FILE IN:
SERVICE MANUAL
SECTION: SINGLE CYLINDER

KOHLER

SINGLE CYLINDER SERVICE MANUAL

THIS MANUAL COVERS MODELS:

K91	K241
K141	K301
K161	K321
K181	

REVISION NO. 4-72

This is a complete revision.

ENS-575 4-72 Z Class I LITHO IN U.S.A.

CONTENTS

SUBJECT	PAGE
OPERATING INSTRUCTIONS - GENERAL	SECTION 1
Pre-start Checks	1.1
Starting Procedure	1.1
Stopping Procedure	1.1
Engine Number Explanation	1.2
General Specifications	1.2
Service Schedule	1.3
Trouble Shooting Guide	1.4
LUBRICATION	SECTION 2
Oil Level	2.1
Oil Type	2.1
Oil Change	2.1
Run-in Recommendations	2.2
Reduction Gear Oil Instructions	2.2
AIR INTAKE	SECTION 3
Dry Type Air Cleaners	3.1
Oil Bath Air Cleaners	3.1
FUEL, FUEL SYSTEM	SECTION 4
Fuel Specifications	4.1
Carburetor Adjustment (Gasoline)	4.1
Carburetor Reconditioning (Gasoline)	4.2
Fuel Pump	4.4
Fuel Filter	4.4
GOVERNOR	SECTION 5
Operation	5.1
Adjustment	5.2
IGNITION	SECTION 6
Magneto Ignition	6.1
Battery Ignition	6.2
Breakerless Ignition	6.3
Operational Tests	6.4
Spark Plugs	6.4
Breaker Points	6.5
Condenser	6.5
Trigger Module	6.6
Ignition Coils	6.6
Permanent Magnets	6.7
Ignition Timing	6.7
ELECTRIC STARTING - CHARGING	SECTION 7
System Types	7.1
Battery	7.1
Motor - Generator	7.2
Voltage Regulator	7.5
Alternator Systems	7.7

SUBJECT	PAGE
ELECTRIC STARTING - CHARGING (CONT'D.)	SECTION 7
Starting Motors	7.13
Ring Gear Replacement	7.16
RETRACTABLE STARTERS	SECTION 8
Fairbanks-Morse Starters	8.1
Eaton Starters	8.3
Rope Replacement - Alignment	8.4
ENGINE - GENERAL	SECTION 9
Cooling System	9.1
Engine Tests	9.1
INSPECTION - DISASSEMBLY	SECTION 10
Inspection	10.1
Repair - Replacement Methods	10.2
Disassembly Procedure	10.4
RECONDITIONING	SECTION 11
Cylinder Bore	11.1
Crankshaft	11.2
Connecting Rod	11.2
Piston	11.2
Valves	11.3
Cylinder Head	11.4
Ring Gear	11.4
Dynamic Balance	11.5
REASSEMBLY	SECTION 12
Reassembly Procedure	12.1-12.6
SPECIAL FUEL SYSTEMS	SECTION 13
Gas Fuel Systems	13.1
Combination Gas-Gasoline	13.12
Kerosene Fuel Systems	13.12
MODIFICATIONS - ACCESSORIES	SECTION 14
Clutches	14.1
Reduction Gear	14.3
Automatic Chokes	14.4
Winterized Engines	14.5
Tool List	14.5
SPECIFICATIONS - TOLERANCES	SECTION 15
Torque Specifications	15.1
Fits and Clearances	15.2
Wear Tolerances	15.4
Valve Details	15.4
Piston Wear Measurements	15.5
Oil Seal Installation Details	15.5

SAFETY PRECAUTIONS

- Do not add fuel while engine is running. Stop engine and, if possible, allow cooling period to prevent spilled fuel from igniting on contact with hot engine parts.
- Always disconnect spark plug cable to prevent unintentional starting before making any adjustments on equipment powered by engine.
- Make sure all safety guards on engine and driven equipment are in proper position and secure.
- Make sure hands, feet, and clothing are at a safe distance from any movable parts prior to starting.
- Do not tamper with governor settings. The governor establishes safe operating limits. These limits must not be exceeded.

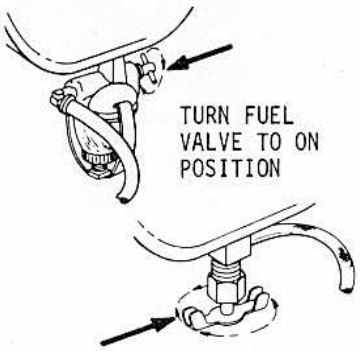
OPERATING INSTRUCTIONS

PRE-START CHECK LIST

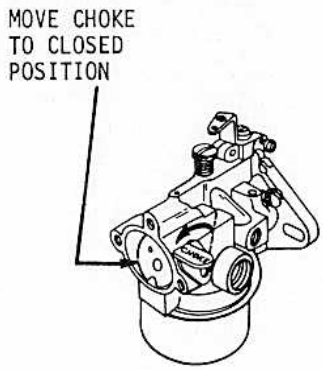
- OIL LEVEL: Add oil as needed to keep level in safe range between L and F marks on the dipstick. See Page 4 for oil recommendations.
- FUEL: Fill fuel tank with clean, fresh REGULAR grade of gasoline. Use leaded or non-leaded type but make sure octane rating is at least 90. Don't mix oil with gasoline. If engine has a fuel filter, clean sediment bowl if needed.
- COOLING: Check air intake screens and cooling fins--keep them clean and unrestricted.
- AIR CLEANER: Make sure cleaner and intake parts are tight and properly installed to prevent unfiltered air from entering the engine.
- BATTERY (ELECTRIC START): Keep battery surface clean to prevent self-discharge. Check electrolyte level. Connections must be tight and negative (-) terminal must be the ground terminal.
- REDUCTION GEAR (R MODELS): Make sure lubricating oil is at proper level in reduction gear unit before operating--see page 4 for details.

STARTING PROCEDURE

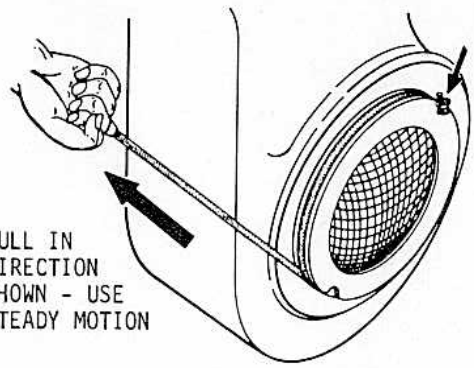
TURN FUEL ON



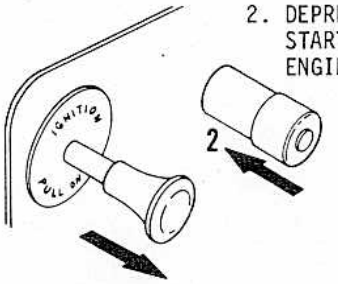
CLOSE CHOKE



MANUAL START MODELS



ELECTRIC START

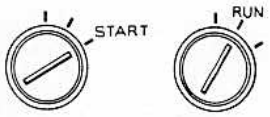


2. DEPRESS AND HOLD START BUTTON UNTIL ENGINE STARTS

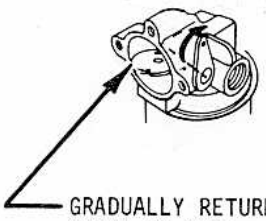
1. PULL IGNITION KNOB OUT*

*OR MOVE TOGGLE SWITCH TO "ON" POSITION

KEYSTART - MOVE KEY TO START POSITION, *RELEASE WHEN ENGINE STARTS (SWITCH AUTOMATICALLY RETURNS TO RUN)



OPEN CHOKE



GRADUALLY RETURN CHOKE TO OPEN POSITION AFTER ENGINE STARTS

STOPPING PROCEDURE

DISENGAGE DRIVE ● TURN IGNITION OFF ● TURN FUEL OFF

EMERGENCY STOP: IF ENGINE CONTINUES RUNNING WHEN IGNITION IS TURNED OFF, CLOSE CHOKE AND OPEN THROTTLE TO STALL ENGINE--DON'T PULL IGNITION LEADS TO STOP.

G 24-E
SER NO D-265388
SPEC NO 4651 3E

GENERAL

This manual covers the Kohler single cylinder, horizontal crankshaft engine models listed in the chart below. These are 4-stroke cycle air-cooled engines. When ordering replacement parts and in any communication involving an engine, always report the MODEL, SERIAL and SPECIFICATION numbers as found on the nameplate which is mounted on the carburetor side of the engine blower housing. The significance of these numbers is explained as follows.

MODEL NUMBER: This number indicates the model series within which the engine is built. It also is a code indicating (a) the cubic inch displacement and (b) number of cylinders. The model K241 for example indicates a 24 cubic inch displacement, 1 cylinder engine. Letter suffixes following the model number indicate a specific version--the letter suffix code is as follows:

MODEL SUFFIX LETTER EXPLANATION

SUFFIX LETTER	C	G	H	P	R	S	T
DESIGNATES	CLUTCH MODEL	HOUSED WITH FUEL TANK	HOUSED (LESS FUEL TANK)	PUMP MODEL	REDUCTION GEAR	ELECTRIC START	RETRACTABLE START
Model number without suffix letter indicates basic rope start version.							

SPECIFICATION NUMBER: The specification number indicates model variation. It is used to indicate a combination of various groups used to build an engine. It may have a suffix letter which is sometimes important in determining supersession of parts. The first two digits of the specification number is the code designating engine model--the remaining numbers are issued in numerical sequence as each new specification is released--for example 2899, 28100, 28101. The current model code designation is as follows:

SPECIFICATION NUMBER MODEL CODE EXPLANATION

MODEL	K91	K141	K161	K181	K241	K301	K321
CODE DESIGNATION (FIRST 2 DIGITS)	26,27,31	29	28	30	46	47	60

SERIAL NUMBER: The serial number lists the order in which the engine was built. If a change occurs to a model or specification, the serial number is used to indicate the point at which this change was made. In 1969, the letter prefix to the engine serial number was dropped. The letter prefix was the code designation for year of manufacture as shown in the chart below. The first digit in the serial number is now used as the code indicator; for example, in serial number 2127796, the 2 indicates that the engine was built in 1970--the numerical code is also shown below. Note that in 1969 some engines had the letter prefix designation while others had the numerical indicator. The code since 1965 is as follows:

SERIAL NUMBER CODE EXPLANATION

YEAR OF MANUFACTURE	LETTER PREFIX					FIRST DIGIT (NUMBER)				
	1965	1966	1967	1968	1969	1969	1970	1971	1972	1973
CODE DESIGNATION	A	B	C	D	E	1	2	3	4	5

GENERAL SPECIFICATIONS

ENGINE MODEL	BORE (NOMINAL)	STROKE (NOMINAL)	DISPLACEMENT (CU. IN.)	WEIGHT (APPROX. LBS.)	LUBE OIL CAPACITY (US-QUARTS)	SPARK PLUG GAP	BREAKER POINT GAP
K91	2-3/8"	2"	8.86	41	.5	.025"	.020"
K141 (Spec 29355 & Earlier)	2-7/8"	2-1/2"	16.22	63	1	.025"	.020"
K141 (Spec 29356 & Later)	2-15/16"	2-1/2"	16.9	63	1	.025"	.020"
K161 (Spec 281161 & Earlier)	2-7/8"	2-1/2"	16.22	63	1	.025"	.020"
K161 (Spec 281162 & Later)	2-15/16"	2-1/2"	16.9	63	1	.025"	.020"
K181	2-15/16"	2-3/4"	18.6	63	1	.025"	.020"
→ K241	*3-1/4"	2-7/8"	23.9	116	2	.025"	.020"
K241A	3-1/4"	2-7/8"	23.9	116	*	.025"	.020"
K301	3-3/8"	3-1/4"	29.07	116	2	.025"	.020"
K301A	3-3/8"	3-1/4"	29.07	116	*	.025"	.020"
K321	3-1/2"	3-1/4"	31.27	119	2	.025"	.020"
K321A	3-1/2"	3-1/4"	31.27	119	*	.025"	.020"

**Capacity varies from 1 to 1-3/4 quarts.*

SERVICE SCHEDULE

SERVICE FUNCTION	PERFORM SERVICE AT INTERVAL INDICATED (X)				
	EACH DAY	EVERY 25 HOURS	EVERY 50 HOURS	EVERY 100 HOURS	EVERY 500 HOURS
LUBRICATION SYSTEM					
OIL LEVEL - Check and add oil as needed.	X				
OIL CHANGE - Thoroughly drain, refill with oil of proper grade and weight.		X			
AIR INTAKE SYSTEM					
DRY TYPE AIR CLEANER - Clean element. (Replace element every 200 hours under normal operating conditions.)			X		
OIL BATH AIR CLEANER - Drain oil, clean bowl, wash element, add new oil to level mark.		X			
FUEL SYSTEM					
FUEL SEDIMENT BOWL - Remove and clean bowl. If filter element used, swish in clean fuel. Reinstall and check for and correct leakage.				X	
IGNITION SYSTEM					
SPARK PLUG - Remove plug, clean and re-gap. (Use new plug if needed.) Reinstall plug and tighten to 324 in. lbs. torque.				X	
BREAKER POINTS - Remove cover, check condition of point contacts, service (or replace) as necessary.				X	
IGNITION TIMING - Check and retime as necessary. Set breaker point gap to .020" fully open or use timing light method.					X
ELECTRICAL (CHARGING - STARTING) SYSTEMS					
MOTOR - GENERATOR - Check and correct belt tension if needed. Check brushes and commutator - service as required.			X		
VOLTAGE REGULATOR - Remove cover, check condition and contact point gap. Service as required.					X
MAGNETO - ALTERNATOR - Regular service not required - check condition of leads, tighten loose terminals or connections.					X
STARTING MOTOR - Remove end cap, check condition of brushes and commutator, service or replace if needed.					X
ENGINE - GENERAL					
EXTERNAL SURFACES - Clean air intake screen, cooling fins and block especially in oil fill area.	X				
VALVE CLEARANCE - Remove cover, check clearance between valve stems and tappets (See Valve Clearance Adjustment), adjust as needed.					X
CRANKCASE BREATHER - Remove components, check reed valve and gaskets, clean filter. Reinstall in proper sequence.					X
CYLINDER HEAD - Remove head, scrape out carbon deposits with piece of wood. Install new gasket, reinstall head and tighten bolts in proper sequence and to specified torque value.					X

Note: See appropriate Service Section for specific details on performing the various service functions.

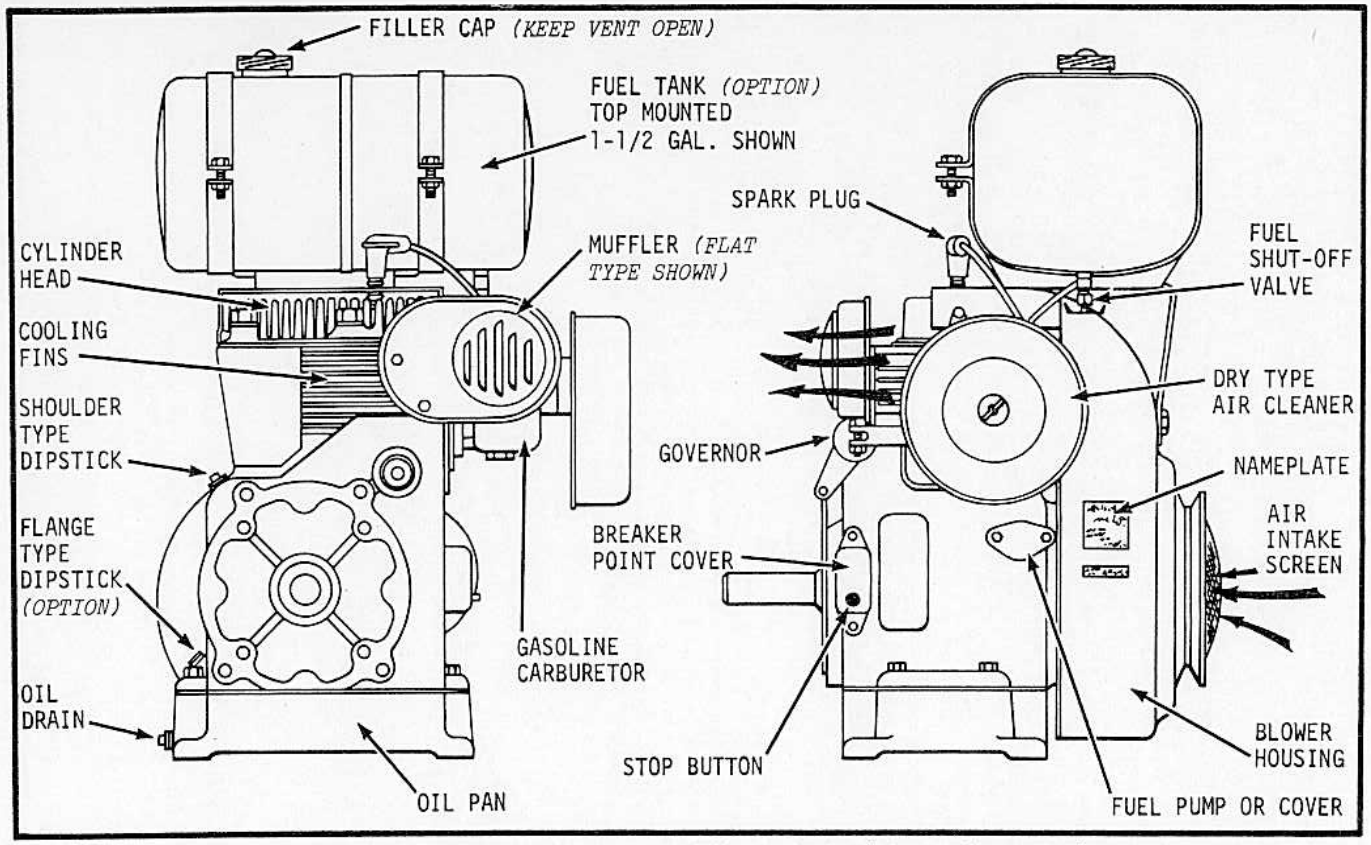


FIGURE 1-4 -- TYPICAL SINGLE CYLINDER ENGINE (ROPE START SHOWN)

TROUBLE SHOOTING

If trouble occurs, don't overlook causes that seem too obvious to be considered such as an empty fuel tank--check for the simplest causes first. To operate, an engine must have fuel, a good ignition spark and, of course, good compression--keep this in mind when trying to pinpoint the cause of a problem. The following is offered as a guide for correcting some of the problems that are possible with a 4 stroke cycle engine.

TROUBLE SHOOTING GUIDE

HARD STARTING OR LOSS OF POWER

a. Faulty ignition.
   1. Leads grounded or loose.
   2. Breaker points faulty or improperly gapped.
   3. Spark plug faulty or improperly gapped.
   4. Coil or condenser defective.
b. Faulty carburetion.
   1. Fuel line clogged (dirt-gum)
   2. Fuel pump faulty.
   3. Carburetor dirty or improperly adjusted.
c. Poor compression.
   1. Head loose or gasket leaking.
   2. Valves sticking or leaking.
   3. Piston rings worn.

OPERATING ERRATICALLY

a. Clogged fuel line.
b. Water in fuel.
c. Vent in gas cap plugged.
d. Faulty fuel pump.
e. Gasket leaking (carb.-manifold)
f. Governor improperly set.
g. Carburetor improperly adjusted.

KNOCKING

a. Fuel octane too low.
b. Ignition timing wrong
c. Carbon build-up in combustion chamber.
d. Engine overheated.

OCCASIONAL "SKIP" AT HIGH SPEED

a. Spark plug fouled, faulty or gap too wide.
b. Ignition timing wrong
c. Carburetor improperly adjusted.

OVERHEATING

a. Air intake screen or fins clogged.
b. Oil level too high (or low).
c. Fuel mixture too lean
d. Ignition timing wrong
e. Engine overloaded.
f. Tappet clearance too close.

IDLES POORLY

a. Idle Speed too low.
b. Idle Fuel improperly adjusted.
c. Gasket leaking (carb.-manifold)
d. Spark plug gap too close.

BACKFIRING

a. Carburetor set too lean (Main Fuel).
b. Breaker points improperly gapped (timing).
c. Valve sticking.

LUBRICATION

OIL LEVEL: With the splash system, the oil level must be maintained on the "Safe" operating range at all times--this is between the F (full) and L (low) mark on the dipstick. Check the level daily and add oil as needed. DO NOT OVERFILL--oil level must not exceed F mark.

On engines with the threaded type plug-dipstick, turn the plug all the way out of crankcase, wipe oil off dipstick then re-insert--do not turn plug in to check oil--shoulder plug on top of hole then remove to observe level. After checking oil, turn plug all the way into crankcase. With the oil fill tube and dipstick arrangement, push dipstick all the way down on tube then take reading. Engine must be level for accurate reading.

OIL TYPE: Oils meeting the requirements of the American Petroleum Institute's (API) Service classification SC are suitable for use in Kohler Air-Cooled Engines. Service SC oils are detergent type oils. Oil viscosity (weight) is selected according to the anticipated ambient temperatures. The temperature-viscosity recommendations are:

AIR TEMPERATURE	OIL VISCOSITY	OIL TYPE
Above 30° F. 30° to 0° F. Below 0° F.	SAE 30 SAE 10W-30 SAE 5W-20	API Service SC* API Service SC* API Service SC*
**SC standard recommendation--CC (MIL-2104B) and SD class oils may also be used.*		

OIL CHANGE: On new engines, the oil should be changed after the first five hours of operation--thereafter each 25 hours of operation under normal conditions. If extremely dusty or dirty conditions prevail, change oil more frequently. If possible, run engine just prior to changing oil--the oil will flow more freely and carry away a greater amount of contamination when it is hot.

OIL REFILL QUANTITIES (U. S. STD. QUARTS)

K91	K141	K161	K181	K241	K241A*	K301	K301A*	K321	K321A*
.5	1	1	1	2	1	2	1	2	1
**A type oil pan capacity varies from 1 to 1-3/4 quarts--on these, add 1 quart of oil, check level then add oil as necessary to bring up to full level.*									

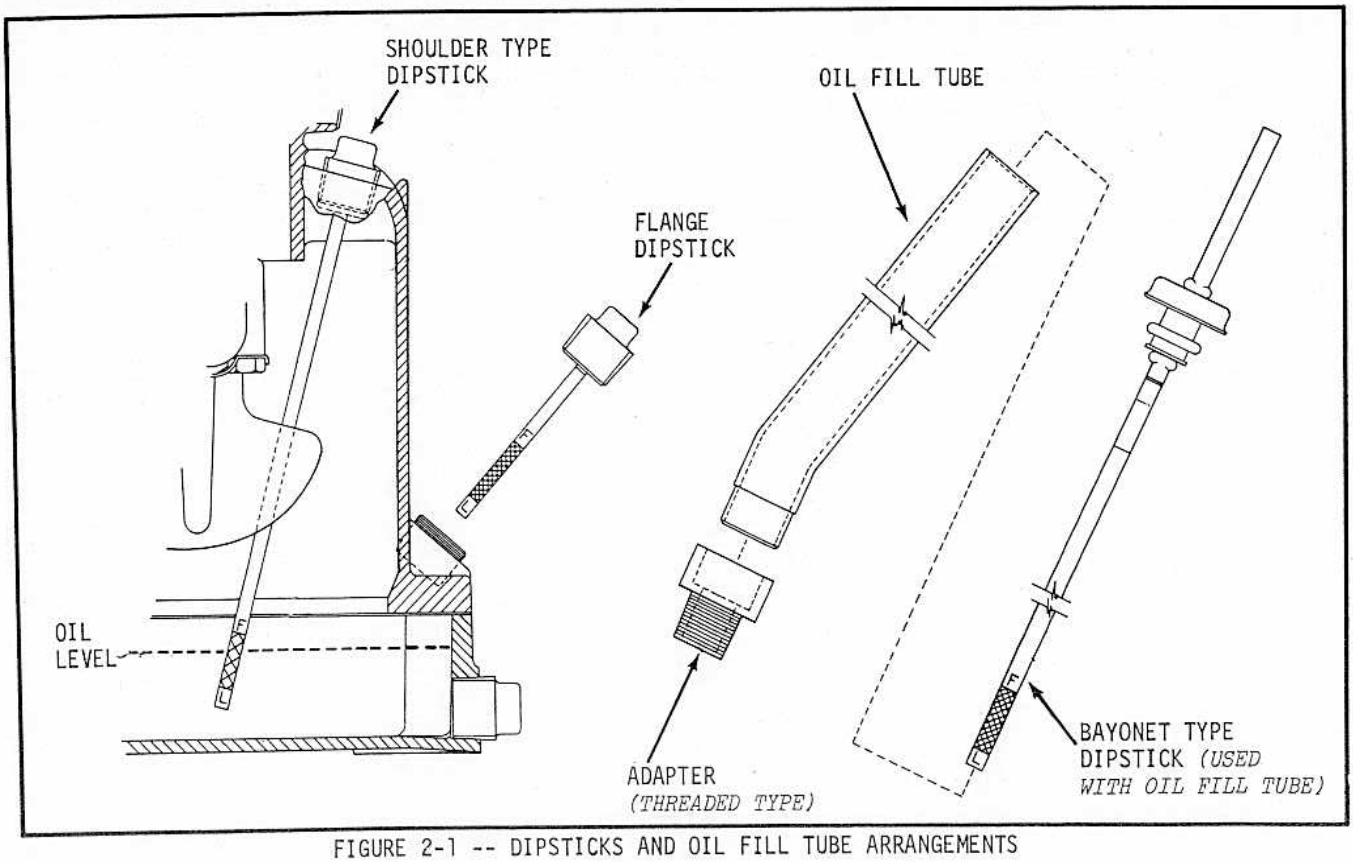


FIGURE 2-1 -- DIPSTICKS AND OIL FILL TUBE ARRANGEMENTS

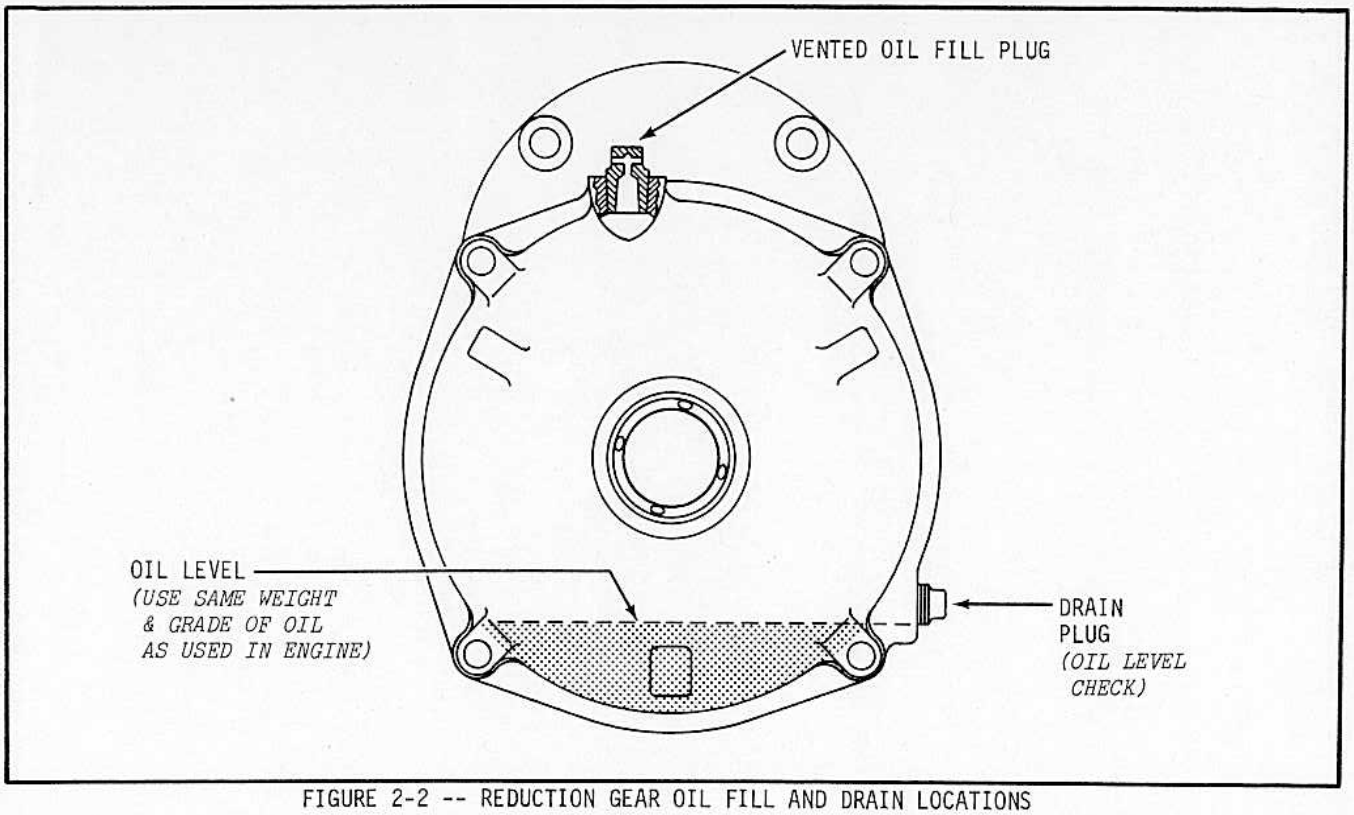


FIGURE 2-2 -- REDUCTION GEAR OIL FILL AND DRAIN LOCATIONS

Run-In Oil: A special "break-in" oil is used in the factory on new Kohler Engines. Each new engine is test run on this oil for a specific period of time to allow proper seating of the rings. After factory "run-in", the break-in oil is drained. Further use of break-in or non-detergent type oil is not required or recommended for new Kohler Engines. Use detergent type API Service SC.

On overhauled engines or on those having new blocks, the use of non-detergent oil is recommended only during the first 5 hours of operation. This helps seat piston rings, however, use should be discontinued after the run-in period. Use API Service SC (detergent type) oil after the initial run-in period.

LUBRICATION - REDUCTION GEAR UNITS: On engines equipped with reduction gear units, remove the oil plug on lower part of cover about every 50 hours to check oil level. Oil level should be up to the bottom of the oil plug hole. Use the same weight and grade of oil as used in engine. To add oil, remove the vented plug at the top of the unit.

Oil change is not required at any specific intervals with these reduction gears--the units are sealed (except for vented filler plug) and oil does not, therefore, get contaminated. However, drain oil if unit has been out of service for considerable length of time then add new, fresh oil before restarting.

AIR INTAKE

Dirt induced through improperly installed, poorly serviced or inadequate air cleaner 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. Also, a clogged element causes a richer fuel mixture which may lead to formation of harmful sludge deposits. Always cover carburetor or air horn when air cleaner is removed.

DRY AIR CLEANERS

SERVICE - REPLACEMENT: Dry type elements should be replaced after 100 to 200 hours if engine is operated under good clean air conditions--service and replace element more frequently under extremely dusty or dirty conditions. Dry elements should be cleaned after about each 50 hours of operation--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 filter element. When replacing element, use only genuine Kohler elements. Carefully handle new element--do not use if gasket surfaces bent or twisted. Check the following when installing new or serviced 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. Wing nut must be finger tight--don't overtighten.

PRECLEANERS: Precleaners are available for use with dry type air cleaners. The precleaner traps much of the dirt, preventing it from entering the dry element thereby extending its life. No modification is needed--the precleaner slips right over the dry element. Servicing of the precleaner is accomplished by washing it in soap and water then, after rinsing and squeezing out excess water, allowing it to air dry (whenever possible), then reinstall it over element. DO NOT oil this type precleaner.

OIL BATH AIR CLEANERS

OIL BATH AIR CLEANER: If operating under extremely dusty conditions, it may be advantageous to install an oil bath air cleaner in place of the standard dry type cleaner. This will eliminate the need for frequent replacement of the dry element. Normally converting to an oil bath type cleaner involves removal of the dry type cleaner and installation of an elbow and the oil bath unit in its place. The oil bath cleaner should be serviced after every 25 hours of operation; however, if extremely dusty or dirty conditions exist, service cleaner more frequently--even every 8 hours or twice daily if conditions warrant this. To service normal capacity type oil bath air cleaners, remove wing nut and remove air cleaner components as a unit. Use the following procedure for cleaning.

