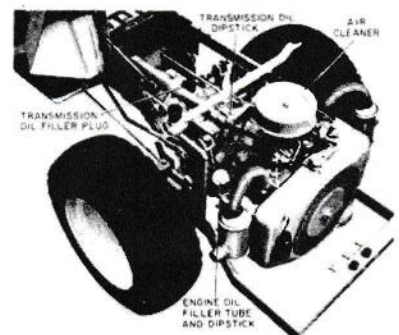
	Gravely Engine Model	Kohler Engine Model	Onan Engine Model
424	G-24 same as	K-241	NB
430	G-30 same as	K-301	NB
432	G-32 same as	K-321	
450			CCKA



424, 430, 432 Kohler Engine



424, 430 Onan Engine



450 Onan Engine

TABLE OF CONTENTS

Introduction	1
Safety Precautions	3
Air Intake System	4
Lubrication	4
Fuel System	5
Governor System	8
Ignition System	9
Electrical System	15
Front Axle and Steering	22
Engine — General Service	24
Inspection - Disassembly	27
Engine Reconditioning	30
Dynamic Balance System	34
Assembly	37
Fits and Clearances	58
Torque Values	59
Conversion Table	59

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.

AIR INTAKE SYSTEM

The importance of maintaining an air cleaner in proper condition can not be overemphasized! Dirt induced through improperly installed, improperly serviced or inadequate dry type 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 extremely 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.

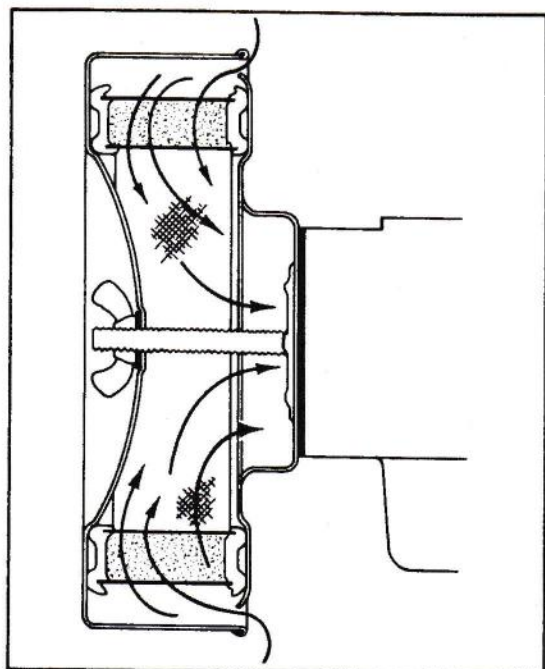


Figure 1 — Dry Type Air Cleaner

LUBRICATION

Engine

Capacity — 5 pints of API classification SC oil

Summer — SAE 30

Winter — SAE 5W20

Check oil level daily in engine. Maintain at full mark. Do not overfill. Change engine oil every 25 operating hours or oftener under dusty conditions. Drain plug is located on the right hand side of the engine base.

Transmission

Capacity — 5 U. S. Quarts

Use SAE 90W EP all purpose gear lubricant for year round use.

Check lubricant level daily. Maintain at full mark. Do not overfill. Drain plug is lowest bolt on L. H. axle housing.

FUEL SYSTEM

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 $\frac{1}{4}$ turn counterclockwise.
D. Engine runs rough or stalls at idle speed.	D. Improper idle adjustment — readjust idle fuel needle.

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

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

STEP 2 — For preliminary adjustment, turn **Main Fuel** screw **2** turns in counterclockwise direction, turn **Idle Fuel** screw $1\frac{1}{4}$ turns in counterclockwise direction.

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

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

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

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

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

Carburetor Reconditioning

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

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

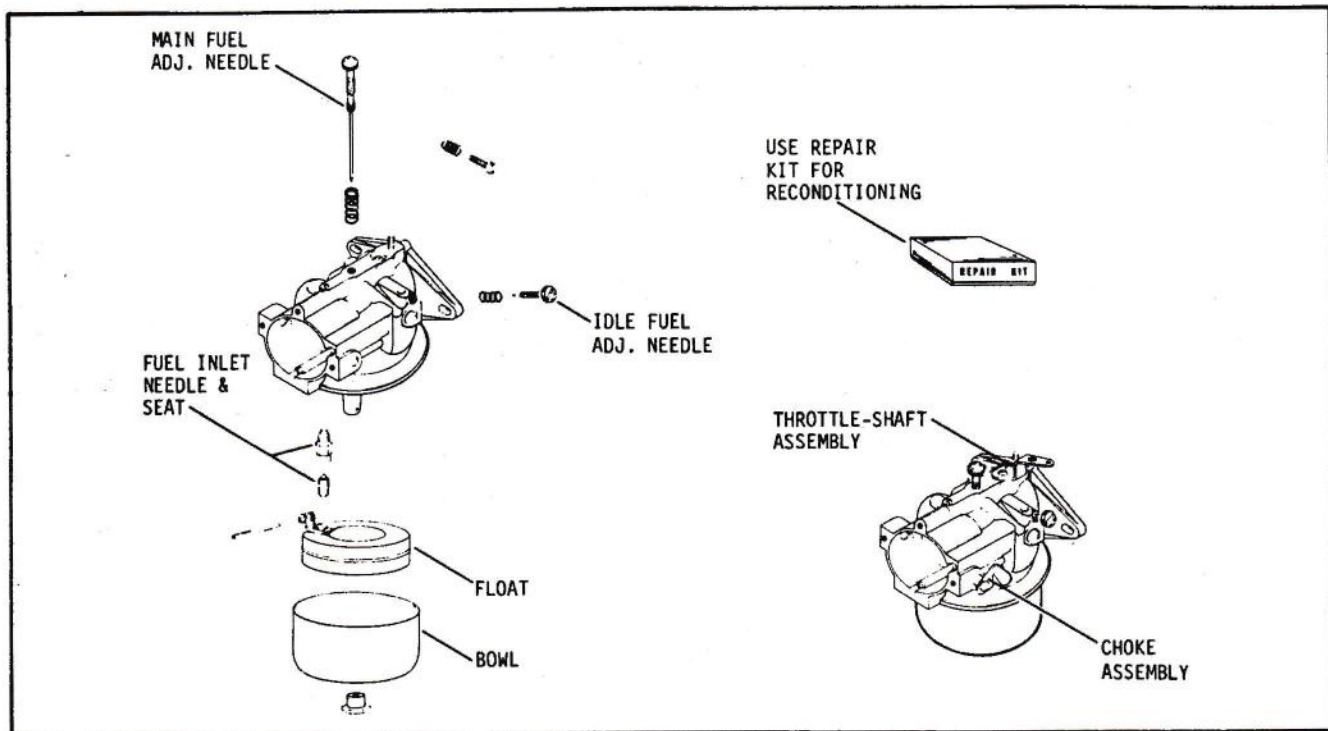


Figure 2 — Carburetor

Disassembly of Carburetor

1. Remove carburetor from engine.
2. Remove bowl nut, gasket and 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 (when required) 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 $1\frac{1}{2}$ turn after seating lightly against jet.
CAUTION: DO NOT USE FORCE ON ADJUSTMENT NEEDLES.

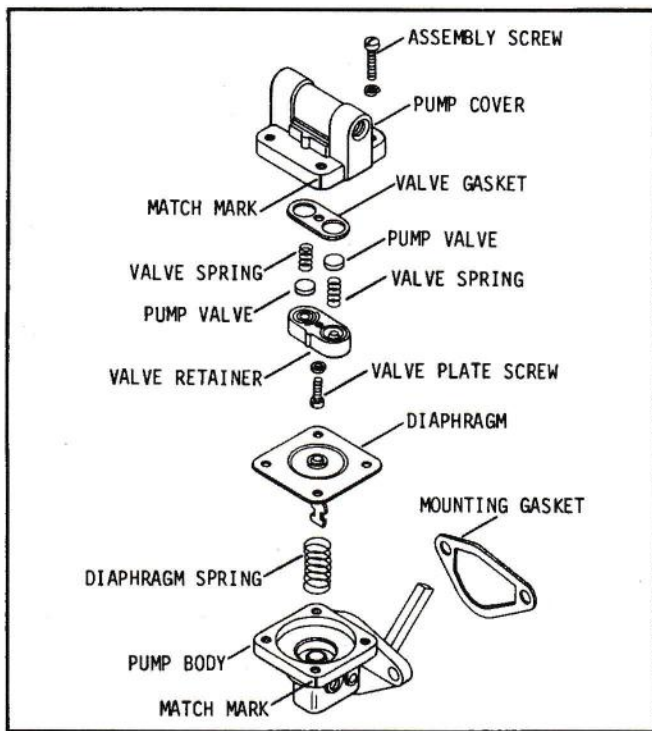


Figure 3 — Fuel Pump

FUEL PUMP

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 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

The governor gear — flyweight mechanism is mounted within the crankcase and driven off a gear on the camshaft.

In operation, centrifugal force causes the flyweights to move outward with increase in speed and inward with decreasing speed. As the flyweights move outward, they force the rod portion of the assembly to push outward. Tension of the governor spring pulls the flyweights back inward with decrease in engine speed. The rod, in turn, contacts a tab on the governor cross shaft causing it to rotate with changing speed. One end of the cross shaft protrudes through the side of the crankcase. Through external linkage, the action of the cross shaft is transmitted to the throttle (or butterfly) valve in the carburetor. When the engine is at rest, the tension of the governor spring should hold the throttle valve in open position.

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

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

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

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

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

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

SPEED ADJUSTMENT

After making initial adjustment and hooking up throttle wire, start engine and check operating speed with hand tachometer. Maximum allowable speed for K241, K301 and K321 models is 3600 RPM. **Do not exceed this speed.**

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

SENSITIVITY ADJUSTMENT

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.

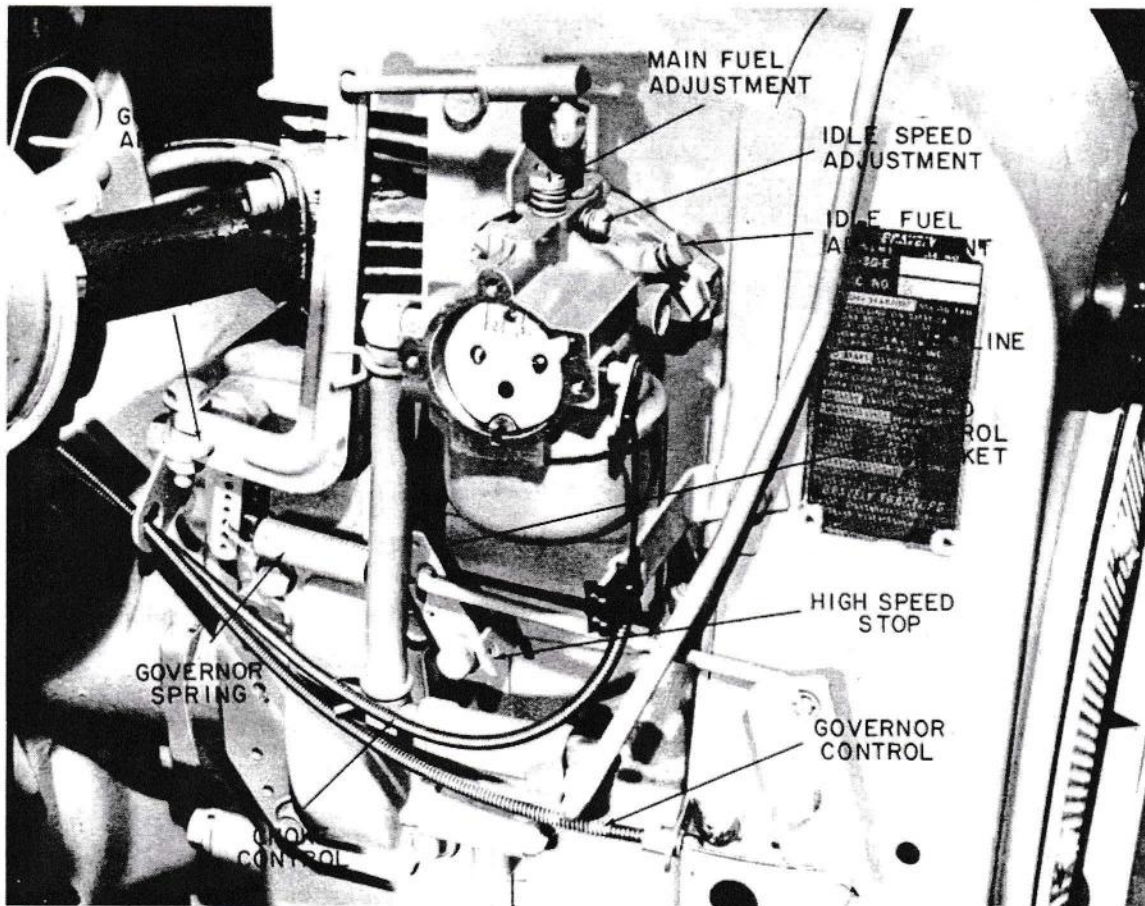


Figure 4

IGNITION SYSTEM

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

OPERATIONAL TEST

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

SPARK PLUG

Engine misfire or generally poor operation is often caused by spark plugs in poor condition or with improper gap setting. Always clean area around spark plug before removing to prevent dirt from falling into engine. The first thing to do after removing a spark plug is to carefully note its condition as this is often an indicator of the ignition trouble. Plugs fail for various reasons. Often the porcelain insulator cracks or becomes coated with oil,

carbon or other deposits. This can cause the high voltage ignition impulse to pass from the center electrode to ground without jumping the spark gap. As an engine operates, the electrodes are gradually burned or worn away. In time, the gap becomes so wide that the available ignition voltage cannot jump the gap and the engine misses.

Spark Plug Service: Every 100 hours remove plug, check condition and reset gap. Good operating conditions are indicated if plug has light coating or gray or tan deposit. A dead white, blistered coating could indicate overheating. A black (carbon) coating may indicate an "overrich" fuel mixture caused by clogged air cleaner or improper carburetor adjustment. **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". Tighten plug to 3/4 in. lbs. (27 ft. lbs.) torque when installing.

BREAKER POINTS

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

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

CONDENSER

If the condenser shorts out, the coil will be unable to produce output voltage. On the other hand, if it opens or decreases in capacitance, the output voltage will be greatly reduced and 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.

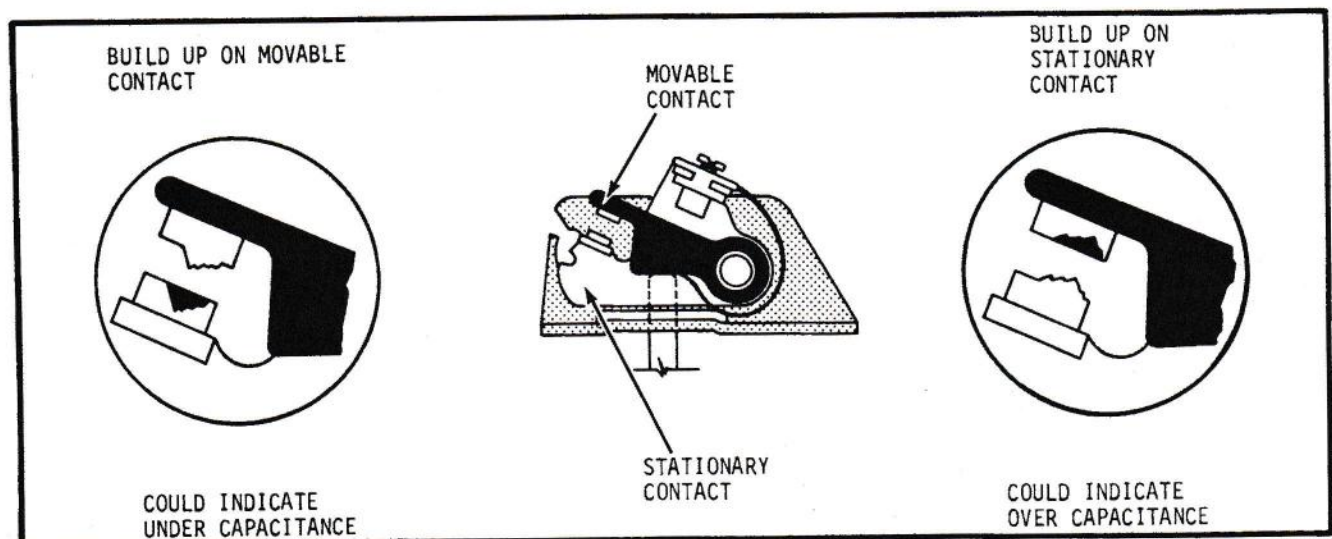


Figure 5 — Metal Transfer — Breaker Points

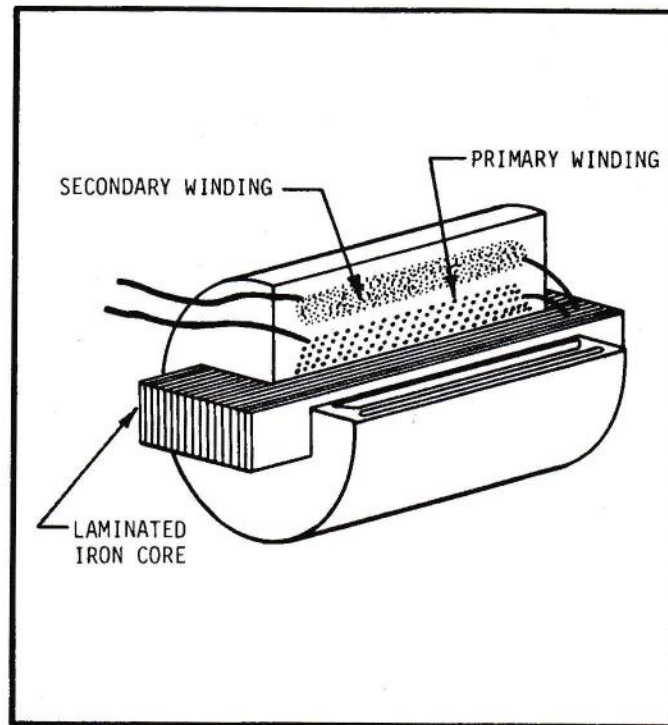


Figure 6 — Typical Magneto Ignition Coil

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

IGNITION COIL

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

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

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

PERMANENT MAGNETS

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

IGNITION TIMING PROCEDURE

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

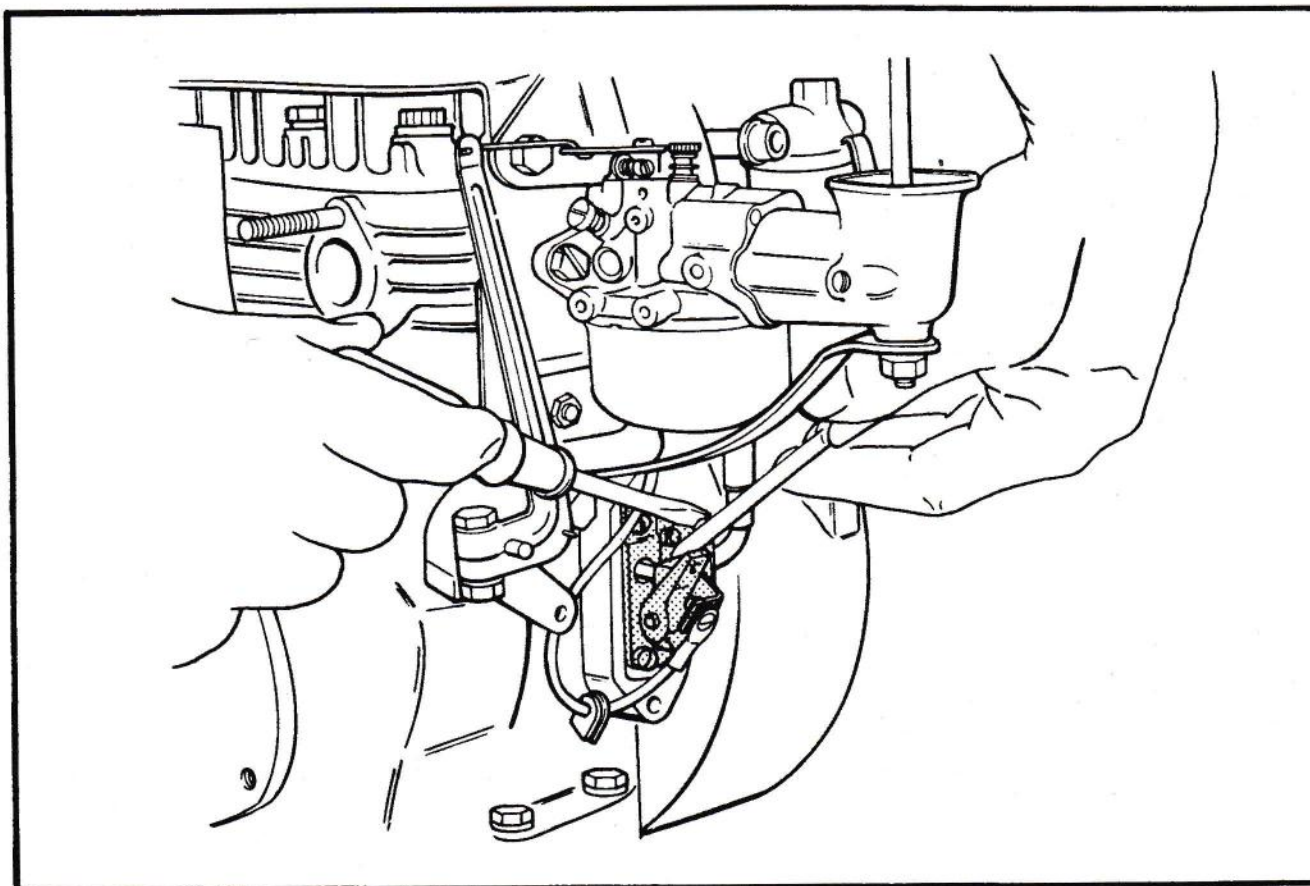


Figure 7 — Adjusting Breaker Point Gap

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 from front or 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 necessary.**

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.

BREAKERLESS — ALTERNATOR IGNITION

The Kohler Breakerless-Alternator Ignition system uses solid state devices which eliminate the need for mechanically operated breaker points. With the breakerless ignition, timing is permanently set for the lifetime of the engine. Except for the spark plug, the entire system is virtually service-free. The system provides an instantaneous, high energy spark which not only prolongs the service life of the plug but makes spark gap and even condition of the plug less critical.

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

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

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

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

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

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

Ignition Coil Assembly Tests: (A) — Remove high tension lead from terminal on coil. Insert one tester lead in coil terminal and the other to the coil mounting bracket. Continuity through the coil **should be** indicated. (B) —

Connect one tester lead to the coil mounting bracket and the other to the ignition switch wire. Continuity should not be indicated here. Replace ignition coil assembly if wrong results are obtained from either of these tests.

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

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

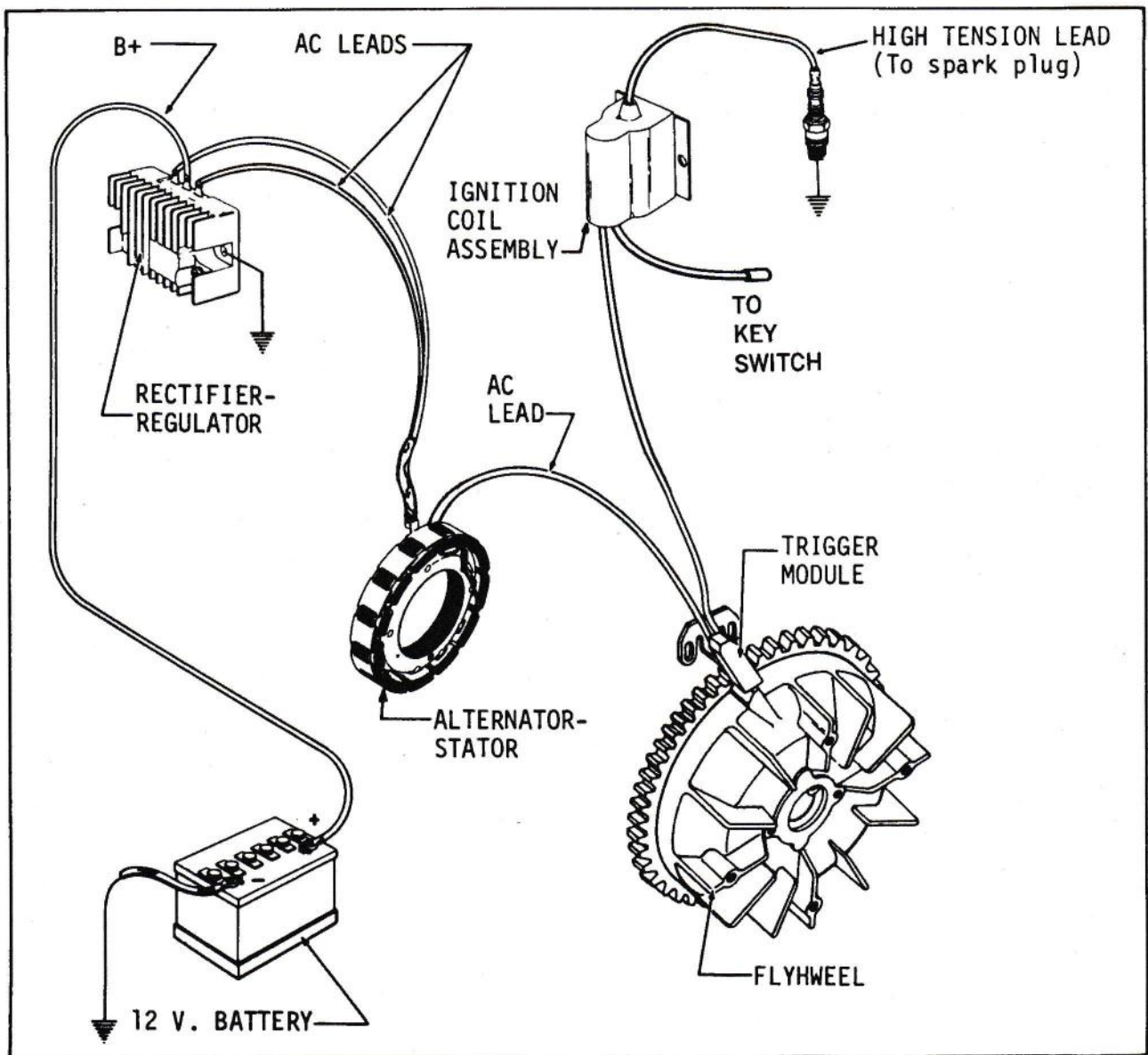


Figure 8 — Breakerless - Alternator System (Schematic)

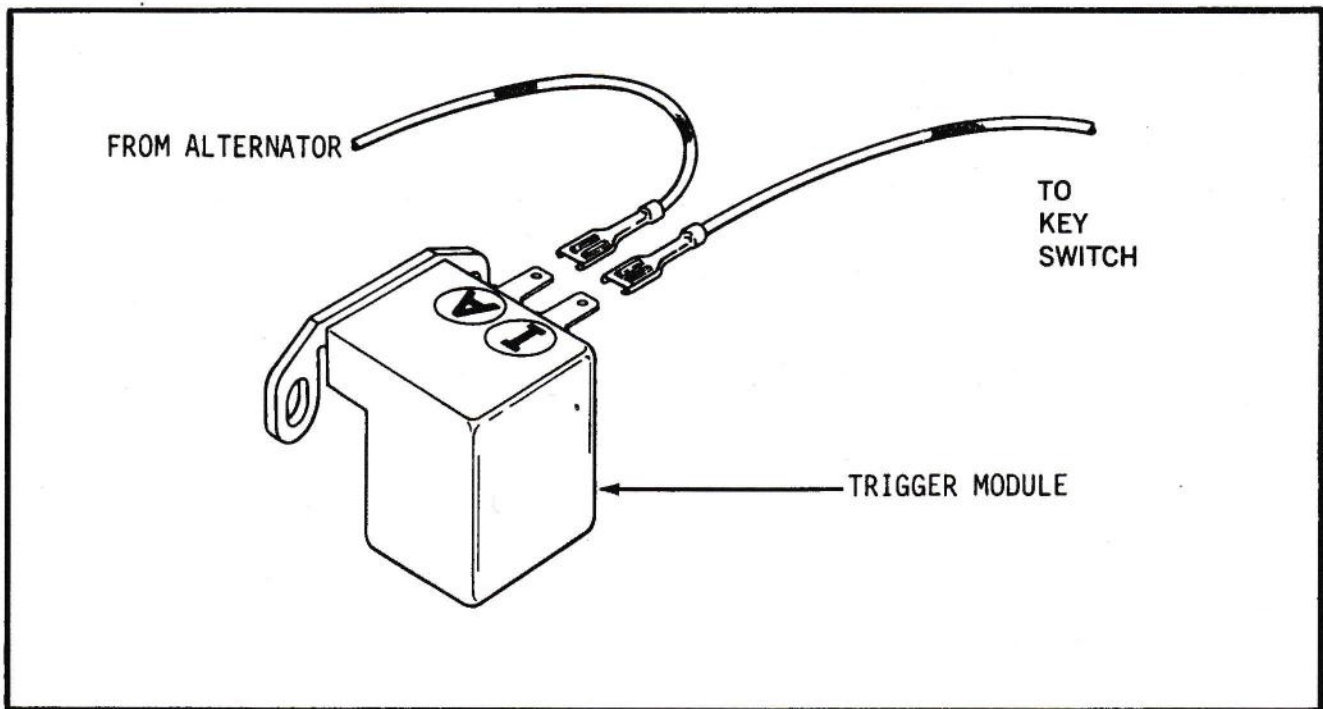


Figure 9 – Wiring Connection Detail on Trigger Module

ELECTRICAL SYSTEM

Storage batteries are of the lead-acid type. Lead is used in the construction of the cellplates and sulfuric acid serves as the electrolyte. With "dry charged" batteries, the plates are charged but an electrolyte of specific grade must be added just before using.

All tractors 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 0.05 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 Precautions: 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.

MAGNETO — ALTERNATOR SYSTEMS

The Magneto-Alternator System consists of a magneto ignition circuit and a battery charging or alternator circuit.

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

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

Service: The magneto coil is secured to a stator post by a tab which is wedged between the post and the inside of the coil. If coil replacement becomes necessary, the flywheel must first be removed to gain access to the stator.

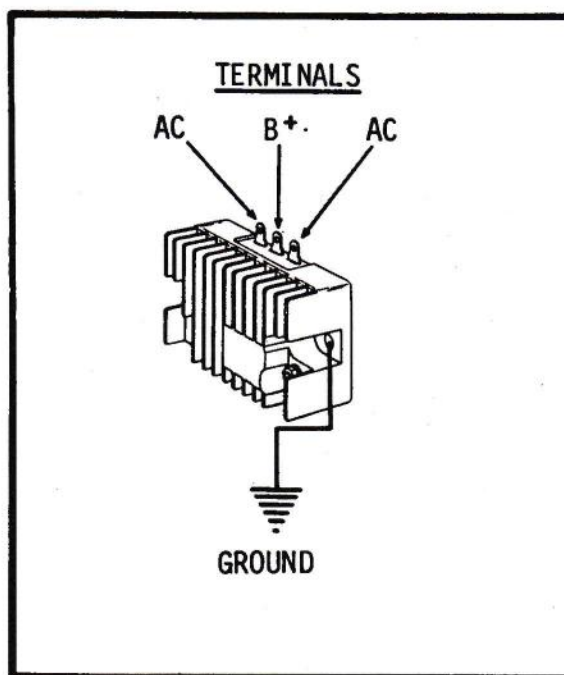


Figure 10 — Rectifier - Regulator Assembly

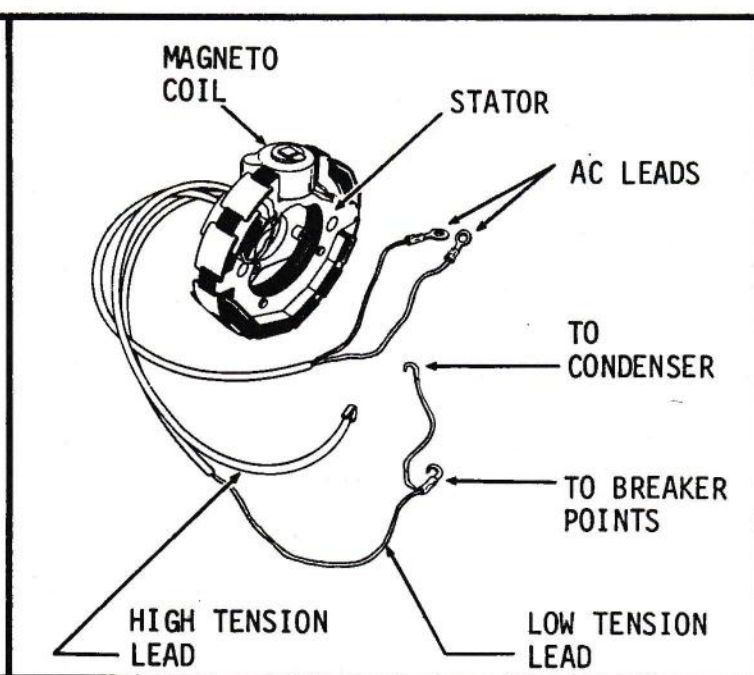


Figure 11 — Alternator Stator Assembly

The retaining tab must be pulled out of the slot before the faulty coil can be removed from the stator post. When installing new coil, position tab with clip in hole on stator, then slip coil over tab and stator post. After the coil is in place, bend protruding end of tab over to prevent interference with magnet ring.

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

TROUBLE ANALYSIS MAGNETO - ALTERNATOR

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

Precautions

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

COMPACT STARTING MOTOR

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

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

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

Also, as with all starting motors, the cranking time must be limited to prevent overheating of the starter. On these compact starters, the maximum time allowed for cranking is 30 seconds followed by a 15 second cooling period. The cranking limit is not unreasonable for if an engine fails to start after this length of time, ignition or carburetion troubles are indicated and these should be corrected before the engine is placed in operation.

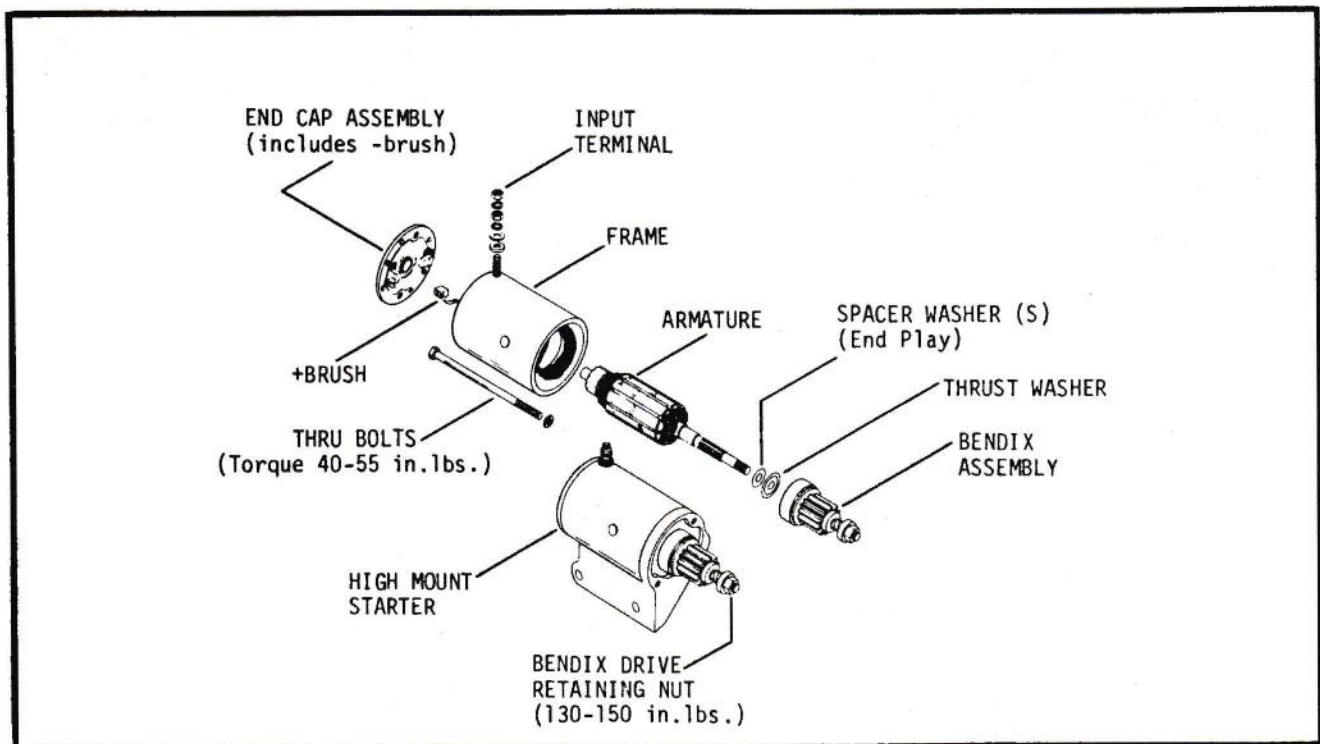


Figure 12 - Compact Starting Motor

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

The end cap assembly must be removed to inspect and service the brushes and commutator. Remove the two thru bolts then carefully slip end cap off end of armature. Lift spring and remove positive brush from holder if complete removal of end cap is necessary.