1. Remove cover, lift element out of bowl, drain dirty oil from bowl.

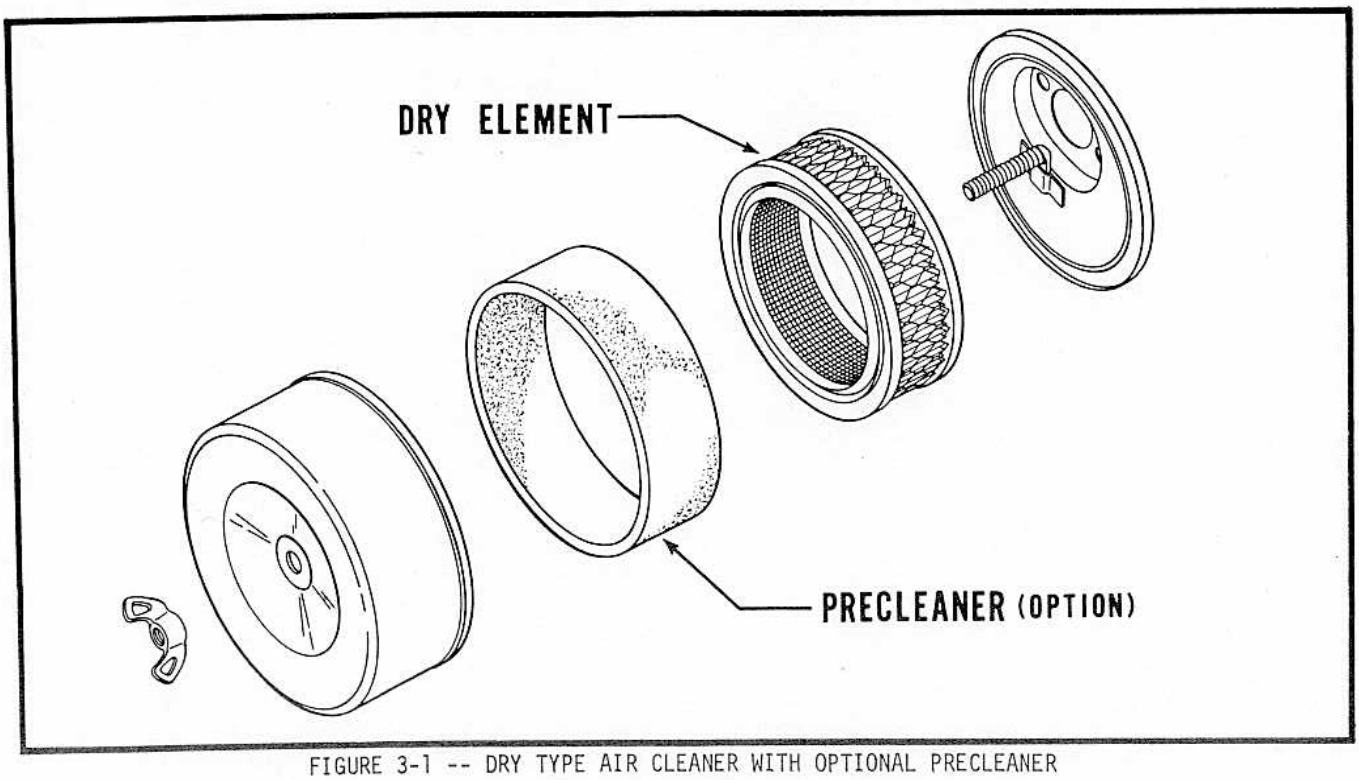


FIGURE 3-1 -- DRY TYPE AIR CLEANER WITH OPTIONAL PRECLEANER

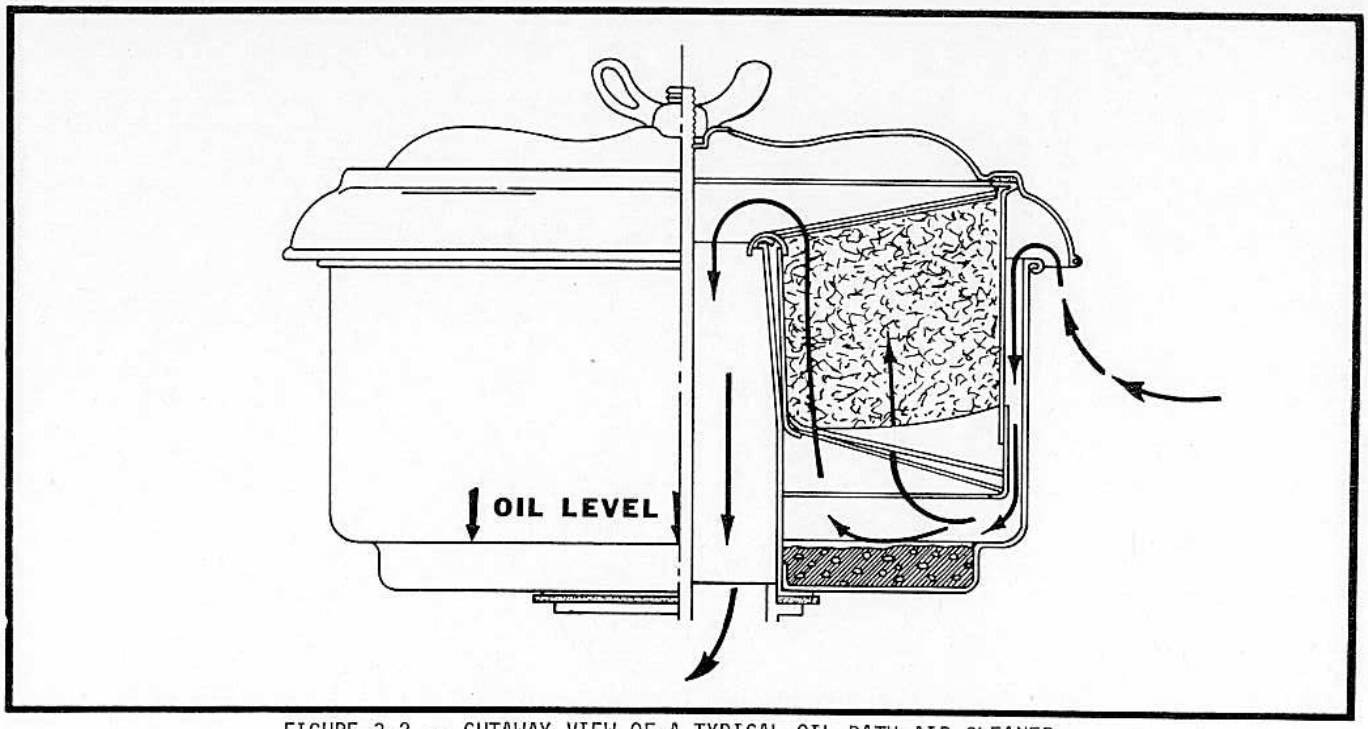


FIGURE 3-2 -- CUTAWAY VIEW OF A TYPICAL OIL BATH AIR CLEANER

2. Thoroughly wash cover and bowl in clean solvent. Swish element in solvent, allow element to drip dry. DO NOT dry with air hose as this can ruin filtering material in this type of cleaner. Lightly re-oil element after cleaning with same type of oil as used in engine.
3. Inspect air horn, filter bowl and cover gaskets. Replace gaskets if badly grooved or cracked.
4. Install gasket then place cleaned filter bowl on air horn. Add oil (same grade and weight as engine oil) to OIL LEVEL mark stamped on filter bowl.
5. Reinstall element in bowl, position cover, place copper washer (when used) then secure with wing nut--firmly tighten with fingers only.
6. Check to make sure cleaner is properly installed so that no unfiltered air can enter carburetor.

FUEL SYSTEMS

This section covers gasoline fuel systems--refer to Section 13 for information pertaining to gas or kerosene fuel systems. Always use a clean, fresh REGULAR grade of gasoline. Leaded or non-leaded type gasoline may be used provided the octane rating is 90 or higher. Use of the non-leaded type gasoline not only lowers emission of air pollutants but results in a considerable reduction of deposits in the combustion chamber. Purchase brand name fuels from popular service stations to eliminate chances of using stale gasoline as this results in formation of gum deposits which can quickly clog carburetor passages. If the engine is to be stored during an off season, drain the fuel system, run the tank dry or add a gasoline stabilizer to the tank. CAUTION: Some stabilizers are not suitable for use in non-metallic tanks--check this before using.

Engines using a gravity feed fuel system such as top mounted fuel tank may not have a fuel pump. Always use a vented fuel tank filler cap and keep the vent open to prevent stoppage or starvation of fuel.

CARBURETOR

Carburetors are adjusted in the factory and should not have to be reset. If, however, one of the following conditions is noted, readjust carburetor immediately as continued operation with incorrect setting can lead to fouled spark plugs, overheating, excessive valve wear or other problems. If black exhaust smoke is noted, check the air cleaner first--an "overrich" mixture is usually caused by a poorly serviced, clogged air cleaner element, not an improperly adjusted carburetor.

If readjustment becomes necessary, stop the engine, then turn the MAIN and IDLE fuel adjusting screws all the way in until they bottom lightly--don't force them closed as this will damage the needle valves. For preliminary setting, turn MAIN fuel screw out (counterclockwise) 2 full turns and the IDLE 1-1/4 turns. For final adjustments, start engine and allow it to warm up then operate at full throttle and under load, if possible. Turn MAIN fuel in until engine slows down (lean side) then out until it slows down again from overrich setting--note positions of screw at both settings, then set it about halfway between the two. The IDLE fuel setting can then be adjusted in the same manner for smoothest idle. Rough idle is often due to the idle speed being set too low--check this also.

IDLE SPEED: Idle no-load speed on most engines is set at 1200 RPM; however, with parasitic loads such as presented by hydrastatic drives, the idle speed may have to be increased as much as 1700 RPM for best no-load idle.

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

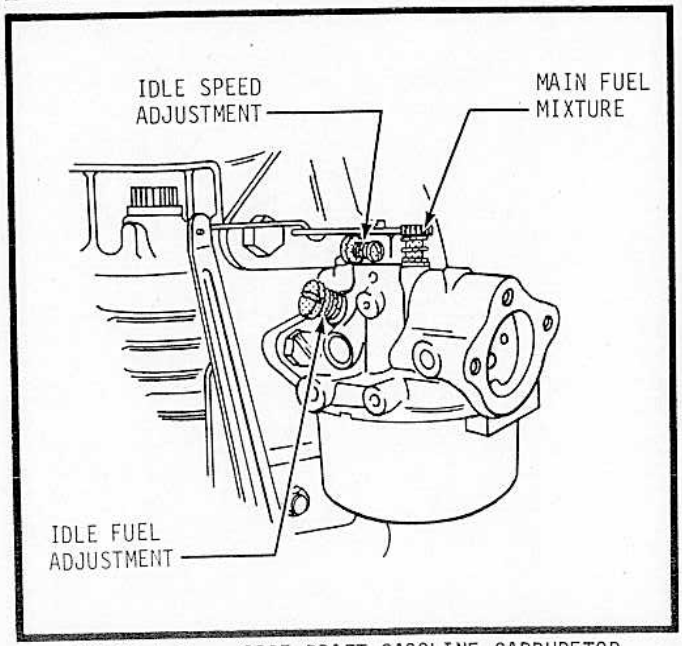


FIGURE 4-1 -- SIDE DRAFT GASOLINE CARBURETOR

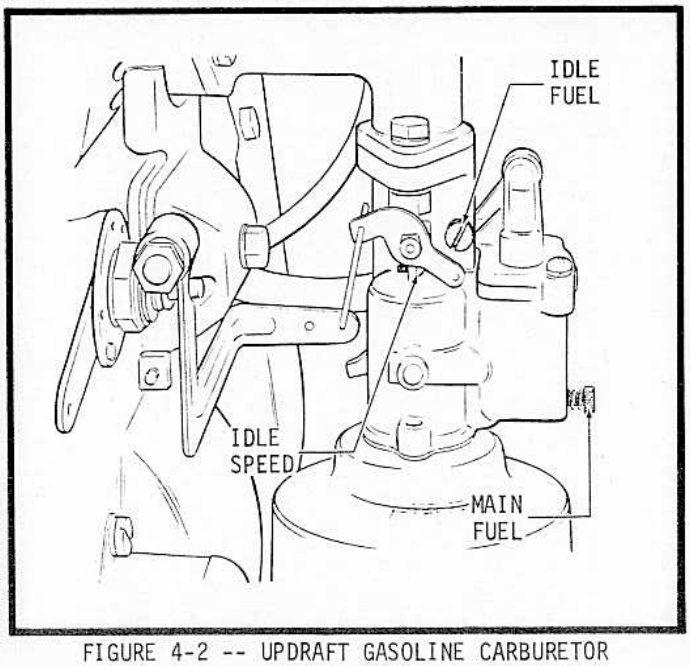


FIGURE 4-2 -- UPDRAFT GASOLINE CARBURETOR

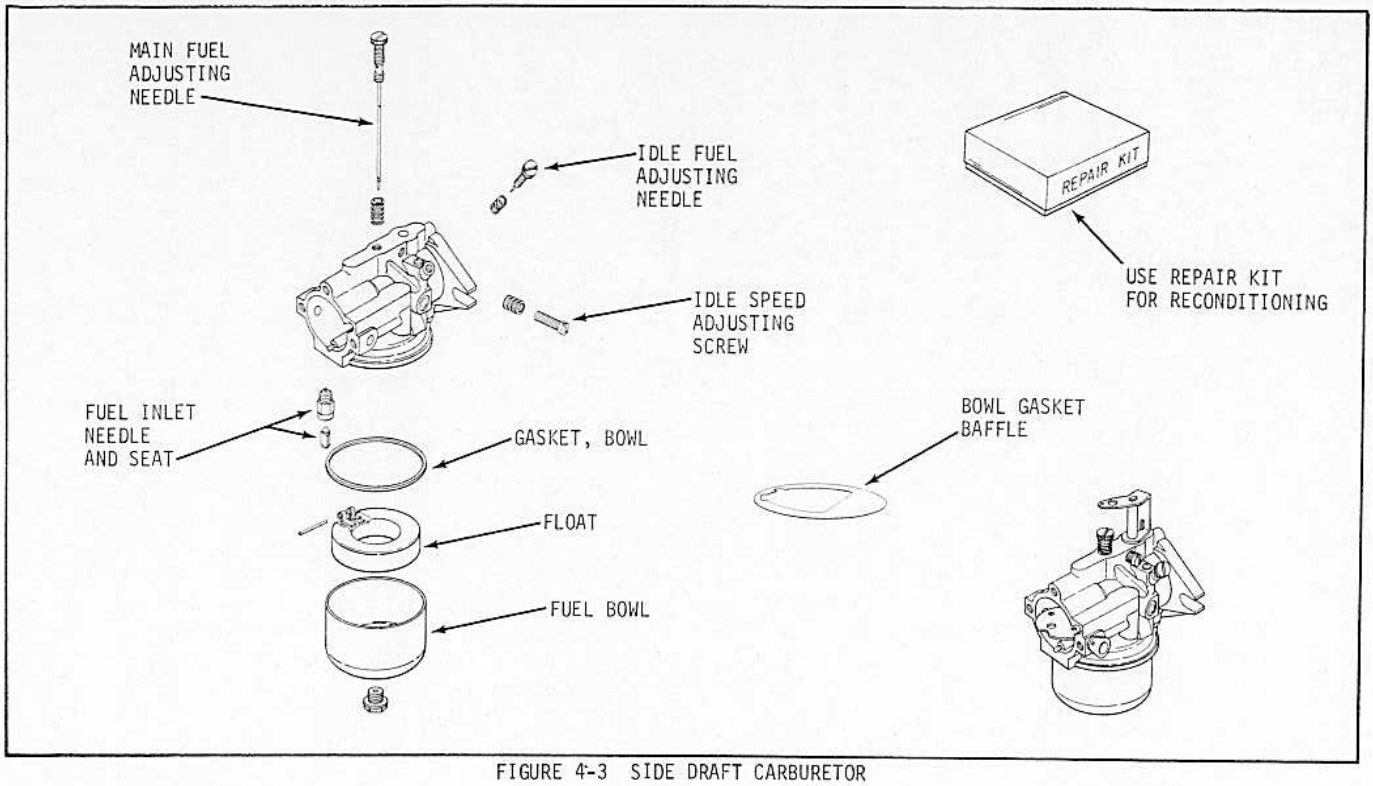


FIGURE 4-3 SIDE DRAFT CARBURETOR

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 all deposits are removed from bore, especially where throttle plate seats in casting. Blow out all passages with compressed air. Replace all worn and damaged parts. Always use new gaskets. Carburetor repair kits are available for most carburetors. They include the bowl nut gasket (if required), bowl ring gasket, float pin, bowl baffle gasket and fuel inlet needle and seat.

Disassembly of Carburetor - Side Draft

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

Assembly of Carburetor - Side Draft

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 1-1/4 turns after seating lightly against jet. CAUTION: DO NOT USE FORCE ON ADJUSTMENT NEEDLES.

Disassembly of Carburetor - Up Draft

1. Remove carburetor from engine.
2. Remove bowl cover and gasket.
3. Remove float pin, float, needle and needle seat. Check float pin for wear.
4. Remove idle fuel adjustment needle, main fuel adjustment needle and springs. Do not remove choke plate and shaft unless replacement of these parts is necessary.

Assembly of Carburetor - Up Draft

1. Install throttle shaft and plate. Elongated side of valve must be toward top.
2. Install needle seat. A 5/16" socket should be used. CAUTION: DO NOT OVERTIGHTEN. TORQUE TO 25 TO 30 IN. LBS.
3. Install needle, float and float pin.
4. Set float level. With bowl cover casting inverted and float resting lightly against needle in its seat, there should be 7/16" plus or minus 1/32" clearance between machined surface casting and free end of float (side opposite needle seat).
5. Adjust by bending lip of float with small screwdriver.
6. Install new carburetor bowl gasket, bowl cover and bowl cover screws. Tighten securely.
7. Install main fuel adjustment needle. Turn in until screw seats in nozzle and back out 2 turns.
8. Install idle fuel adjustment needle. Back out approximately 1-1/2 turns after seating lightly against jet.
9. Install idle speed screw and spring. Adjust desired idling speed with engine running (see carburetor adjustment procedure).

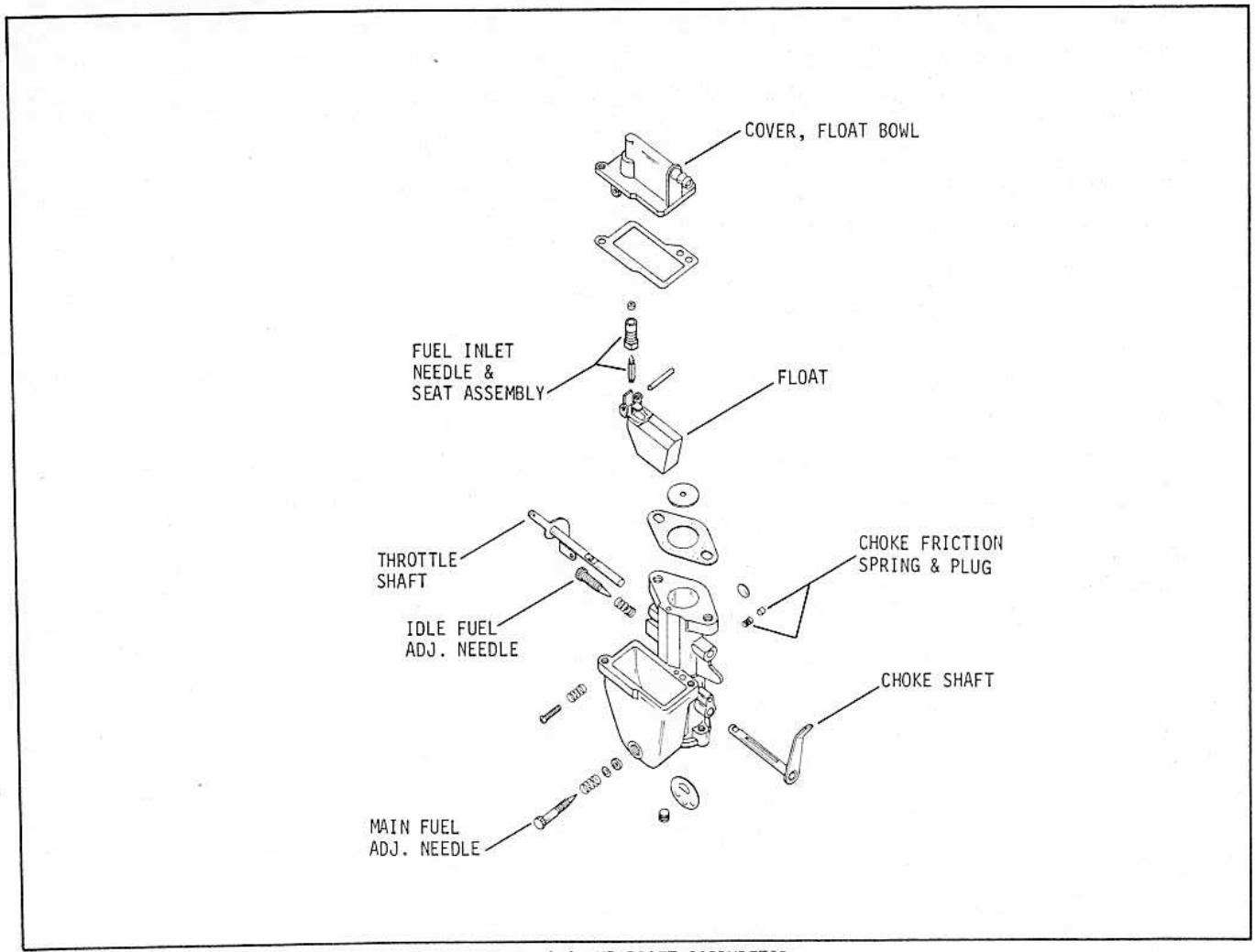


FIGURE 4-4 UP DRAFT CARBURETOR

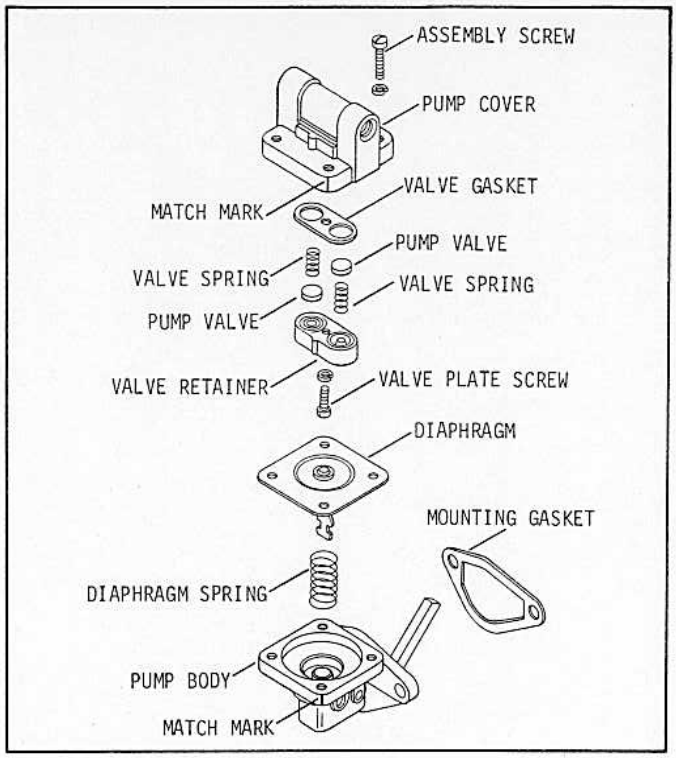


FIGURE 4-5 FUEL PUMP (MECHANICAL TYPE)

FUEL PUMP

All Kohler Single Cylinder Engines, except the model K91, have a mounting pad and provision on crankcase for either a mechanical or vacuum operated fuel pump. On some applications with gravity feed systems, the pad is covered and the fuel pump is not used.

The mechanical pump operates off a cam on the camshaft. The fuel pump lever rides on the cam and transmits this mechanical action to a diaphragm within the pump body. Some mechanical pumps have an external lever for priming. The vacuum pump is almost identical to the mechanical pump except that it does not have the pump lever. A diaphragm in the vacuum pump operates off the pulsating negative pressures within the crankcase. On K91 engines requiring a fuel pump, an adapter is placed between the carburetor and engine block. The vacuum pump is turned into the threaded fuel inlet on the carburetor and a rubber hose connects the pump to the adapter. This type vacuum pump is nonserviceable and must be replaced if faulty.

Repair kits are available for reconditioning most other fuel pumps. The procedure is essentially the same for both the mechanical and the vacuum type fuel pumps. Differences are pointed out wherever applicable in the following reconditioning procedure.

Reconditioning Procedure:

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

FUEL FILTER

A sediment bowl filter may be used to trap solid impurities in the fuel. Before servicing, turn fuel off at valve located on top of filter assembly, then loosen retaining bail at bottom of fuel bowl, remove and clean bowl. After reinstalling and opening fuel valve, use primer (if so equipped) on fuel pump to pump fuel back into bowl. Not all pumps have priming levers - on those without lever, rotate engine by hand to pump fuel back into sediment bowl.

GOVERNOR SYSTEMS

All Kohler Single Cylinder Engines are equipped with centrifugal flyweight (or flyball on K91) mechanical type governors. The governor gear--flyweight mechanism is mounted within the crankcase and driven off a gear on the camshaft.

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

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

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

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

While the internal mechanism is basically the same on all engines, the external arrangement is different on the Model K241, K301 and K321. Be sure to follow adjustment procedure for the model and for the type of governor setting used.

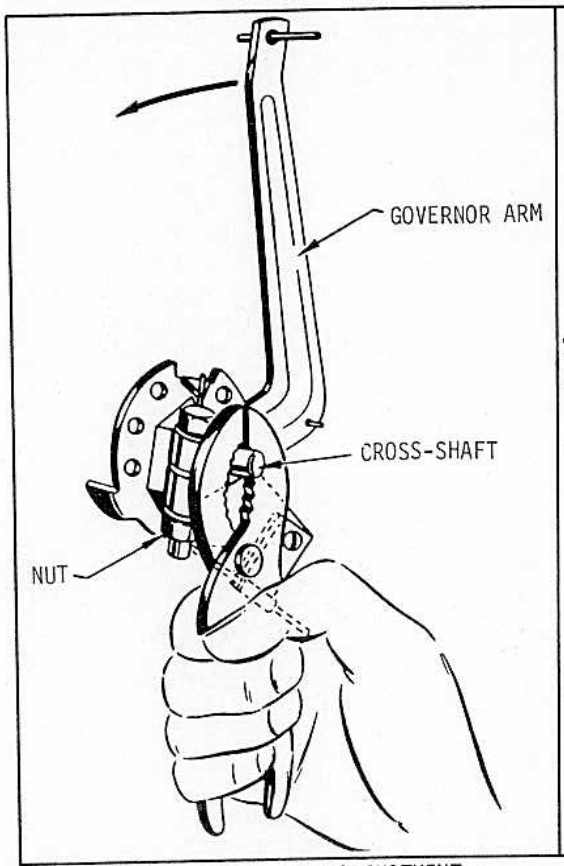


FIGURE 5-1 -- INITIAL ADJUSTMENT
K91, K141, K161, K181

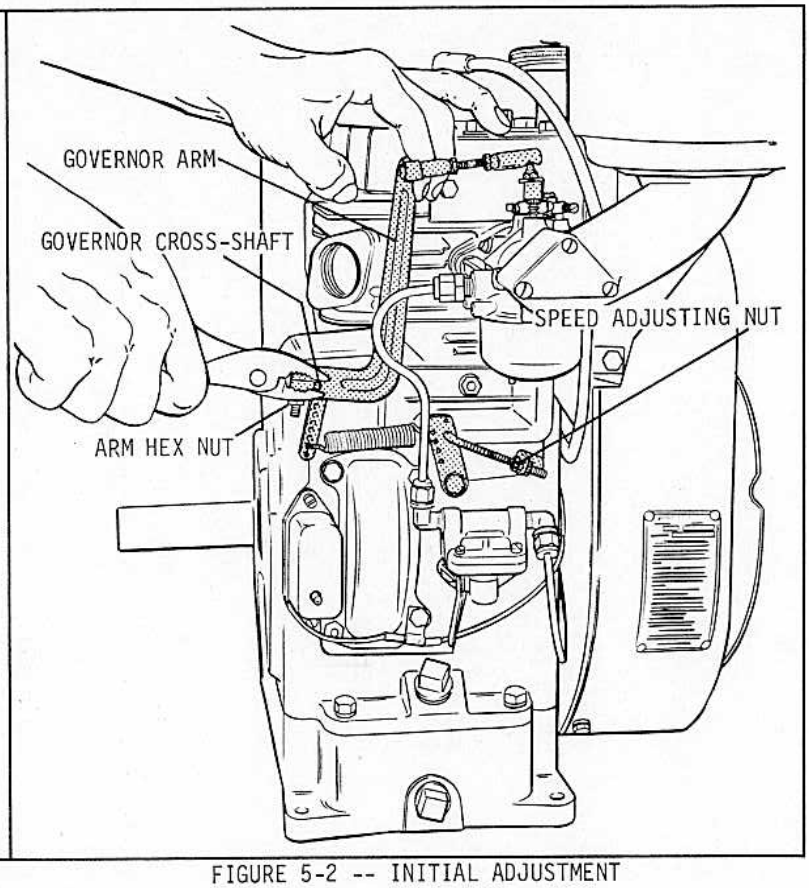


FIGURE 5-2 -- INITIAL ADJUSTMENT
K241, K301, K321

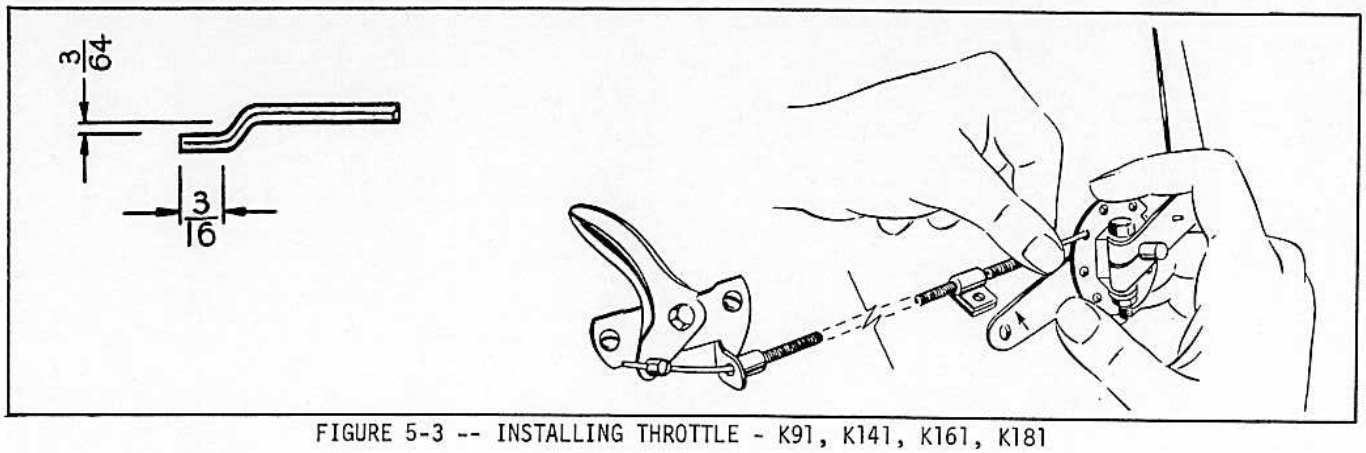


FIGURE 5-3 -- INSTALLING THROTTLE - K91, K141, K161, K181

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

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

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

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

THROTTLE WIRE INSTALLATION -- K91, K141, K161, K181

Use the following installation procedure for initial hook-up of throttle control or if wire has to be disconnected.

a. Bend end of throttle wire as shown in Figure 5-3.

b. With control handle in an open position, insert throttle wire into speed control disc hole nearest throttle bracket.

c. Install cable clamp and bolt to throttle bracket.

d. Remove drive pin from speed control disc and operate control handle, rotating disc from idle to full speed. See speed, sensitivity adjustments.

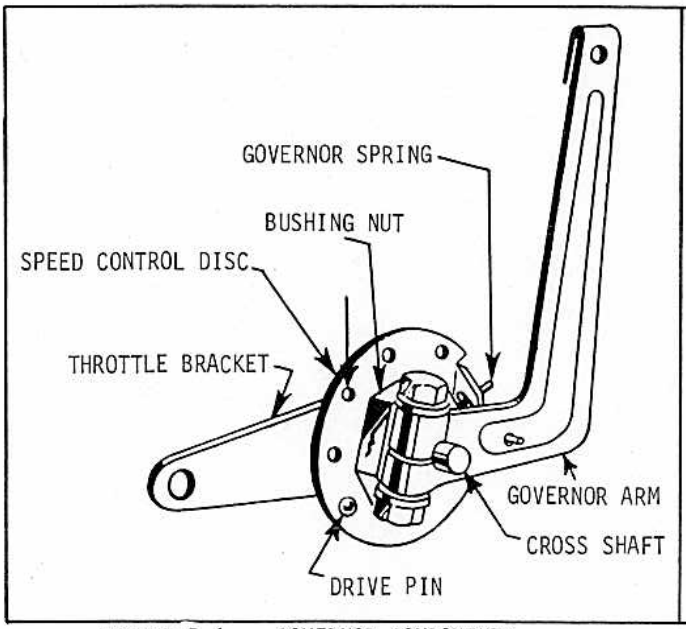


FIGURE 5-4 -- GOVERNOR COMPONENTS
K91, K141, K161, K181

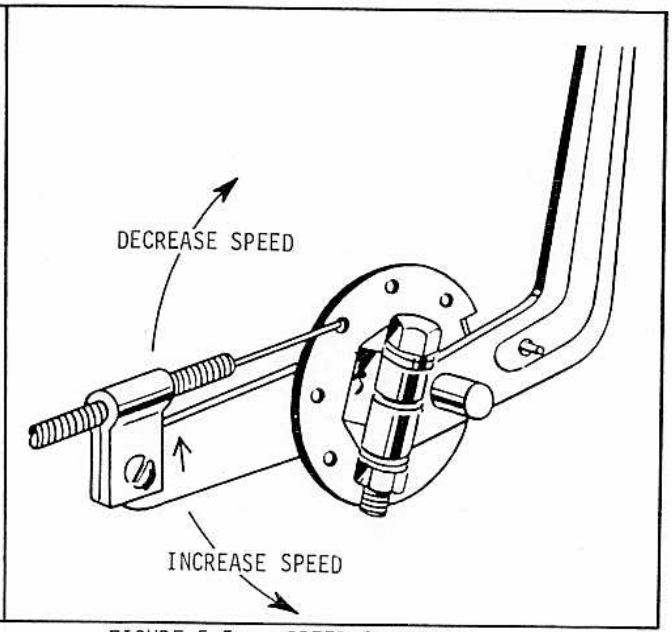


FIGURE 5-5 -- SPEED ADJUSTMENT
K91, K141, K161, K181

SPEED ADJUSTMENT -- K91, K141, K161, K181

After making initial adjustment and connecting throttle wire on variable speed applications, start engine and check maximum operating speed with hand tachometer. If adjustment is necessary to bring speed within correct operating range, use the following procedure for both Constant and Variable Speed settings (see Figure 5-5).

STEP 1: Loosen bushing nut slightly.

STEP 2: Move throttle bracket in counterclockwise direction to increase engine speed or move throttle bracket in clockwise direction to decrease engine speed. Caution: Do not allow engine to operate at speeds above maximum. Maximum permissible speed for K91 is 4000 RPM, while 3600 RPM is maximum for most K141, K161, K181 models--a slightly higher speed may be allowed in certain applications--check this before exceeding 3600 RPM.

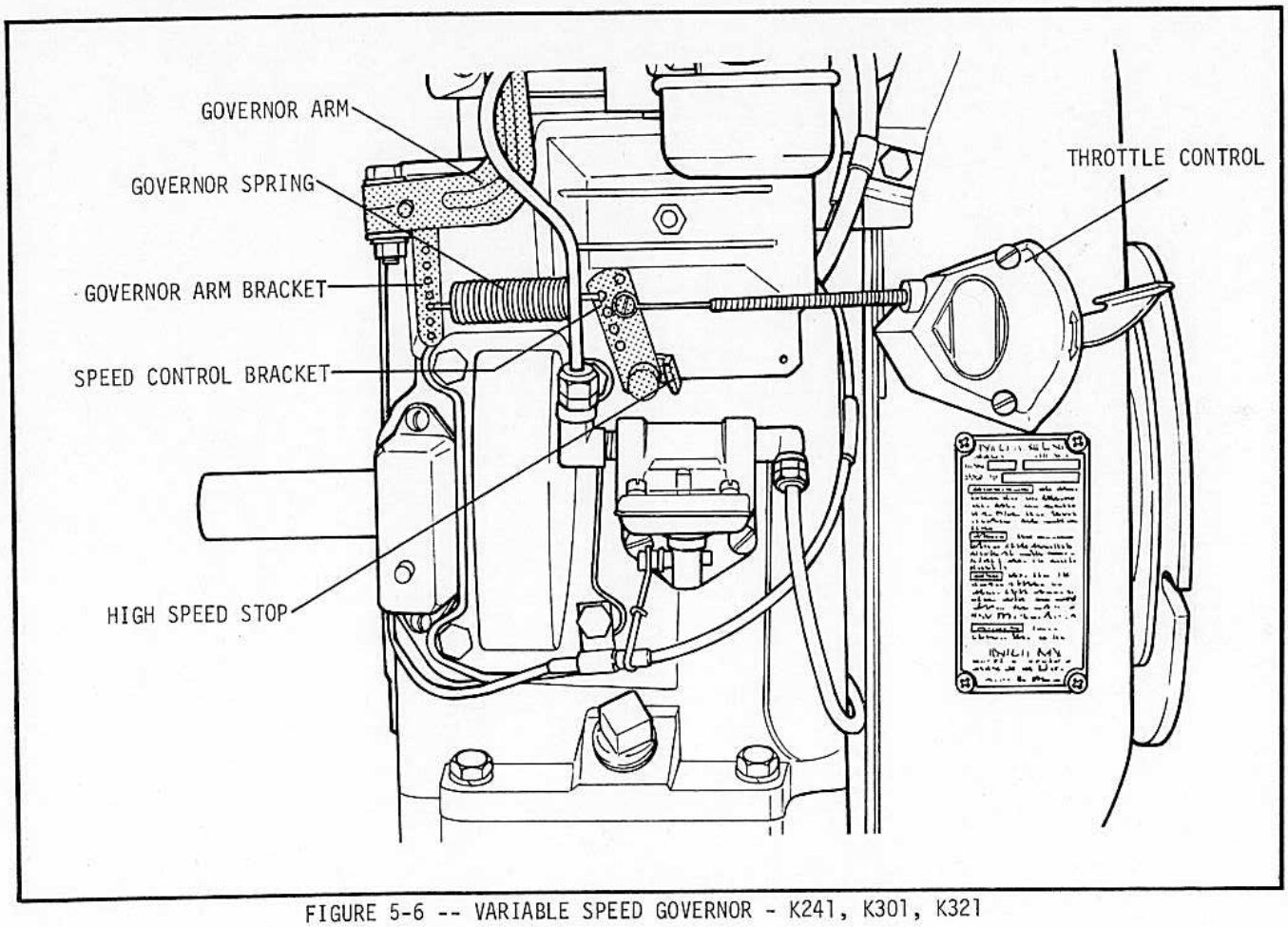


FIGURE 5-6 -- VARIABLE SPEED GOVERNOR - K241, K301, K321

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

THROTTLE WIRE INSTALLATION -- K241, K301, K321

Use the following procedure for initial hookup of throttle control or if wire has been disconnected.

STEP 1: Mount throttle control on blower housing as shown in Figure 5-6.

STEP 2: Move control handle to OPEN or F position then insert wire into hole in handle (inside cover).

SPEED ADJUSTMENT -- K241, K301, K321

After making initial adjustment and hooking up throttle wire on variable speed applications, start engine and check operating speed with hand tachometer. Maximum allowable speed for most K241, K301 and K321 models is 3600 RPM. Do not exceed this speed. If adjustment is necessary use procedure for type of governor used.

Constant Speed: To increase engine speed, tighten governor adjusting screw until correct speed is attained. To decrease speed, loosen adjusting screw.

Variable Speed: Loosen capscrew and move high speed stop bracket until correct speed is attained then retighten capscrew. (See Figure 5-6)

SENSITIVITY ADJUSTMENT -- K241, K301, K321

On the K241, K301 and K321, governor sensitivity can be adjusted by repositioning the governor spring in the holes on the governor arm and speed control brackets. If set too sensitive, speed surging will occur with change of load. If a big drop in speed occurs when normal load is applied, the governor should be set for greater sensitivity.

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

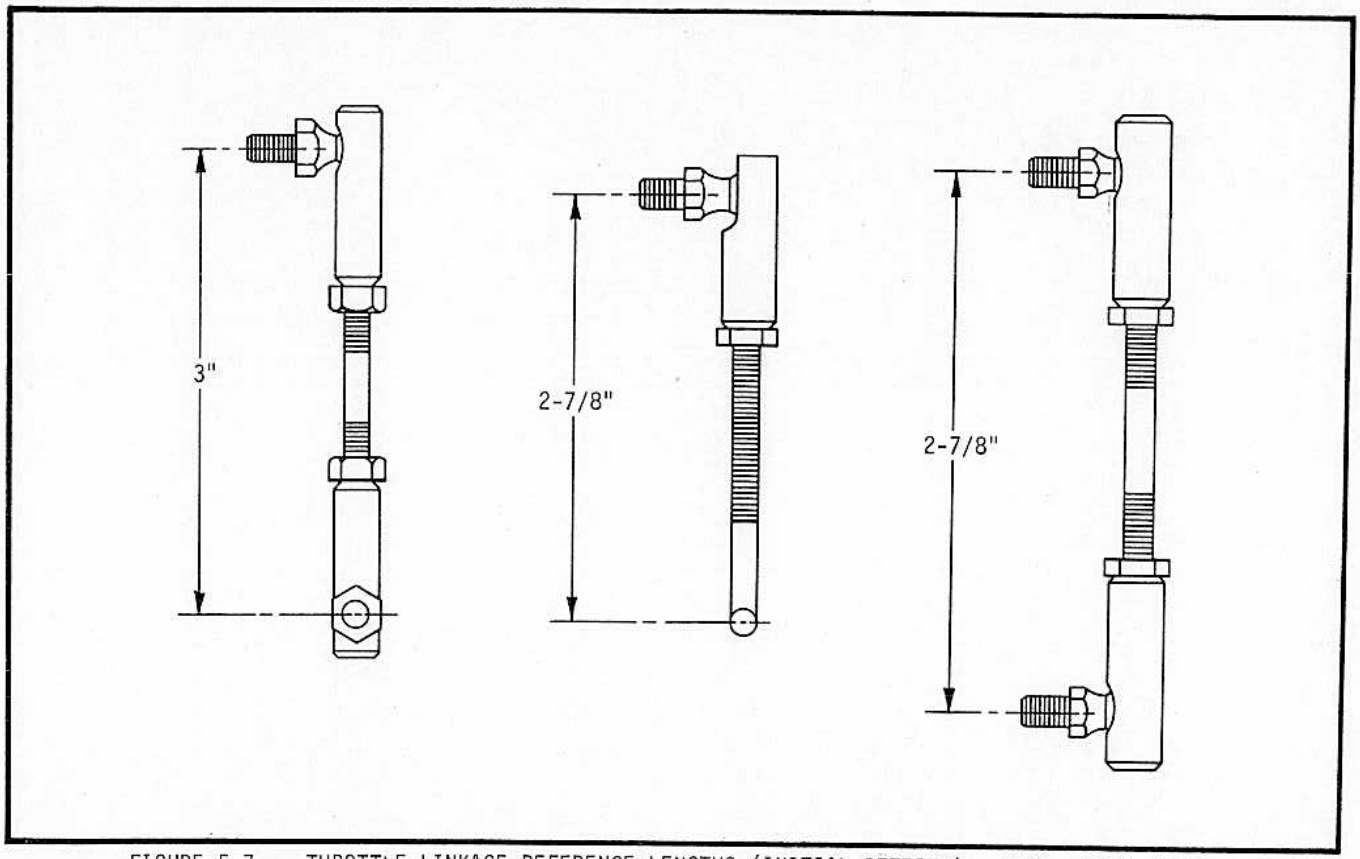


FIGURE 5-7 -- THROTTLE LINKAGE REFERENCE LENGTHS (INITIAL SETTING) - K241, K301, K321

IGNITION SYSTEMS

Three basic types of ignition systems are used on the single cylinder engines--these are: the flywheel magneto types, the battery ignition types and the breakerless ignition types. As can be seen in the chart below, there are several different versions within each basic group--identification of the various systems may be made through the components shown in the accompanying illustration. Most parts are not interchangeable with parts from another system--make sure replacement parts are correct for the particular system involved.

IGNITION TYPES

Magneto Ignition Systems

1. Magneto rotor type--ignition only.
2. Magneto flywheel (magnet ring) type--ignition only.
3. Magneto flywheel type with 3 amp lighting coils.
4. Magneto flywheel type with 10 amp alternator.

Battery Ignition Systems

1. Battery ignition with motor-generator.
2. Battery ignition with 10 amp alternator.
3. Battery ignition with 15 amp alternator.
4. Battery ignition with 30 amp alternator.

Breakerless Ignition Systems

1. Breakerless ignition with 10 amp alternator.
2. Breakerless ignition with 15 amp alternator.

While most of the components of the various systems differ in appearance, their function is generally the same. A brief description of the basic systems follows. Service recommendations of the individual components are given later in this section.

MAGNETO IGNITION SYSTEMS

On all magneto ignition systems, high strength permanent magnets provide the source energy for ignition. With rotor type systems, the magnet is pressed onto the crankshaft and is rotated inside the coil-core assembly on the bearing plate. On the other systems, a permanent magnet ring on the inside of the flywheel revolves around the stator (coil-core) assembly. Movement of the magnets past the stator magnetically induces current flow in the ignition coil windings and the alternator or lighting coils when furnished. The magnets are placed with alternate North and South poles so that the direction of magnetic flux changes direction which induces an alternating current in the coil windings--this effect is shown in the magneto cycle illustration. Current flow reaches maximum in the ignition coil at the instant the magnetic flux reverses direction--the ignition must be timed to occur when this energy is highest for the best spark. The ignition coil has a low tension primary winding and a high tension secondary winding. The secondary winding has up to 100 more turns than the primary and is of relatively thin wire to step up the voltage. Current flows in the primary only while the breaker points are

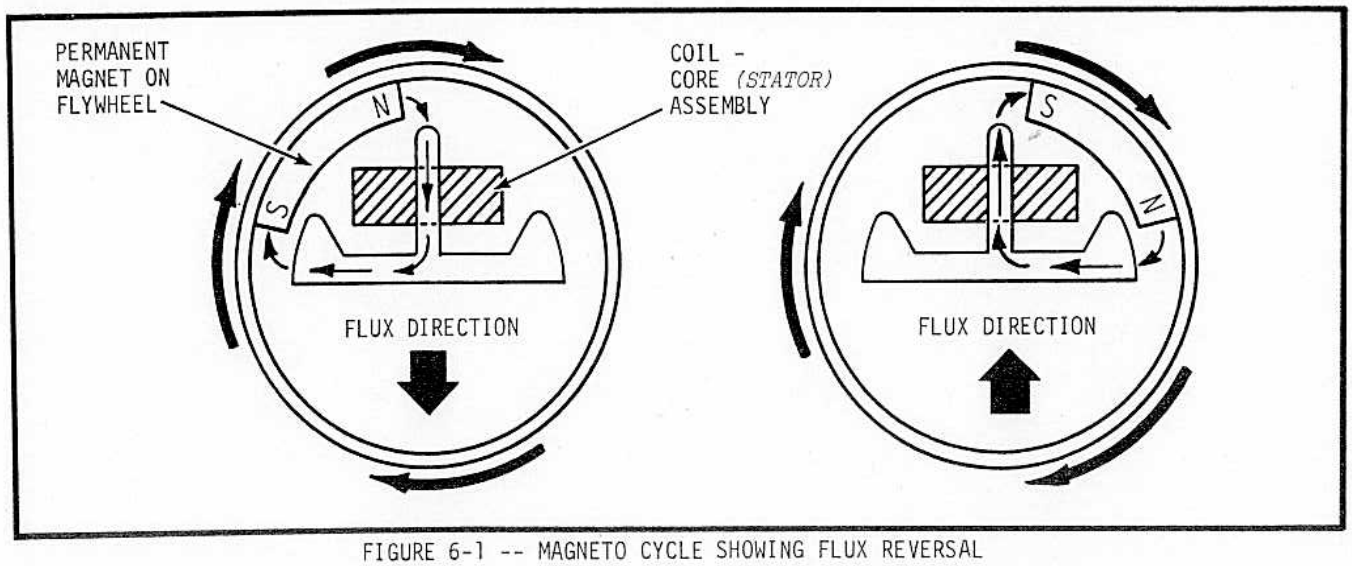


FIGURE 6-1 -- MAGNETO CYCLE SHOWING FLUX REVERSAL

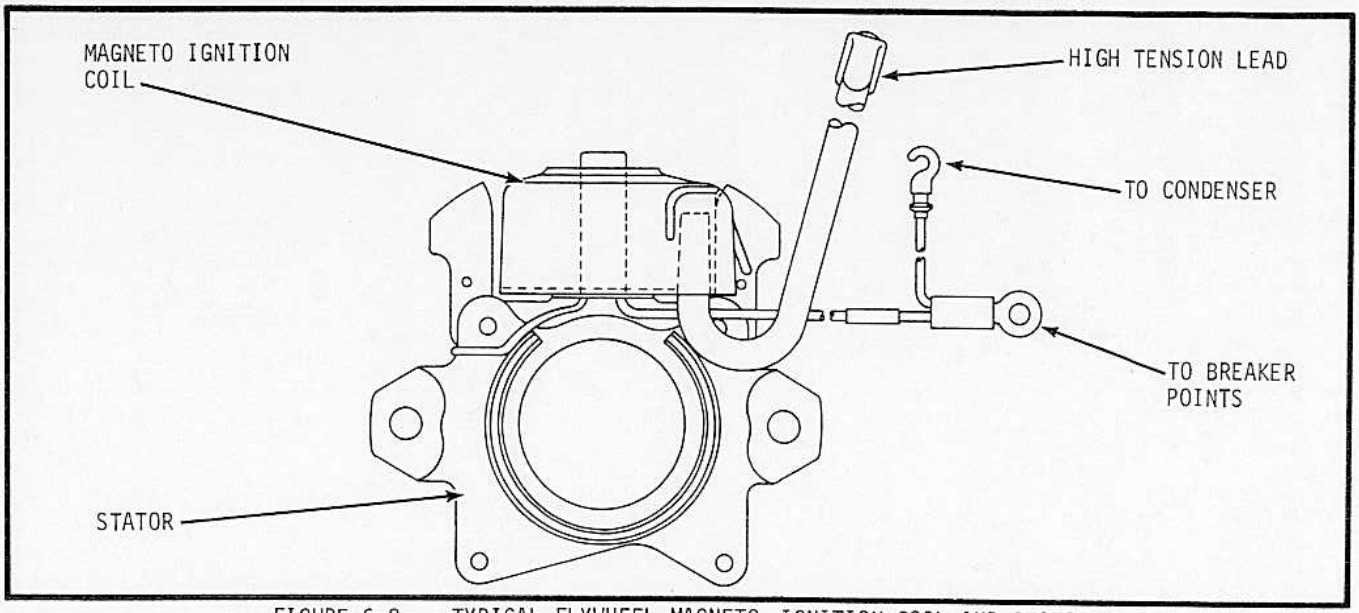


FIGURE 6-2 -- TYPICAL FLYWHEEL MAGNETO IGNITION COIL AND STATOR

closed. Current flowing in the primary creates, magnetically, a difference in electrical potential between it and the secondary winding. When ignition is required, the breaker points open to break the primary circuit--this results in a sudden collapse of the magnetic field which, in turn, induces sufficient energy in the secondary to bridge the spark gap and ignite the fuel-air mixture in the combustion chamber. The collapsing magnetic field also induces energy in the primary; however, this energy is quickly absorbed by the condenser which prevents the energy from arcing across the air gap between the breaker points. Energy in the primary can go as high as 250 volts while in the secondary this could reach 25, 000 volts (250 volts x 100 turns = 25, 000 volts); however, the secondary energy increases only to a high enough value to bridge the spark gap which is usually somewhere between 6, 000 to 20, 000 volts --the actual value is determined by such variables as engine speed, compression, spark gap and condition of the spark plug. Timing of the ignition spark is established by setting of the spark gap--if the gap is set wider this causes ignition to occur earlier while reducing the gap causes it to occur later.

BATTERY IGNITION SYSTEMS

The battery ignition systems function in the same way as the magneto ignition systems described in the foregoing, except that the energy source for the ignition coil is the battery. On these systems, battery charge is maintained by a belt driven motor-generator or by a 10, 15 or 30 amp flywheel-alternator. With the alternator systems, a permanent magnet ring on an inside rim of the flywheel revolves around the alternator stator on the bearing plate. This produces Alternating Current but is changed to Direct Current in the rectifier-regulator unit to charge the battery--these units are described in the next section since they provide a charging rather than ignition function.

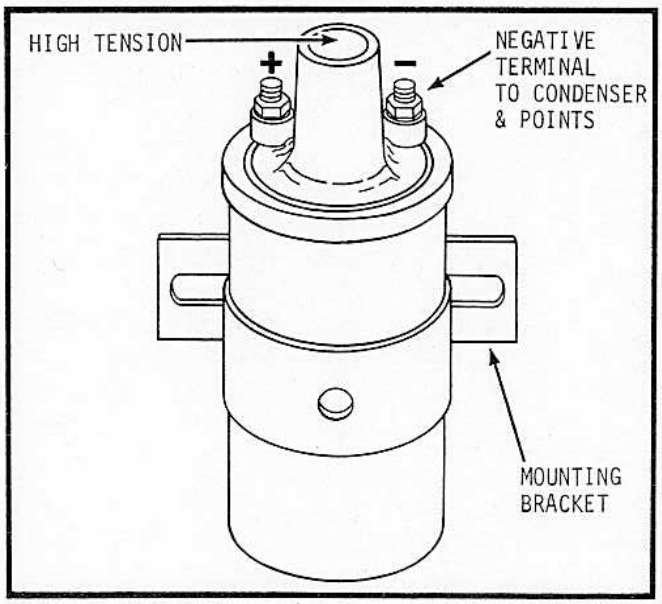


FIGURE 6-3 -- TYPICAL BATTERY IGNITION COIL

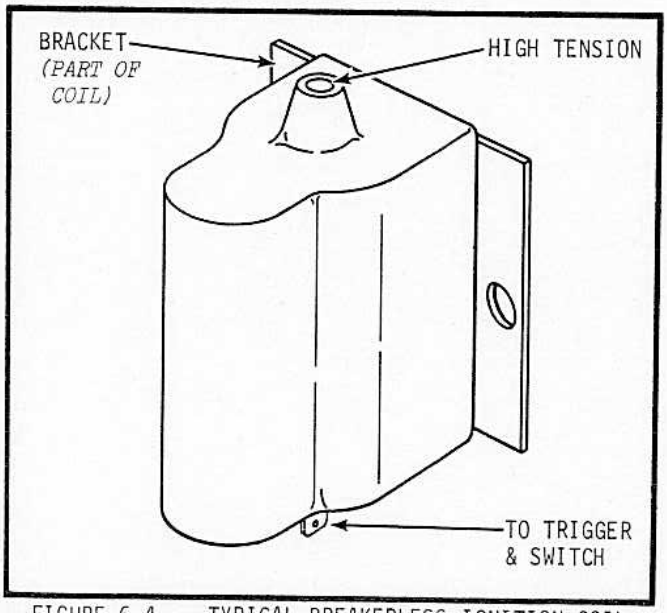


FIGURE 6-4 -- TYPICAL BREAKERLESS IGNITION COIL

BREAKERLESS IGNITION SYSTEMS

The breakerless systems function in the same general way as the previously discussed magneto ignition systems except that the breakerless systems do not have breaker points or a conventional condenser. A trigger module containing solid state electronic devices serves the same function as the breaker points. The breakerless ignition system includes four major components which are: ignition winding (on alternator stator), trigger module, ignition coil assembly and flywheel with a trigger projection. The system also includes a 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. The trigger module includes three diodes, a resistor, a sensing coil and magnet, plus an electronic switch called an SCR. 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. Operation is briefly described in the following.

Operation: (Refer to the accompanying wiring diagram for location of components described.) Only 1/2 of the energy produced in the ignition winding is used for charging the capacitor. When the alternating current flows in one direction, it takes the shortest path (least resistance) through diode 1 and returns to the winding. When the current reverses direction, it travels through diode 2 (being blocked

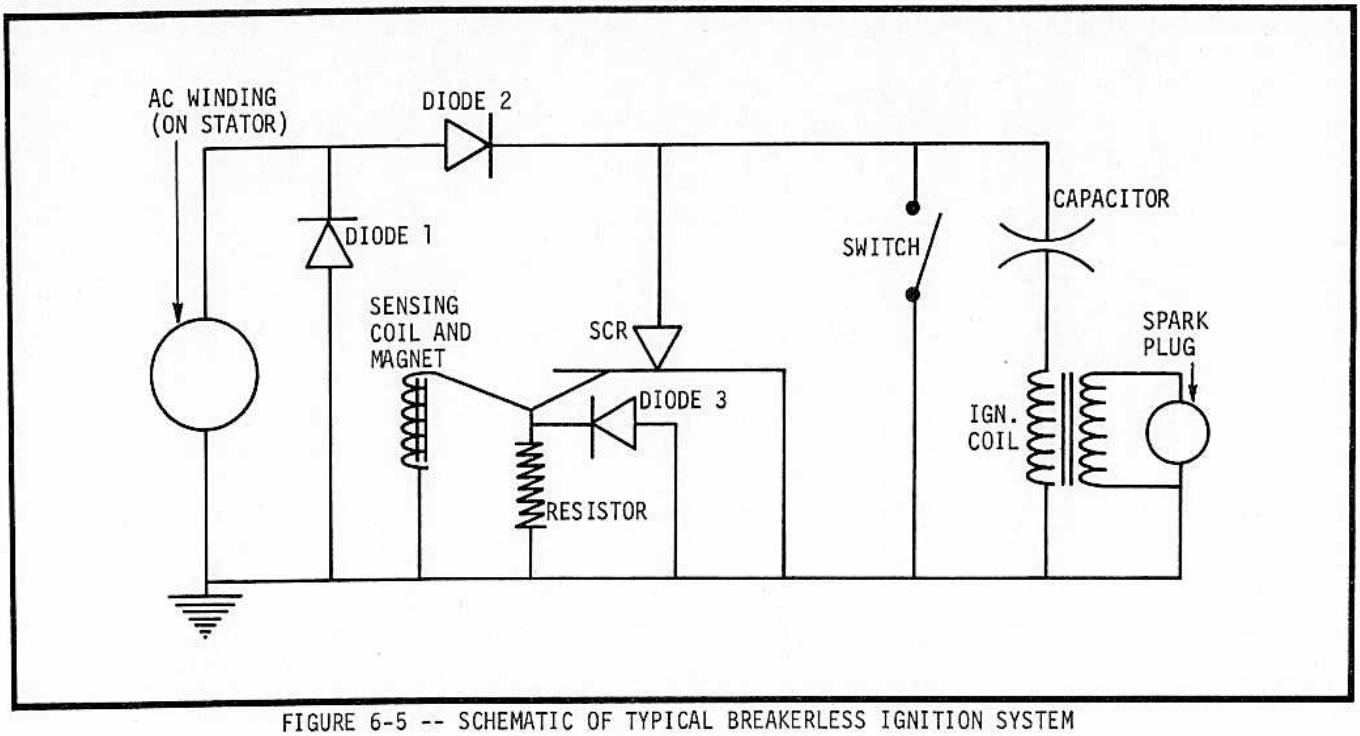


FIGURE 6-5 -- SCHEMATIC OF TYPICAL BREAKERLESS IGNITION SYSTEM

by diode 1) and flows into the capacitor. The capacitor thus builds up charge and cannot discharge since diode 2 blocks the return of the current. The only circuit available for discharge is through the SCR but at this point, it is turned off. To turn the SCR on, a small current must be applied to the gate terminal of the SCR.

When the projection of the flywheel is adjacent to the sensing coil, it interrupts the magnetic field of the permanent magnet located inside this coil. The small current induced in the coil is applied to the gate which switches the SCR on to complete the circuit from the charged side of the capacitor through the high tension coil to the negative side of the capacitor. This instantaneous discharge of energy induces a very high density magnetic field around the primary winding which cuts the secondary winding and thus creates sufficient energy to fire the spark plug. Unlike the conventional system, there is no build-up time nor does the sudden collapse of the magnetic field create the spark. When the capacitor discharges completely and current through the SCR drops to 0 value, the SCR again switches off ready for the next ignition cycle. Diode 3 functions to block reverse current from reaching and damaging the gate of the SCR. The resistor prevents transient voltage from entering the gate circuit which could turn the SCR on at the wrong moment.

IGNITION SYSTEM OPERATIONAL TEST

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.

COMMON CAUSES - - POOR OR NO IGNITION

NO IGNITION SPARK

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

POOR IGNITION

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

SPARK PLUG SERVICE

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

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

Spark Plug Service: Every 100 hours remove plug, check condition and reset gap. Good operating conditions are indicated if plug has light coating of gray or tan deposit. A dead white, blistered coating could indicate overheating. A black (carbon) coating may indicate an "overrich" fuel mixture caused by clogged air cleaner or improper carburetor adjustment. Do not sandblast, wire brush, scrape or otherwise service plug in poor condition--best results are obtained with new plug. Set spark gap at .025" for gasoline, .018" for gas fuels, .020" on shielded plugs. Tighten plug to 18 to 22 foot lbs. with a torque wrench.

SPARK PLUG SPECIFICATIONS

ENGINE MODEL	PLUG SIZE	HEX. SIZE	PLUG REACH	STANDARD PLUGS		RESISTOR PLUGS	
				SOLID POST	KNURLED NUT	NON-SHIELDED	SHIELDED
K91	14mm	13/16"	3/8"	J-8 270321-S	J-8 220040-S	XJ-8 232604-S	XEJ-8 220258-S
K141	14mm	13/16"	3/8"	J-8 270321-S	J-8 220040-S	XJ-8 232604-S	XEJ-8 220258-S
K161	14mm	13/16"	3/8"	J-8 270321-S	J-8 220040-S	XJ-8 232604-S	XEJ-8 220258-S
K181	14mm	13/16"	3/8"	J-8 270321-S	J-8 220040-S	XJ-8 232604-S	XEJ-8 220258-S
K241	14mm	13/16"	7/16"	H-10 235040-S	Not Available	XH-10 235041-S	XEH-10 235259-S
K301	14mm	13/16"	7/16"	H-10 235040-S	Not Available	XH-10 235041-S	XEH-10 235259-S
K321	14mm	13/16"	7/16"	H-10 235040-S	Not Available	XH-10 235041-S	XEH-10 235259-S

Gap Setting -- Gasoline .025" (Shielded .020") Tightening Torque -- All plugs 18 to 22 foot lbs.
Gap Setting -- Gas Fuels .018"(Champion plugs listed--use Champion or equivalent plugs.)