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

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

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

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

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

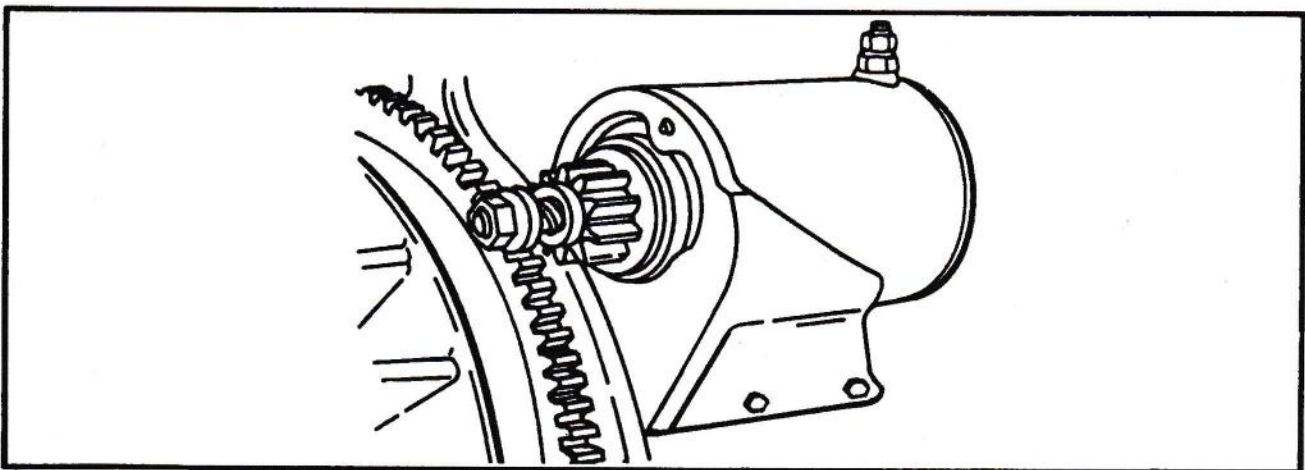


Figure 13 — Bendix Drive - Ring Gear Engagement

TEST PROCEDURE — STARTER ON ENGINE

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

PERMANENT MAGNET TYPE STARTING MOTORS

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

DRIVE UNIT

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

PRECAUTIONS

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

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

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

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

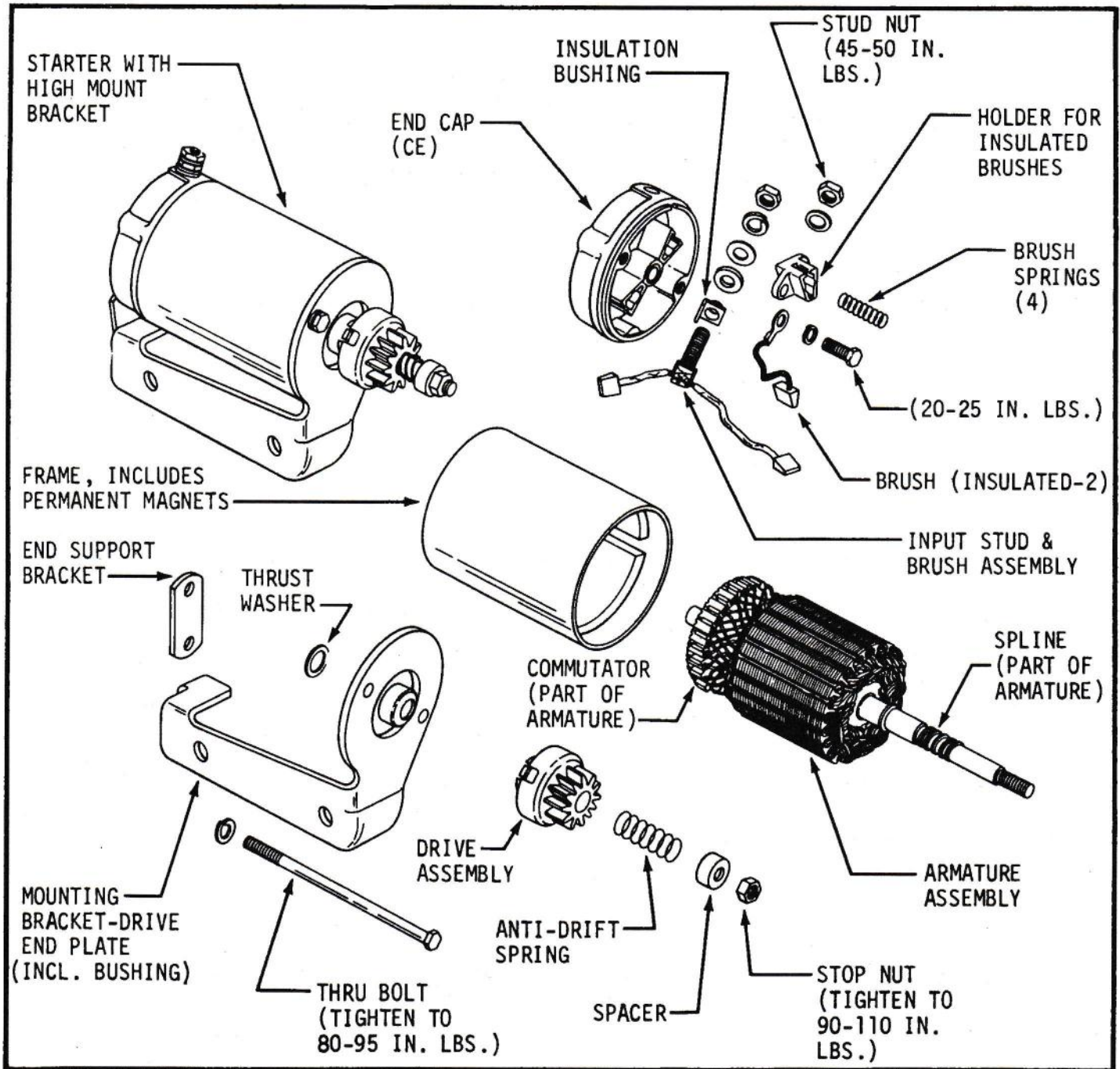


Figure 14

STARTER SERVICE

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

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

1. Remove drive unit.
2. Remove thru bolts.
3. Remove end bracket capscrew from end cap, then turn bracket so that it will not interfere with removal of mounting bracket.
4. Slip mounting bracket and frame off over drive end of armature.
5. Separate end cap from armature — NOTE — Brush springs will probably fall out when brushes pull free of the commutator.
6. Clean up commutator with a coarse, lint-free cloth — if badly worn or grooved, turn down on lathe.
7. Replace brushes as follows: The input brushes are part of the terminal stud assembly. To replace, remove nuts, and pull stud out thru inside of end cap. Insert new stud terminal-brush unit after transferring insulation bushing from old unit. To replace, remove nuts, and pull stud out thru inside of end cap. Insert new stud terminal-brush unit after transferring insulation bushing from old unit. To replace insulated brushes, simply remove capscrew and lockwasher. Always use new brushes and springs. Assemble brushes with chamfered side away from springs. Keep brush leads away from contact with metal of end cap.
8. To keep brushes in position so that they will fit over the commutator as the end cap is reinstalled, wrap rubber bands over brushes and end cap — cut and remove the rubber bands after brushes are started on the commutator.
9. Reverse procedure to reassemble reconditioned starter — make sure bolts, etc., are tightened to the torque values specified on the accompanying illustration. Apply a light film of LU3001 grease (American Bosch) to the shaft where it contacts the bearings — do not lubricate spline on armature shaft.

FRONT AXLE AND STEERING

KING PIN WELDMENT

To remove king pin, remove wheel and tie-rod arm. Remove key from pin, slide king pin down out of axle. NOTE: There are L.H. and R.H. kingpin weldments, due to the placement of the key way. Clean bore in axle before installing new king pin. Lightly grease new king pin before installation.

Axle and Bushing Assembly

The axle is held in place by the axle pivot weldment. If an axle does not pivot freely, it is usually due to a lack of lubrication of the axle

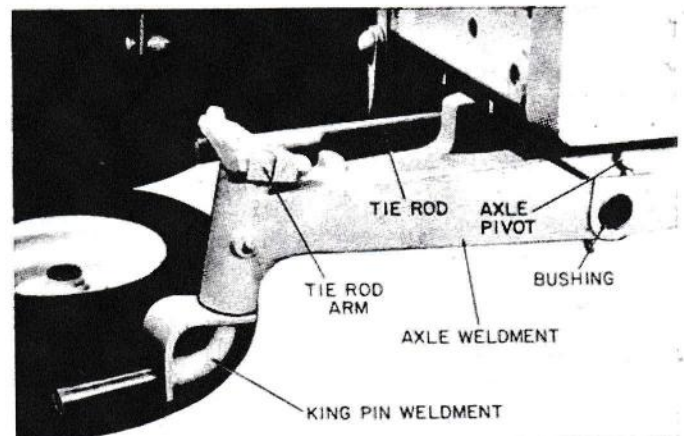


Figure 15

pivot weldment. Lubricate through the fitting, if the axle will still not move, it will be necessary to remove the axle. When an axle is removed, be sure to clean the axle pivot weldment and the bore in the axle. They should be lubricated well with general purpose grease when reassembled.

Bushings

Tractors prior to Serial Number 006322A have 7/8 inch inside diameter bushings in the front axle. Tractors from Serial Number 006322A and up have one inch inside diameter bushings in the front axle. The bore of the axle is unchanged, therefore, the bushings are interchangeable. They should be reamed after installation.

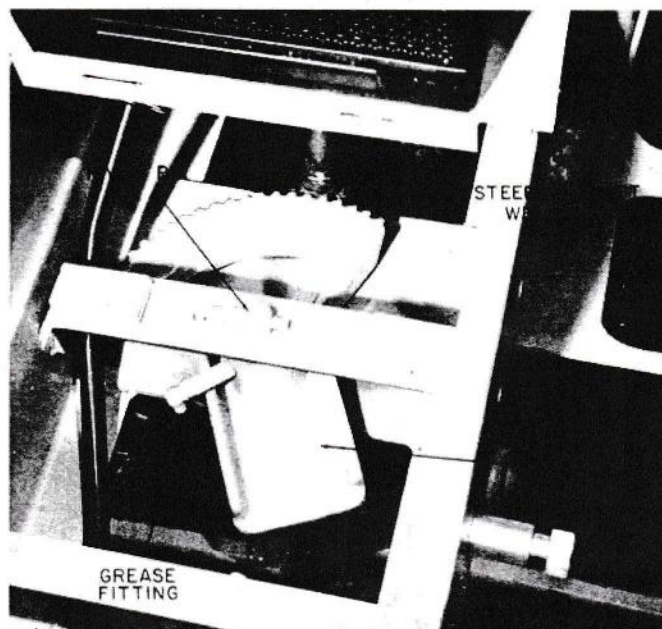


Figure 16

Exposed Steering Gear System

If the teeth of the steering gear become worn, it will be necessary to replace the steering gear.

Remove tie rods from the steering gear, then remove the cotter pin securing the pivot pin in position, remove pivot pin from gear. Slide gear out of tractor.

It will be necessary to change the grease fitting to the new gear.

After installation of the new gear, be sure to grease it liberally through the grease fitting with general purpose grease.

A thin layer of grease on the teeth also aids operation.

To remove the steering shaft weldment, remove steering wheel and snapping. Remove cotter pin securing the shaft in the frame crossmember. Raise the shaft up out of the frame crossmember and then down out of the tractor.

To install new shaft, slide it up through the instrument panel and then move it into position in the frame crossmember. Secure in place and reinstall steering wheel.

Steering Gear Box System

In the event of steering gearbox difficulties, it is advantageous to remove the gearbox as a complete unit.

To remove, remove the hood, fuel tank, battery and steering wheel and the snapping from the steering column weldment.

Remove the tie rods from the tierod arms. Remove the four bolts securing the gearbox to the frame. Work the gearbox down through the frame and out of the tractor.

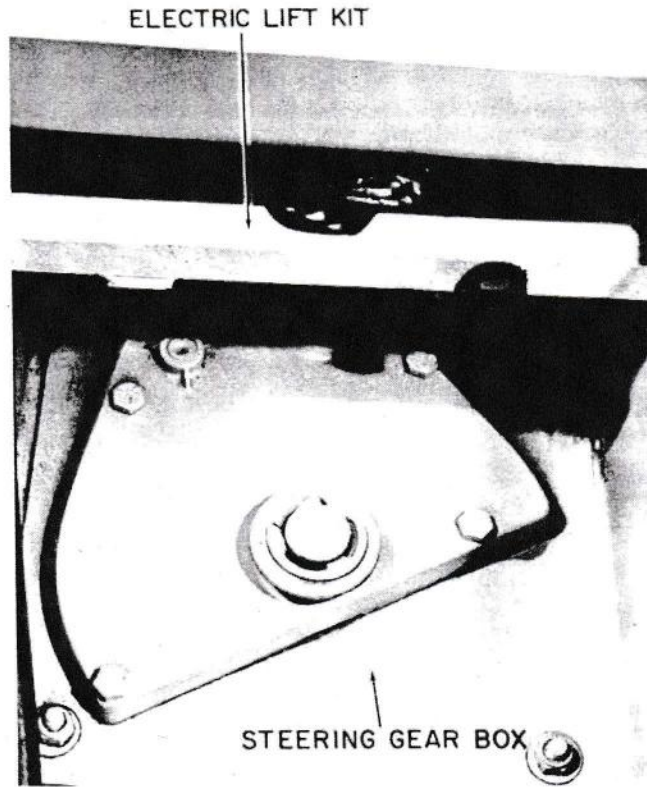


Figure 17

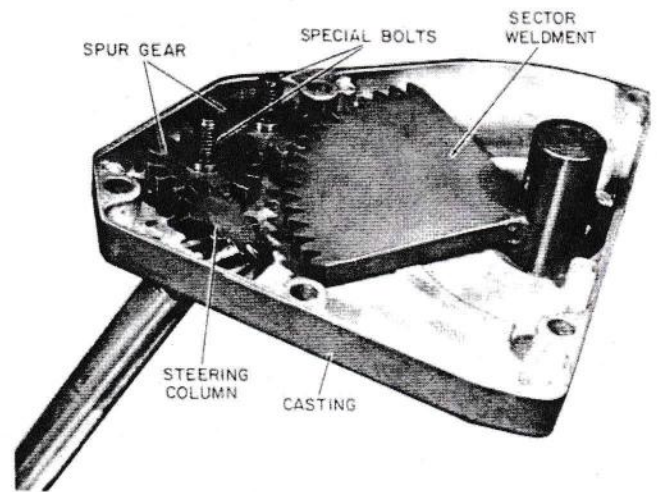


Figure 18

After removal of the steering gearbox from the tractor, turn it upside down, holding the steering column in a vise and remove the steering pitman and mounting plate. Check internal parts for damage and replace necessary parts.

Pack housing with general purpose grease before reinstalling mounting plate and steering pitman.

ENGINE - GENERAL SERVICE

COOLING

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

EXTERNAL SURFACES

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

STORAGE

If tractor 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 tractor.
- d. Spread a light film of oil over any exposed surfaces 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 ½ 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.

Construction — "U" Tube Manometer

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

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

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

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

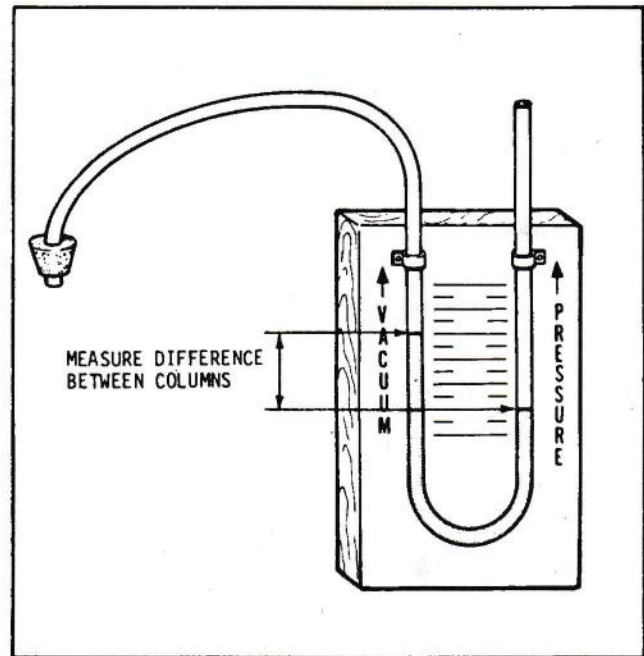


Figure 19 — "U" Tube Manometer

LOW COMPRESSION

POSSIBLE CAUSE	REMEDY
A. Cylinder head gasket blown.	A. Remove head, replace gasket, reinstall head, re-check 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)

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. Consistent readings of 110 to 120 psi indicate good compression.

Many major engine repair operations can be done without removing the engine from the tractor. Valve grinding and ring replacement can be done without engine removal. Crankshaft removal requires engine removal.

Removal

NOTE: See figure 20. Make stubs out of two 7/16 bolts by removing heads. Grind wrench flats or cut a screwdriver slot in the unthreaded end of stud. This will aid removal and installation of the engine.

1. Drain oil from transmission.
2. Disconnect choke control from carburetor.
3. Disconnect governor control from engine.
4. Shut off fuel at tank and separate fuel line. CAUTION: A small amount of fuel will be spilled as the line is separated.
5. Remove cable from positive (+) battery post.
6. Remove cable from starter motor.

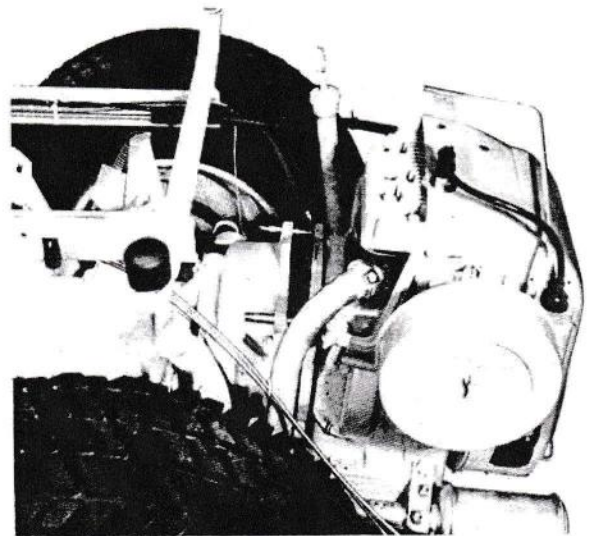


Figure 20

7. Separate wiring harness at connector(s).
8. Remove the bolts securing the rear hitch to the engine oil base. Swing rear hitch to one side.
9. Remove the two top bolts securing the engine to the chassis. Replace with two studs.
10. Remove the two lower bolts securing the engine to the chassis.
11. Slide engine back off chassis.

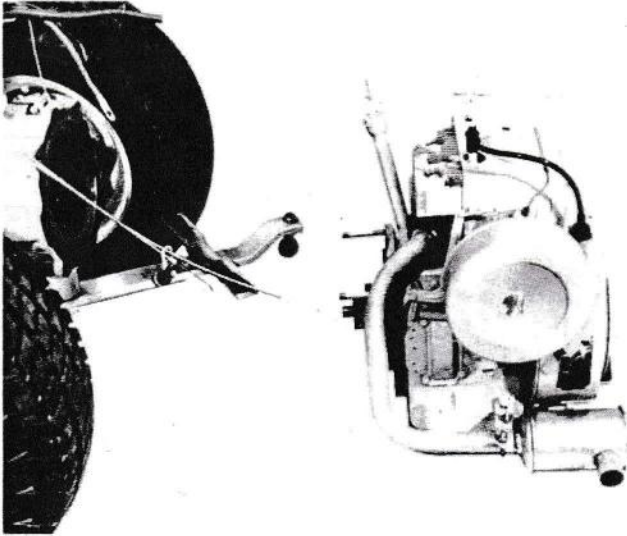


Figure 21

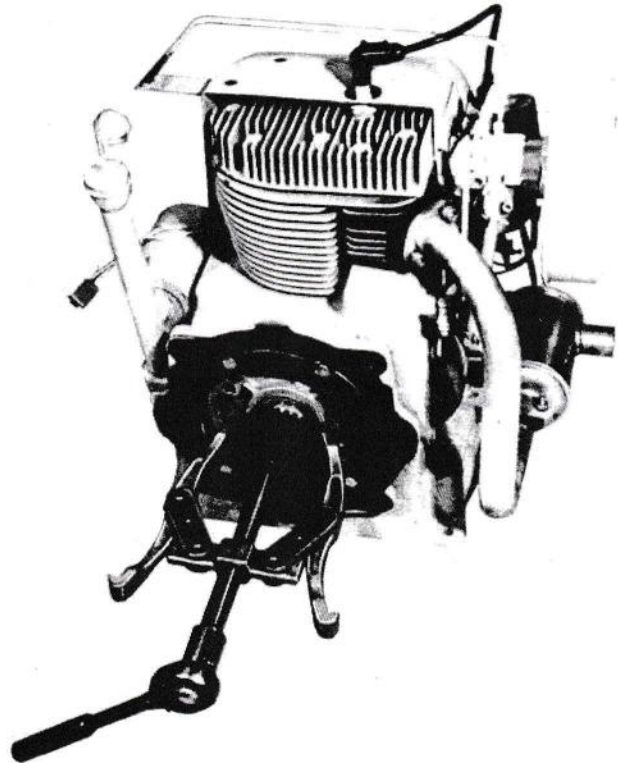


Figure 22

Transmission Drive Gear Removal

A gear puller must be used to remove the gears from the crankshaft.

Engine Adapter Plate

The engine adapter plate is secured to the engine crankcase with 4 $\frac{3}{8}$ -inch bolts. Remove bolts and then remove adaptor plate.