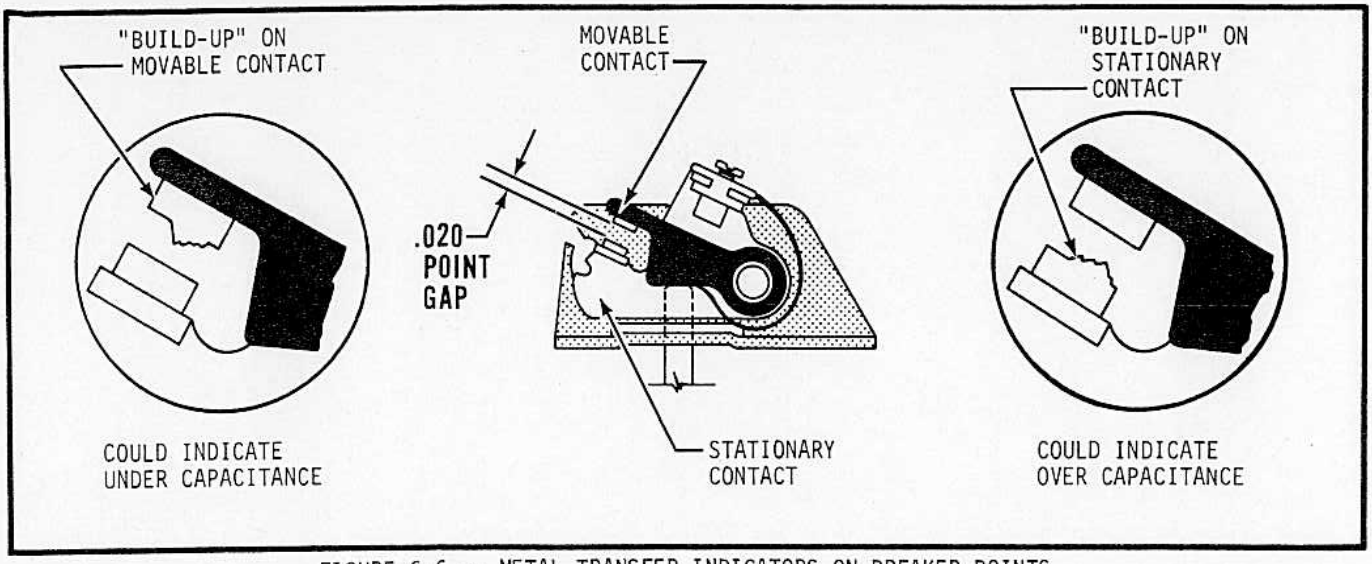


FIGURE 6-6 -- METAL TRANSFER INDICATORS ON BREAKER POINTS

BREAKER POINT SERVICE

Engine operation is greatly affected by breaker point condition and adjustment of the gap. If points are burned or badly oxidized, little or no current will pass and as a result the engine may not operate at all, or if it does run it is likely to miss particularly at full throttle. Adjusting breaker point gap affects the time that the contacts are opened and closed. If the points are adjusted to a wider gap, they will open earlier and close later in terms of cam movement. A definite time is required for the magnetic field within the ignition coil to build up to sufficient value. If the contact points are closed for too short a time, a weak spark will be produced by the coil. If points are set too wide, they will open before the primary current reaches the maximum value and on the other hand if set too close, they will open after the primary current has passed its maximum value.

CONDENSER

If the condenser shorts out, the coil will be unable to 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.

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

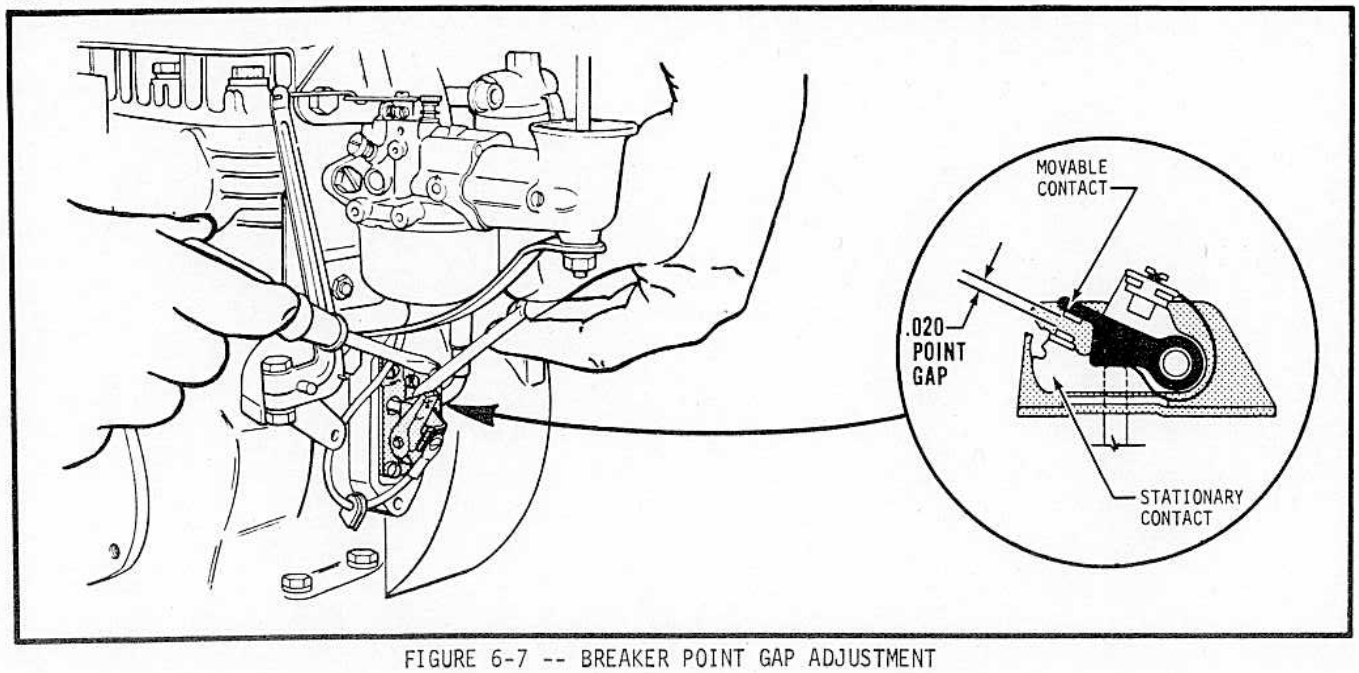


FIGURE 6-7 -- BREAKER POINT GAP ADJUSTMENT

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.

TRIGGER MODULE (BREAKERLESS)

The trigger module used on breakerless ignition systems is a solid state device which includes diodes, resistor, sensing coil and magnet plus an electronic switch called an SCR. The terminal marked A must be connected to the alternator while terminal I must be connected to the ignition switch or ignition coil. Operating with these leads reversed will cause damage to the solid state devices. If a faulty trigger module is suspected, disconnect and remove the trigger from the engine and perform the following tests with a flashlight tester. Reset air gap when reinstalling trigger.

DIODE TEST: Turn tester switch ON and connect one lead to the I terminal and the other to the A terminal then reverse these leads--light should come on with leads one way but not the other way. If light stays on or off both ways, this indicates diodes are faulty--replace trigger module.

SCR TEST: Turn tester on then connect one lead to the I terminal and the other to the trigger mounting bracket--note: if light comes on, reverse the leads as the light must be off initially for this test. Lightly tap magnet with a metal object--when this is done, tester light should come on and stay on until leads are disconnected. If light does not come on, this indicates SCR is not switching properly in which case trigger module should be replaced.

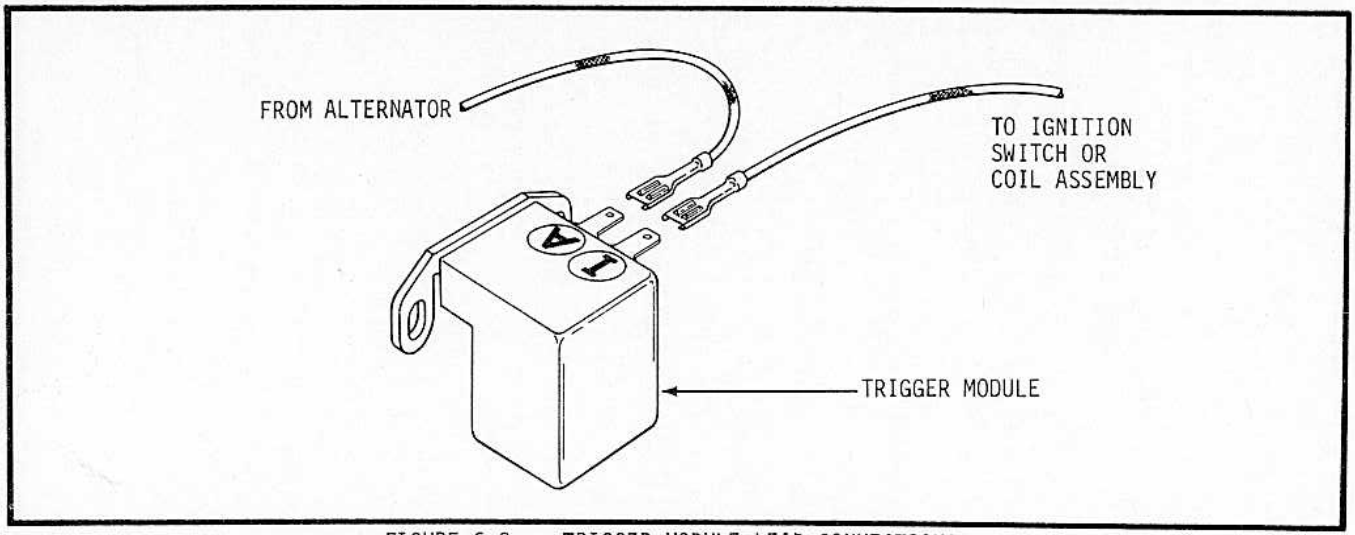


FIGURE 6-8 -- TRIGGER MODULE LEAD CONNECTIONS

GAP: The air gap between trigger assembly and projection on the flywheel is usually set at about .005 to .010". Although the actual gap setting is not critical to operation at normal speeds, decreasing the gap to .005" may promote faster starting under cold 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 proper gap is measured on feeler gauge. Do not set closer than .005"--make sure flat surfaces on trigger and projection are parallel to each other. Retighten capscrews after gap is readjusted. 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.

IGNITION COILS

Ignition coils do not require servicing on a regular basis; however, they 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.

BATTERY TYPE IGNITION COILS: The coil must be hooked up properly. With the battery type ignition coil, the positive (+) coil primary terminal must be connected to the positive battery terminal. The negative (-) coil terminal is connected directly to the breaker points.

BREAKERLESS TYPE IGNITION COIL: Use an ohmmeter to test breakerless type coil assembly.
(A) -- Remove high tension lead from terminal on coil. Insert one ohmmeter lead in coil terminal and the other to the coil mounting bracket. A resistance of about 11, 500 ohms should be indicated here.
(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.

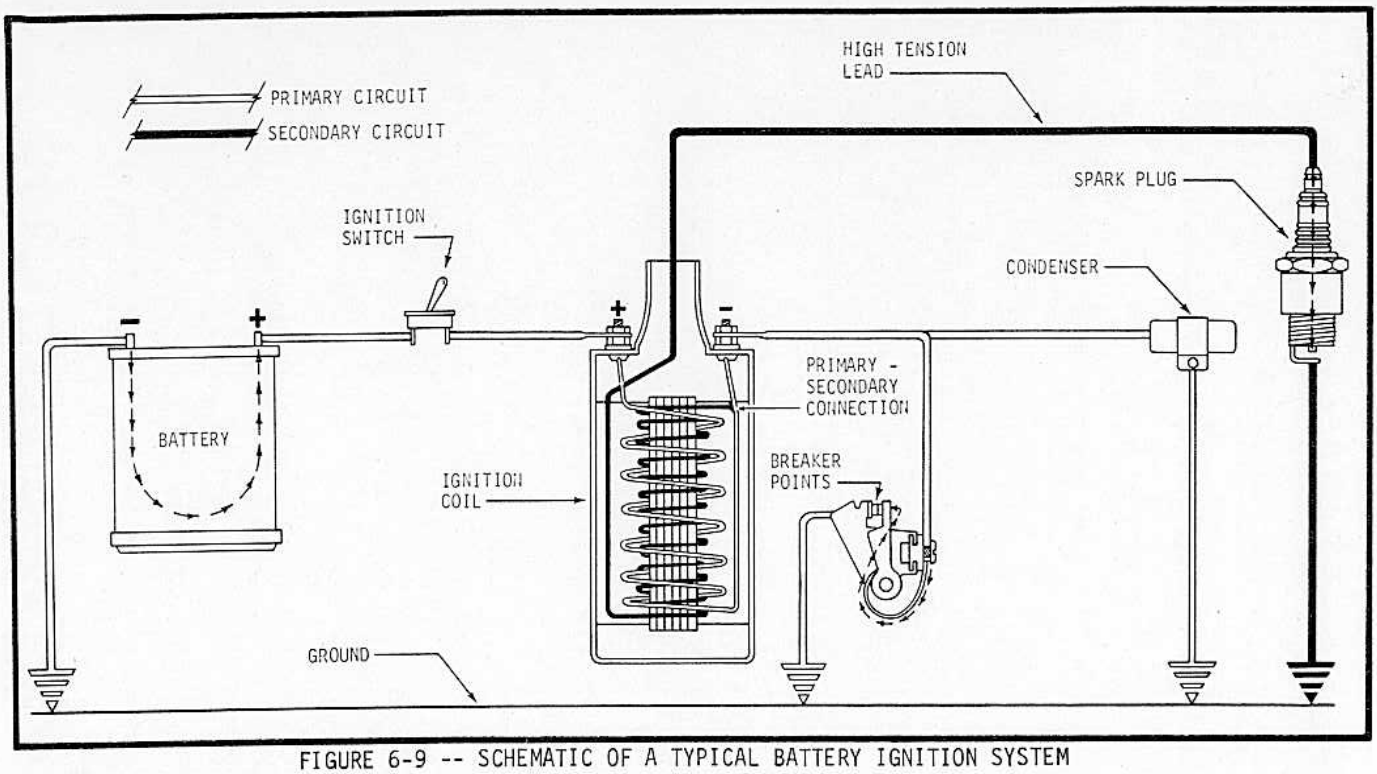


FIGURE 6-9 -- SCHEMATIC OF A TYPICAL BATTERY IGNITION SYSTEM

MAGNETO TYPE IGNITION COILS: Special test instruments are required to accurately test magneto 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.

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

Timing is permanently set on breakerless ignition systems--the following adjustment procedure does not pertain to these engines. Engines are equipped with a timing sight hole in either the bearing plate or in the blower housing. A snap button may cover the hole on some--the button is easily pried loose with a screw driver so that the timing marks can be observed. Two timing marks are stamped on

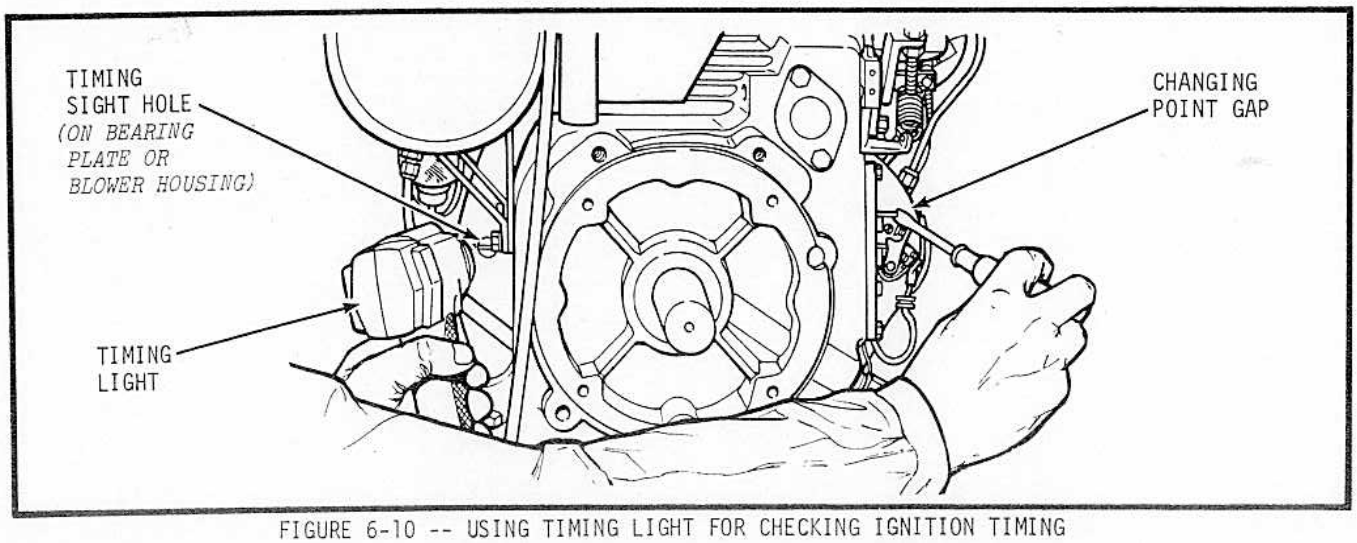


FIGURE 6-10 -- USING TIMING LIGHT FOR CHECKING IGNITION TIMING

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.

The same timing procedure is used for both the magneto ignition and battery ignition systems. Two methods can be used for timing--the timing light method is the more precise way of achieving exact timing. The timing light can be used with magneto ignition systems; however, a storage battery will have to be used per timing light manufacturer's instructions.

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 (T mark on K91 and pre-ACR models) 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.

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

A. Remove high tension lead at spark plug--wrap one end of a short piece of fine wire around spark plug terminal. Reconnect lead to terminal--free end of wire must protrude from under boot. (Note: Step A for timing lights with alligator clips--some lights have sharp prongs on spark lead --on these simply push prong thru boot until it contacts metal connector.)

B. Connect one timing light lead to the wire that has just been wrapped around spark plug terminal.

C. Connect second timing light lead to hot (ungrounded) side of battery--see timing light instructions for battery size, wiring, etc.

D. Connect third timing light lead to ground.

E. Remove snap button, rotate (by hand) engine until S mark visible--chalk S line for easy reading.

F. Start engine, run at 1200 - 1800 RPM, aim timing light into sight hole--light should flash just as S mark is centered in sight hole or even with center mark on bearing plate or blower housing.

G. If timing is off--remove breaker point cover, loosen gap adjusting screw, shift breaker plate until S mark is exactly centered. Retighten adjusting screw before replacing breaker point cover.

ELECTRICAL STARTING-CHARGING SYSTEMS

Motor-generator and alternator type charging systems are used on the electric start single cylinder engines. The motor-generator type is used in conjunction with conventional battery ignition systems. The alternator types are used with flywheel-magneto, battery and breakerless ignition systems. The ignition systems are described in the foregoing section--this section deals only with components of the charging and starting circuits. The main components of the two basic circuits are:

MOTOR-GENERATOR SYSTEMS

Charging Circuit

1. Battery (12 Volt)
2. Voltage (& current) Regulator
3. Motor-Generator
4. V-Belt

Cranking Circuit

1. Motor-Generator

ALTERNATOR SYSTEMS

Charging Circuit

1. Battery (12 Volt)
2. Rectifier-Regulator
3. Alternator Stator
4. Permanent Magnet Ring

Cranking Circuit

1. Starting Motor

The systems are discussed in the above order on the following pages. Since the battery is common to both systems, it is described separately.

BATTERY

Use 12 volt (negative - terminal ground) with amp hour rating of at least 32 for best results.

BATTERY NEGATIVE TERMINAL (-) GROUNDED

As a battery discharges, 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 should be recharged. In fully charged condition, the specific gravity will be in the 1.260 - 1.280 range. (NOTE: In tropical areas where the temperature stays well above freezing, an electrolyte with lower specific gravity may be used--full charge specific gravity on these is 1.225.)

A regulator may be blamed for an undercharged or repeatedly discharged battery when the fault is actually self-discharge caused by a build-up of corrosive acid across the top of the battery. Even a light coating of this grayish-white substance can complete a circuit to drain and exhaust the energy in the battery--this can be especially bad when moisture is present. To maintain a battery in top condition, check and perform the following services at frequent intervals.

1. Regularly check level of electrolyte--add water (distilled) 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 as this will destroy the electrolyte.

3. Make sure battery hold-downs are secure--if loose, vibration will cause premature failure. Be careful not to damage battery case by overtightening hold-downs.

4. Clean cable clamps and terminals occasionally with a wire brush. When reinstalling clamps press firmly into position--do not pound.

5. An undercharged battery may freeze when unused during cold weater--keep the charge up or store battery in warm area.

CAUTION: Adequate ventilation must be provided when batteries are being recharged. Sparks, open flames, smoking should also be avoided since hydrogen gas is produced which, if ignited, could cause an internal explosion which could shatter the case of the battery. This gas is produced in quantity only while the battery is receiving a high rate of charge but can linger for several hours afterward in a poorly ventilated area.

MOTOR GENERATOR

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

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

Motor generators mounted at front (flywheel) end of engine rotate in clockwise direction--units mounted at rear (PTO) end rotate in the reverse or counterclockwise direction when viewed from pulley end. Units with 10, 12, and 15 amp charging capacities are used depending on the engine model and application. 10 and 12 amp units are most common.
CAUTION: Never operate the motor-generator during cranking for more than 30 seconds at a time without pausing to allow it to cool for at least 2 minutes. Overheating, caused by excessively long cranking periods, may seriously damage motor-generator.

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

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

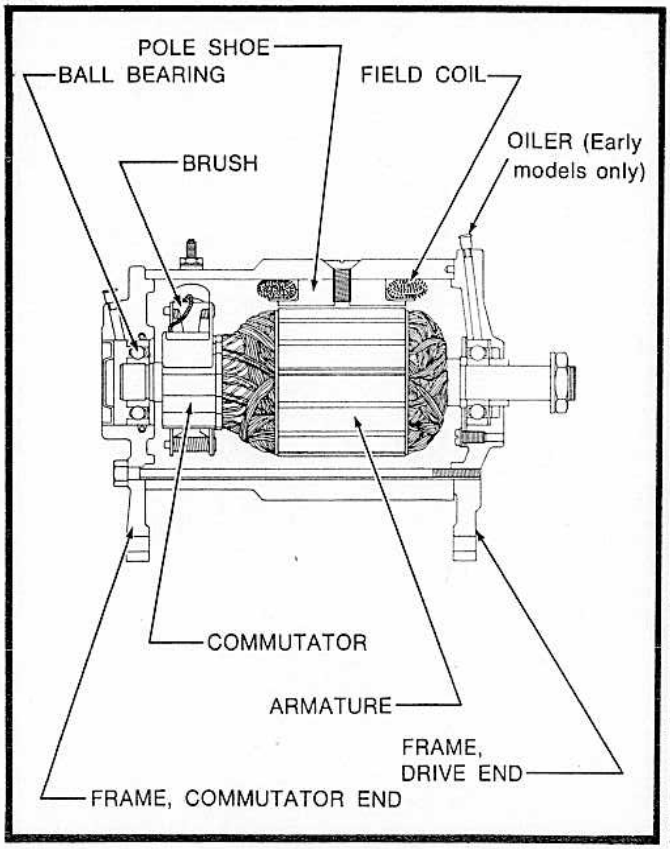


FIGURE 7-1 -- CUTAWAY VIEW OF MOTOR-GENERATOR

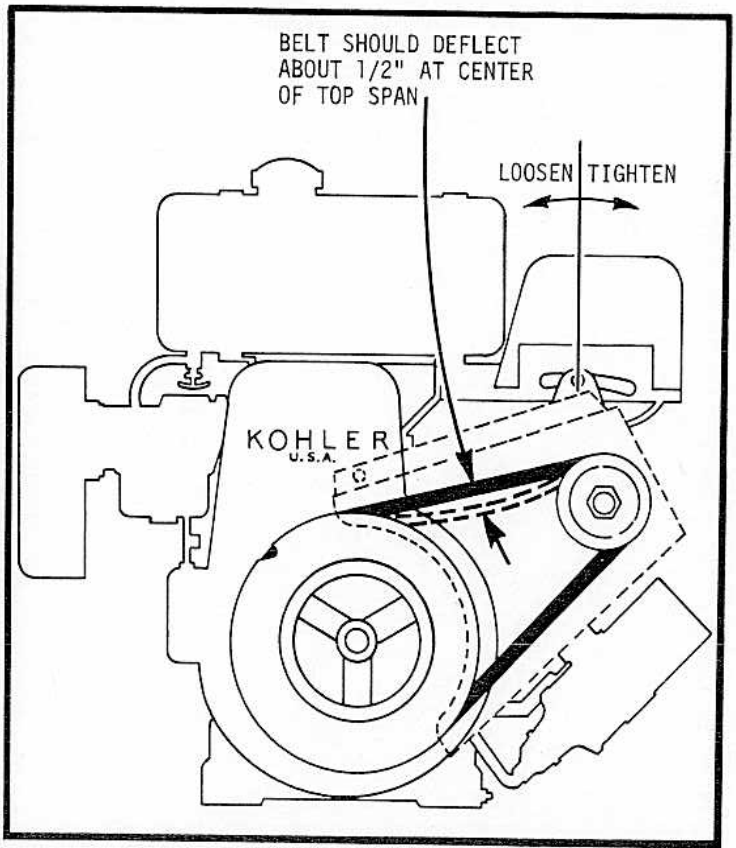


FIGURE 7-2 -- BELT TENSION CHECK AND ADJUSTMENT

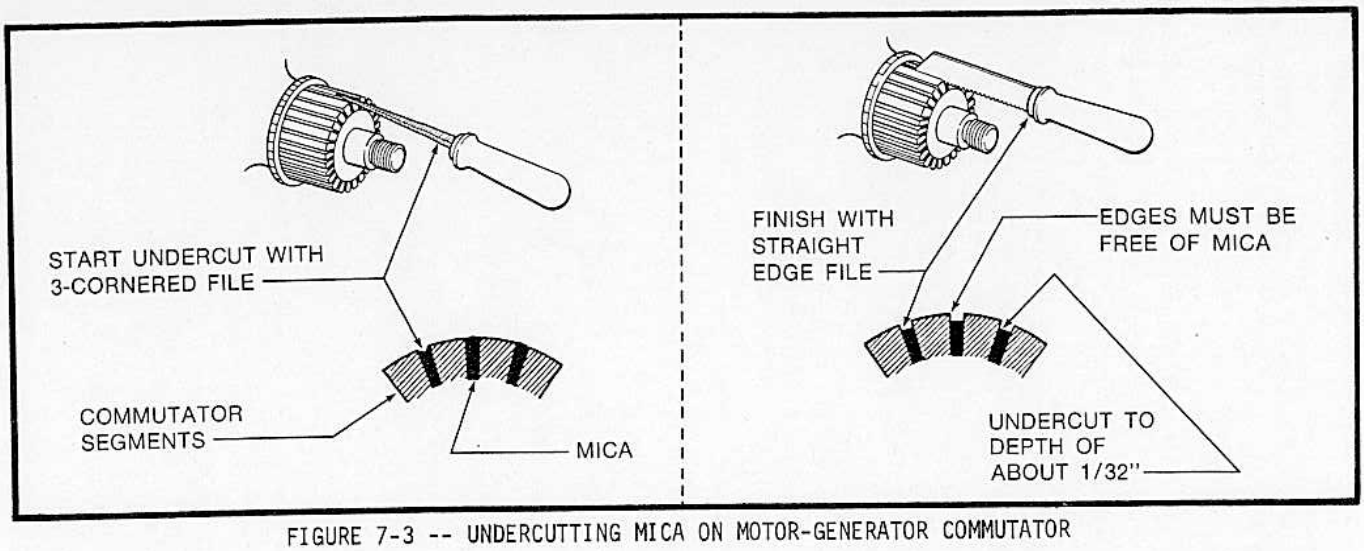


FIGURE 7-3 -- UNDERCUTTING MICA ON MOTOR-GENERATOR COMMUTATOR

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

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

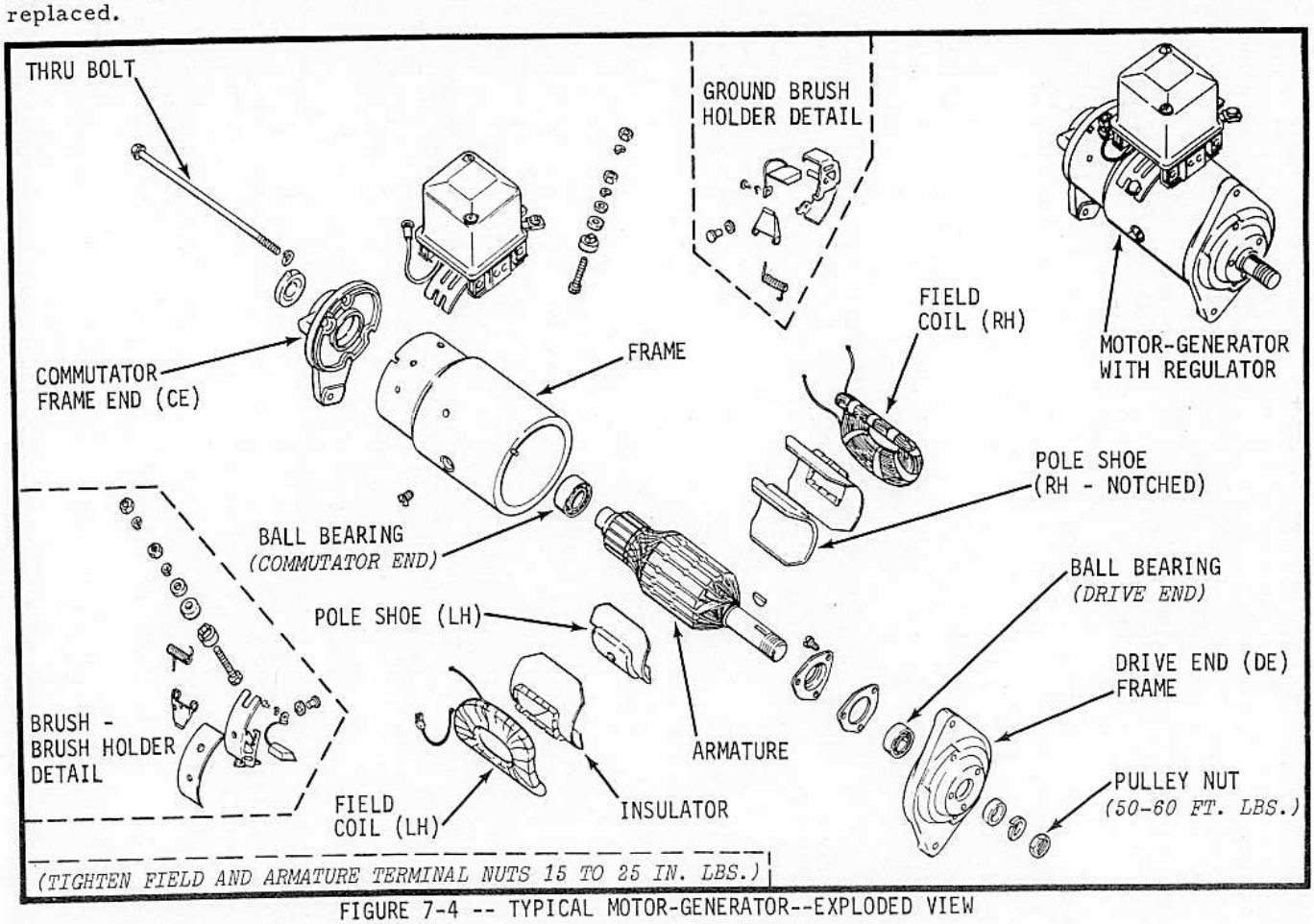


FIGURE 7-4 -- TYPICAL MOTOR-GENERATOR--EXPLODED VIEW

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

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

1. Unscrew thru bolts and remove commutator end frame from the field frame.

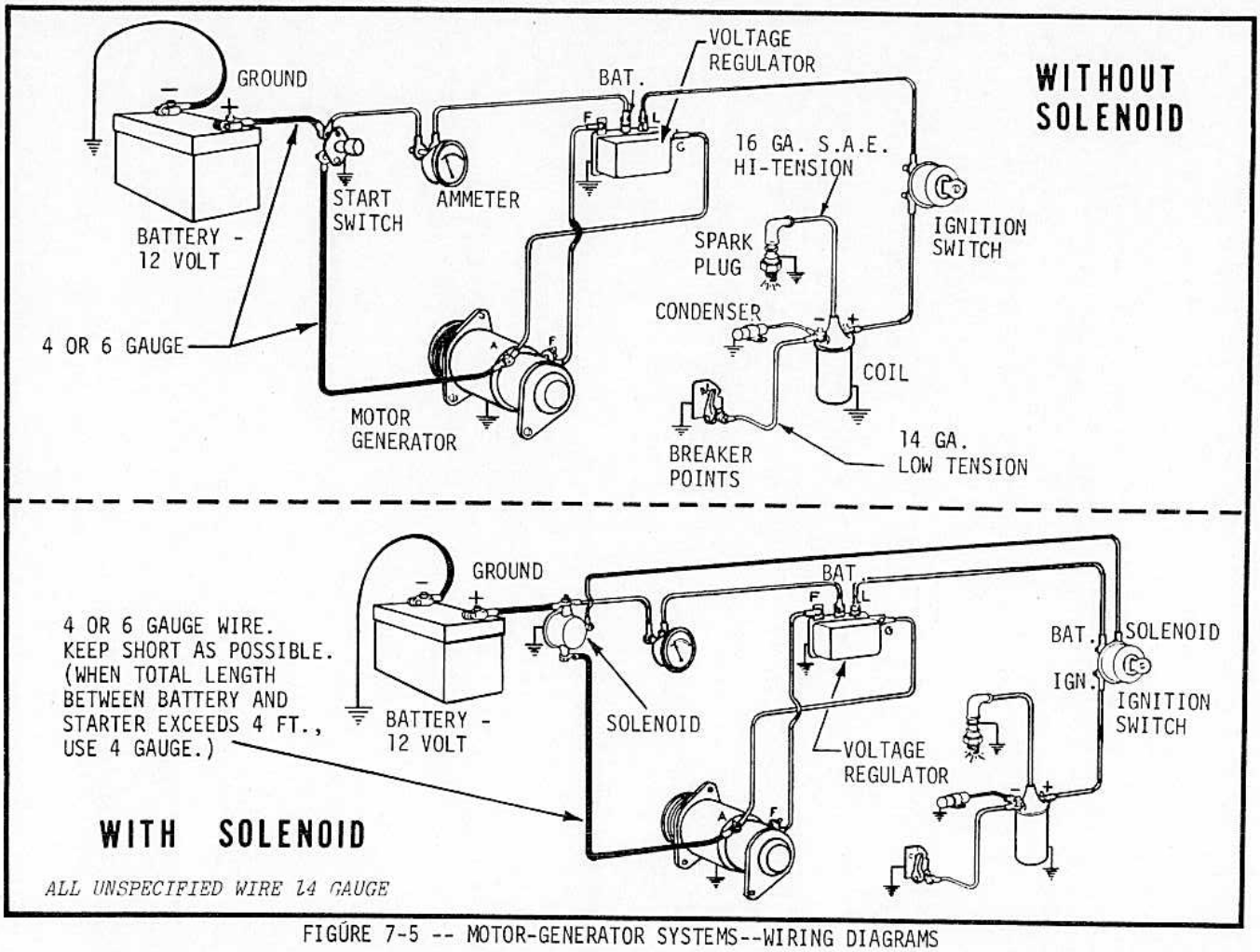


FIGURE 7-5 -- MOTOR-GENERATOR SYSTEMS--WIRING DIAGRAMS

2. Place armature in a vise with soft jaws and remove shaft nut, pulley and the drive end frame.

3. Remove brush holders if new ones are to be installed, by drilling out the rivets holding them to the field frame. Install new holders, securing them to frame with new rivets or screws, nuts and washers.

4. The armature or field coils must not be cleaned in degreasing tank or with degreasing compounds since insulation damage might occur. Ball bearings should be thoroughly cleaned and repacked with high melting point ball bearing grease. Other parts should be cleaned and carefully inspected for wear or other damage. Any defective part should be repaired or replaced. On reassembly, all soldered electric connections should be made with rosin flux. Acid flux must not be used on electrical connections. When reassembling unit, make sure pulley retaining nut is tightened to the correct torque value (600-720 inch lbs.) as this properly pre-loads the bearings.

Motor Tests: If unit fails to crank properly, inspect entire cranking circuit for loose or badly corroded connections and damaged wiring. Check battery to determine condition. When battery is satisfactory and wiring and connections are in good condition, close starting switch. If unit fails to crank, wire around motor switch with a heavy jumper lead. If motor-generator operates, the switch is defective and should be replaced. If unit fails to operate, the trouble can be attributed to the engine or to the motor-generator. Excessive friction in the engine from tight bearings or pistons or from too heavy oil causes hard cranking. If unit fails to crank properly when engine is known to be in good operating condition and the rest of the cranking circuit is found to be satisfactory, the motor-generator should be removed for further checking.

With the motor-generator removed from the engine, the armature should be checked for freedom of operation by turning the shaft. Tight, dirty or worn bearings, a bent armature shaft or loose pole shoe screws may cause the armature to drag and fail to turn freely. If armature does not turn freely, the motor must be disassembled.

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

VOLTAGE REGULATOR

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

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

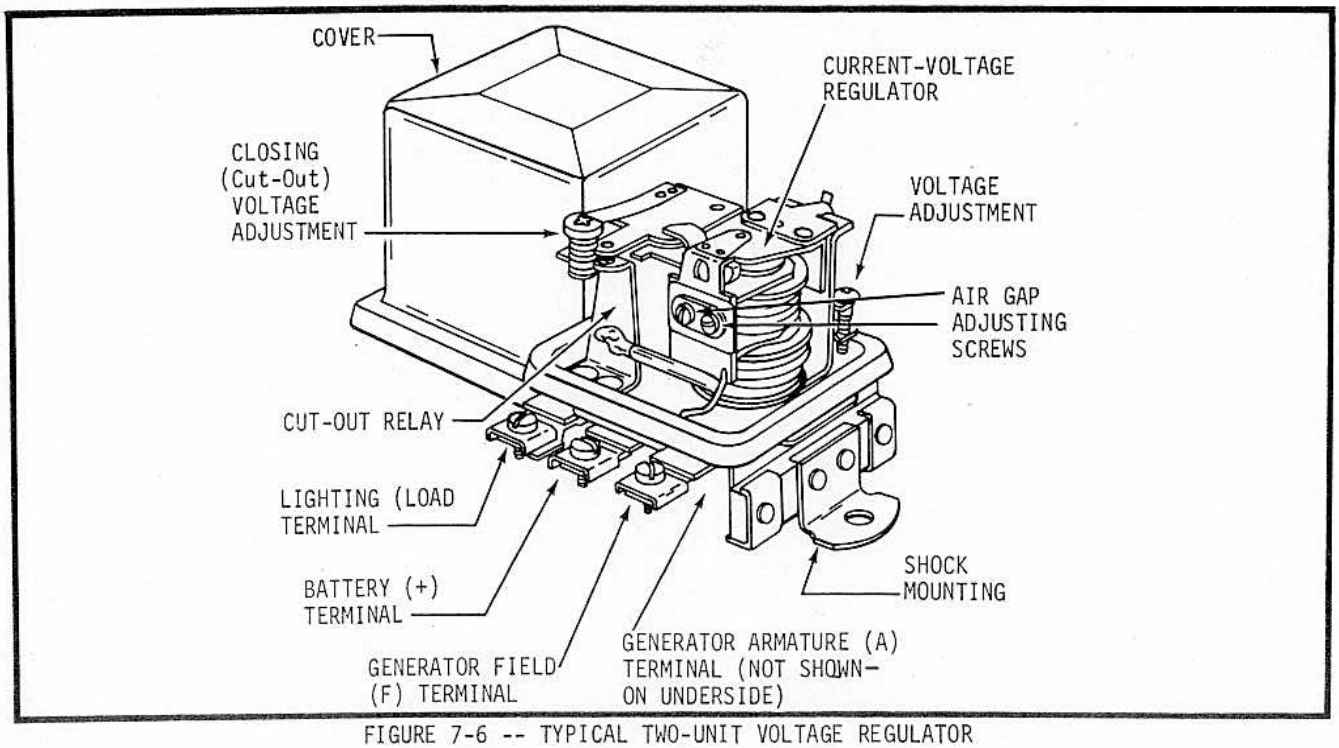


FIGURE 7-6 -- TYPICAL TWO-UNIT VOLTAGE REGULATOR

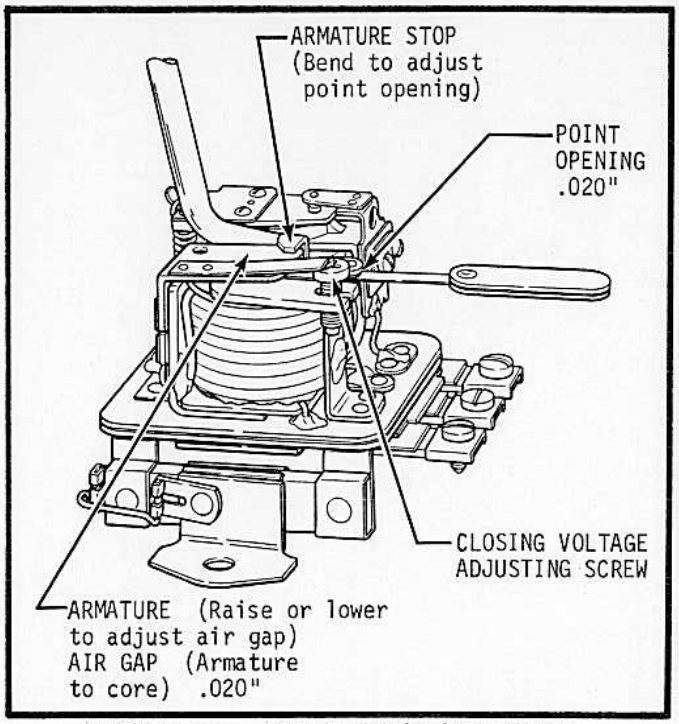


FIGURE 7-7 -- CUTOUT RELAY ADJUSTMENTS

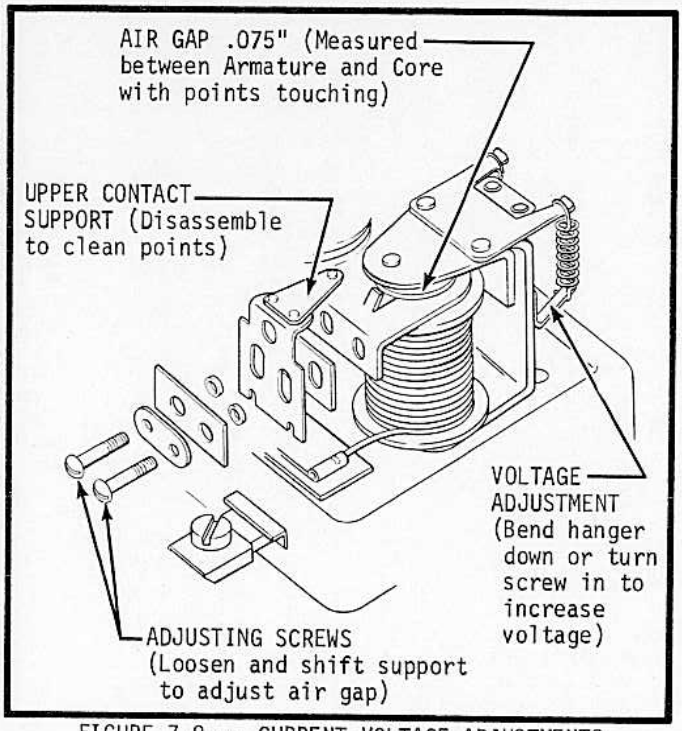


FIGURE 7-8 -- CURRENT-VOLTAGE ADJUSTMENTS

Cutout Relay: This unit requires three checks and adjustments: air gap, point opening, and closing voltage. The air gap and point opening adjustments are made with the battery disconnected.

Air Gap: Place fingers on the armature directly above the core and press armature down until the points just close, then measure the air gap between the armature and the center of the core. Gap should be .020. Adjust by raising or lowering armature at its hinge mounting. Retighten screws after adjustment.

Point Opening: Adjust point opening by bending the armature stop. Opening should be .020.

Closing Voltage: Adjust closing voltage by turning screw clockwise to increase spring tension and voltage, counterclockwise to decrease spring tension and closing voltage. Be sure that closing voltage adjustment is at least 0.5 volt less than the current-voltage regulator unit setting. This should be 12.8 volts.

Current-Voltage Unit: This unit requires two inspections and adjustments: the armature air gap and the voltage setting.

Armature Air Gap: To check air gap, push the armature down until contact points are still just touching, then measure air gap. This should be .075". Adjust by loosening contact mounting screws and raising or lowering the contact bracket as required. Be sure points are lined up and screws are retightened after adjustment and before resetting voltage setting.

Voltage Setting: Adjust the voltage setting by turning adjusting screw--clockwise to increase the the voltage setting and counterclockwise to decrease the voltage setting. After each adjustment, replace cover and allow ample running time to again stabilize voltage and temperature before rechecking the voltage setting.
CAUTION: If adjusting screw is turned down (clockwise) beyond normal range required for adjustment, the spring support may fail to return when pressure is relieved. If this happens, turn screw counterclockwise until enough clearance develops between the screw head and spring support. Then bend spring support upward carefully with a small pliers until contact is made with the screw head. The final setting should always be approached by increasing spring tension. In other words, if setting is too high, unit should be adjusted below the required value then raised to the exact setting by increasing spring tension. Be sure screw is exerting force on hanger.

Spring Replacement: When current-voltage unit is badly out of adjustment or requires spring replacement, use following procedure:

Replacing regulator spring requires care to prevent bending or distorting spring support or the armature hinge. Preferably spring should be hooked at lower end first then stretched up with a screwdriver blade or other suitable tool, inserted between the turns until the upper end of the spring can be hooked.

ALTERNATOR CHARGING SYSTEMS

10 amp, 15 amp and 30 amp alternator charging systems are used. The systems can be easily identified by the rectifier-regulator unit which is mounted externally on either the engine or equipment powered by the engine. The rectifier-regulators are shown on Figure 7-9. Other components of the systems are also different and there can be, therefore, no interchangeability of parts between the systems. Terminals on the 15 amp rectifier-regulator are, for example, positioned in a different pattern than those on the 10 amp rectifier-regulator to prevent the two systems from being hooked up in error. Because of the differences, wiring, test procedures and precautions differ for each system. The systems are described separately on the following pages.

10 AMP ALTERNATOR SYSTEMS

The 10 amp 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. 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. This unit should be mounted in a well ventilated area.

Service: 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 - 10 AMP ALTERNATOR SYSTEM

TEST WITH ENGINE RUNNING AT 3600 RPM - NO LOAD

CONDITION: NO CHARGE TO BATTERY	POSSIBLE FAULT/REMEDY
TEST A -- Disconnect B+ cable to positive (+) terminal of battery. Connect DC Voltmeter between B+ cable and ground. Check DC voltage:	
A-1 -- If above 14 volts.	A-1 -- Alternator system OK--ammeter may be giving false reading. Repair or replace ammeter.
A-2 -- If less than 14 volts (but above 0 volts).	A-2 -- Check for defective rectifier-regulator (TEST C).
A-3 -- If 0 volts.	A-3 -- Check for defective stator or rectifier-regulator (TEST C).
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 minimum load of 5 amps * on battery to reduce voltage.	
B-1 -- If charge rate increases.	B-1 -- Indicates alternator system OK, battery was fully charged.
B-2 -- If charge rate does not increase.	B-2 -- Check for defective stator or rectifier-regulator (TEST C).
TEST C -- Unplug leads at rectifier-regulator, connect VOM (multimeter) across AC leads, check AC voltage:	
C-1 -- If less than 20 volts.	C-1 -- Defective stator, replace with new assembly.
C-2 -- If more than 20 volts.	C-2 -- Defective rectifier-regulator, replace with new unit.
CONDITION: BATTERY CONTINUOUSLY CHARGES AT HIGH RATE	POSSIBLE FAULT/REMEDY
TEST D -- Check B+ to ground with DC Voltmeter:	
D-1 -- If over 14.7 volts.	D-1 -- Rectifier-regulator not functioning properly. Replace with new unit.
D-2 -- If under 14.7 volts.	D-2 -- Alternator system OK. Battery unable to hold charge. Check specific gravity of battery. Replace if necessary.

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

Precautions

The rectifier-regulator will be damaged if engine is operated for any length of time without a battery in the system. A battery with a cracked case with all its acid drained out acts the same as no battery at all. Under these conditions, the rectifier-regulator overheats which ruins the solid state electronic devices inside the unit. Damage will not occur if an engine is run with a dead or completely discharged battery or even with a shorted battery--the rectifier-regulator does not overheat under these conditions.

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

Pre-Service Procedure

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

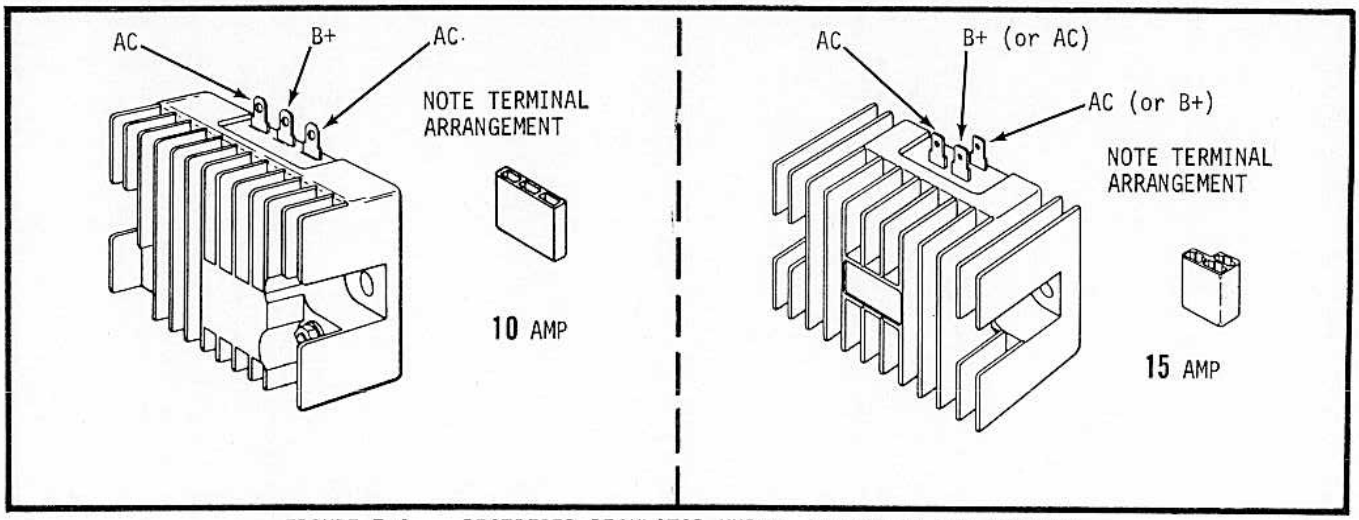


FIGURE 7-9 -- RECTIFIER-REGULATOR UNITS--10 AND 15 AMP SYSTEMS

15 AMP ALTERNATOR

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

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

Two different types of ignition circuits are used in conjunction with the 15 amp battery charging systems. They are the battery ignition and breakerless ignition circuits. Magneto type ignition is not

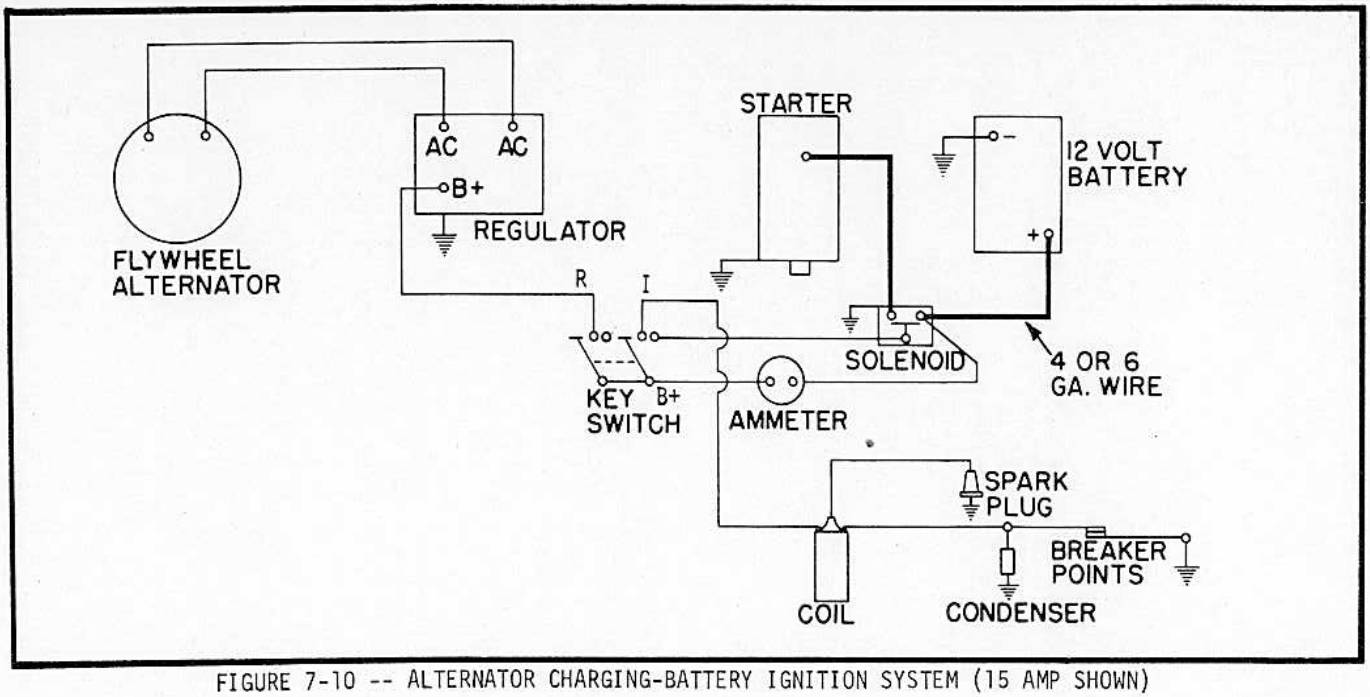


FIGURE 7-10 -- ALTERNATOR CHARGING-BATTERY IGNITION SYSTEM (15 AMP SHOWN)

available with 15 amp systems. The ignition circuits are described in the foregoing section. The stator used with the battery type ignition circuit has 18 posts but only 16 are wound. On breakerless ignition circuits, these two extra posts are wound to provide energy for ignition. The ignition winding on the breakerless circuits are of very thin wire which is covered by an epoxy--be careful when installing the flywheel not to touch the sharp edges against the wires as they can be easily cut in spite of the protective covering.

Service: No adjustments are possible on the alternator system and field service is not recommended. The faulty part should be replaced by a new part. The Trouble Analysis Chart on page 7.10 can be used to pinpoint the faulty part on a 15 amp system.

Tests: There are only a few tests that can be applied to the charging circuit. If the battery is not being charged, check out the battery first for cracked cells, etc., --if the battery proves to be in good condition, that is, the tests reveal it is able to hold charge, the trouble is either in a faulty rectifier-regulator

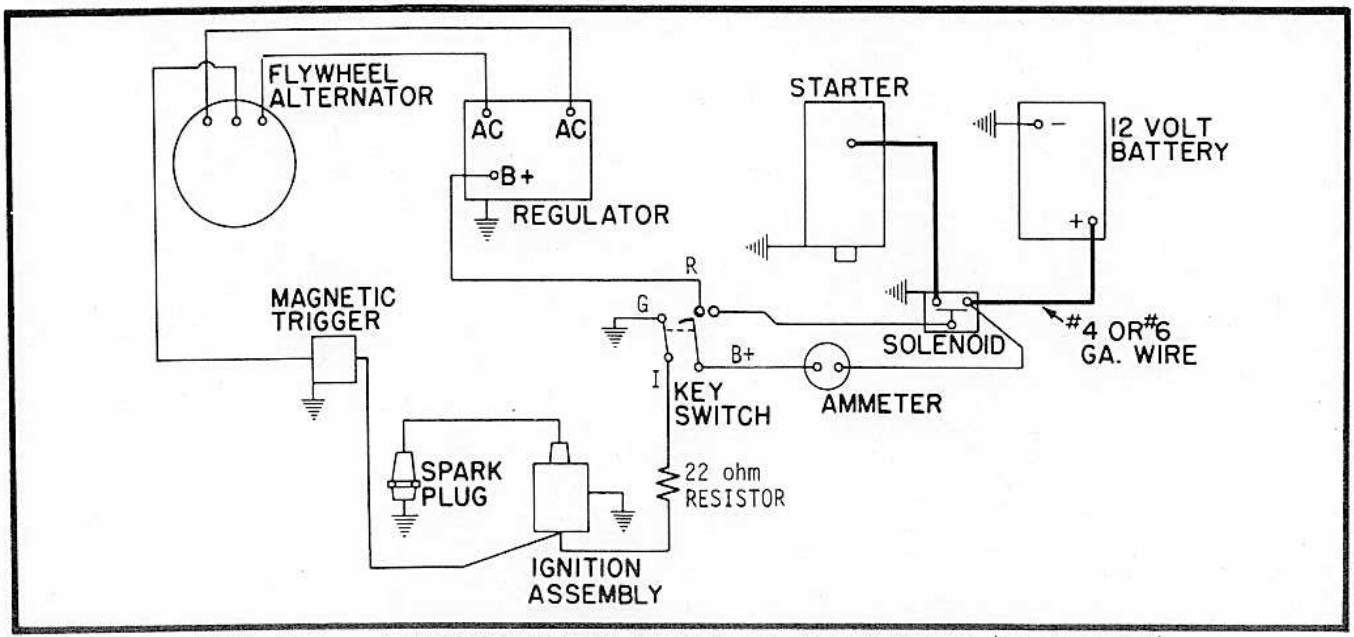


FIGURE 7-11 -- ALTERNATOR CHARGING-BREAKERLESS IGNITION SYSTEM (15 AMP SHOWN)

or in the stator windings. Check stator per test procedures outlined in the accompanying trouble shooting chart.

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

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

Precautions--15 Amp Systems

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

Pre-Service Procedure

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

TROUBLE SHOOTING - 15 AMP SYSTEM

TEST WITH ENGINE RUNNING AT 3600 RPM - NO LOAD

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

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

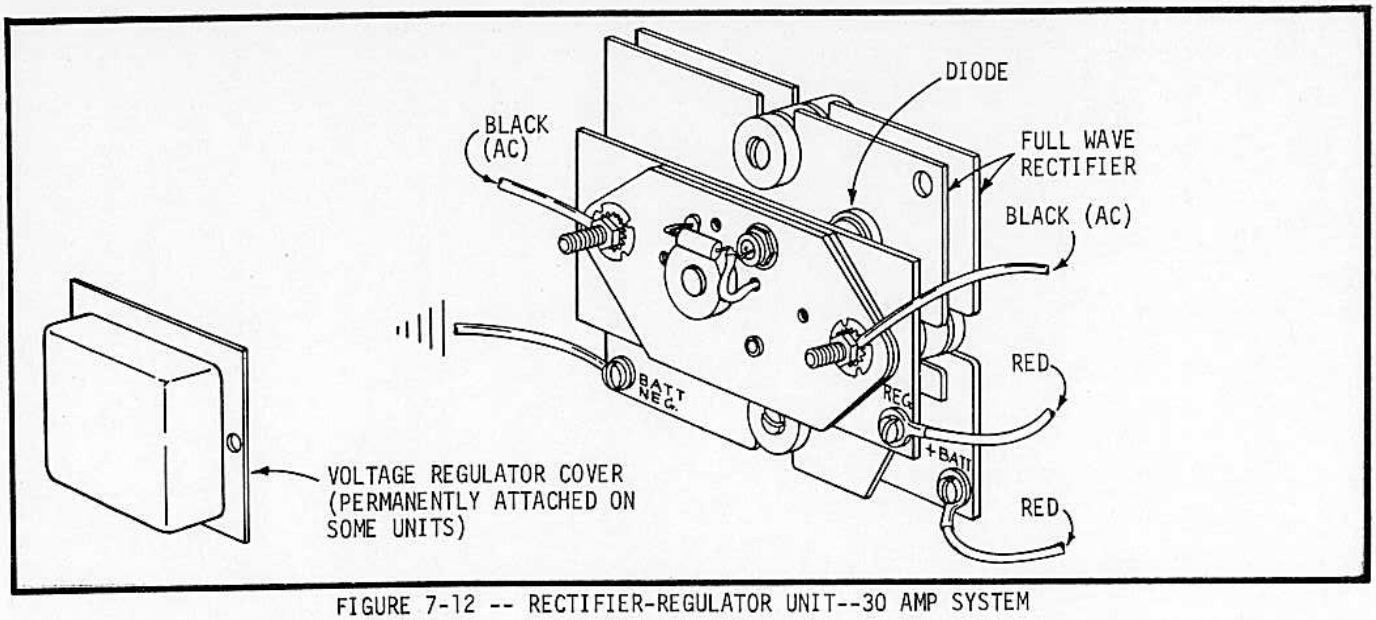


FIGURE 7-12 -- RECTIFIER-REGULATOR UNIT--30 AMP SYSTEM

30 AMP ALTERNATOR SYSTEM

The 30 amp flywheel-alternator is available as an option on the K241, K301 and K321 engines. It is used with conventional battery ignition systems. The main components of this system are:

1. Permanent magnet ring
2. Alternator stator
3. Rectifier-Regulator

The magnet ring is inside the flywheel, the stator is assembled to the bearing plate or gear housing and the rectifier-regulator is mounted on the outside of the engine or, in some cases, on the equipment powered by the engine.

Operation: As the magnets rotate around the stator, an Alternating Current (AC) is induced in the primary windings of the stator. This current is carried thru the two black leads to the full wave rectifier segment of the rectifier-regulator where it is converted to Direct Current (DC) for charging the battery.

Regulation is provided by the solid state (no moving parts) electronic devices in the rectifier-regulator. These "sense" battery voltage and allow a bucking current to flow in the secondary or regu-

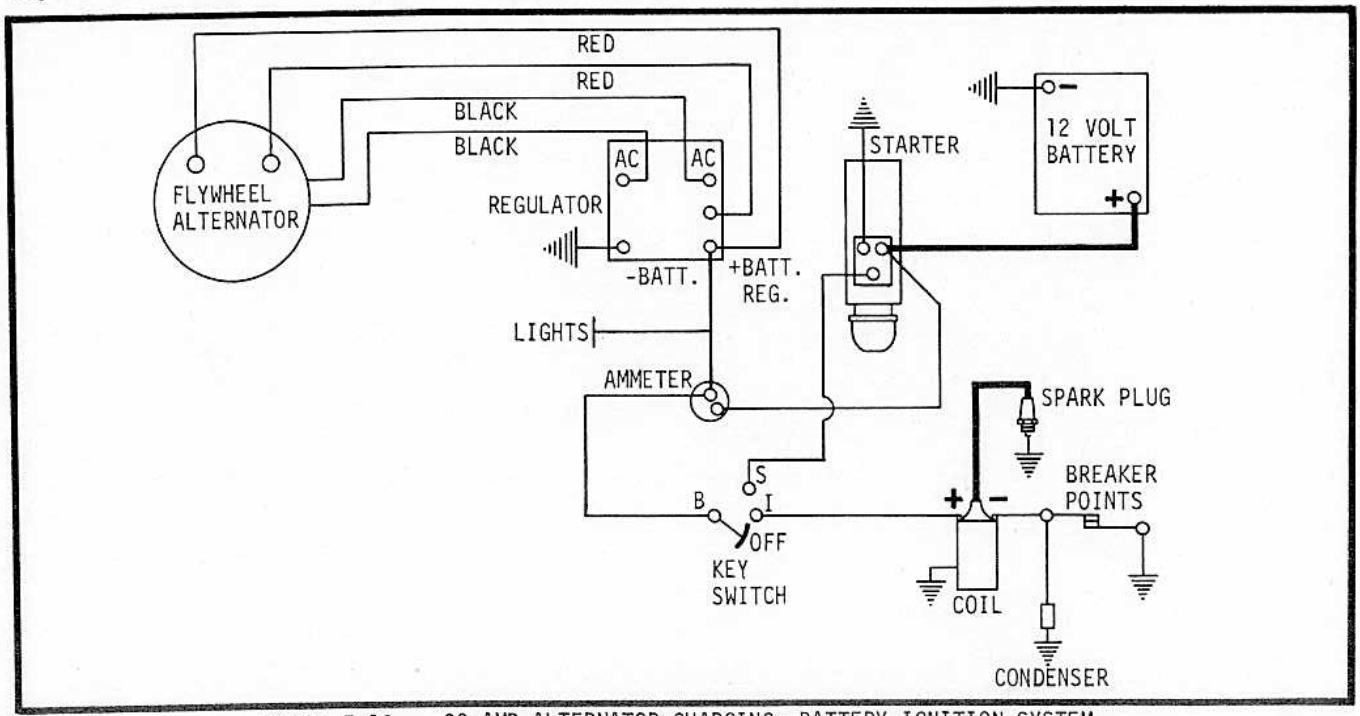


FIGURE 7-13 -- 30 AMP ALTERNATOR CHARGING--BATTERY IGNITION SYSTEM

TROUBLE ANALYSIS - 30 AMP ALTERNATOR SYSTEM

CONDITION	POSSIBLE FAULT	TEST AND CORRECTIVE ACTION
NO OUTPUT	A. Faulty windings in stator	A. Remove four input leads from Rectifier - Regulator. Check resistance on RX1 scale of Ohmmeter. Replace stator if readings not at test values. Test 1 - Connect Ohmmeter leads to 2 red leads - about 2.0 ohms resistance should be noted. Test 2 - Connect Ohmmeter leads to 2 black leads - about 0.1 ohms should be noted.
	B. Defective diode(s) in rectifier	B. With engine stopped, connect leads of flash-light type continuity tester between BAT-NEG and one of the AC terminals then reverse these leads--lamp should turn ON one way and OFF the other. Repeat procedure on the other AC terminal. If lamp indication is the same both ways, diode is faulty.
NO CHARGE (When load applied to battery)	A. Faulty regulator winding	A. Remove red lead from "REG." terminal on Rectifier - Regulator. Start engine and operate at full speed. With regulator winding disconnected, alternator should charge at full output. Replace stator if full output of at least 30 amps is not attained.
FULL CHARGE - NO REGULATION	A. Faulty regulator winding	A. Remove 2 red leads from Rectifier - Regulator -- connect these two leads together then start engine and operate at full speed. A maximum 4 amp charge should be noted if stator is OK.
	B. Defective regulator	B. If stator checks out, trouble is in regulator portion of Rectifier - Regulator. Replace unit.

lator windings of the stator when the voltage reaches a specific level. Above this level, any increase in battery voltage brings about a corresponding increase in current flow in the regulator windings. As current increases in the regulator windings, its magnetic field bucks that of the primary winding which, in turn, decreases AC output to a corresponding degree.