INSPECTION-DISASSEMBLY

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

1. Excessive sludge and varnish formation.
2. Scoring of the cylinder walls.

3. Severe piston damage.
4. Evidence of external oil leakage.

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

Scoring of the Cylinder Wall

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

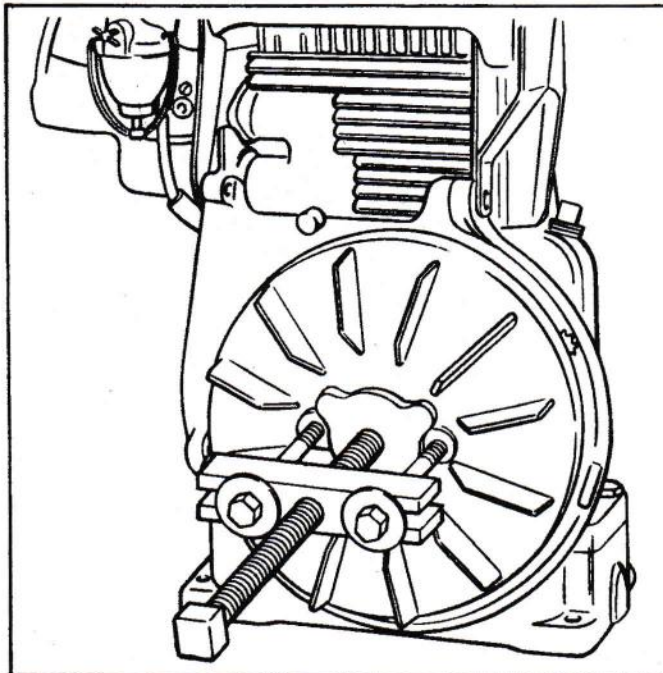


Figure 23 — Remove Flywheel With Puller

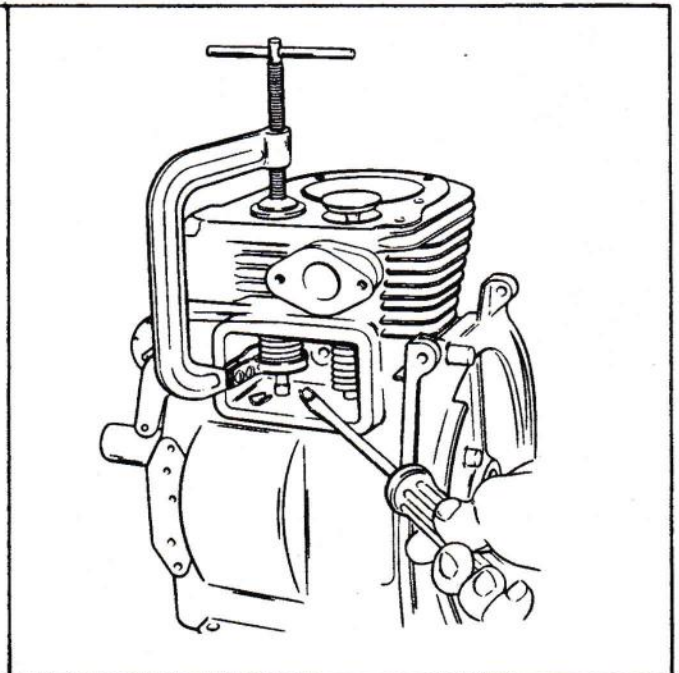


Figure 24 — Using Valve Compressor

Severe Piston Damage

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

Evidence of External Oil Leakage

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

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

DISASSEMBLY PROCEDURE

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 blower housing, cylinder baffle and head baffle.
6. Remove rotating screen and starter pulley.
7. Flywheel is mounted on tapered portion of the crankshaft. Use of a puller is recommended for removing flywheel.
8. Remove breaker point cover, breaker point lead, breaker assembly and push rod if so equipped.
9. Remove magneto assembly.
10. Remove valve cover and breather assembly.
11. Remove cylinder head.
12. Raise valve springs with a spring compressor and push valve keepers off valve stems. Remove valve spring retainers, springs and valves.
13. Remove oil base and unscrew connecting rod cap. Remove piston assembly from cylinder block.
14. 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.
15. 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.
16. Remove camshaft and valve tappets.
17. Loosen and remove governor arm from governor shaft.
18. Unscrew governor bushing nut and remove governor shaft from inside of cylinder block.
19. Loosen (do not remove) screw located to lower right of governor bushing nut until governor gear is free to slide off stub shaft.

ENGINE RECONDITIONING

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

1. INSPECTION

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

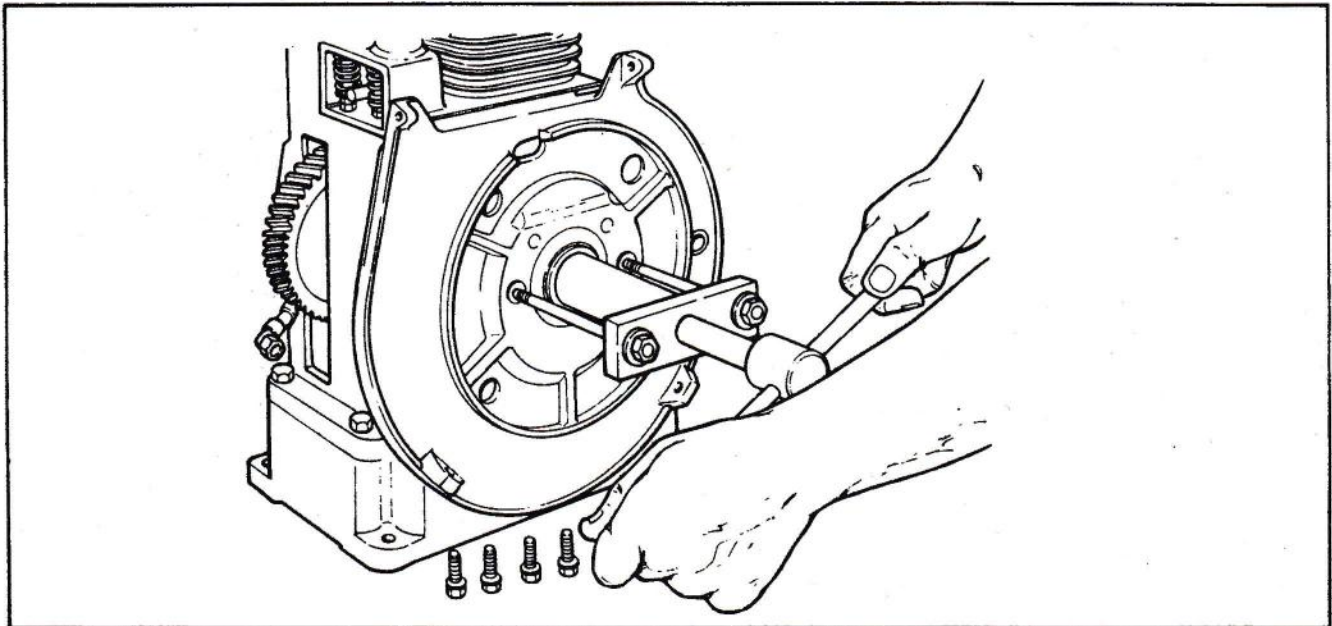


Figure 25 — Pulling Bearing Plate

- C. **Cylinder bore** — If badly scored, excessively worn or tapered or out of round more than .005, reboring is 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:

- B-1 — Lower hone into bore and after centering, adjust so that stones are in contact with falls. Diesel fuel oil or kerosene can be applied to the stones as a cutting-cooling agent.
- B-2 — 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.
- B-3 — 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.
- B-4 — After reboring, carefully clean cylinder wall with soap and water, then after drying thoroughly, apply light coat of SAE 10 oil to prevent rust.

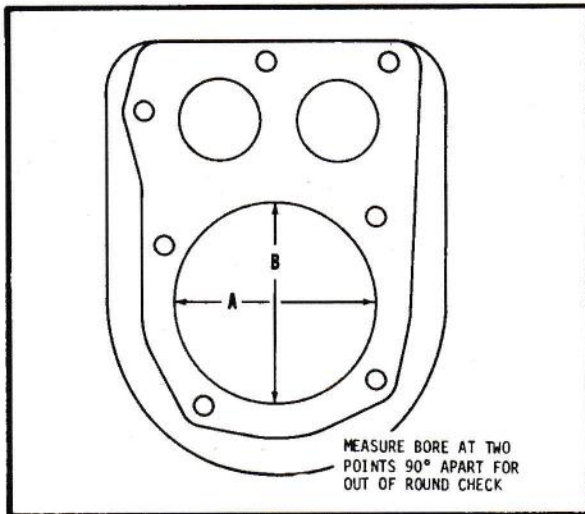


Figure 26 — Measuring Cylinder Bore

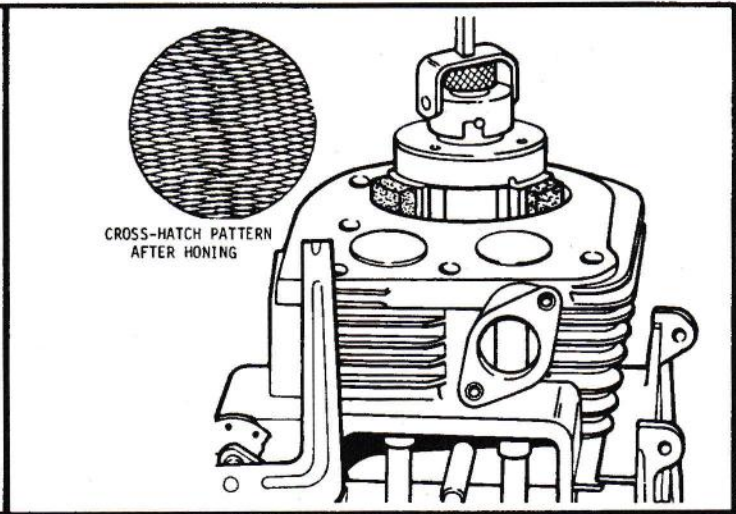


Figure 27 — Honing Cylinder Walls

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

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.

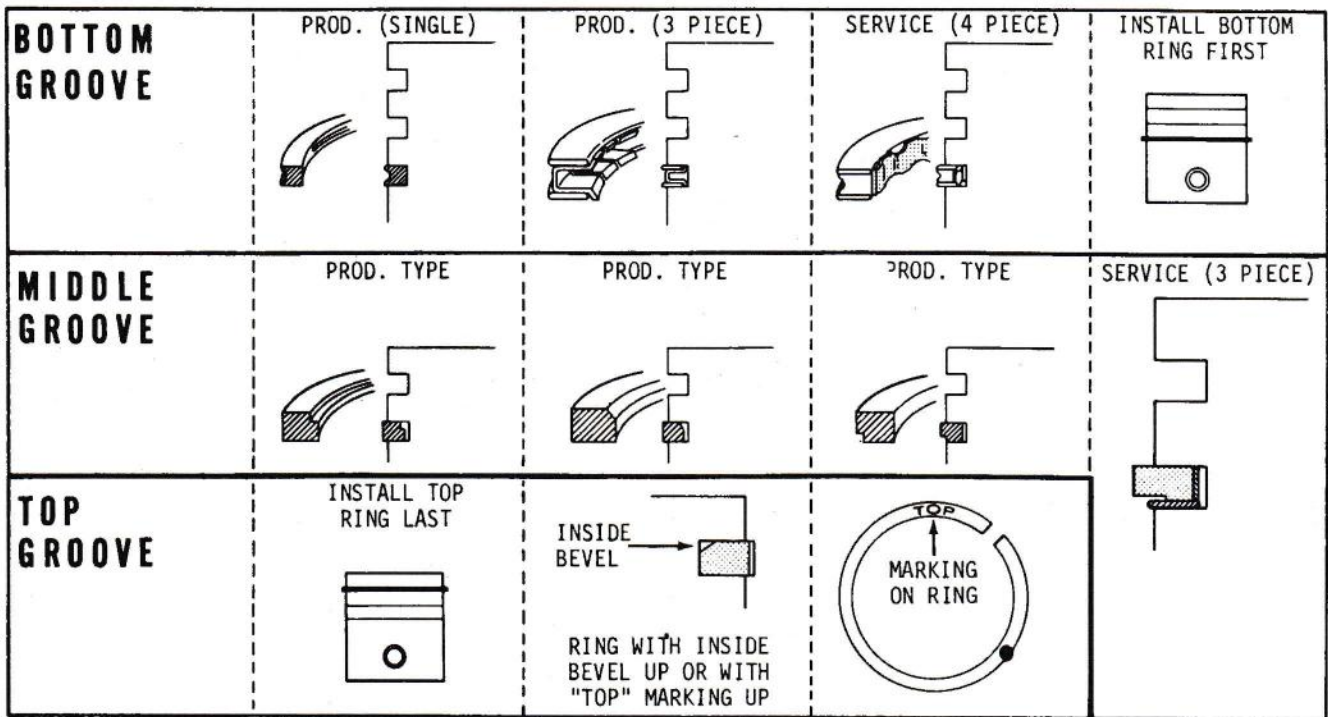


Figure 28

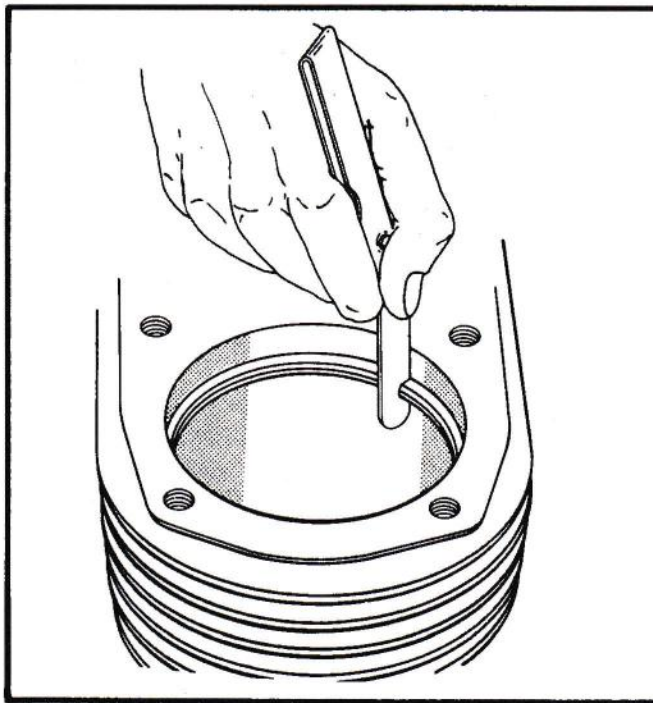


Figure 29 — Measuring Piston Ring End Gap

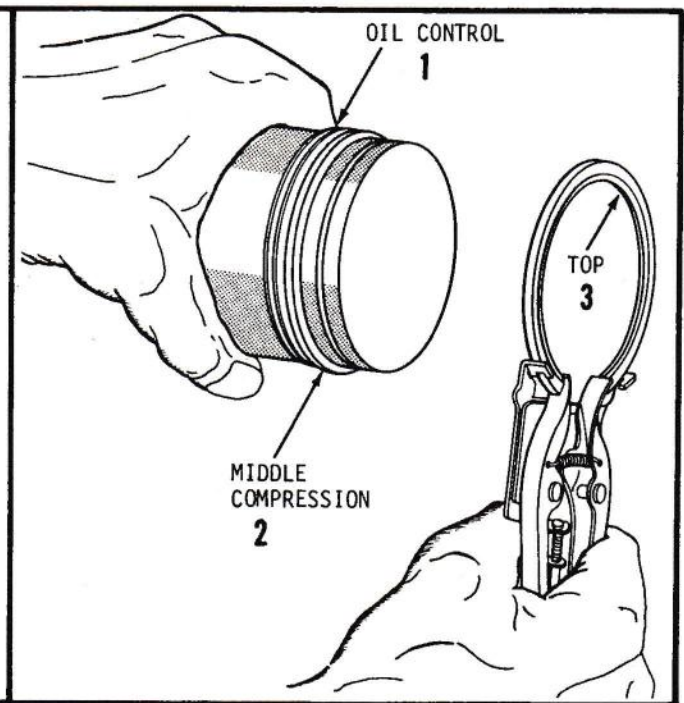


Figure 30 — Ring Installation Sequence

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.

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 pin should be used when a new connecting rod is used with the original piston. After checking pin, rod and piston boss to make sure proper clearances are available, assemble piston to rod with pin (light interference to loose fit) and lock pin with new retainers — make sure retainers are fully engaged in grooves.

VALVES — VALVE MECHANISM

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

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

Valves and Valve Seats: Exhaust valves are always hard faced. Intake valve seats are usually machined into block. 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.

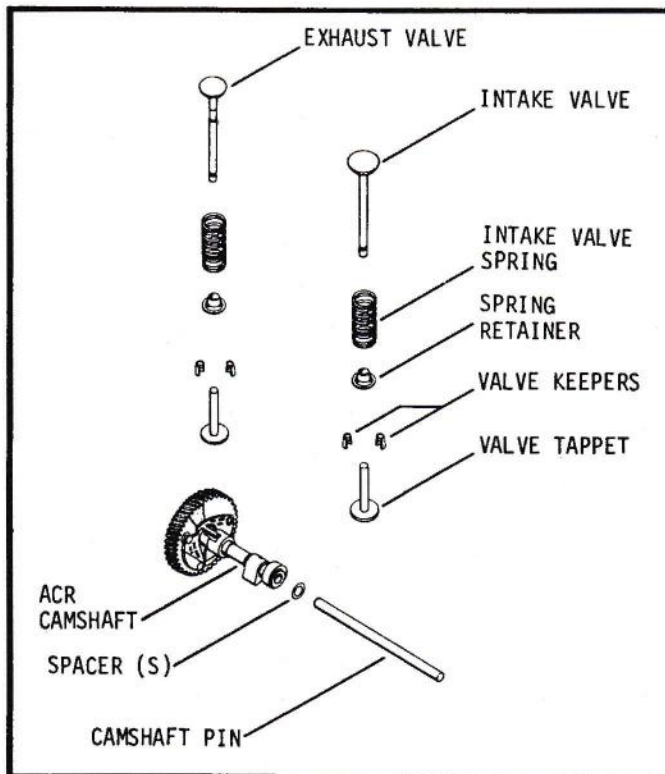


Figure 31 — Camshaft And Valve Mechanism

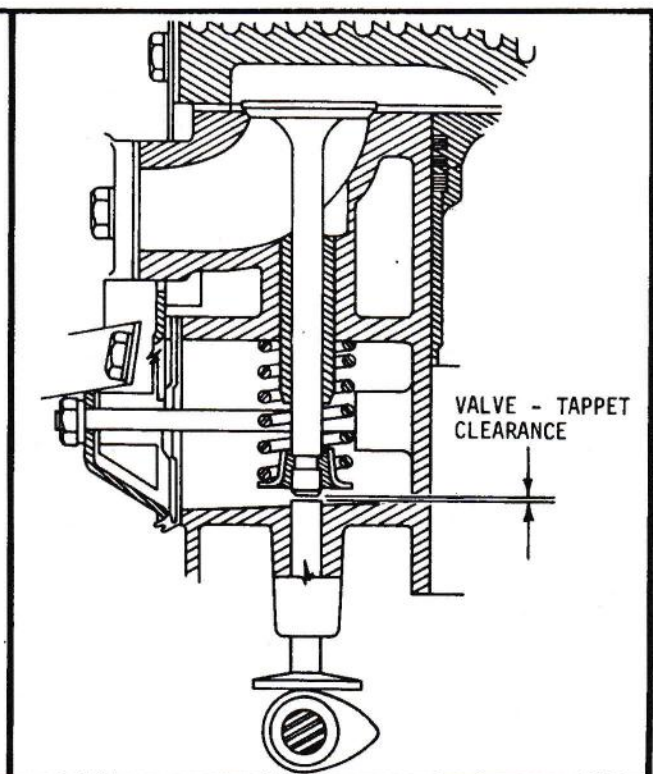


Figure 32 — Valve - Tappet Clearance

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. Loosen the locking nut, turn adjusting nut in or out until proper clearance is attained then securely tighten locknut.

CYLINDER HEAD

Blocked cooling fins often cause localized “hot spots” which can result in “blown” cylinder head gaskets. If gasket fails in area surrounding one of the retaining capscrews, high temperature combustion gases 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 similiar blade to scrape deposits. Be careful not to nick or scratch aluminum, especially in gasket seat area.

RING GEAR

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.

DYNAMIC BALANCE SYSTEM

The Dynamic Balance System is standard on the G-32 (K-321) engine.

On conventional single cylinder engines, counterbalancing is by necessity a compromise. The counterweights are designed to balance only about 1/2 of the inertial force created by the reciprocating weights such as piston, piston pin, etc. The reason for this is that this force varies from 0 value when the piston is midway in the cylinder to maximum force when the piston reaches TDC and BDC. If the counterweights were designed to exactly balance the maximum force, they would in effect create an unbalance each time the counterweights rotate to 90° and 180° positions when the inertial force drops to zero. By designing the counterweights to split the force, vibration is kept within acceptable limits for most applications.

The Dynamic Balance system consists of two balance gears which run on needle bearings. The gear-bearing units are assembled to two stub shafts which are press fitted into special bosses in the crankcase. Snap ring retainers hold the gears and spacer washer are used to control end play. The gears are driven off the crankgear in the direction opposite to rotation of the crankshaft.

Operation: The balance gears function to oppose then add to the force exerted by the counterweights to effectively reduce vibration. As shown in Figure 34-A, the reciprocating weights are exerting maximum force (indicated large arrow) in the vertical direction shown while the counterweights exert force (indicated small arrow) in the opposite direction. In this position, the balance gears each add force to the force of the counterweights

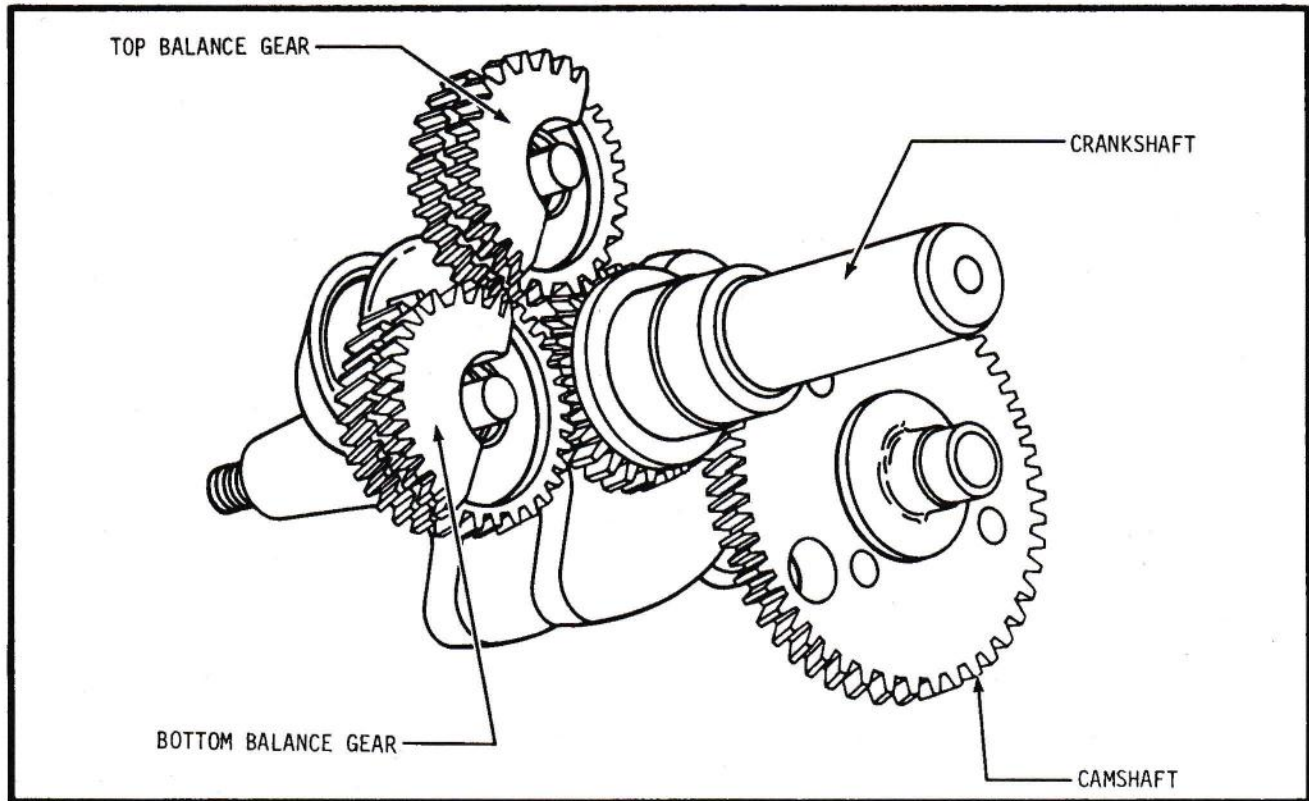


Figure 33 – Components - Dynamic Balance System

thus providing a closer balance between the opposite forces. This same balancing effect is evident when the piston reaches BDC as shown in Figure 34-B, however, in this case the direction of the two forces is toward each other.

When the piston is midway in the cylinder as shown in Figure 34-C, no inertial force is exerted but the counterweights now present a force in a horizontal direction. In this case, the force of the balance gears is exerted in opposite direction to counteract the force of the counterweights. When the crankshaft has rotated another 180° and the piston is again midway in the cylinder, the force of the balance gears is directed inward while that of the counterweights is outward which also provides a balancing effect. Both horizontal and vertical forces are thus reduced resulting in smoother operation with less vibration.

When working on Dynamic Balance models, make sure that the proper end play is attained and that the gears are properly timed to the engine. Use the following procedure to install and time Dynamic Balance components (refer to Figure 35 for timing mark identification). Gears and needle bearings can be serviced separately.

1. **Stub Shafts:** If new shaft is required, carefully drive old shaft out of boss in crankcase (hole in crankcase for this). Make sure boss is not cracked during removal. Press new shaft into block until it projects .691" above surface of the boss — use Loc Tite around new shaft.
2. **Top Balance Gear-Bearing Assembly:** Slip one .010" spacer on stub shaft then install top gear-bearing assembly on stub shaft (with timing marks out) — do not install bottom gear until after the crankshaft is reinstalled. Proper gear end play (.005-.010") is attained with one .005" spacer, one .010" spacer and one .020" spacer which are installed on the snap ring retainer end of the shaft — install the thickest spacer (.020") next to the retainer. After installing retainer, recheck end play and adjust (add or subtract .005" spacers) if needed.
3. **Crankshaft:** Press crankshaft into block — align **primary** timing mark on top balance gear with **standard** timing mark next to crankgear — press shaft until crankgear is engaged 1/16" into top gear (narrow side). Rotate crankshaft to align timing marks on crankgear and cam gear, then press crankshaft remainder of the way into the block.

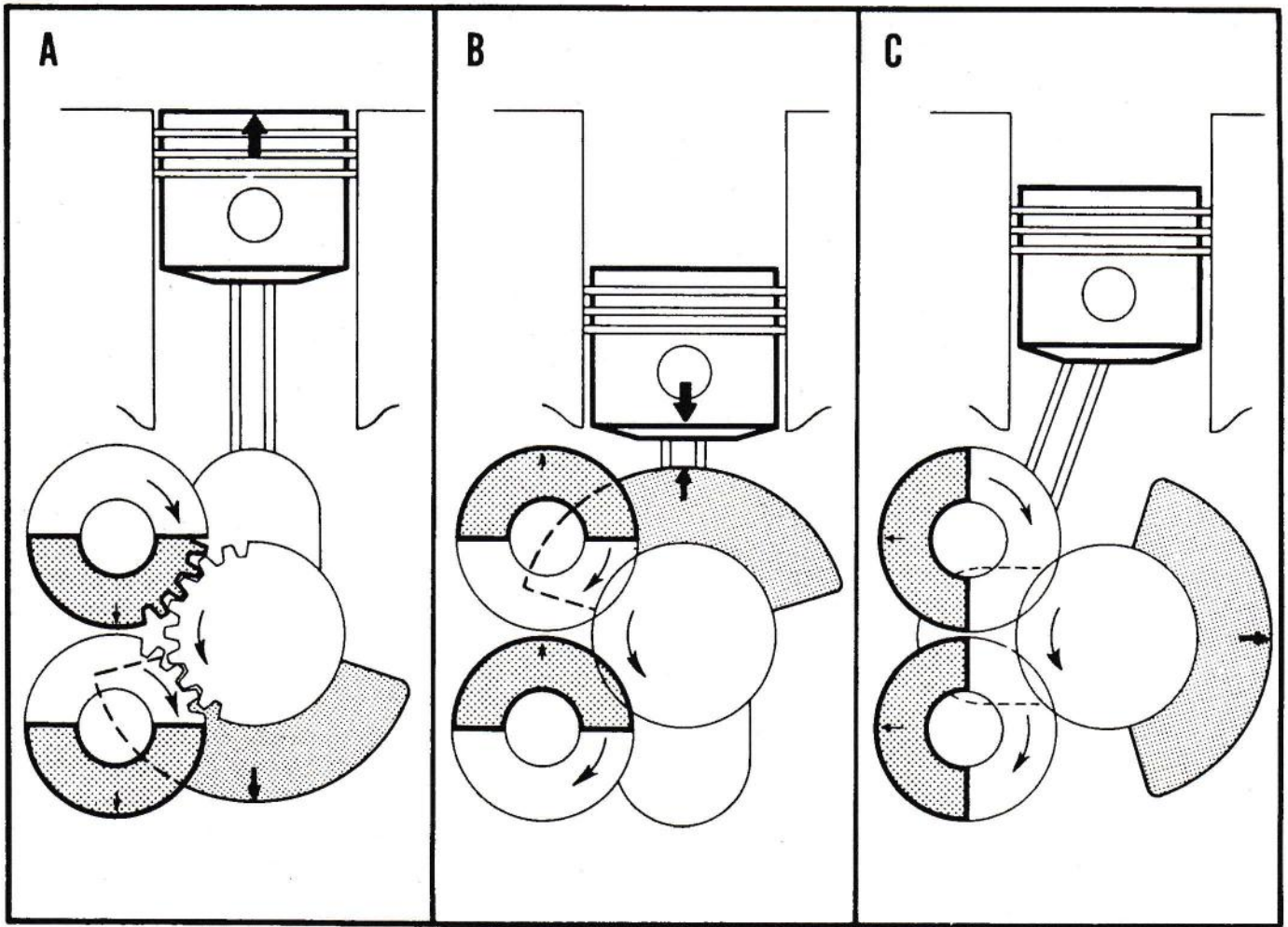


Figure 34 — Operating Principle - Dynamic Balance System

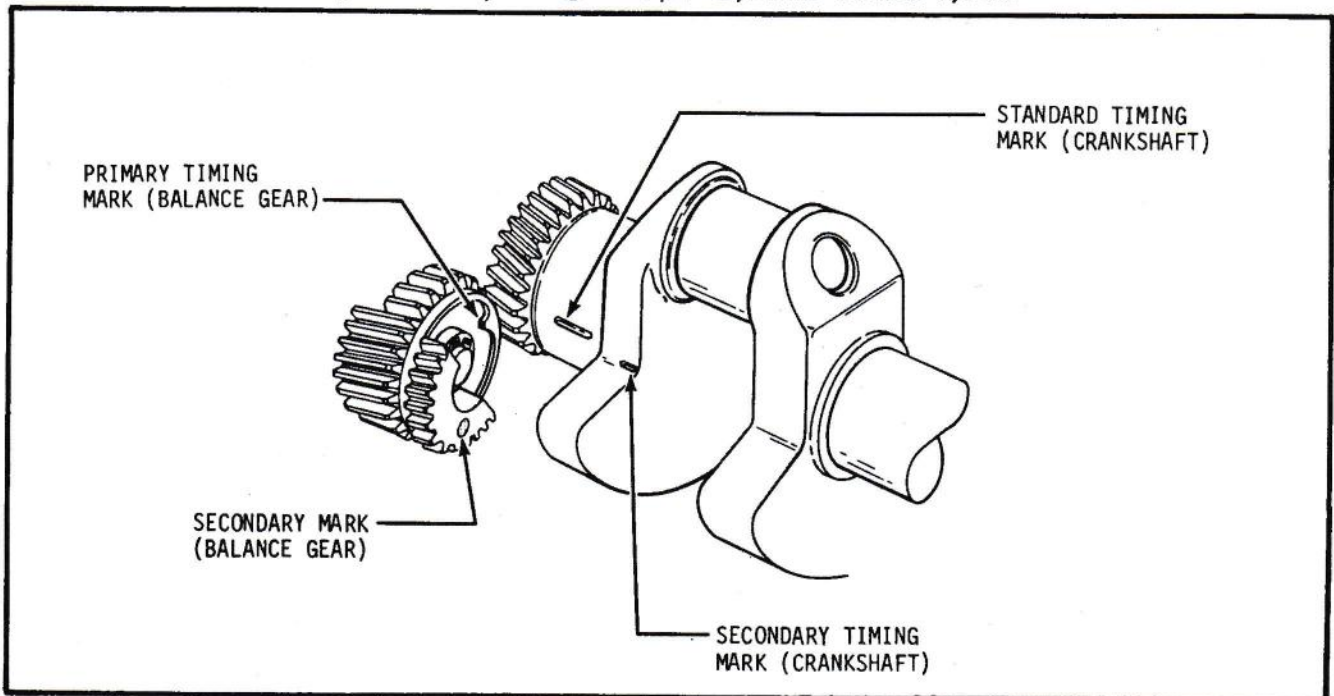


Figure 35 — Timing Marks - Balance Gears and Crankshaft

4. **Bottom Balance Gear-Bearing Assembly:** Rotate crankshaft until it is approximately 15° past BDC then slip one .010" spacer over stub shaft before installing bottom gear-bearing assembly. Align secondary timing mark on this gear with secondary timing mark (on counterweight) of crankshaft then install gear-bearing on shaft. Secondary timing mark will also be aligned with standard timing mark on crankshaft after installation if properly timed. Use one .005" spacer and one .020" spacer (largest next to retainer) to obtain proper end play of .005 to .010". Install snap ring retainer then recheck and adjust end play as needed.

ASSEMBLY

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

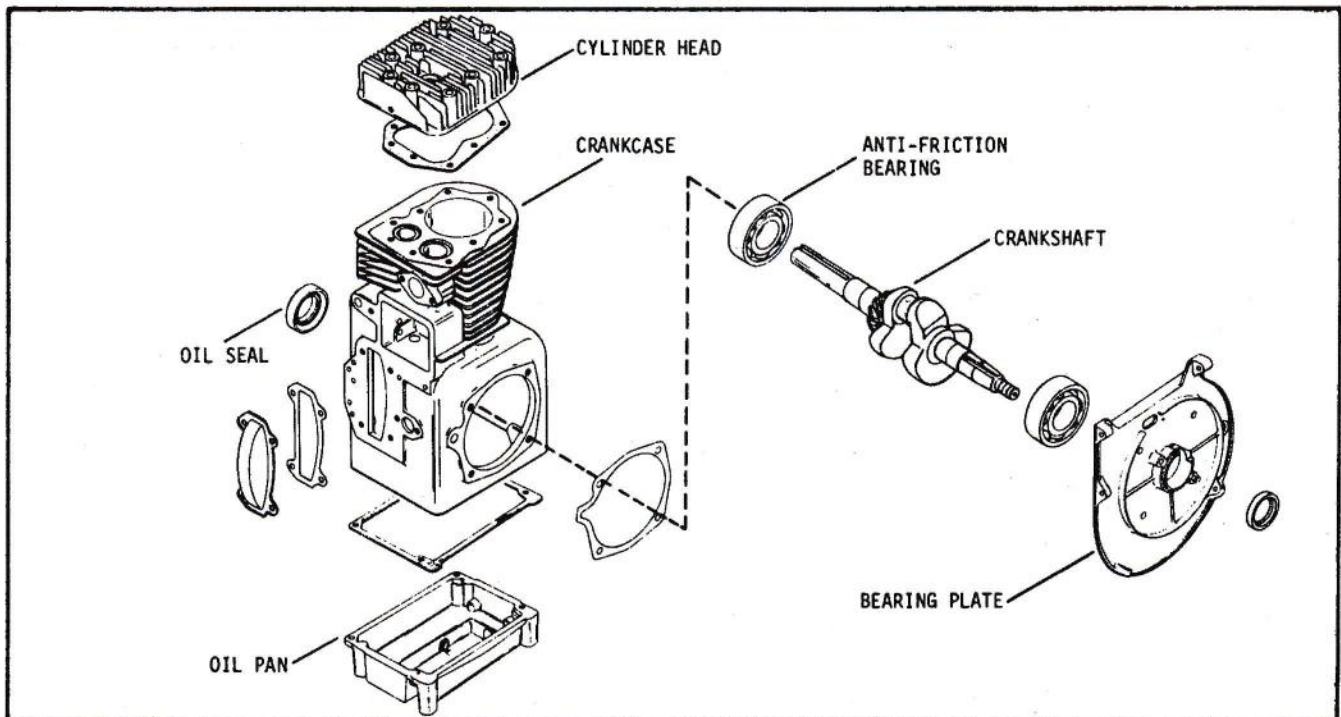


Figure 36 – Exploded View, Major Components Of Typical Engine

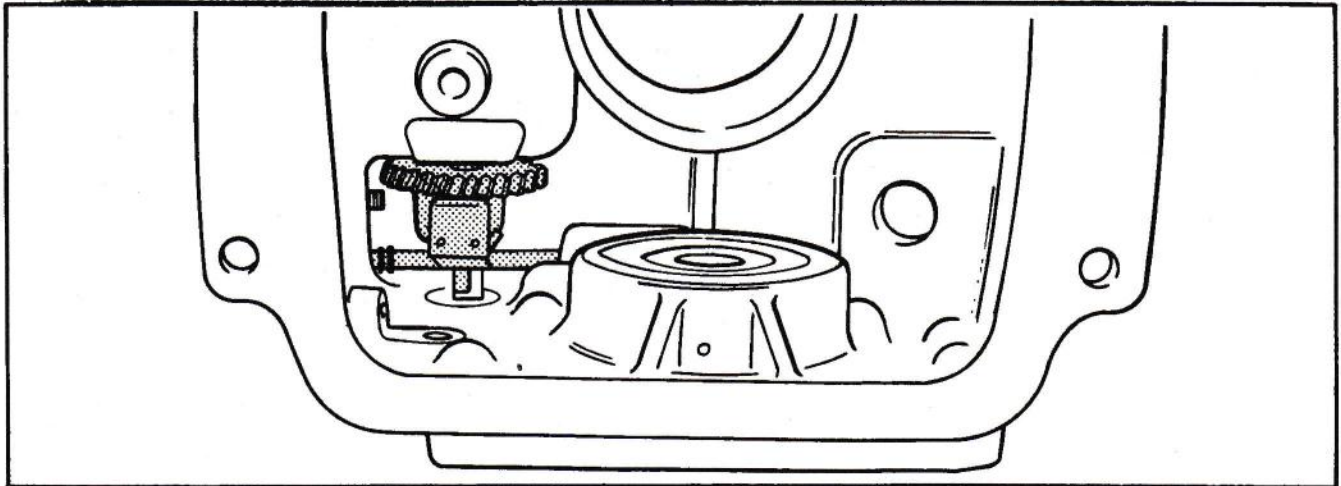


Figure 37 – Governor Gear Assembly in Crankcase

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.

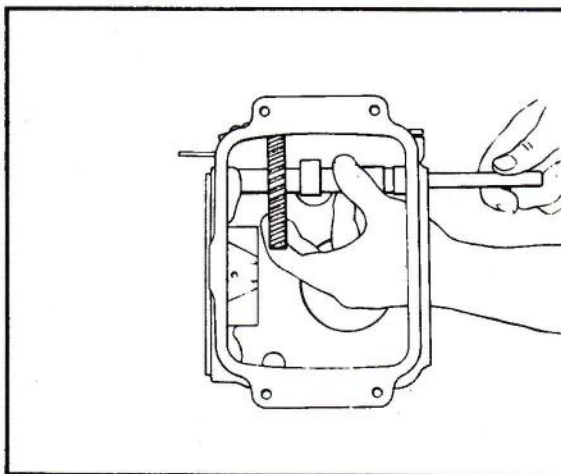


Figure 38 – Installing Camshaft

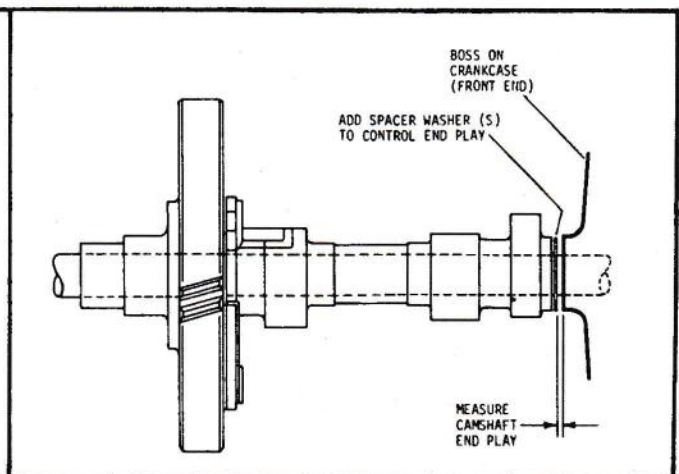


Figure 39 – Camshaft End Play

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.
- c. When marks are aligned, press crankshaft into bearing — make sure gears mesh as shaft is pressed into bearing. After shoulder bottoms against inner race, recheck timing mark to make sure they are still aligned.
- d. Crankshaft end play is controlled by the thickness of gaskets used between the bearing plate and block. End play must be checked after bearing plate is installed — directions stated in Step 6.