Service: With the exception of the magnet ring, the 30 amp system has no moving parts and is, therefore, virtually service free. The only requirement is an occasional check to make sure that all connections are tight and that the leads are in good condition. If problems do occur, refer to the accompanying trouble shooting guide to pinpoint the cause.

Precautions: The following precautions must be taken to avoid damaging components of the 30 amp alternator system.

1. Battery polarity must be correct--negative (-) battery terminal is connected to ground.
2. Rectifier-regulator must be in common ground with engine and battery.
3. Make sure that no fuses, resistors or wires smaller than #10 AWG are in connection from battery to rectifier.
4. Disconnect wire at terminal marked "BATT. NEG." if arc welding is done on equipment in common ground with engine.
5. Disconnect battery to regulator lead when battery is being recharged.
6. DO NOT operate engine with battery disconnected from Alternator System.
7. Make sure AC leads are prevented from being grounded at all times.

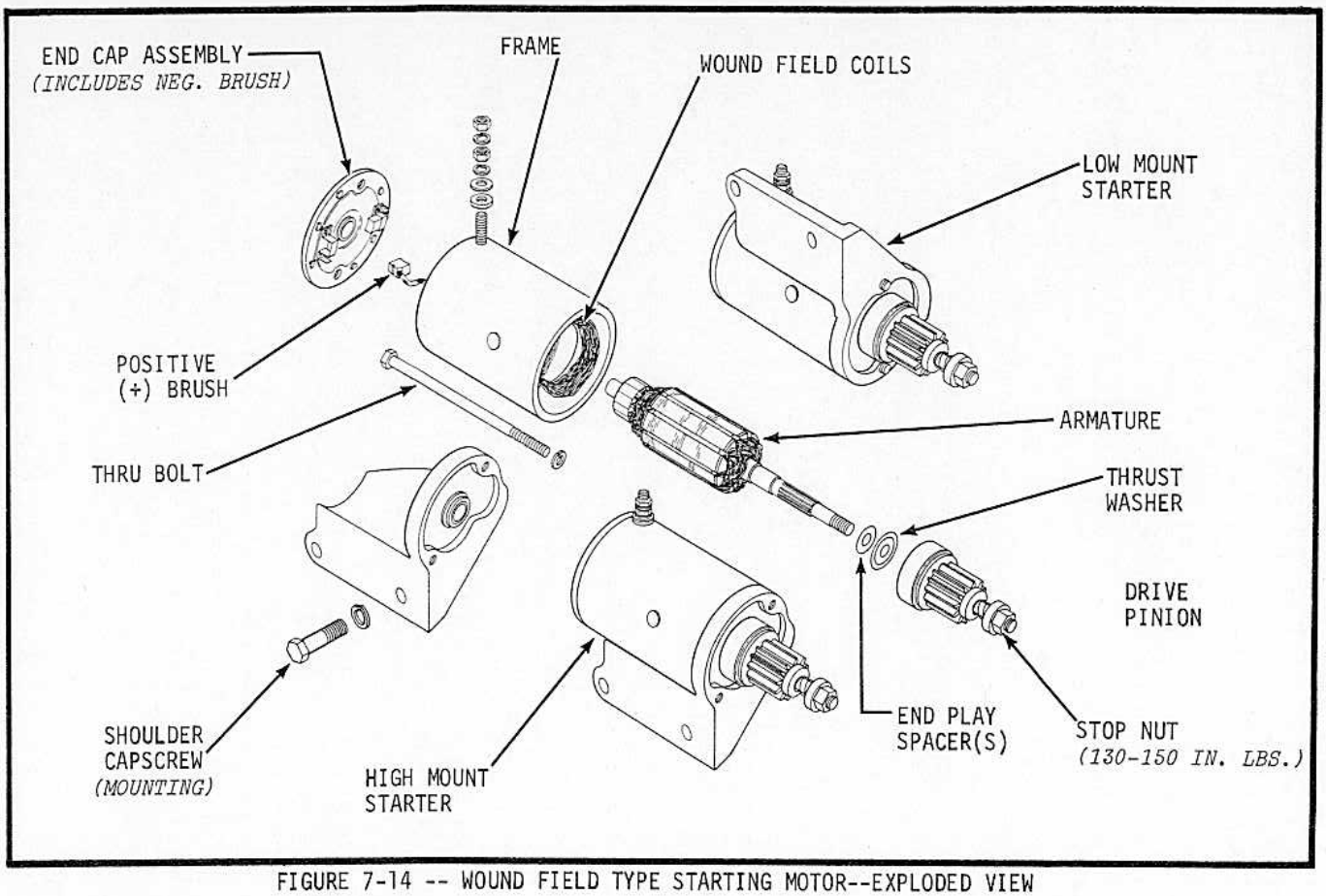


FIGURE 7-14 -- WOUND FIELD TYPE STARTING MOTOR--EXPLODED VIEW

STARTING MOTORS

The motor-generator, which functions as a starting motor when the starting circuit is complete, is described in detail earlier in this section. There are two other general types of starting motors used. One is the wound field type while the other is the permanent magnet (PM) type. The general operation, trouble shooting procedure, and precautionary measures are the same for both types; however, other details differ and the types are therefore described separately.

Operation: On the wound field type 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 the PM starters, the permanent magnets provide this strong field and only a small current is required to turn the armature. When the starting circuit is closed and the armature starts to rotate, the 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 anti-drift 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 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 gears may clash.

● Even though these starters 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. 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.

SERVICE - WOUND FIELD STARTERS

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.

Brush Replacement: Brushes should be replaced if unevenly worn or when worn down to less than 5/16" in length. Brush replacement can be made with a new end cap assembly or with a Brush Kit. The kit contains brushes, springs and attaching parts. The rivet holding the negative brush must be drilled out and the new brush riveted in its place. Make sure good mechanical and electrical contacts are made. The 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 #10 oil--make sure there is no excess of oil to splatter from these parts. Insert positive brush in 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 thru bolts to 40 - 55 inch lb. torque value.

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

SERVICE - PM TYPE STARTERS

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 pinion 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.

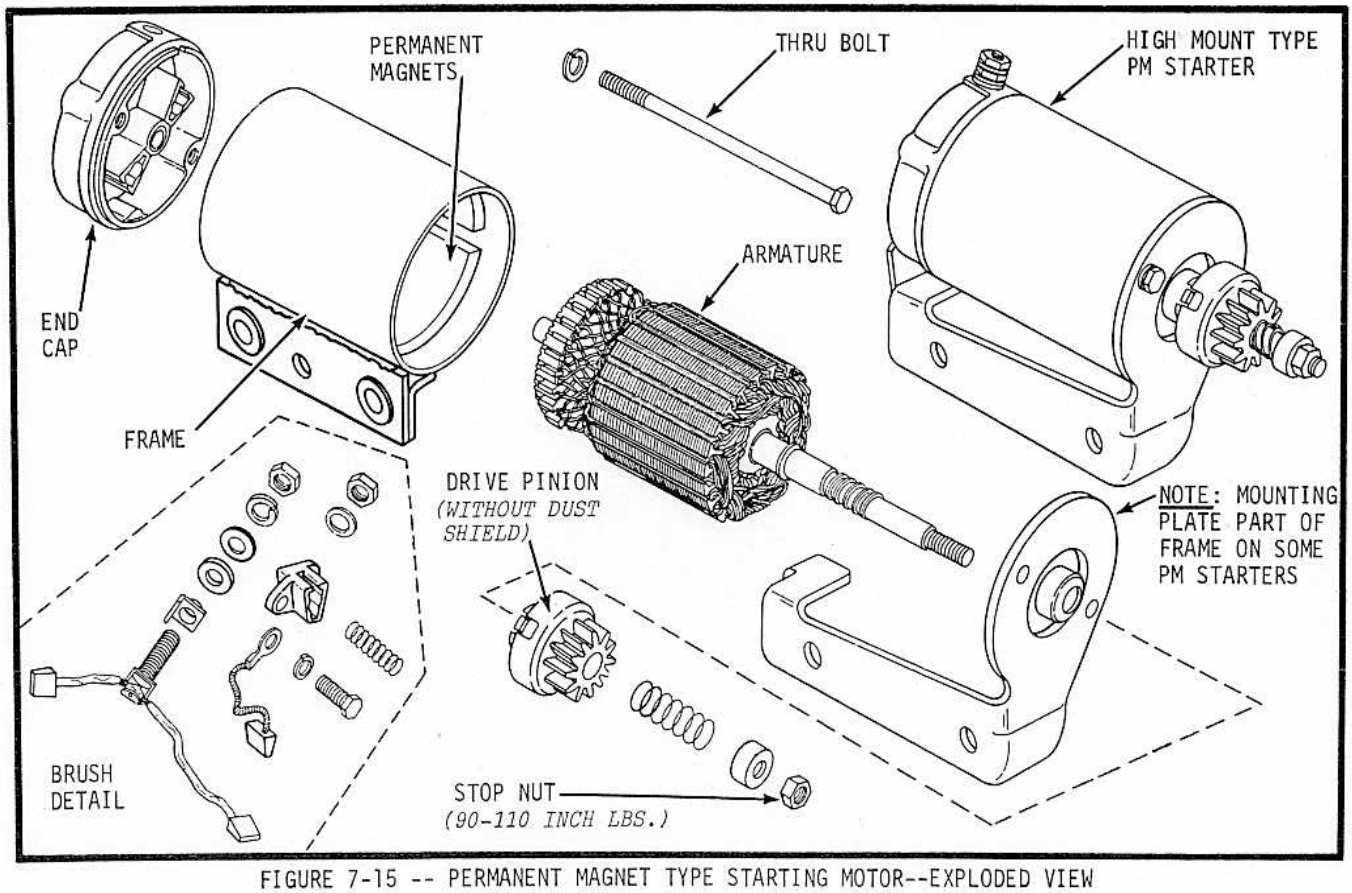


FIGURE 7-15 -- PERMANENT MAGNET TYPE STARTING MOTOR--EXPLODED VIEW

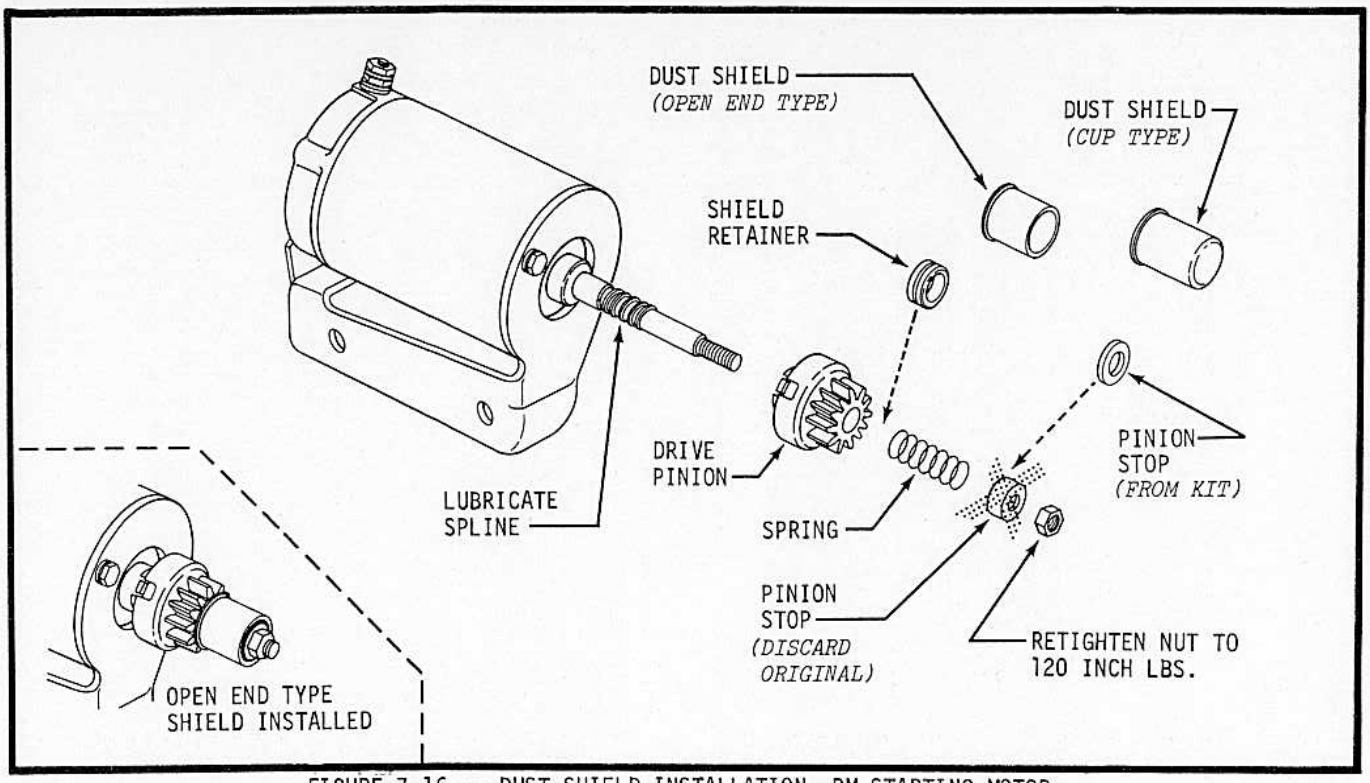


FIGURE 7-16 -- DUST SHIELD INSTALLATION--PM STARTING MOTOR

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 insulated brushes, simply remove capscrew and lock washer. 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, use a brush holder tool as shown which can easily be cut out of thin sheet metal.

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 (unless dust shield is used) as dust may build up here and cause sticking.

DUST SHIELDS: Kits are available for adding dust shields to the permanent magnet type starting motors. The dust shield is recommended for all applications where dust and oil could build up on the drive shaft and cause the drive pinion to stick. When the shield is used, the drive shaft can be lubricated which improves its operation. The kits should also be used to replace dust shields on starters which already have the shield. (Refer to Parts Bulletin #65 for kits).

Each kit includes a new pinion stop, a dust shield retainer and a dust shield. The K181 kit includes a tapered open end type shield while the K241-K321 kit has a cup type shield. The dust shield can be quickly added after the starter is removed from the engine.

1. Remove the drive nut, pinion stop and spring--discard the stop.
2. Thoroughly clean the drive shaft and pinion then apply a small amount of Lubriplate AERO grease (or equivalent) to the shaft.
3. Install the shield retainer next to the drive pinion as shown, install the spring and pinion stop (from kit) then reinstall and tighten the retaining nut to 120 in. lbs. torque.
4. Push the dust shield on until it snaps into position over the shield retainer. This completes the installation.
5. When reinstalling the starter, make sure the shoulder capscrews are used as these establish alignment of the drive pinion to ring gear.

STARTING MOTORS - TROUBLE SHOOTING

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.

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

RING GEAR REPLACEMENT

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 removed from the engine for ring gear replacement.

Several methods may be used to remove the damaged ring gear. One method is to break the gear into sections 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 an oven to about 400° 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.

RETRACTABLE STARTERS

Retractable starters are lubricated during manufacture and should require no further lubrication until disassembly for cord or rewind spring replacement or for other repair.

Frequently check mounting screws to make sure starter is securely tightened on blower housing of engine. If screws are loose, starter realignment may be necessary. Also make sure that air intake screen is maintained in clean condition at all times.

FAIRBANKS-MORSE STARTERS

Starters have die cast aluminum housings. A friction shoe assembly under spring tension is used and engages in the drive cup when the starter handle is pulled. The drive cup is held in place on the engine with the flywheel nut. A pin on the cup is engaged in crankshaft keyway to prevent slippage of the drive cup.

Operation

A. Be sure starter screen is kept clean when operating engine or serious engine damage can result from lack of cooling air.

B. After engine has started, do not allow starter rope to snap back into starter housing. Continue to hold handle and allow starter rope to rewind slowly. Note: Releasing handle when starter rope is extended will shorten life of starter.

C. Do not use starter in a rough manner, such as jerking or pulling starter rope all the way out. A smooth, steady pull will start engine under normal conditions.

D. Always pull starter handle straight out so that rope will not receive excessive wear from friction against guide. Proper procedure will prevent unnecessary wear.

E. If recoil starter should ever fail, starter assembly can be removed and engine cranked with a rope. The starter drive cup will serve as a pulley for emergency purposes.

Disassembly

If starting rope breaks or if starting spring fails, the following procedure should be followed. See Parts Identification Illustration for parts reference numbers. CAUTION: HANDLE REWIND SPRINGS WITH EXTREME CAUTION.

To remove starter from engine, remove 4 blower housing to mounting flange bolts, then move starter to bench for disassembly.

STEP 1 - Loss of parts can be avoided by holding washer #7 in position with thumb while removing retainer ring #6 with a screwdriver (Illus. A).

STEP 2 - Remove washer #7, spring #8, washers #9 & #10 then remove friction shoe assembly (includes parts #11, 12, 13 and 14).

STEP 3 - Model 425 Only - Relieve tension on rewind spring by removing handle then allowing rotor to unwind slowly. Model 475 Only - To prevent rotation, hold rotor #7 (as shown in Illus. B) while removing screws and flanges #3 and #5. Gradually release rotor to allow spring to slowly unwind.

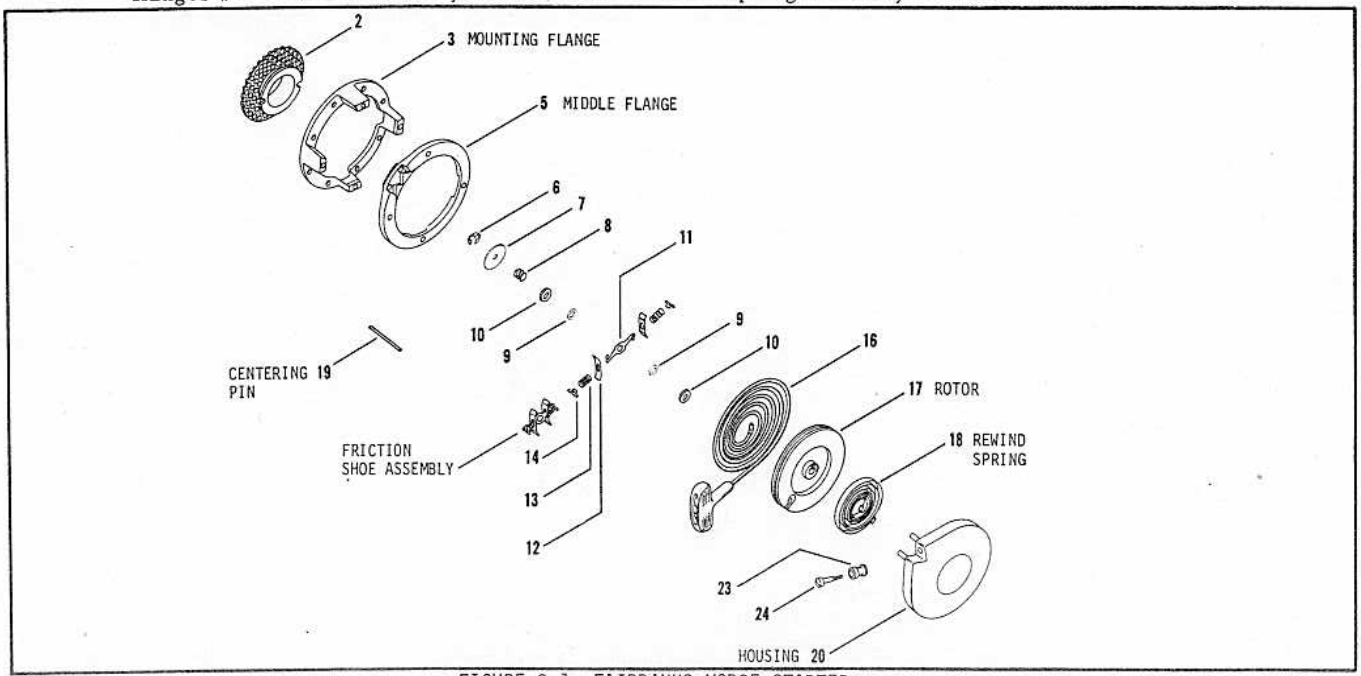


FIGURE 8-1 FAIRBANKS-MORSE STARTER, PARTS IDENTIFICATION

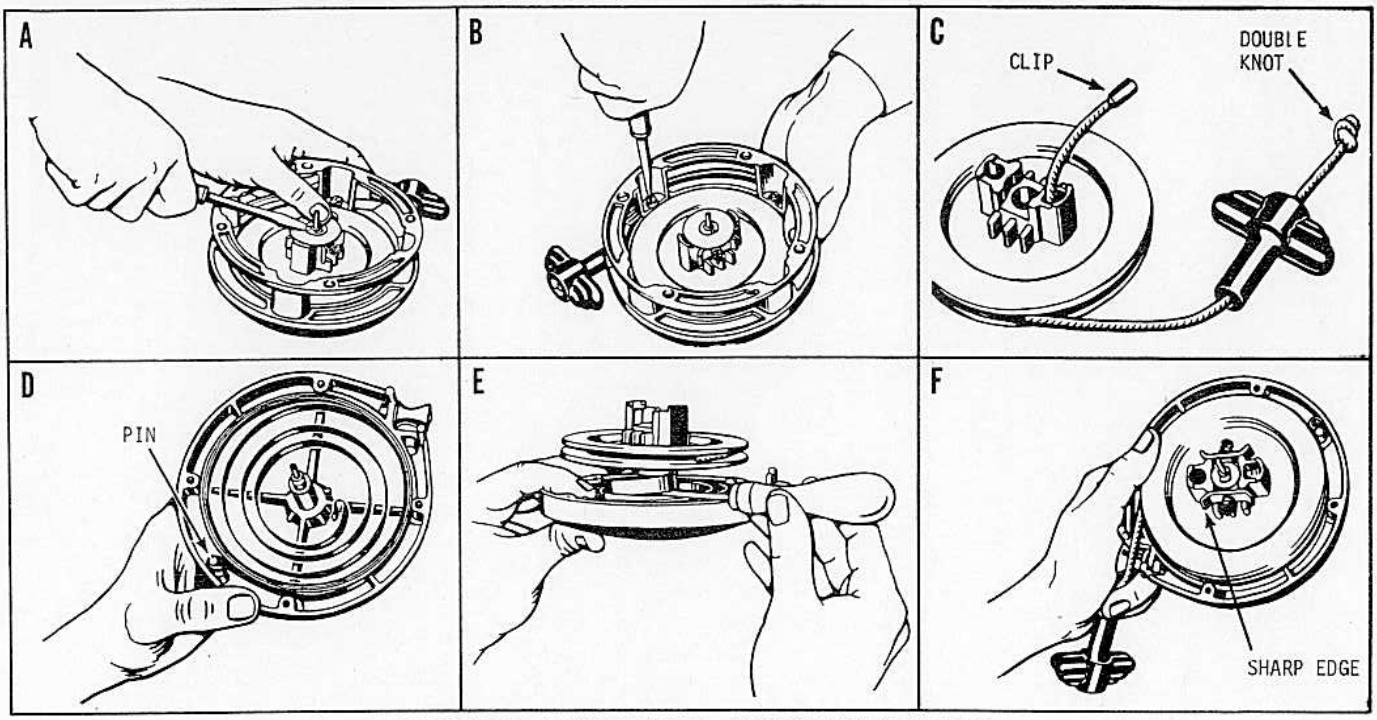


FIGURE 8-2 - RECONDITIONING, FAIRBANKS-MORSE STARTER

STEP 4 - Prevent rewind spring from escaping from cover by carefully lifting rotor about 1/2 inch and detach inside spring loop from rotor. (Note: If spring should escape, it can easily be replaced in cover by coiling in turns.)

Starting Rope Replacement: 1. When installing a new rope #16 in rotor, thread through rotor hole (Illus. C), then wind rope on rotor, as explained in Paragraphs 2 and 4, Assembly. Replace handle and washer, if used, and tie a double knot in the end of the rope.

Rewind Spring Replacement: 1. Start with the inside loop, remove spring carefully from cover by pulling out one loop at a time, holding back rest of turns. When replacing with new spring, note the position of spring loop.
2. Spring holders furnished with replacement springs simplify the assembly procedure. Place spring in proper position as shown, (Illus. D), with the outside loop engaged around the pin. Then press the spring into cover cavity thus releasing the spring holder. A few drops of SAE 20 or 30 oil should then be applied to spring and light grease on cover shaft.

Reassembly

STEP 1 - Model 475 Only - Place rotor (complete with cord and handle) into cover #20 and hook inside loop of spring to rotor with the aid of a screwdriver, (Illus. E).
Model 425 Only - Be sure rope is completely wound in proper rotation on rotor before installing in cover.

STEP 2 - Replace washers #9 & #10, friction shoe assembly, washers #9 & #10, spring #8, washer #7 and retaining ring #6.

STEP 3 - Starter rope is now completely wound on rotor in the direction as shown (Illus. F). IMPORTANT: For pre-tension, Model 475, four additional turns are added in the same direction. For pre-tension, Model 425, rotate rotor five turns with the aid of cord in the direction shown. Thread cord thru slot and replace handle.

STEP 4 - 475 Models Only - Holding rotor in a similar manner as shown in Illus. B, the following parts are replaced.
Flanges (#5 and #3) - Screw (#4)
425 Models Only - Holding rotor in a similar manner as shown in Illus. B, the following parts are replaced.
Flanges (#5 and #3)

STEP 5 - Note: The starter will be damaged if it is not centered properly. To insure the proper centering of the starter, pull out the centering pin #19 about 1/8 of an inch. Place the starter on the four screws, make sure the centering pin engages the centerhole in the crankshaft and press into position. Hold the starter with one hand and place the lockwashers and nuts on the screws and tighten securely.

Reinstalling Starter on Engine:

A. To align starter, place it on the blower housing in the desired position, with the centering pin engaged in the center hole of the crankshaft. (If the centering pin is too short to reach the crankshaft, use a pair of pliers and pull the pin out to the correct length.)

B. Press the starter into position and install the four screws with lock washers and flat washers.

C. Hold the starter assembly in this centered position and securely tighten the four screws.

EATON RETRACTABLE STARTERS

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

Disassembly

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

STEP 2 - Relieve rewind spring tension as follows:
a. Pull rope handle out about 8 inches - tie knot in rope to prevent rope from being pulled into housing.
b. Insert screwdriver blade under rope retainer on handle, slip rope out of retainer and untie knot at handle.
c. Hold pulley - sheave with thumb to prevent rewind spring from unwinding rapidly, then untie other knot and slowly allow spring to unwind.

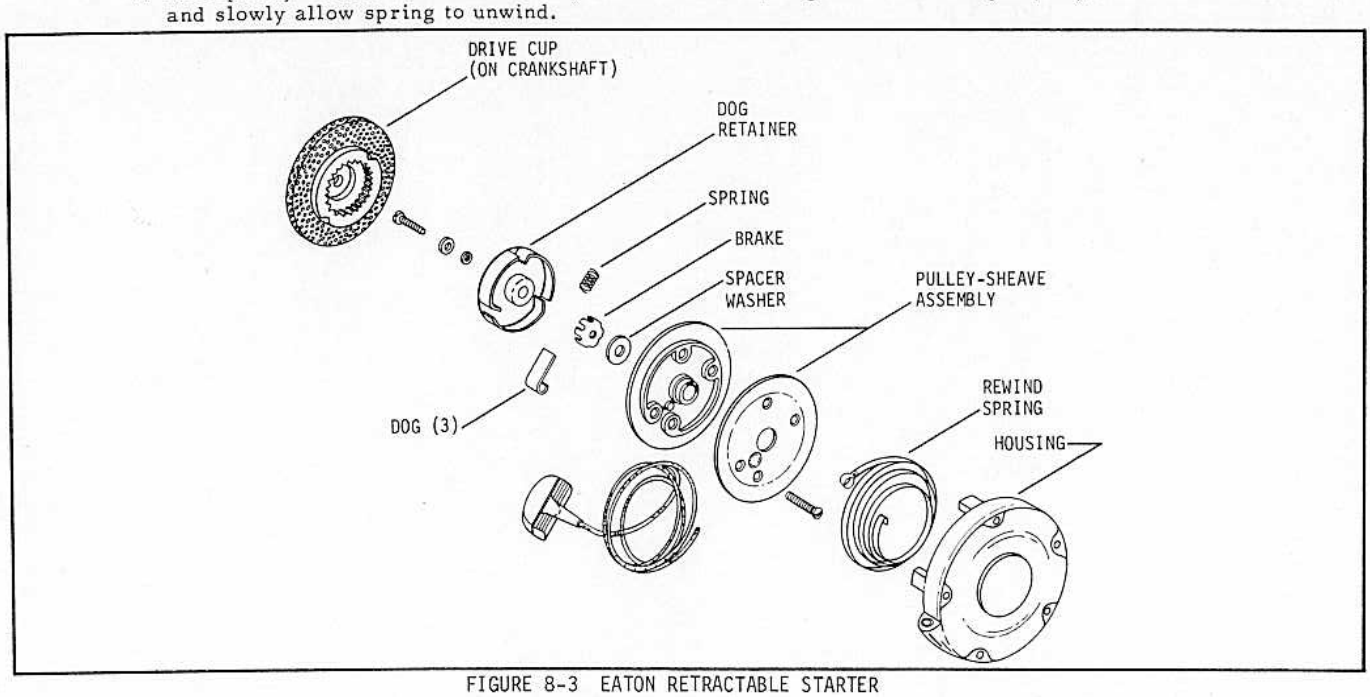


FIGURE 8-3 EATON RETRACTABLE STARTER

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

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

STEP 5 - Rewind Spring Replacement (omit Step 5 if rewind spring replacement unnecessary)
a. Carefully remove rewind spring -- start on inside loop, pull one loop out at a time.
b. Place new spring in housing, then, after blocking spring to prevent lateral movement, carefully remove retaining clip and tape if used -- tape must be cut and removed in segments -- do not peel from spring.

Reassembly

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

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

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

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

ROPE REPLACEMENT - ALIGNMENT

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

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

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

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

ENGINE-GENERAL SERVICE

COOLING

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

EXTERNAL SURFACES

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

ENGINE STORAGE

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

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

ENGINE TESTS

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

A. Clogged Crankcase Breather can cause positive pressures to build up in the crankcase. Disassemble breather assembly, thoroughly clean, then recheck pressure after re-installing.