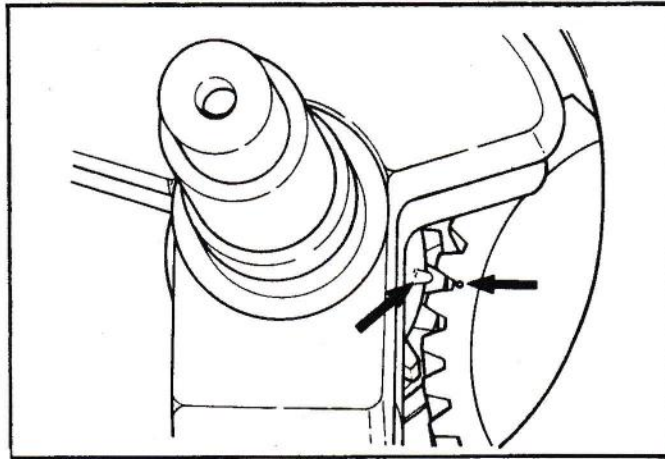


Figure 40 — Timing Marks On Crankshaft and Camshaft

6. Bearing Plate

- a. Press front main bearing (shielded side up) into bearing plate. Make sure bearing is straight and true in bore and bottomed properly. If cocked, crankshaft end play will be adversely affected.
- b. Crankshaft end play is determined by thickness of gaskets used between block and bearing plate. Initial use of one .020" and one .010" gasket should bring end play within limits — this must be checked after bearing plate is installed.
- c. Install gaskets with thicker gasket next to block, place bearing plate on crankshaft and carefully press plate onto shaft and into position on block. Install cap screws with copper washers and secure bearing plate to block. Draw screws up evenly to avoid distortion of bearing plate.
- d. Crankshaft end play is measured (with feeler gauge) between inner race of rear bearing (P.T.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 achieve proper 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, stagger ring gaps so they are not in line and insert complete assembly into cylinder bore. Be sure connecting rod marking is toward flywheel side of engine. Use a ring compressor to prevent ring breakage during installation. Gently push piston into bore with hammer handle — **do not pound**.

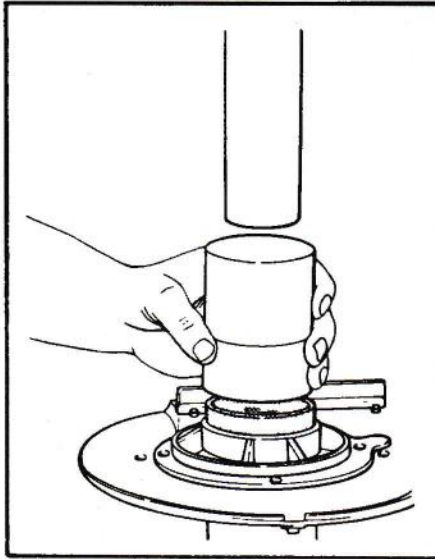


Figure 41 — Pressing Bearing In Bearing Plate

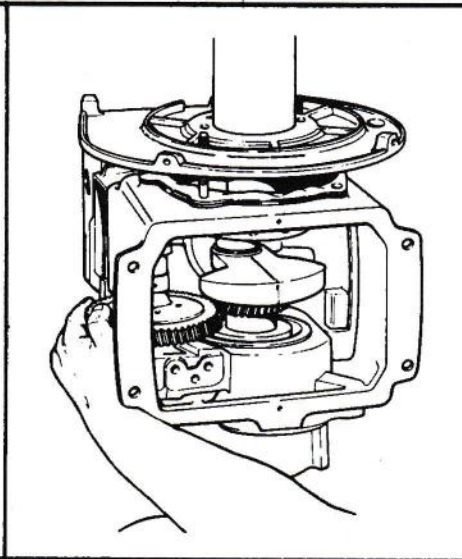


Figure 42 — Installing Bearing Plate

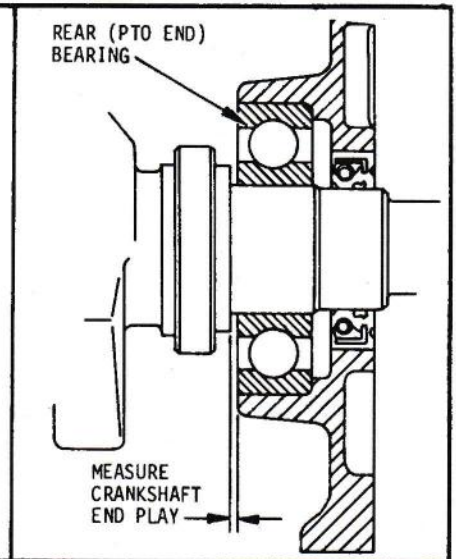


Figure 43 — Crankshaft End Clearance

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.
- 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.

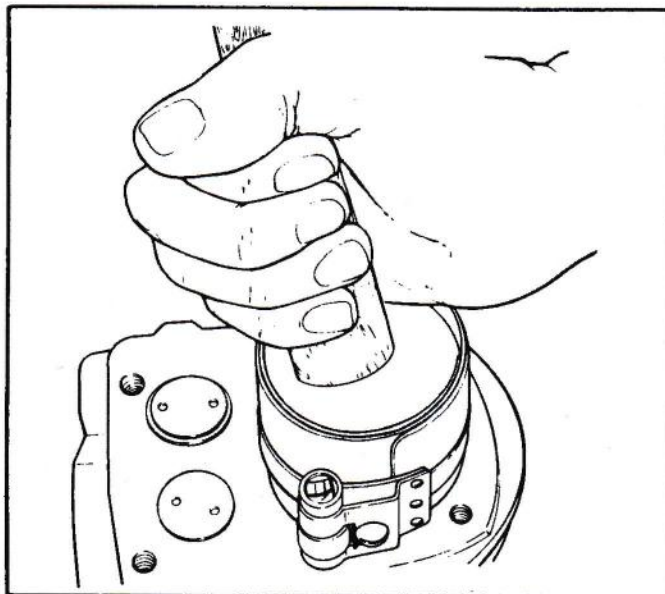


Figure 44 — Installing Piston - Ring Assembly

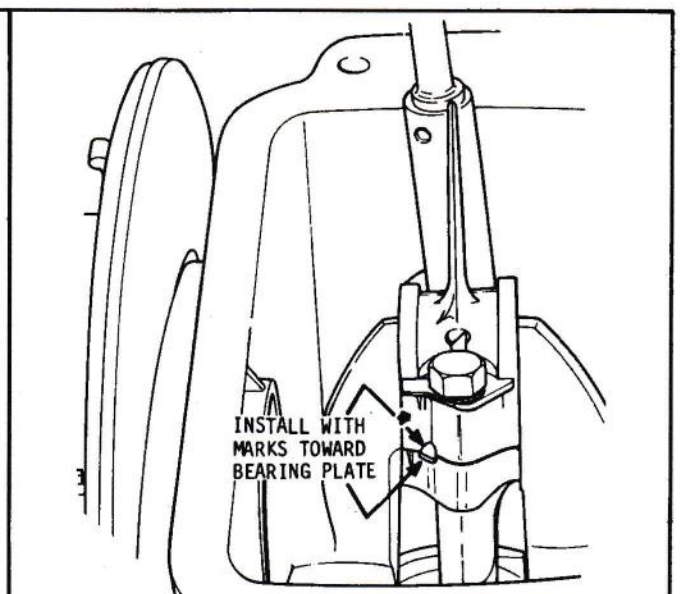


Figure 45 — Installing Connecting Rod Cap Screw

9. Installation of Oil Seals on Crankshaft

- a. Guide oil seals into position on crankshaft without damaging lips of seals. Any foreign matter on knife-like edge or any bending of seal may cause damage and an oil leak can result.

- b. After oil seals are started on shaft, place block on its side. The oil seals may now be driven squarely into bearing plate and cylinder block.

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.

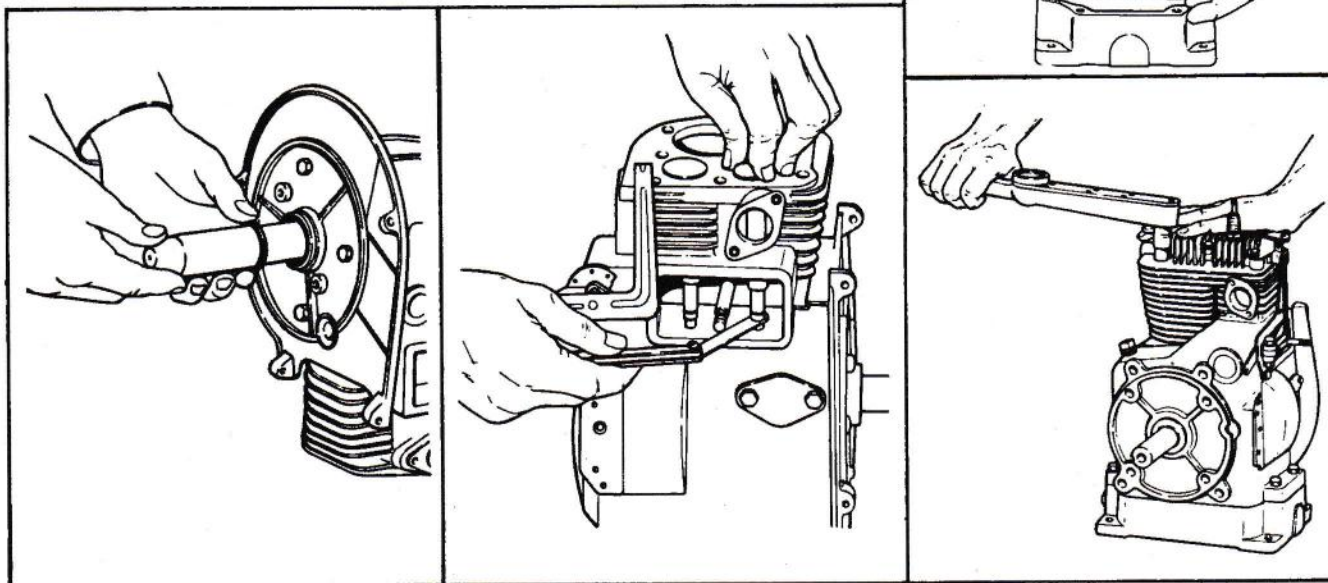


Figure 46 — Installing Oil Seals

Figure 47 — Checking Valve - Tappet Clearance

Figure 48 — 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.
- c. After correct clearance is obtained, remove valves and install valve springs and retainers. 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

- a. 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.

- b. Several different breather types are used. The accompanying illustration shows the correct order of assembly. Make sure reed valve is installed properly.
- c. Cover must be securely tightened to prevent oil leakage.

14. Magneto

- a. 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.

15. Flywheel

- a. Place wave washer on crankshaft and place flywheel in position. The square key holds flywheel on shaft.
- b. Install 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 flywheel with screws and spacers.

16. Breaker Points (430 Without Hood Door)

- a. Install push rod.
- b. Fasten breaker in place with two screws.
- c. Place cover gasket in position and attach magneto lead.

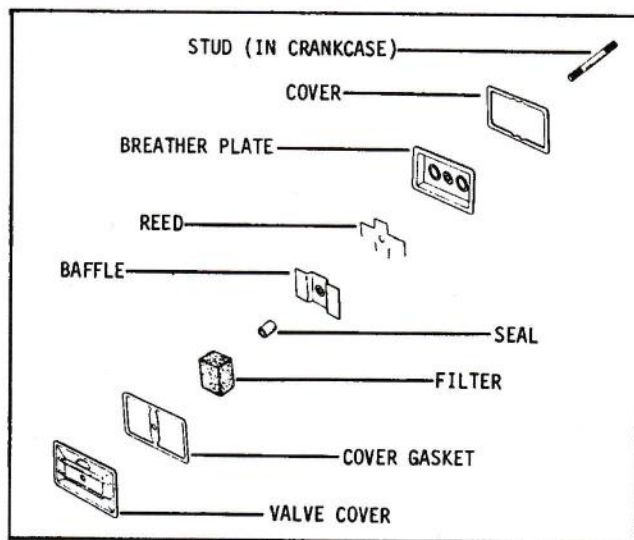


Figure 49 – Typical Crankcase Breather

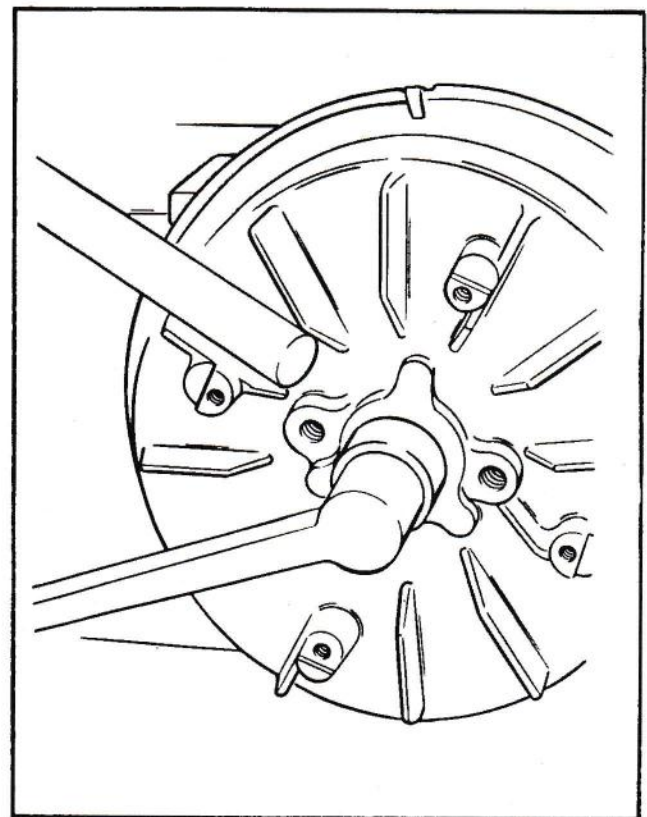


Figure 50 – Installing Flywheel

- d. Set breaker gap at .020 full open. For ignition 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

- 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 tank and fuel pump.

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 **non-detergent** 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 non-detergent type oil and refill with **detergent type API Service SC** oil of proper weight. **Do not continue** using non-detergent oil after the first 5 hours of operation.

TRANSMISSION DRIVE GEAR INSTALLATION

Gear must be heated prior to installation.

Use care when installing gear. The bearing plates of the engine can be damaged. The gear is secured with two woodruff keys.

Engine Adaptor Plate Installation

Install the adaptor plate and gasket on the engine. Secure in place with four $\frac{3}{8}$ x 1 hex bolts. Torque to 20 ft. lbs.

Engine Installation

1. Install special studs in top holes of engine adaptor plate. Be sure gasket is in place.
2. Slide engine in place on transmission, slide studs through top holes of the chassis casting.
3. Install two lower bolts securing engine to chassis. Do not tighten.
4. Swing rear hitch in place and install bolts securing hitch to engine oil base.
5. Remove studs from two top holes and install bolts. Tighten all bolts securely. Torque to 35 ft. lbs.

6. Connect wiring harness at connector.
7. Install cable on starter motor.
8. Connect fuel line. Turn on fuel.
9. Connect governor control to engine.
10. Connect choke control to carburetor.
11. Replace + cable on battery.
12. Add five quarts SAE 90W EP gear lubricant to transmission.

Special Tools

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

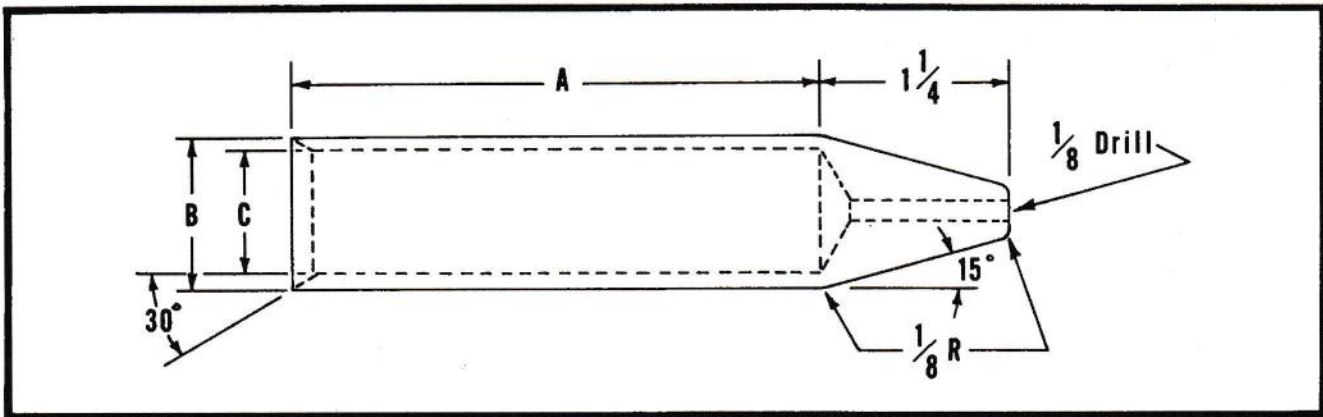


Figure 51 — Dimensional Diagram - Seal Sleeve

SEAL SLEEVE DIMENSION	K241, K301, K321
A	7-5/16"
B	1.245/1.250" 1.495/1.500"
C	1.002/1.003" 1.252/1.253"

SEAL DRIVER DIMENSION	K241, K301, K321
A	8-13/16"
B	1-11/16"
C	1.248/1.253"

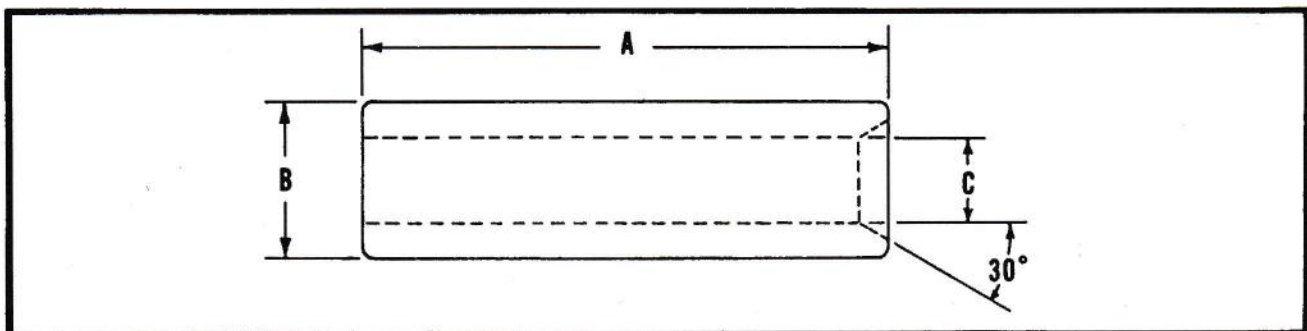


Figure 52 — Dimensional Diagram - Seal Driver

TORQUE VALUES — MAJOR ITEMS	ENGINE MODEL		
	K241	K301	K321
CYLINDER CAPSCREW	420 in. lbs.	420 in. lbs.	360 in. lbs.
CONNECTING ROD CAPSCREW	300 in. lbs.	300 in. lbs.	300 in. lbs.
FLYWHEEL RETAINING NUT	60 ft. lbs.	60 ft. lbs.	60 ft. lbs.
SPARK PLUG	27 ft. lbs.	27 ft. lbs.	27 ft. lbs.

VALVE DETAILS

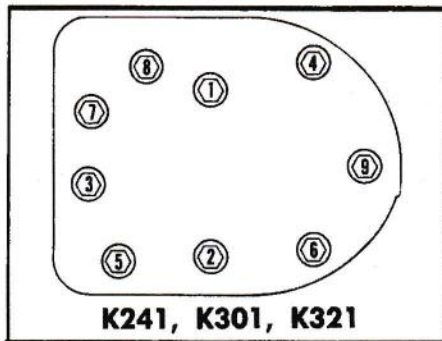


Figure 53 — Head Bolt Tightening Sequence

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

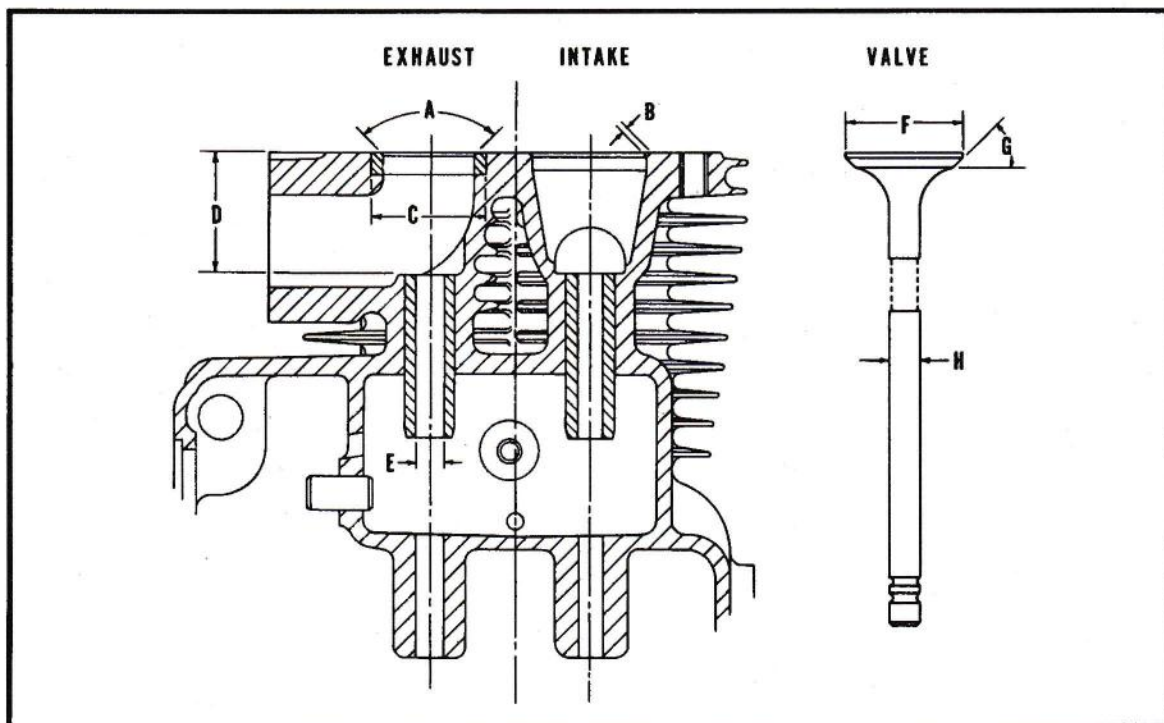


Figure 54 — Valve Detail Drawing - Location

Differential

Before assuming internal swiftmatic difficulties, carefully examine the external linkage and parts for binding. Carefully check the following:

1. Check linkage for binding, sheared roll pin, broken cotter pins.
2. Check to see that the control arm and level assembly is not binding on the cross shaft weldment.
3. Check to see that the two-speed extension spring is in place.
4. Check bolts and nuts securing the frame to chassis for tightness. Torque to 65 ft. lbs.
5. Check stationary clutch bolt. Be sure it is not sheared.
6. Raise the rear tires. Turn one wheel by hand. The other wheel should turn the opposite direction. Check for tight spots or roughness while turning.

If these checks do not isolate the difficulty, it will be necessary to examine the internal parts of the two speed shifting mechanism and differential.

Differential Removal

1. Drain transmission oil.
2. While transmission is draining, raise rear of tractor and remove rear wheels. Remove axle mount rear hitch or frame assembly axle connector (if so equipped).
3. Loosen the jam nut and special set screw and remove wheel hub from L. H. axle. Remove woodruff key.
4. Remove bolts securing Brake Support to the axle housing. Slide brake support and band off axle and out of way.
5. Remove high-low clutch link and the high-low clutch arm. Remove bolts securing axle housing to chassis casting. Remove axle housing from axle.
6. Remove R. H. wheel hub and brake assembly as in steps 3 and 4.

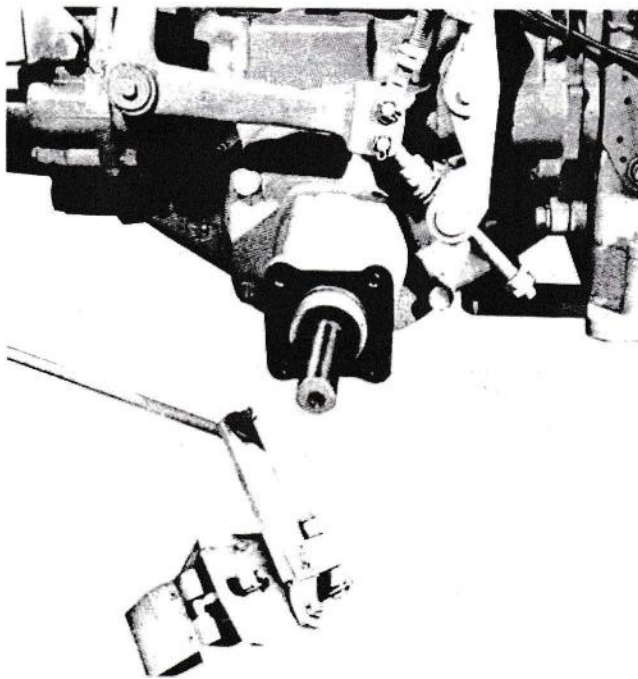


Figure 55

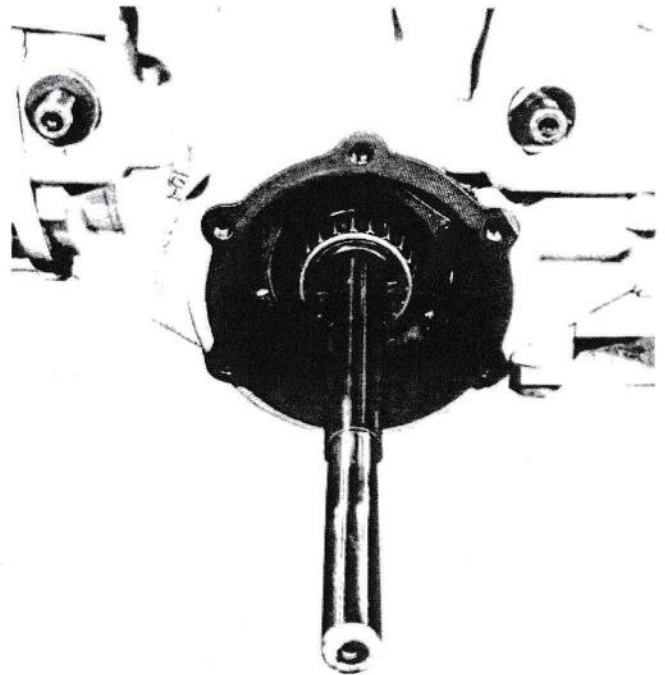


Figure 56

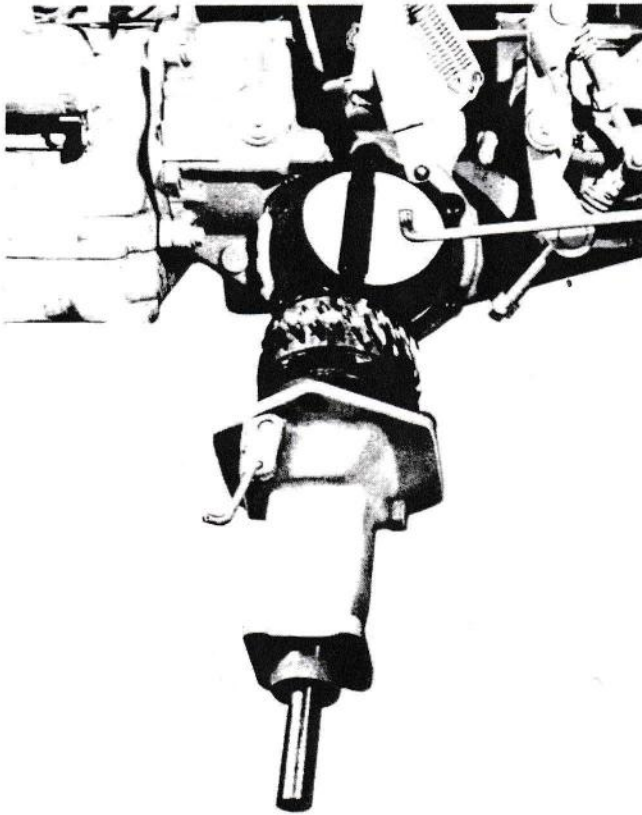


Figure 57



Figure 58

7. Disconnect two-speed shifter link.
8. Remove bolts securing axle housing to chassis casting.
9. Remove axle housing and differential assembly from tractor.
10. Hold the axle housing in vise, and remove differential assembly from axle housing.

Carefully examine the bearings on the differential assembly. Check for roughness and scoring. Be sure bearings are fully pressed in position on the housings.

11. Secure the differential assembly upright in a vise shifting gear side up.

NOTE: The following steps (12 through 18) refer to the differential in tractors serial numbers prior to 79. Refer to steps 20 through 30 for tractor serial number 7928 and up.

12. Bend down locking plates and remove six (6) bolts securing clutch housing to the worm gear.
13. Lift off clutch housing with axle. Remove shims.
14. Remove internal parts of differential. Carefully check all parts for damage or abnormal wear. Abnormal conditions include:
 1. Scoring of thrust washers.
 2. Scoring of spider pin arms.
 3. Scoring of bore of gears.

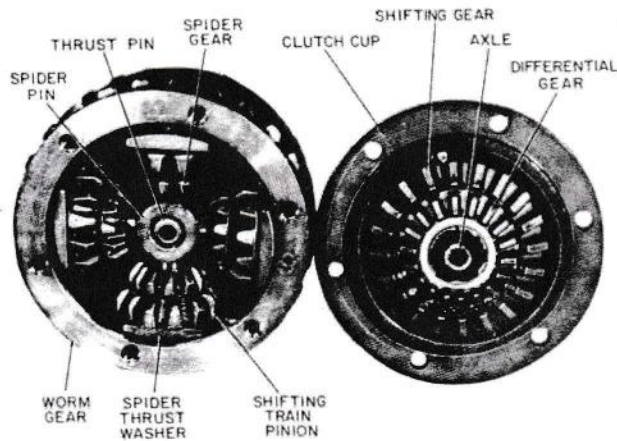


Figure 59



Figure 60

4. Scoring on the back of gears.
 5. Chipped teeth.
 6. Heavy wear on gear teeth.
15. Examine the internal surfaces of the worm gear. An even wear pattern is normal, however it should not exceed .010 inches. If the gear is pitted in spots or has small gouges, polish these areas.
 16. Reassemble the differential mechanism. Use new needle thrust bearings if thrust washers or gears have been replaced. Assemble in this sequence on all four spider arms: spider gear, shifting train pinion, needle thrust bearing, needle thrust race, shims, spider thrust washer. Install in bronze gear.
Earlier production tractors had shifting train pinions on two spider arms and two thick thrust washers on the arms with only spider gears. These should be converted to the style described above and illustrated in figure 59.
 17. Adjust shimming using a differential gear. The gear should be solid on all four spider gears. If the differential gear wobbles, decrease shimming on gears which gear is sitting solid on. This allows these gears to move away from center and in effect lowers them.
 18. Reinstall clutch housing and shims back on worm gear. Install bolts using new locking plates. Torque to 20 ft. lbs.
 19. Check end play of shifting gear. 0-.010 inch maximum.
Remove clutch plate and adjust shims accordingly if necessary. Reinstall bolts. Torque to 20 ft. lbs. Secure locking plates to bolts.
-
20. Bend down locking plates and remove bolts securing clutch housing to worm gear.
 21. Lift off clutch housing with axle. Remove shims.
 22. Turn differential over and bend down locking tabs and remove bolts securing pinned housing to worm gear.
 23. Lift off pinned housing with axle.
 24. Remove internal parts of differential, carefully check all parts for damage or abnormal wear. Abnormal wear includes:
 1. Scoring of spider pin arms.
 2. Scoring of bore of gears.

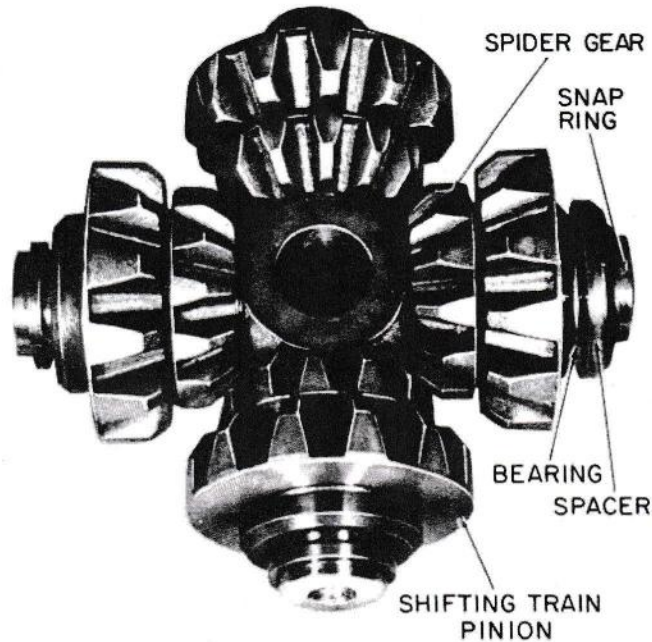


Figure 61

3. Scoring on back of gears.
4. Chipped teeth.
5. Heavy wear on teeth.
25. The internal differential assembly does **not** ride on the inside surface of the bronze gear.
26. Reassemble the differential mechanism. Use new needle thrust bearings if gears have been replaced. Assemble in this sequence on **all four spider arms**: spider gear, shifting train pinion, bearing, spacer, snap ring.
27. Install differential mechanism in bronze gear. It will be necessary to tilt the differential mechanism to fit it inside the gear.
28. Install pinned housing with differential gear, pinned gear and axle back on bronze gear. Install bolts using new locking plates. Torque to 20 ft. lbs. Secure locking plates to bolts.
29. Reinstall clutch housing and shims back on worm gear. Install bolts using new locking plates. Torque to 20 ft. lbs.
30. Check end play of shifting gear .0-.010 inch maximum. Remove clutch plate and adjust shims accordingly, if necessary. Reinstall bolts and torque to 20 ft. lbs. Secure locking plates to bolts.

Differential Installation

31. Wrap key area of R.H. axle with ultra-thin shim stock to protect oil seal and install differential in R.H. axle housing, being sure the shifting clutch lines up properly.
32. Be sure the machined surface of the axle housings, chassis casting and shims are clean of any oil or debris.
33. Put an equal amount of .020 and .005 shim and a new gasket on each axle housing.
34. Install the R.H. axle housing — differential assembly in place. Secure with 2-3 bolts.
35. Wrap axle with ultra-thin shim stock and install L.H. axle housing. Secure with 2-3 bolts.

36. Check end play of each axle. End play should be approximately .020. Adjust accordingly.
37. After adjusting end play, install all bolts and torque to 45 ft. lbs.
NOTE: The bottom bolt on the L.H. axle housing (oil drain bolt) cannot be torqued. Tighten securely.
38. Clean axle with crocus cloth.
39. Reinstall brake band supports on each axle housing.
40. Install woodruff key in axles and wheel hubs. Tighten special set screws and jam nuts.
41. Connect two-speed shifter link.
42. Install rear wheels.
43. Add 5 quarts of SAE 90W EP gear lubricant to chassis.
44. Test operation.

Brake and Brake Linkage

The brakes are adjusted by tightening or loosening the nut (H, Figure 62) of the brake band assembly on the brake support. Do not overtighten as dragging brake bands will rob power and cause rapid wear of the brake linings. To adjust: tighten the nut until the bands are dragging, then loosen $\frac{1}{2}$ turn.

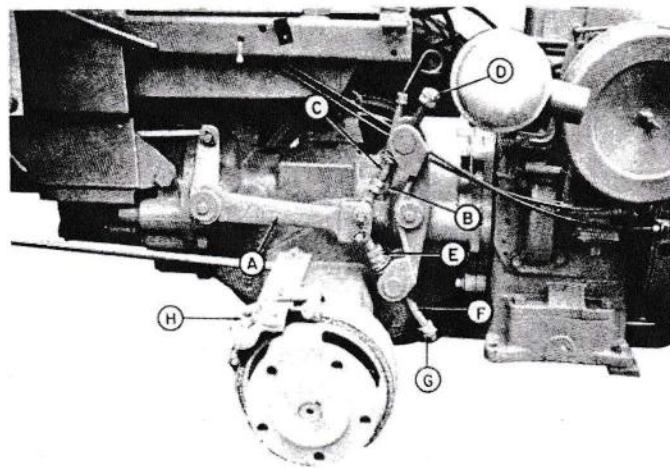


Figure 62

HIGH-LOW

Controls and Linkage

It is necessary that clutch links go over center to hold the clutch cup in position. Improper adjustment can result in damage to clutch cup or other internal parts.

High Adjustment

Move the jam nuts (G, Figure 62) closer to the clutch lever for a more sensitive adjustment or closer to the end of the clutch rod (F) for a less sensitive adjustment. Adjust the jam nuts (B) so when the level is in the high or (2) position, there is approximately .010 inch gap between the coils of the spring.

Low Adjustment

Move the jam nuts (D, Figure 62) closer to the clutch lever for a more sensitive adjustment or closer to the end of the clutch rod (C) for a less sensitive adjustment. Adjust the jam nuts (E) so that when the lever is in the low or (1) position, there is approximately .010 inch gap between the coils of the spring.

In case of improper high-low planetary operation, and before assuming internal problems, carefully check the following:

1. Check linkage for binding, sheared keys, broken cotter pins or missing clevis pins.
2. Check to see that control arm and lever assembly are not binding on the cross shaft weldment.
3. Check to see that the needle bearing in the high-low clutch link is not frozen to the front clutch actuating shaft.
4. Check bolts and nuts securing the frame to the chassis for tightness. Torque to 65 ft. lbs.

When internal problems are indicated, a few simple checks will quickly locate the area of failure.

If the tractor does not move when forward-reverse lever is engaged, check to see that the swiftomatic (range) linkage is working properly. Check for sheared keys or rollpins. Check to see if brakes are frozen or rusted to drums.

To locate the problem; using a light, observe the transmission through the oil filler plug hole. Engage the high-low gear, then while watching the front pin plate, move the forward-reverse lever back and forth. If the planetary turns to the right and left, the problem is in the differential. If it does not turn, the problem is the planetaries or a broken pinion shaft.

To determine planetary or pinion shaft failure, engage PTO and high-low gear. If the PTO shaft turns, then the forward-reverse planetary has failed. If the PTO shaft does not turn, the high-low planetary has failed or the pinion shaft is broken.

It is necessary to remove the engine to determine if it is a high-low planetary failure or a broken pinion shaft.

Internal high-low planetary (1-2 Gear) problems would be indicated if there is no bound linkage or sheared keys and the control levers are engaged and PTO does not turn or tractor wheels do not turn.

To examine the high-low planetary:

1. Remove engine as described on page 26.
2. Remove the clutch lever from the actuating shaft.
3. Turn the actuating shaft to release clutch slide rods.