B. Worn oil seals can cause lack of vacuum. Oil leakage is usually evident around worn oil seals. (See Oil Seal Replacement Instructions)

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

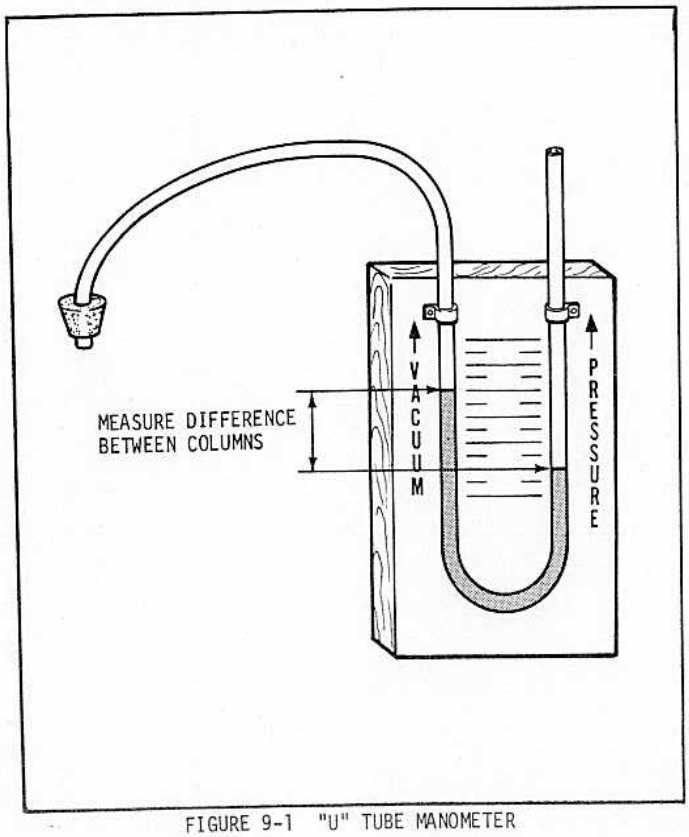


FIGURE 9-1 "U" TUBE MANOMETER

Construction - "U" Tube Manometer

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

(a) Procure length of clear plastic tubing. Bend tube to form "U" and mount on board as shown in accompanying illustration. Make gradual, rather than sharp bend in tube.

(b) Measure inside, straight section of tube and mark inch increments from 0 to 12".

(c) Procure cork having outside diameter which will be a snug fit in the oil fill hole. Drill hole in center of cork to receive one end of tube.

(d) Pour water (colored for easier reading) into tube until level reaches the approximate halfway mark on scale.

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

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

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

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

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

Since ACR engines release compression at speeds lower than 650 RPM, the compression test procedure for these engines is different than for the Model K91 and other pre-ACR engines.

METHOD 1 - SPOT CHECK (WITHOUT GAUGE)

A. Remove high tension lead from the spark plug.

B. Spin flywheel against compression - (clockwise direction) on pre-ACR and Model K91 engines. Piston should bounce backward with considerable force. Pull piston over Top Dead Center (TDC) - considerable resistance should be felt as piston approaches TDC. After piston reaches TDC, it should snap downward on the power stroke.

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

METHOD 2 - COMPRESSION GAUGE TEST

A. Remove spark plug and insert compression gauge in hole.

B. Engine will have to be motored to a speed of about 1000 RPM. Hold throttle wide open and take several compression readings. Consistant readings of 110 to 120 psi indicate good compression.

INSPECTION-DISASSEMBLY

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

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

Sludge is a natural by-product of combustion and a small accumulation is normal. Excessive sludge formation could indicate several things. The most common cause is perhaps too infrequent lubricating oil 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.

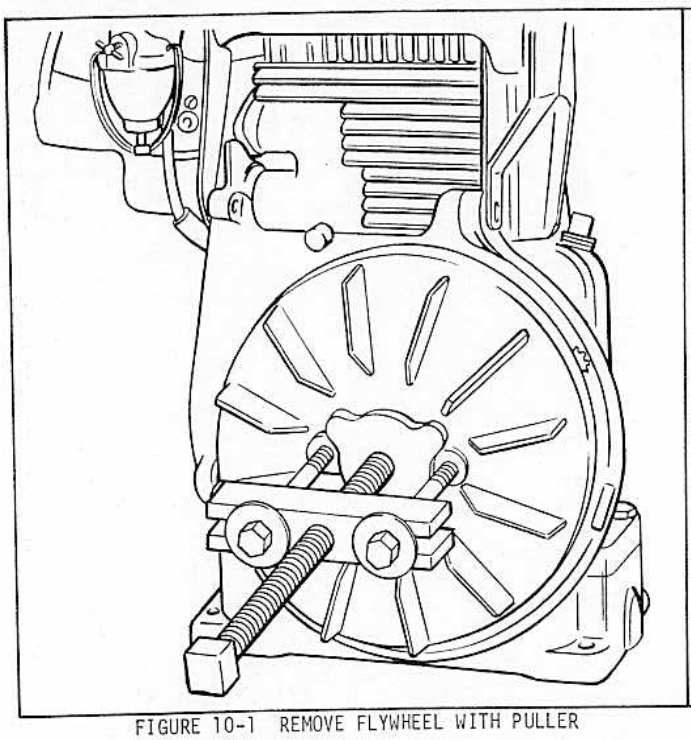


FIGURE 10-1 REMOVE FLYWHEEL WITH PULLER

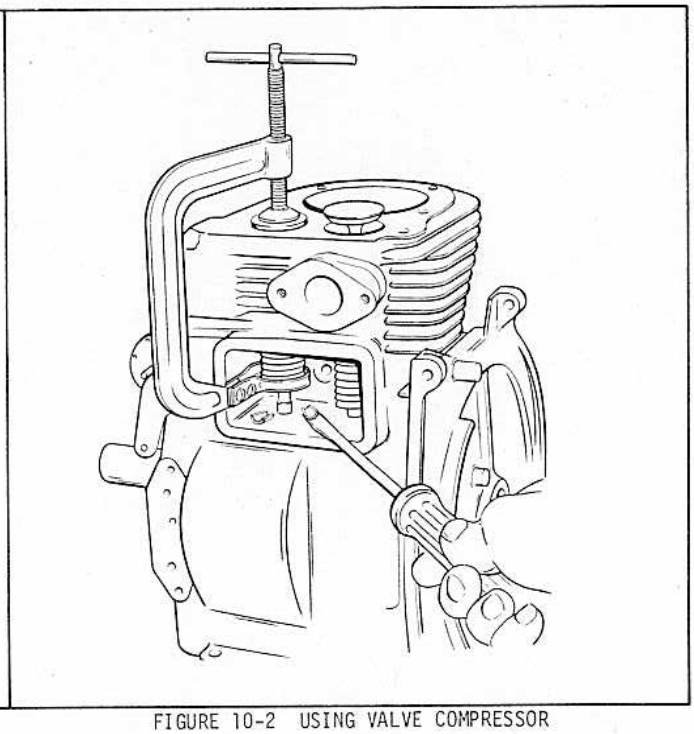


FIGURE 10-2 USING VALVE COMPRESSOR

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.

REPAIR - REPLACEMENT METHODS

There are several different methods to choose when repairing a failed single cylinder engine. If you have complete shop facilities to rebore cylinders and regrind crankshafts, you may choose to completely overhaul the engine using appropriate oversize and/or undersize replacement parts. If the bore, piston, connecting rod are damaged but the crankshaft and all other parts are in good condition, the miniblock may be the best repair method. When an engine, including crankshaft, is extensively damaged or badly worn internally, a short block could be used.

If an engine is in bad shape, both internally and externally, consider replacing it with a Universal Service Engine or a basic catalog engine if available for the engine spec involved. These repair and replacement methods are described briefly in the following.

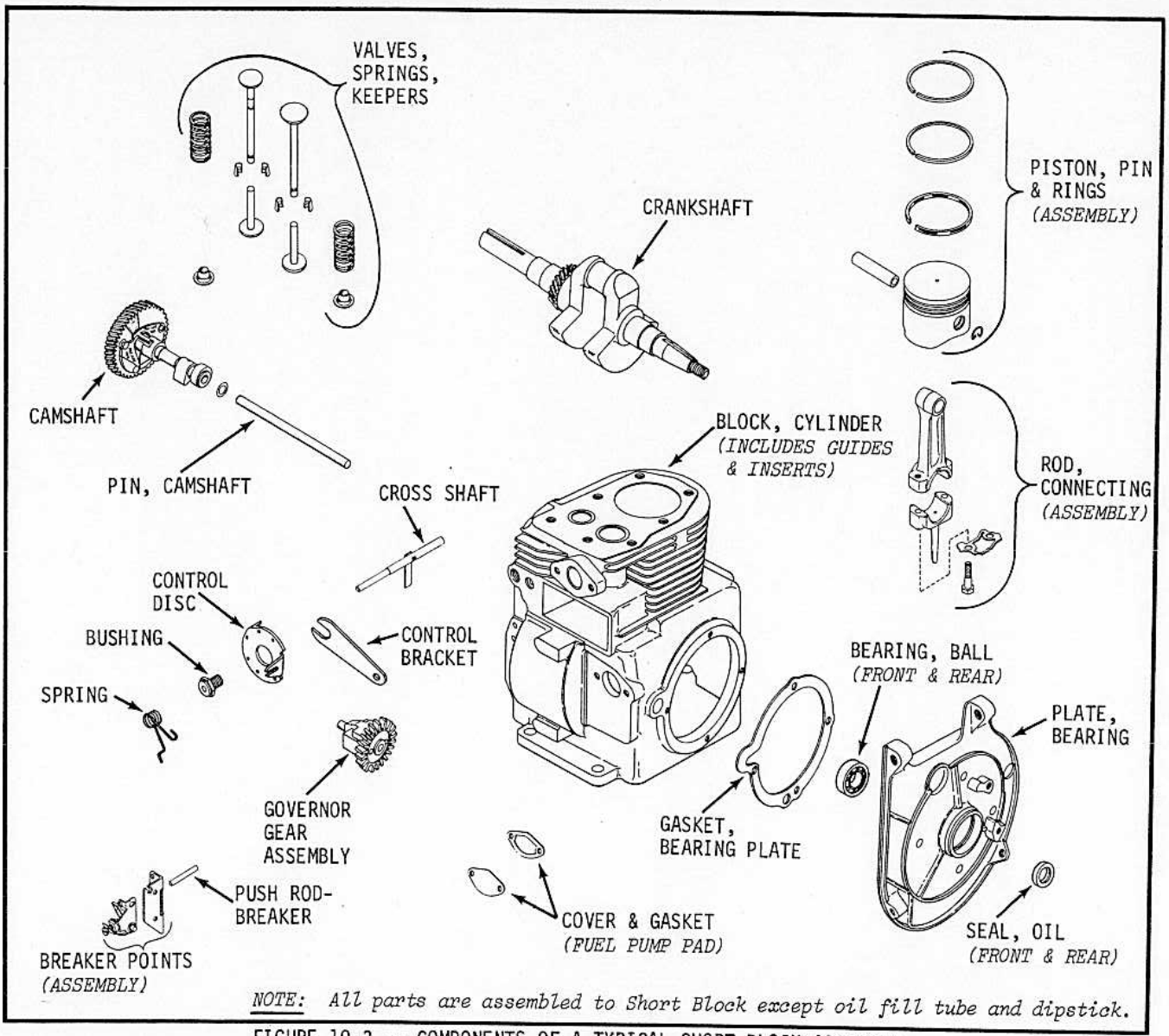


FIGURE 10-3 -- COMPONENTS OF A TYPICAL SHORT BLOCK ASSEMBLY

SHORT BLOCK: Each short block includes a crankcase with all internal parts, such as, valve mechanism, camshaft, piston-rod assembly, crankshaft and bearing plate installed--all other items must either be transferred from the damaged engine or taken from stock to build the short block up to a complete unit. Parts included with each short block are shown in the accompanying illustration.

MINIBLOCK: A miniblock could be considered as a "crankless" short block since it has the same items except that the crankshaft and bearing plate assembly are omitted. Omitting these items not only reduces costs but allows the miniblock to be used in place of a short block in cases where the short block crankshaft is not suitable for the particular application. The crankcase-bearing plate assembly must be in condition to be reused on the miniblock.

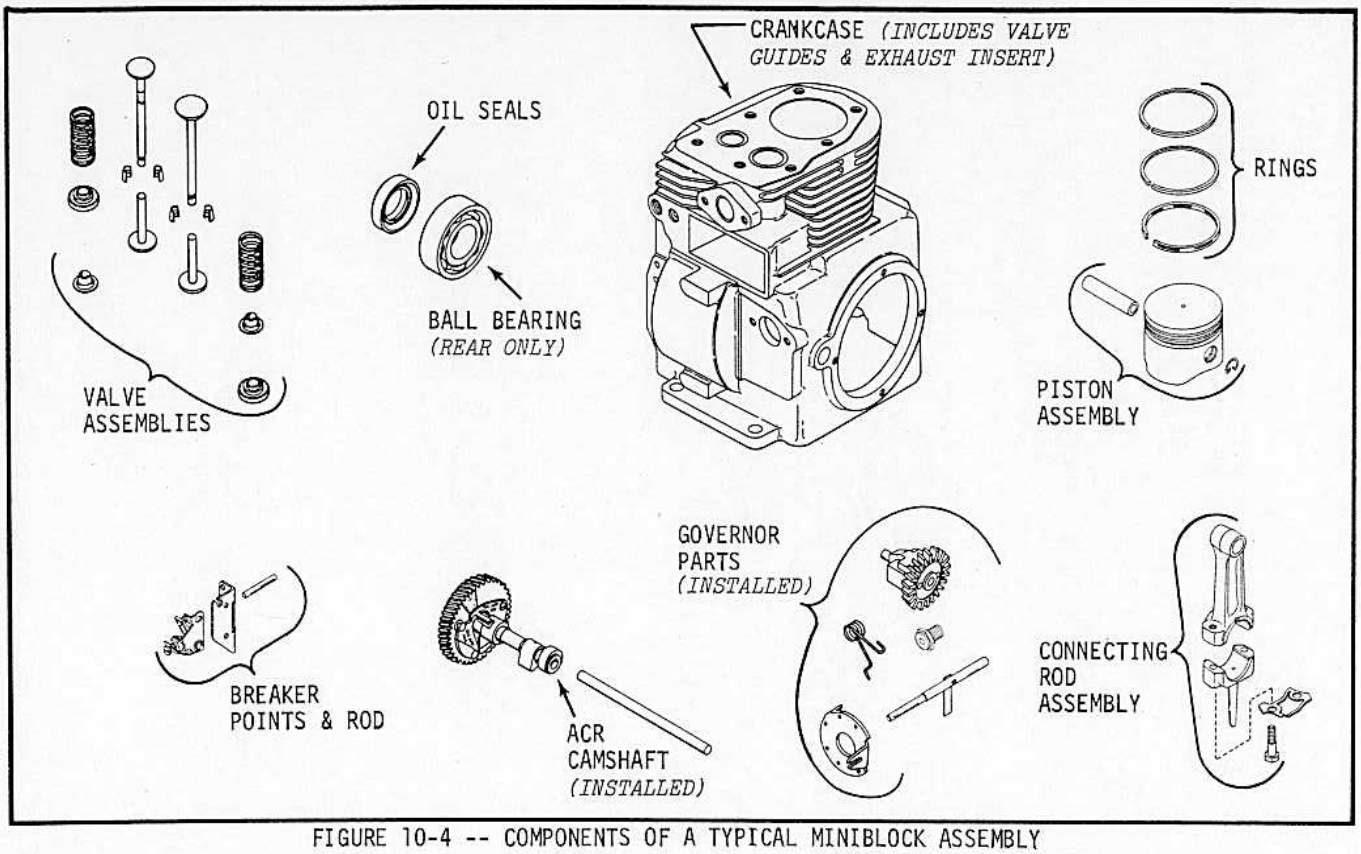


FIGURE 10-4 -- COMPONENTS OF A TYPICAL MINIBLOCK ASSEMBLY

UNIVERSAL SERVICE ENGINES: These are complete engines less such items as fuel tank, starting motor or motor generator. These items may be transferred from the failed engine or added using service kits. The basic catalog engines are complete units built to specifications including fuel tank starters, reduction gears or whatever is called for under the particular specification. Basic catalog engines are available only for certain specification numbers.

ORDERING CORRECT ASSEMBLY

Miniblocks, short blocks and Universal Service Engines are listed by variation number, when available, for the engine spec involved in the Specification Number Index of the parts manual. Miniblocks and short blocks are offered as repair aids while the Universal Service Engines are for complete replacement of failed engines. Basic (catalog) engines are also indicated in the index where available.

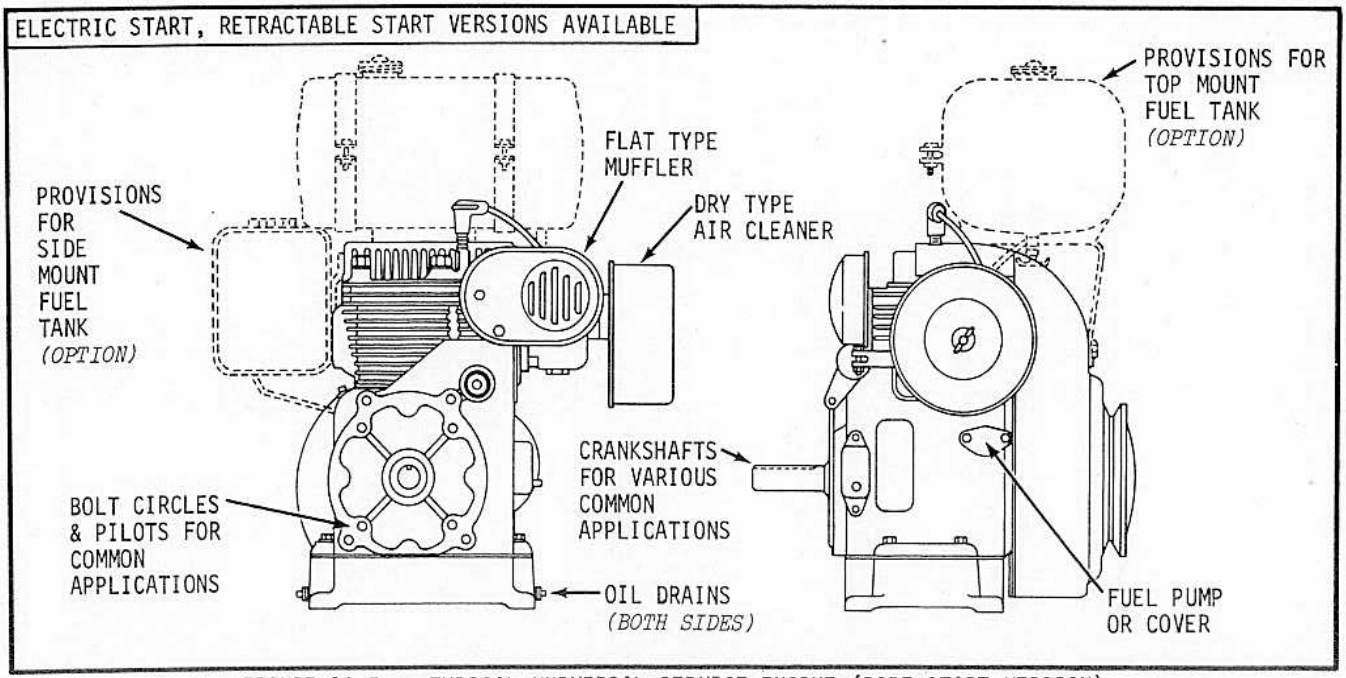


FIGURE 10-5 -- TYPICAL UNIVERSAL SERVICE ENGINE (ROPE START VERSION)

DISASSEMBLY PROCEDURE

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

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

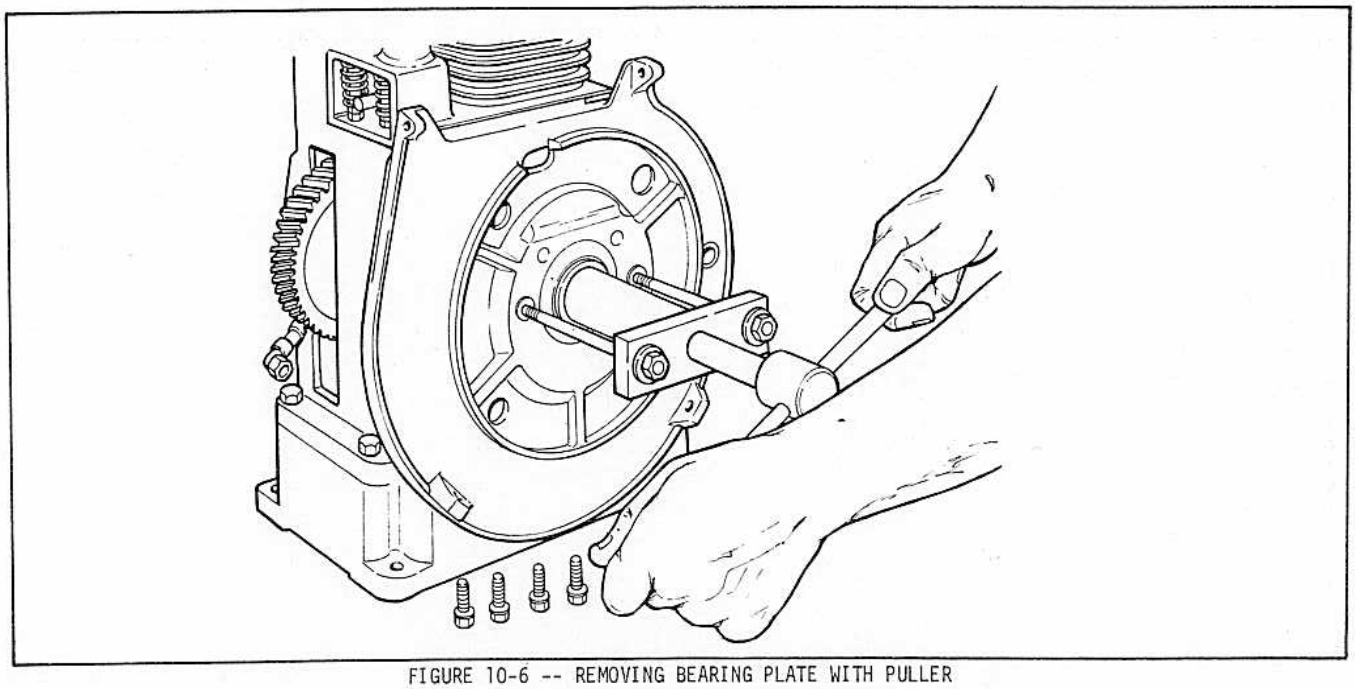


FIGURE 10-6 -- REMOVING BEARING PLATE WITH PULLER

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.

CYLINDER BLOCK

1. INSPECTION

   A. Gasket surfaces - Check all surfaces to make sure that they are free of gasket fragments and sealer materials. Surfaces must also be free of deep scratches or nicks.

   B. Bearings - (Crankshaft) - One bearing is pressed into the cylinder block--the other is located in the bearing plate. Do not remove bearings unless they show signs of damage and are to be replaced. (See Reconditioning - Cylinder Block.) If the bearings turn easily and noiselessly and there is no evidence of scoring or grooving on the races, the bearings can be reused.

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

      B1 - Lower hone into bore and after centering, adjust so that stones are in contact with walls. Diesel fuel oil or kerosene can be applied to the stones as a cutting-cooling agent.

      B2 - With the lower edge of each stone positioned even with the lowest edge of the bore, start drill and honing process. Move hone up and down while reboring to prevent formation of cutting ridges. Check size frequently.

      B3 - When bore is within .0025 of desired size, remove coarse stones and replace with burnishing stones. Continue with burnishing stones until within .0005 of desired size then use finish stones and polish to final size.

      B4 - After reboring, carefully clean cylinder wall with soap and water, then after drying thoroughly, apply light coat of SAE 10 oil to prevent rust.

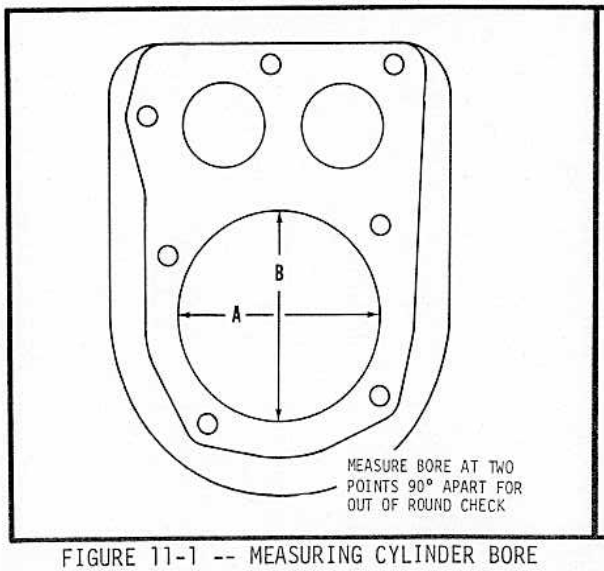


FIGURE 11-1 -- MEASURING CYLINDER BORE

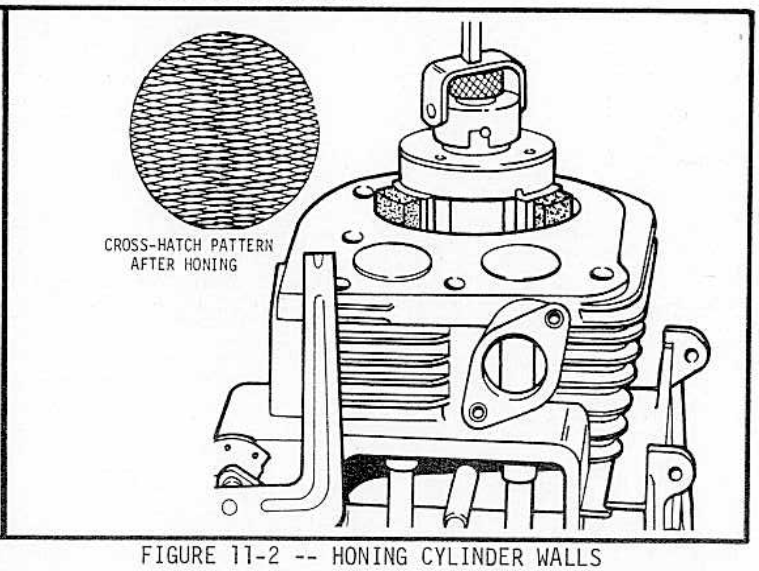


FIGURE 11-2 -- HONING CYLINDER WALLS

CRANKSHAFT

1. Keyways--Gears - If keyways for flywheel are badly worn or chipped, replacement of the crankshaft may be necessary. Broken or badly worn cam 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. If wear is moderate, the .010" undersize connecting rod (big end) must then be used to achieve proper running clearance.

CONNECTING ROD

1. Check bearing area (big end) for excessive wear, score marks, running and side clearance. Replace rod and cap if worn beyond limits stated.

2. Connecting rods with bearing area .010" undersize are available for use with reground crankpin.

PISTON — PISTON RINGS

Production type and service type ring replacement sets are available in the standard size plus .010", .020" and .030" oversize sets. The production standard type set is used only when cylinder is not worn or out of round. Production oversize sets are used only when cylinder has been rebored to the corresponding oversize. Service type sets are used when cylinder is worn but within wear and out of round limits (wear limit .005" oversize, out of round limit .004"). Service sets usually include expanders or other arrangement to provide uniform pressure on ring and better conformity to cylinder wall regardless of wear. Cylinder bore must be deglazed before service ring sets are used. Chrome plated rings, when used, should be installed in the top groove.

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

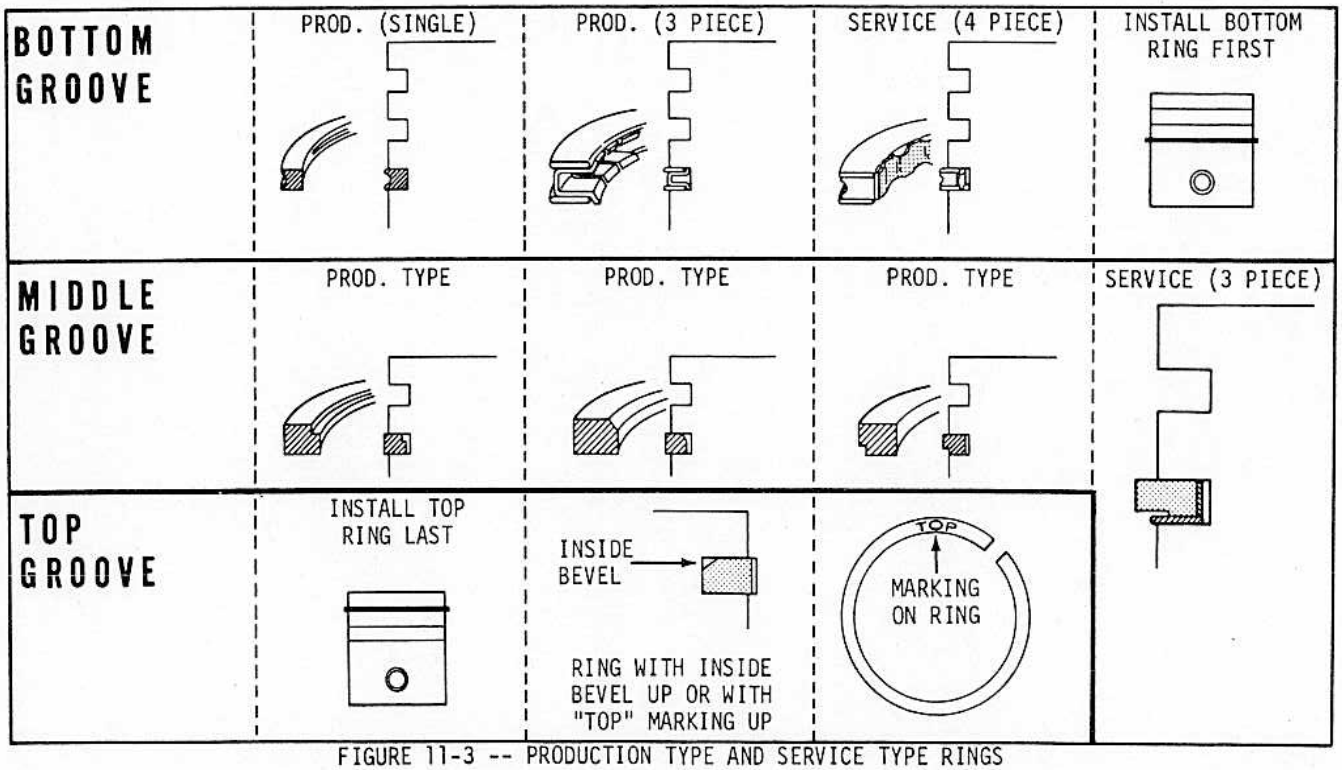


FIGURE 11-3 -- PRODUCTION TYPE AND SERVICE TYPE RINGS

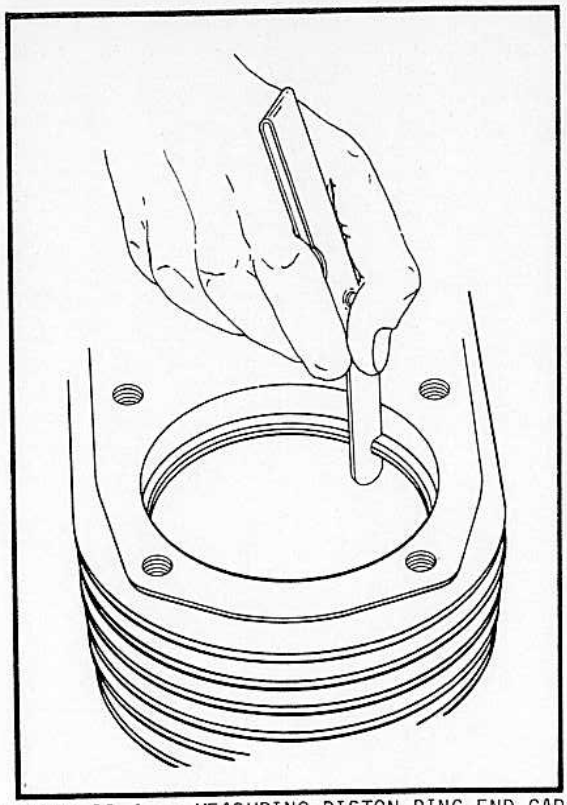


FIGURE 11-4 -- MEASURING PISTON RING END GAP

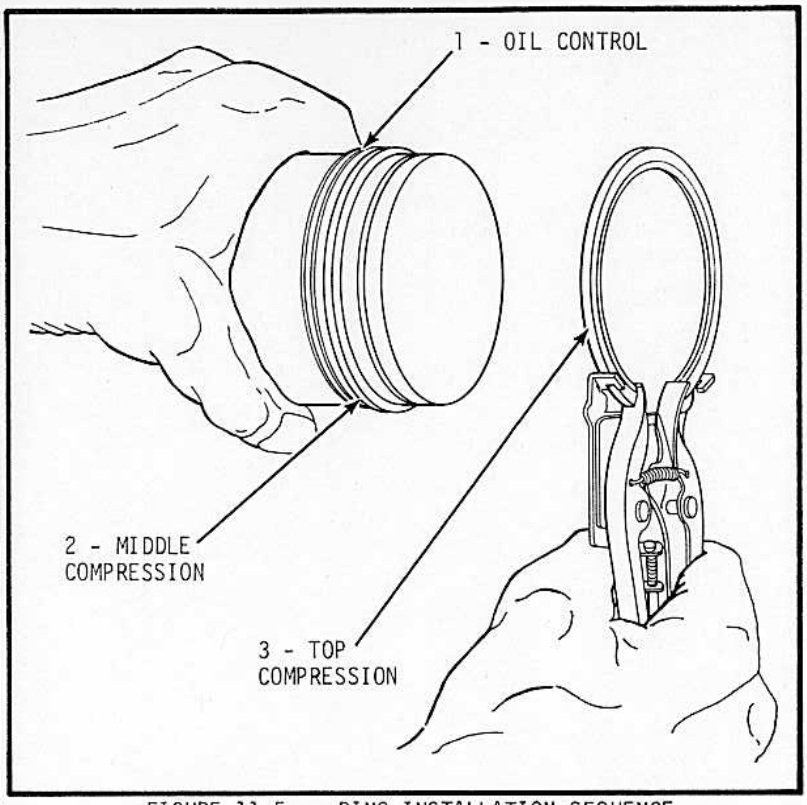


FIGURE 11-5 -- RING INSTALLATION SEQUENCE

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. 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, lubricate pin then 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--refer to page 15.4 for valve details.