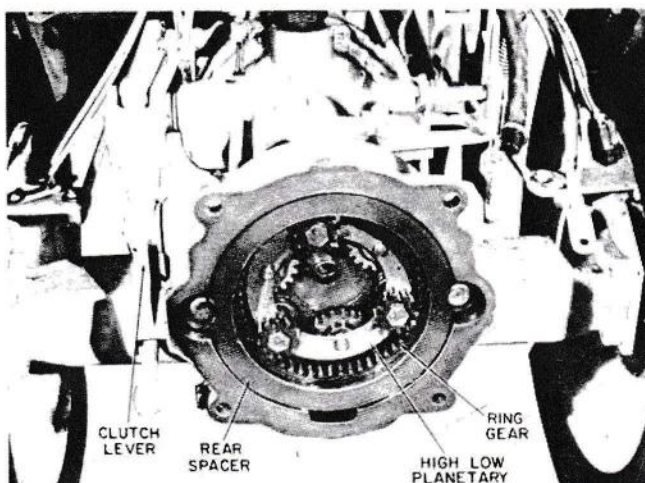


Figure 63

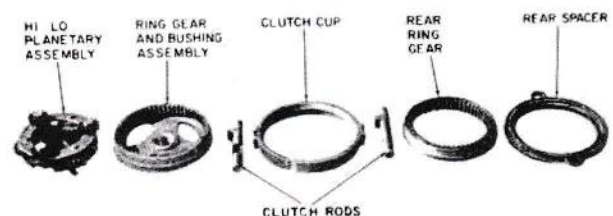


Figure 64

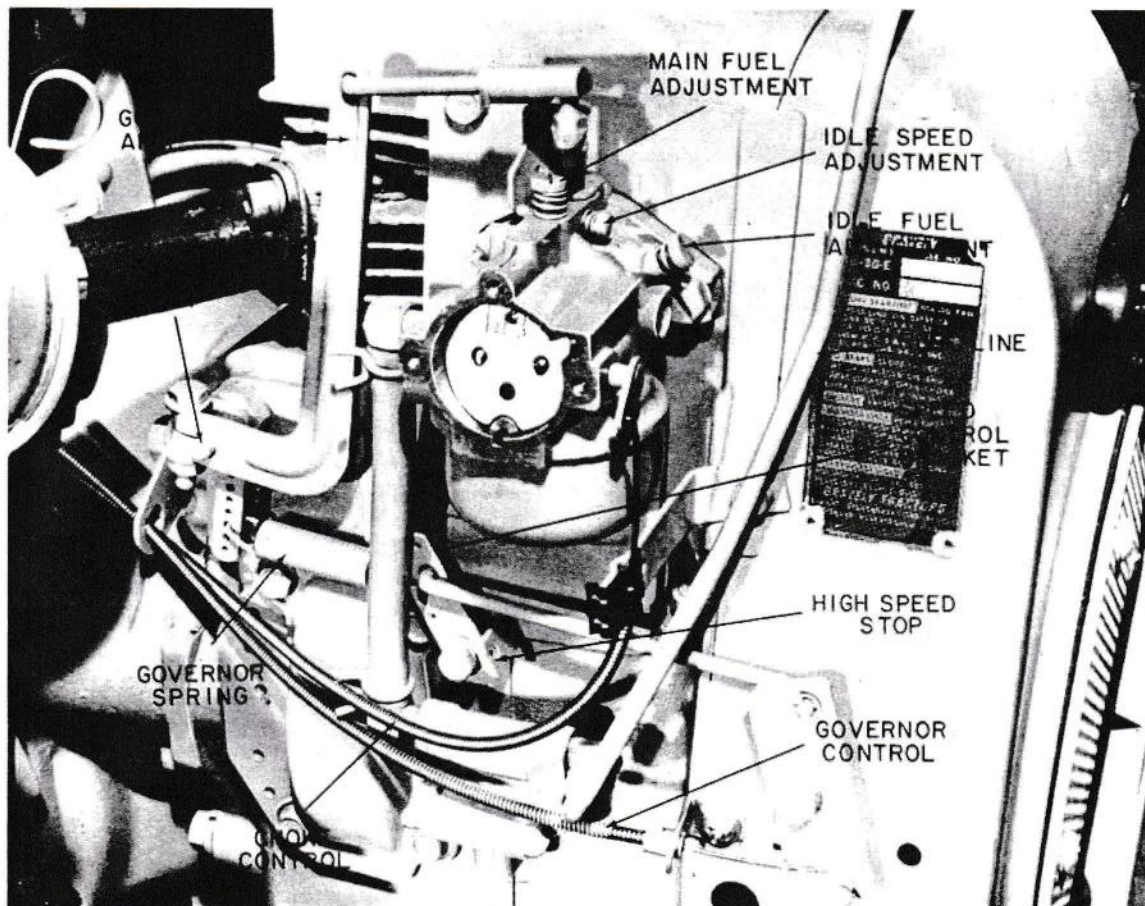


Figure 4

IGNITION SYSTEM

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

OPERATIONAL TEST

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

SPARK PLUG

Engine misfire or generally poor operation is often caused by spark plugs in poor condition or with improper gap setting. Always clean area around spark plug before removing to prevent dirt from falling into engine. The first thing to do after removing a spark plug is to carefully note its condition as this is often an indicator of the ignition trouble. Plugs fail for various reasons. Often the porcelain insulator cracks or becomes coated with oil,

6. Remove cable from positive post of battery.
7. Turn off fuel and separate fuel line.
8. Separate wiring harness at connector.
9. Separate tail light wire (if so equipped).
10. Remove wire from starter motor.
11. Disconnect throttle and choke cables.
12. Support tractor frame just in front of the PTO and remove the two bolts and two nuts securing chassis to frame.

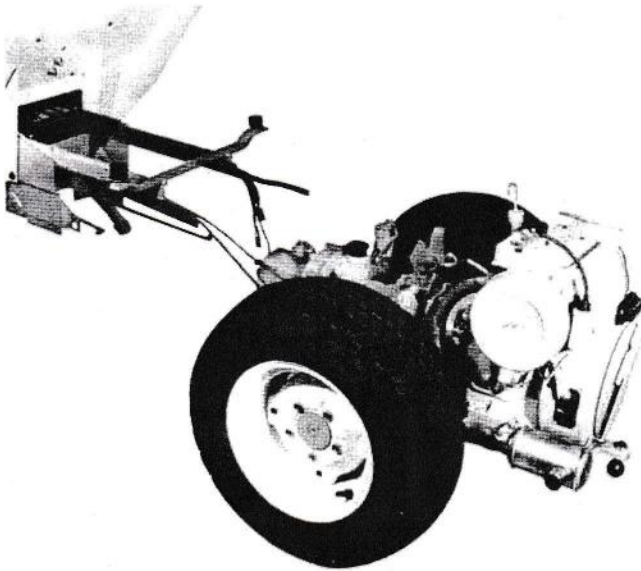


Figure 66

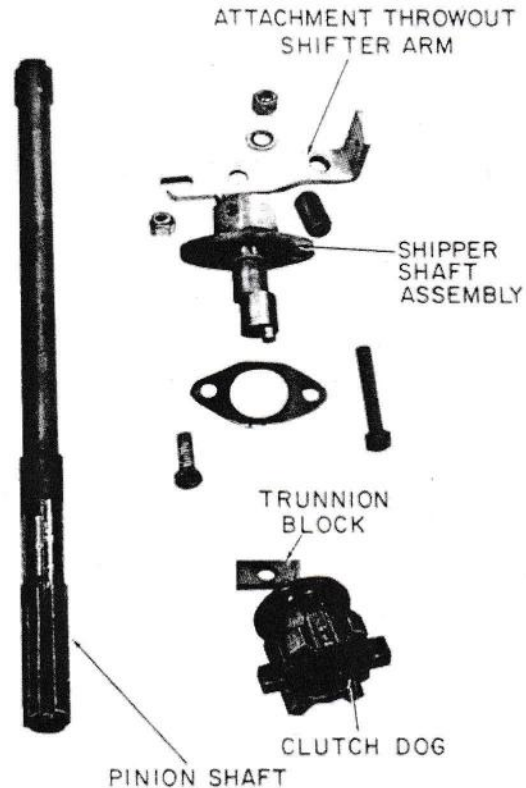


Figure 67

13. Roll chassis back from frame.
14. Lower engine to floor.
15. Remove advance casting coverplate — dog clutch assembly.
16. Remove the attachment throw out shifter arm — shipper shaft assembly.
17. Remove clutch dog from pinion shaft.
18. Remove pinion shaft.

Carefully check all parts for wear or binding. Sight down splines of pinion shaft to see if the shaft is twisted. Carefully check the bearings of the advance casting cover plate for wear.

If there was no gasket under the shipper shaft guide on the advance casting, be sure to reassemble using a gasket.

If the PTO seemed not to be engaging fully, reassemble using two attachment gaskets between the advance casting and the cover plate assembly.

Assembly:

1. Install pinion shaft.
2. Install clutch dog on pinion shaft.
3. Install attachment throw out shifter arm — shipper shaft assembly.
4. Install advance casting coverplate — dog clutch assembly.
5. Roll chassis in frame, use care to be sure controls are in the proper locations to be connected.
6. Secure the frame in place with the two bolts and two nuts. Torque to 65 ft. lbs.
7. Connect the throttle and choke controls.
8. Attach wire to starter motor.
9. Connect wiring harness at connector.
10. Connect tail light wire (if so equipped).
11. Connect cable to positive post of battery.
12. Connect fuel line, turn on fuel.
13. Put in forward-reverse clutch rods in place in the forward-reverse clutch link. Secure with clevis pin.
14. Connect the attachment throwout link to the attachment throw out shifter arm.
15. Connect the two-speed shifter rod to the shifter weldment.
16. Connect both brake rods to brake levers.

FORWARD-REVERSE

Controls and Linkage

It is necessary that the clutch go over center and snap into position. Improper adjustment can result in damage to the clutch cup and other internal parts.

Forward Adjustment — (Over center) Move the jam nuts (A, Figure 68) closer to the clutch lever for a more sensitive overcenter adjustment or closer to the end of the clutch rod (B) for a less sensitive overcenter ad-

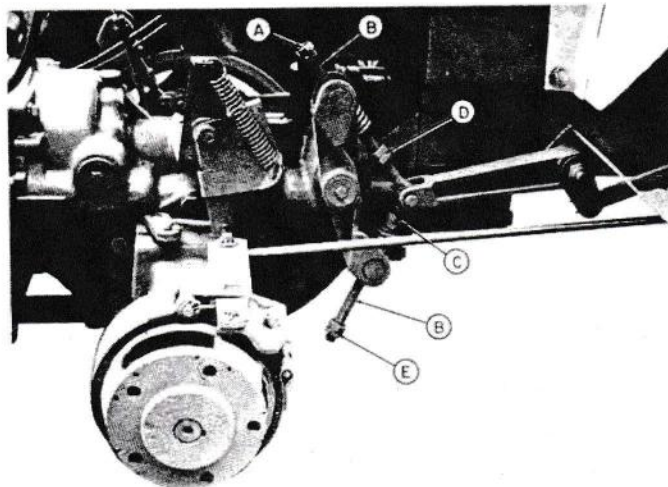


Figure 68

justment. Adjust the jam nuts (C) (Figure 68) so when the lever is in the forward position, there is approximately .010 inch gap between the coils of the spring. NOTE: When properly adjusted clutch will return to neutral with the slightest pull.

Reverse Adjustment — Move the jam nuts (E, Figure 68) closer to the clutch lever for a more positive adjustment or closer to the end of the clutch rod (B) for a less positive adjustment. Adjust the jam nuts (D, Figure 68) so when the lever is in the reverse position, there is approximately .010 inch gap between the coils of the spring.

In case of improper forward-reverse planetary operation and before assuming internal problems, carefully check the following:

1. Check linkage for binding, sheared keys, broken cotter pins, or missing clevis pins.
2. Check to be sure that the forward-reverse lever is not frozen to the clutch lever bushing. Check bolt for tightness.
3. Check to see that the clutch link is not frozen to the clutch link bushing.
4. Check to see that the needle bearing in the high-low clutch link is not frozen to the front clutch actuating shaft.
5. Check bolts and nuts securing the frame to the chassis for tightness. Torque to 65 ft. lbs.
When internal problems are indicated, a few simple checks will quickly locate the area of failure.

If the tractor does not move when forward-reverse lever is engaged, check to see that the swiftmatic (range) linkage is working properly. Check for sheared keys or roll pins. Check to see if brakes are frozen or rusted to drums.

To locate the problem internally in the transmission, using a light, observe the transmission through the oil filler plug hole. Engage the high-low gear then while watching the front pin plate, move the forward-reverse lever back and fourth. If the planetary turns to the right and left, the problem is in the differential. If it does not turn, the problem is the planetaries or a broken pinion shaft.

To determine planetary or pinion shaft failure, engage PTO and high-low gear. If the PTO shaft turns, then the forward-reverse planetary has failed. If the PTO shaft does not turn, the high-low planetary has failed or the pinion shaft is broken.

It is necessary to remove the engine to determine if it is a high-low planetary failure or a broken pinion shaft.

Removal:

1. Remove chassis-engine assembly. See page 52, steps 1 to 13.
2. Lower engine to floor.
3. Remove advance casting cover plate — PTO dog clutch shaft assembly.
4. Remove the attachment throw out shifter arm — shipper shaft assembly.
5. Remove clutch dog from the pinion shaft.
6. Remove the pinion shaft.
7. Remove advance casting.
8. Remove forward-reverse clutch lever.
9. Rotate front clutch actuating shaft and release clutch slide rods.
10. Slide reverse cone, forward-reverse planetary, clutch cup, external gear and gear cup out of chassis.

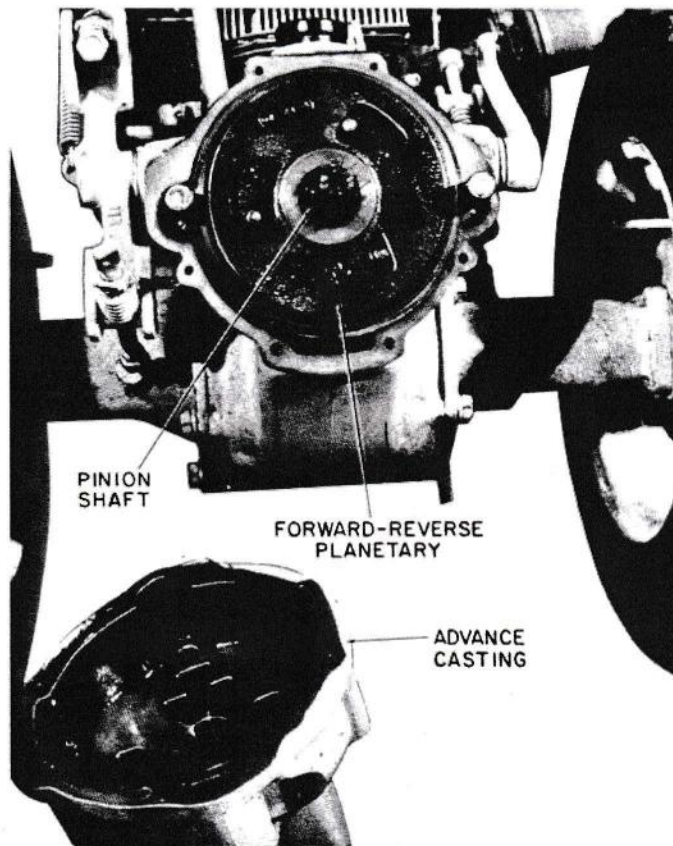


Figure 69

Carefully examine all parts for damage and unusual wear. Check gears for wear on teeth and on pins or bushings. Carefully check for gears that are tight or starting to seize to the pins.

Check the surface of the clutch cup for wear or damage. Also check the friction surfaces of the ring gear and the reverse cone for scoring that can damage the clutch cup.

If the forward-reverse planetary was disassembled, it will be necessary to retime the planetary:

1. Place the sun pinion in place in the bore of the front pin plate.
2. Secure the pin plate quill to the pin plate with three $\frac{1}{4}$ x $\frac{5}{8}$ bolts and $\frac{1}{4}$ nuts.
3. Place the orbit bear pins in place in the orbit gears.
4. Mesh the three gears with the sun pinion so that the timing marks form as equal sided triangle. The timing marks are punch marks on each of the gears.

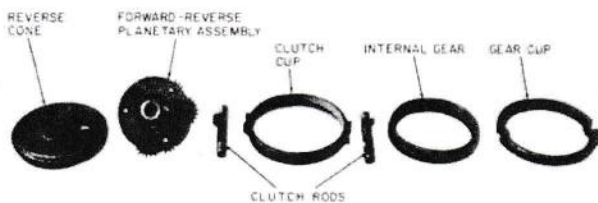


Figure 70

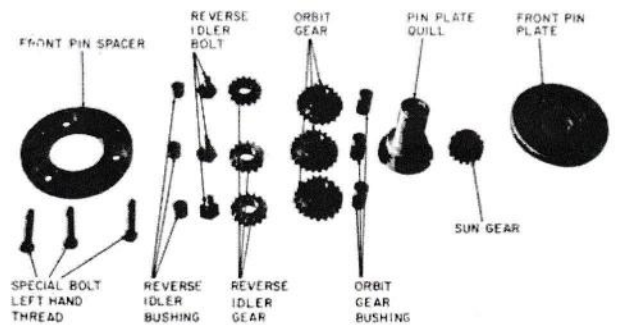


Figure 71

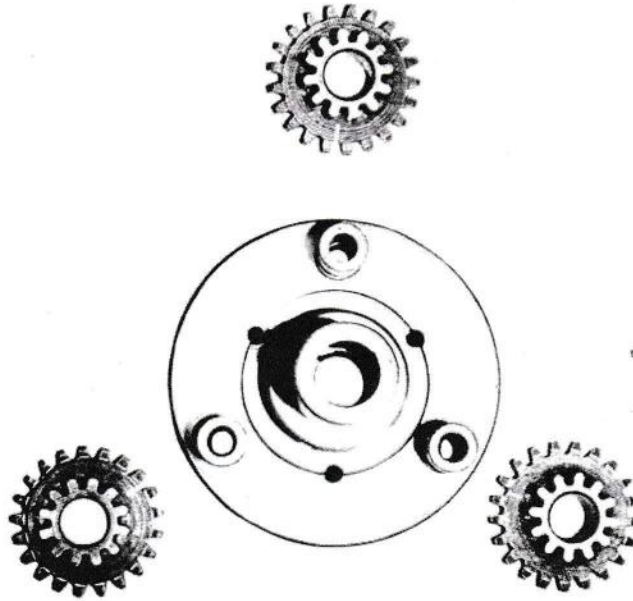


Figure 72

To reassemble for installation, place the planetary in the reverse cone, fit the clutch cup on the reverse cone, fit the internal gear in clutch cup, then place the gear cup on the internal gear.

The notches of the slide rods fit on the outside of the clutch cup with teeth upward to mesh in the teeth of the actuating shaft.

Slide the unit back in the chassis.

To reassemble:

1. Reinstall advance casting. Torque bolts to 15 ft. lbs.
2. Install pinion shaft.
3. Place clutch dog, back on pinion shaft.
4. Reinstall attachment throw out — shipper shaft assembly.
5. Reinstall advance casting cover plate — dog clutch assembly.
6. Install forward-reverse clutch arms.
7. Install chassis-engine assembly. See page 54 steps 5 to 16.

FITS AND CLEARANCES

SPECIFICATION	K241	K301	K321
Bore and stroke	3¼ x 2⅞	3⅝ x 3¼	3½ x 3¼
Bore diameter, new	3.250	3.375	3.500
Crankshaft end play	.003/.020	.003/.020	.003/.020
Crankshaft — conn. rod journal size	1.5000/1.4995	1.5000/1.4995	1.5000/1.4995
Crankpin — conn. rod side clearance	.007/.016	.007/.016	.007/.016
Crankpin length	1.187	1.180	1.180
Journal diameter, new	1.575	1.575	1.575
Connecting rod to crankpin running clearance	.001/.002	.001/.002	.001/.002
Connecting rod to wrist pin clearance	.0003/.0008	.0003/.0008	.0003/.0008
Wrist pin to piston boss	.0000/.0003	One Thumb	One Thumb
	Select Fit	Push Fit	Push Fit
Piston to cylinder bore (thrust face)	.003/.004	.003/.004	.0035/.0045
Piston to cylinder bore (top of skirt)	.0075/.0085	.0065/.0095	.007/.010
Piston pin bore size	.85975	.85975	.85975
Piston pin diameter	.86	.86	.86
Ring side clearance, top ring	.002/.004	.002/.004	.002/.004
Ring side clearance, middle ring	.002/.004	.002/.004	.002/.004
Ring side clearance, oil ring	.001/.003	.001/.003	.001/.003
Ring end gap	.010/.020	.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	.001/.0035	.001/.0035	.001/.0035
Camshaft pin to block (Bearing plate end)	.0005/.002	.0005/.0020	.0005/.0020
Camshaft pin to block (P.T.O.E.) (Int.)	.0015/.0030	.0015/.0030	.0015/.0030
Camshaft pin to breaker cam	.0010/.0025	.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)	.003/.005	.003/.005	.003/.005
Valve clearance, intake (cold)	.008/.010	.008/.010	.008/.010
Valve clearance, exhaust (cold)	.017/.020	.017/.020	.017/.019
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	.0008/.0023	.0008/.0023	.0008/.0023
Governor bushing to gov. cross shaft clear.	.001/.0025	.0010/.0025	.0010/.0025
Governor gear to governor shaft	.0005/.0020	.0005/.0020	.0005/.0020
Ball bearing to cylinder block (Interference)	.0006/.0022	.0006/.0022	.0006/.0022
Ball bearing to bearing plate (Interference)	.0012/.0028	.0012/.0028	.0012/.0028
Ball bearing to crankshaft (Int. to loose)	.0004/.0005	.0004/.0005	.0004/.0005

TORQUE VALUES – STANDARD HARDWARE ITEMS

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

CONVERSION TABLE (INCH LBS. TO FOOT LBS.)

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

Divide inch lbs. by 12 for foot pound values.

Multiply foot lbs. by 12 for inch pound values.

FORM NO. 16113P1
PRINTED IN USA