Guides: Guides must be replaced if worn sufficiently to allow valve stem-guide clearance to exceed limits stated in the Wear Tolerance Chart on page 15.4. Valve guides are not used on K91 models. To remove, press guide 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 specified then use a valve guide reamer and ream new guide to specified I.D.--refer to page 15.4 for valve guide details.

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

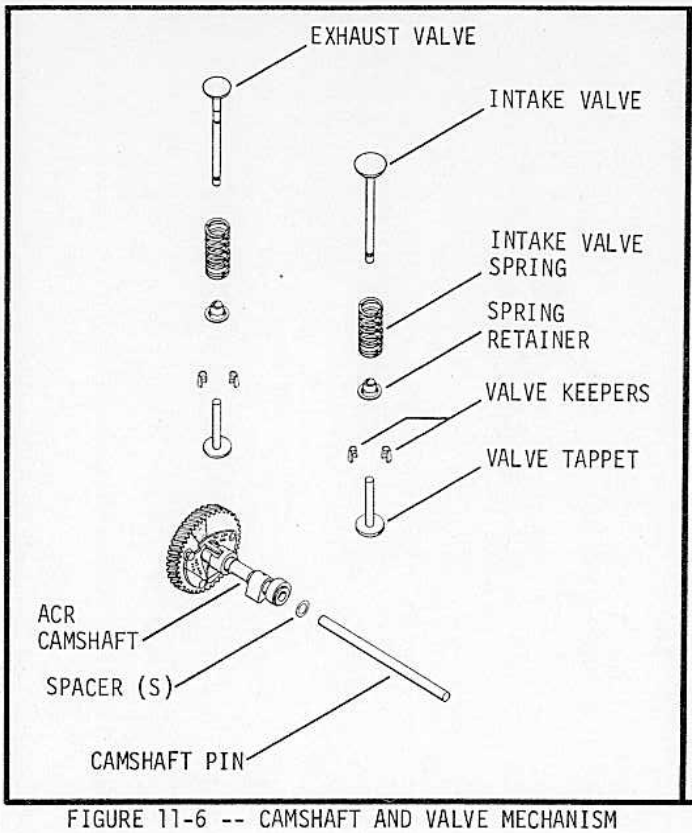


FIGURE 11-6 -- CAMSHAFT AND VALVE MECHANISM

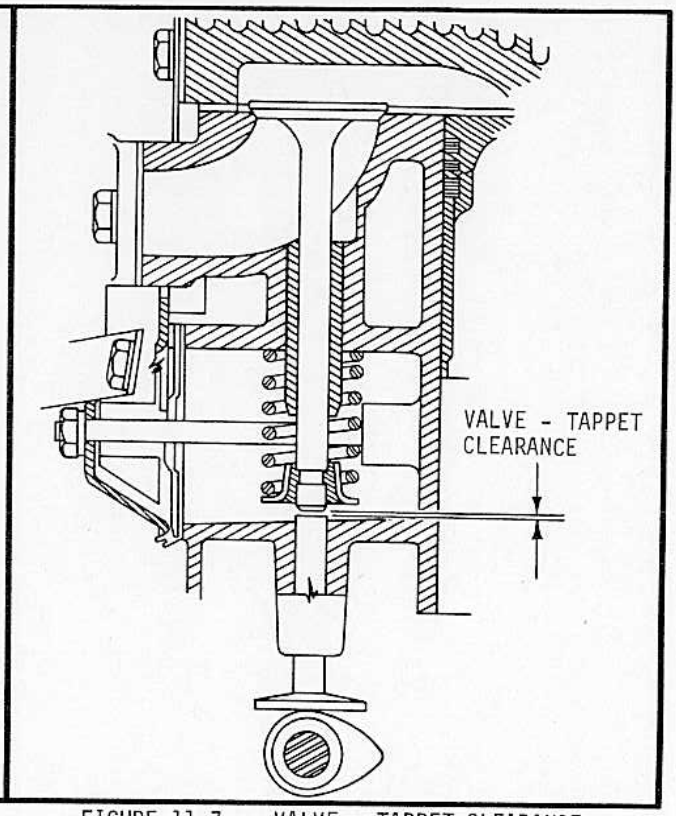


FIGURE 11-7 -- VALVE - TAPPET CLEARANCE

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). If clearance is insufficient, it will be necessary on all engines except K241, K301 and K321 to grind end of valve stem until correct clearance is attained. Make sure stem is ground perfectly flat.

Adjustable tappets are used on the K241, K301 and K321 engines. On these models, loosen the locking nut, turn adjusting nut in or out until proper clearance is attained then securely tighten locknut.

CYLINDER HEAD

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

RING GEAR (Electric Start Engines Only)

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

Dynamic Balance is found in specific versions of the K241 and K301 models and is standard on the K321 engines. This 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 washers are used to control end play. The gears are driven off the crankgear in the direction opposite to rotation of the crankshaft.

When working on Dynamic Balance models, care must be exercised to 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 Dynamic Balance components.

1. Stub Shaft: If new shafts are required, remove old shafts and press new shafts into block until they protrude .691" above the surface of the boss.

2. Balance Gear: Slip one .010" spacer on stub shaft then install gear-bearing assembly on stub shaft (with timing marks out)--if assembly tool is not being used, 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.

TIMING - WITH ASSEMBLY TOOL

Assembly tool Y-357 simplifies procedure for timing balance gears to crankshaft. Retiming is necessary whenever the crankshaft is reinstalled. Refer to illustration 11-8 for timing marks.

STEP 1: Turn both balance gears so that primary timing marks line up with teeth on tool, then insert tool in mesh with gears.

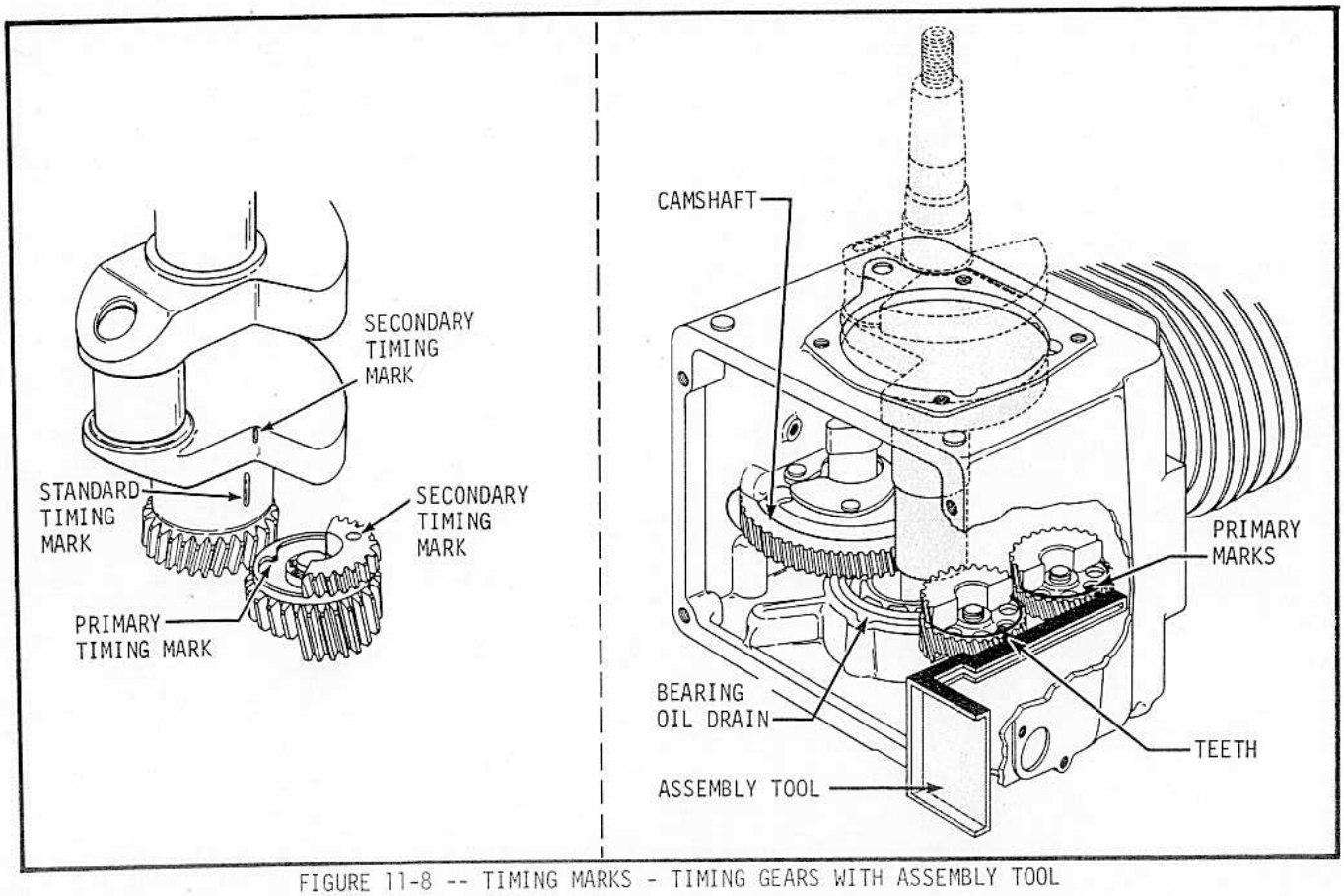


FIGURE 11-8 -- TIMING MARKS - TIMING GEARS WITH ASSEMBLY TOOL

STEP 2: Hold gears with tool butted against gasket surface, align standard marks on crankshaft with bearing oil drain hole, then lower shaft until crankgear is just started into mesh (about 1/16") in balance gears.

STEP 3: Remove tool, align crankshaft - camshaft timing marks then press crankshaft all the way into crankcase.

STEP 4: As a final check, turn crankshaft to see if standard timing mark on crankshaft lines up with the secondary timing mark on the bottom balance gear--if these marks cannot be lined up, timing is off and must be corrected.

TIMING - WITHOUT TOOL

If the assembly tool is not available, use the following procedure to time the balance gears to the engine.

STEP 1: 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.

STEP 2: 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.

REASSEMBLY

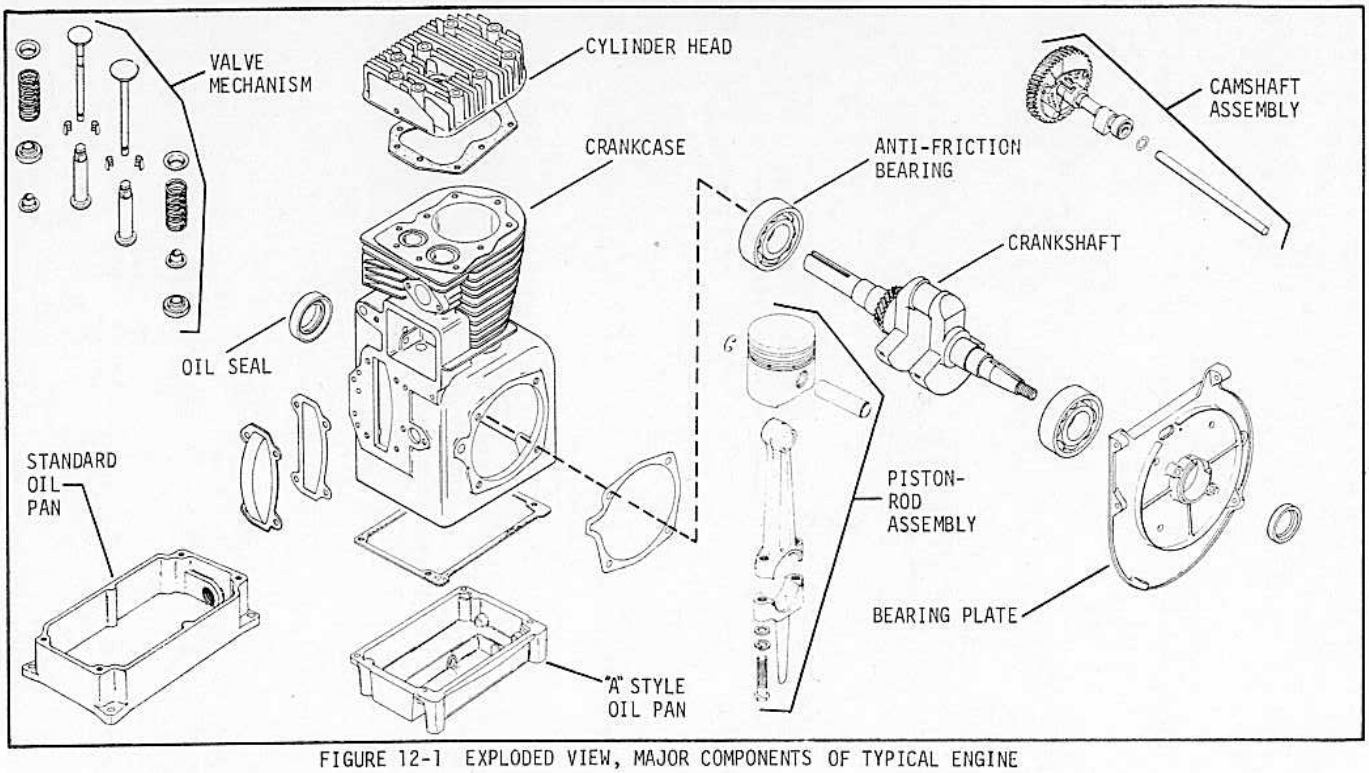


FIGURE 12-1 EXPLODED VIEW, MAJOR COMPONENTS OF TYPICAL ENGINE

1. Rear Main Bearing
   a. Install rear main bearing by pressing it into cylinder block with shielded side facing toward inside of block--if using unshielded type bearing, either side can face inside.

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 or bushing on later models 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. Place speed control disc on governor bushing nut and thread bushing nut into block, clamping throttle bracket into place.
   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.

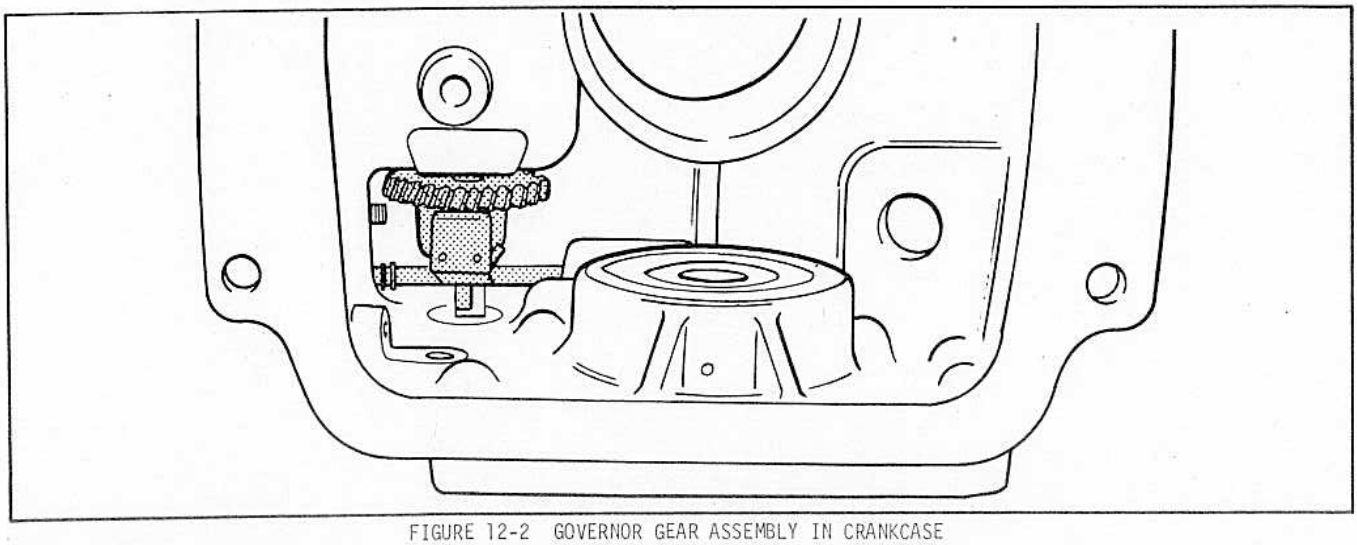


FIGURE 12-2 GOVERNOR GEAR ASSEMBLY IN CRANKCASE

4. Camshaft Installation

a. Turn cylinder block upside down.

b. Tappets must be installed before camshaft is placed. Lubricate and insert tappets in valve guides -- on K141, K161, K181 ACR engines make sure shorter tappet is installed in exhaust valve guide. Intake and exhaust tappets are interchangeable on other models.

c. Position camshaft inside block. Note: On pre-ACR models with the automatic spark advance camshaft, spread actuators and insert cam -- align timing marks on cam and on gear as shown in Figure 12-5.

d. Lubricate rod then insert into block (bearing plate side). Before pushing rod through camshaft, slip one .005" washer (end play) between end of camshaft (opposite gear end) and block. Push rod through camshaft and tap lightly until rod just starts into bore at P. T. O. end of block. Check end play with feeler gauge -- if within tolerance press rod into final position or remove rod and add (or subtract) .005 and .010" thick washers as necessary to attain proper end play (See Fits and Clearance Section).

e. While rod is a tight press fit at P. T. O. end of block, a light to loose fit is necessary at the bearing plate end. New bearing plate gaskets have notch to allow any oil that may leak past to drain back into block. If gasket is not notched, apply gasket sealer around end of rod (outside block) to seal when bearing plate and gaskets are installed.

5. Crankshaft Installation

a. Place block on base of arbor press and carefully insert tapered end of crankshaft through inner race of antifriction bearing (or sleeve bearing on K141).

b. Turn crankshaft and camshaft until timing mark on shoulder of crankshaft lines up with mark (dot) on cam gear as shown in Figure 12-6.

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.

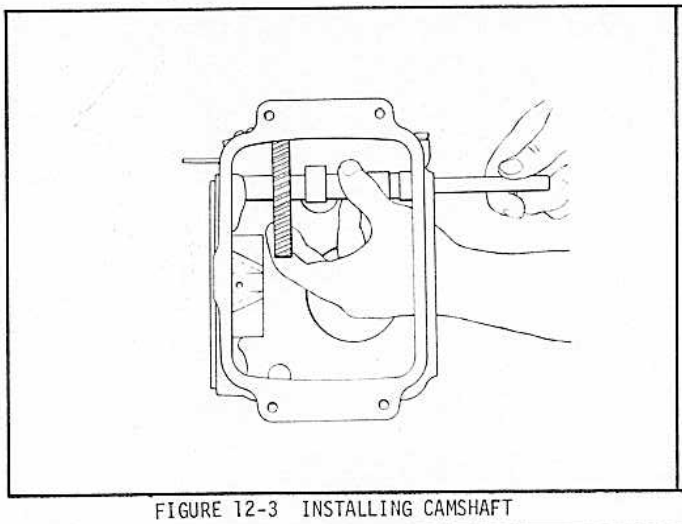


FIGURE 12-3 INSTALLING CAMSHAFT

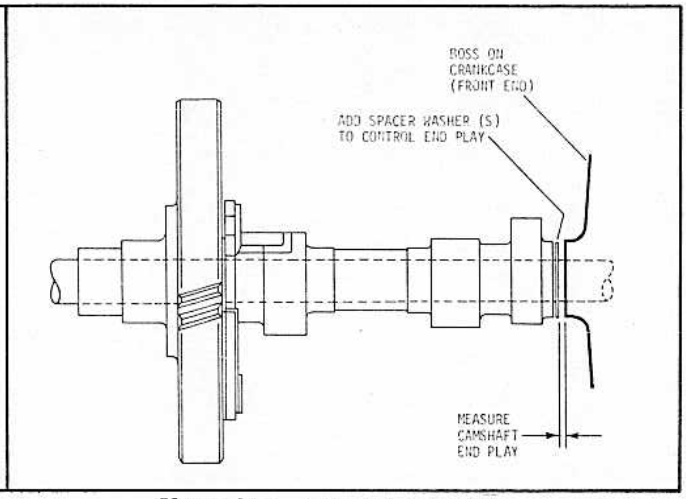


FIGURE 12-4 CAMSHAFT END PLAY

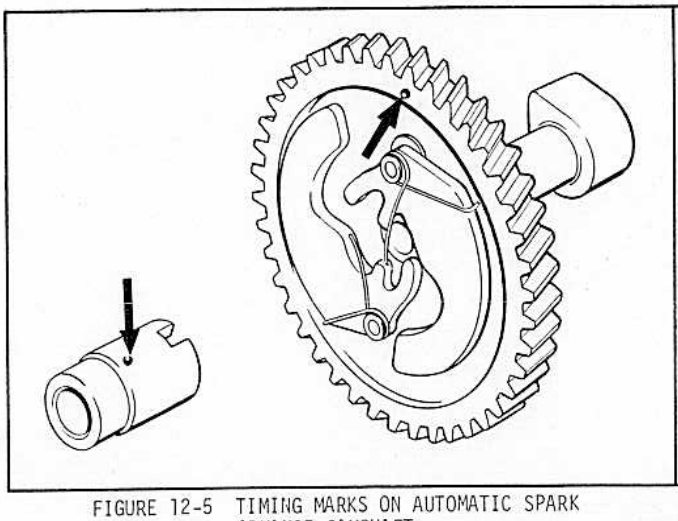


FIGURE 12-5 TIMING MARKS ON AUTOMATIC SPARK ADVANCE CAMSHAFT

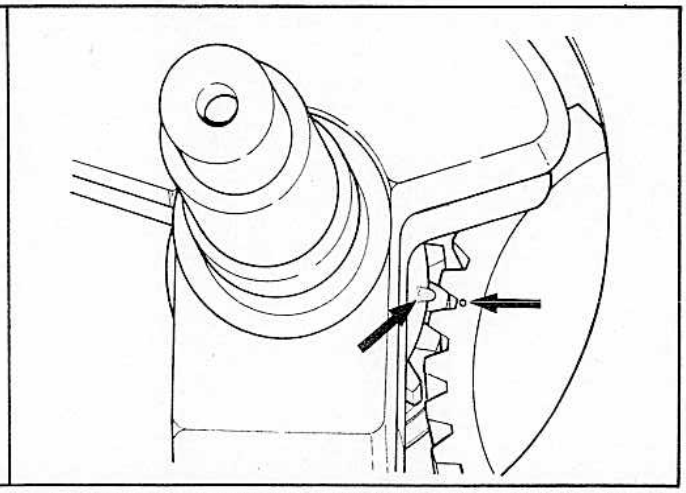


FIGURE 12-6 TIMING MARKS ON CRANKSHAFT AND CAMSHAFT

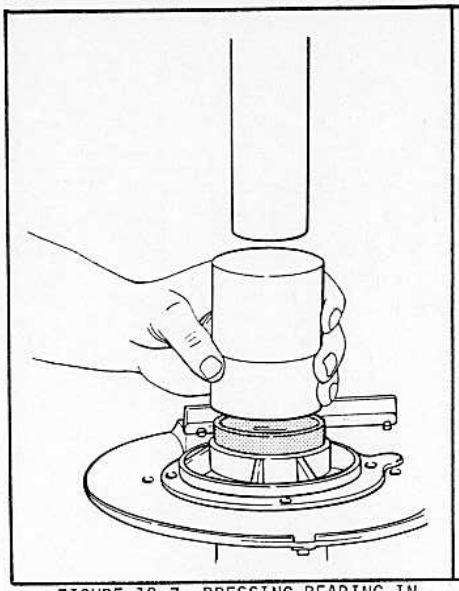


FIGURE 12-7 PRESSING BEARING IN BEARING PLATE

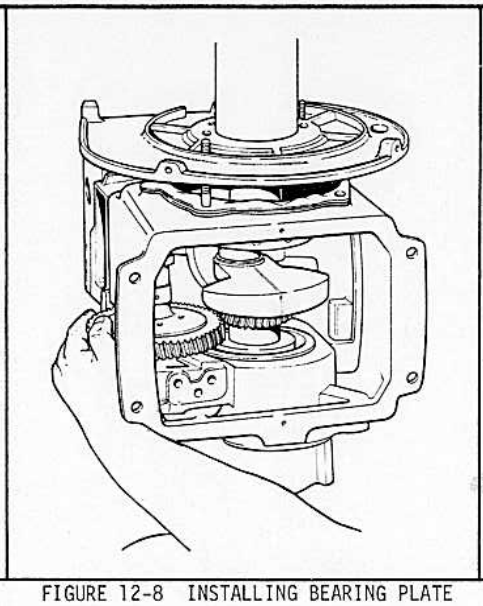


FIGURE 12-8 INSTALLING BEARING PLATE

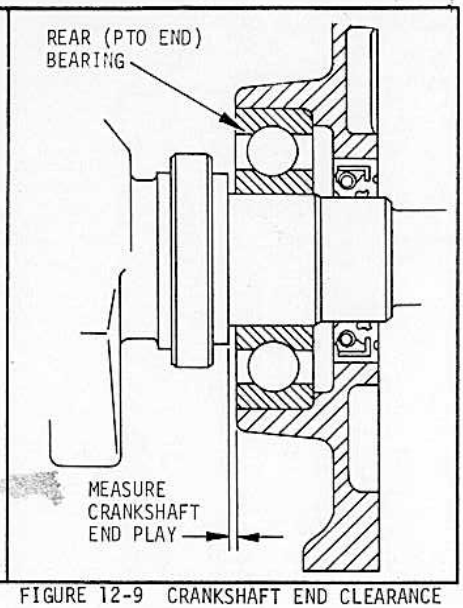


FIGURE 12-9 CRANKSHAFT END CLEARANCE

6. Bearing Plate

a. Press front main bearing 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.
NOTE: Crankshaft end play is especially critical on gear reduction engines.

7. Piston and Rod Assembly

a. Lubricate pin then 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.

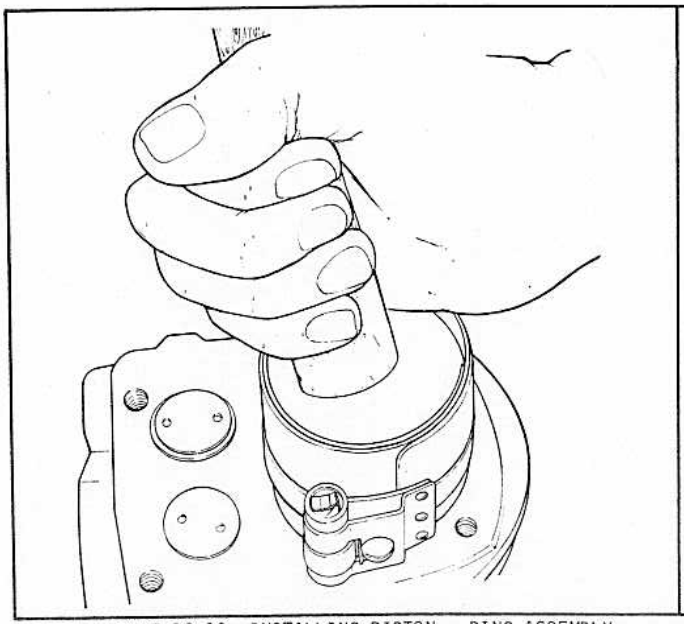


FIGURE 12-10 INSTALLING PISTON - RING ASSEMBLY

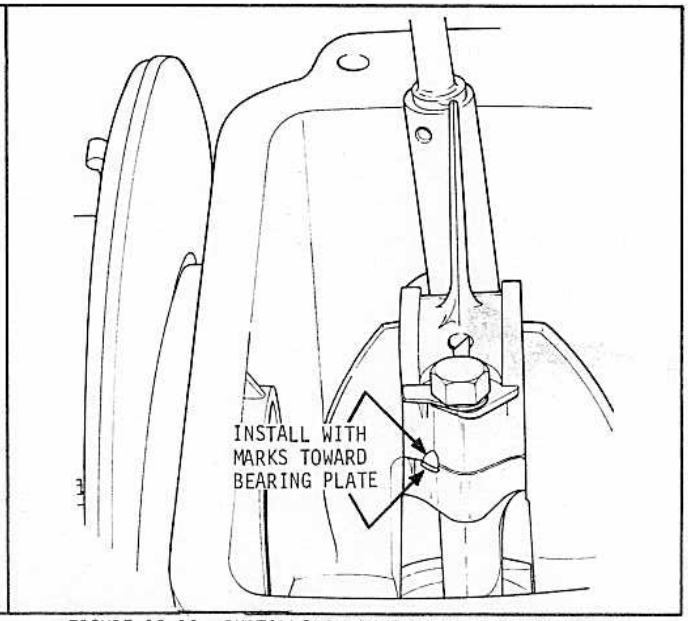


FIGURE 12-11 INSTALLING CONNECTING ROD CAP SCREW

8. Attaching Rod to Crankshaft

a. After piston assembly is installed, place block on end and oil connecting rod big end and crank pin.

b. It is important that marks on connecting rod and cap line up and face flywheel end of engine. (See Figure 12-11)

c. Rod cap, lock or lock washers and cap screws are then attached to connecting rod. Use a torque wrench to tighten cap screws to proper torque value as stated in Clearance Section.

d. If locking tabs are used, bend tabs to lock cap screws.

9. Installation of Oil Seals on Crankshaft

a. Apply grease to lip then guide oil seals into position on crankshaft without damaging lips of seals. Any foreign matter on knifelike edge or any bending of seal may cause damage and an oil leak can result.

b. After oil seals are started on shaft, place block on its side. The oil seals may now be driven squarely into bearing plate and cylinder block. (See Figure 12-12) Refer to pages 15.5-15.6 for correct oil seal depth.

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.

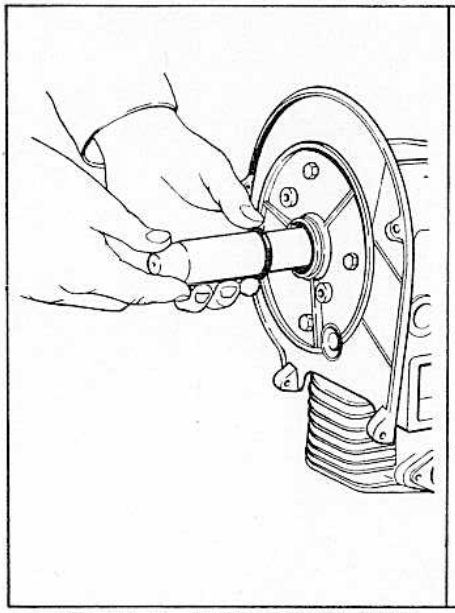


FIGURE 12-12 INSTALLING OIL SEALS WITH SLEEVE

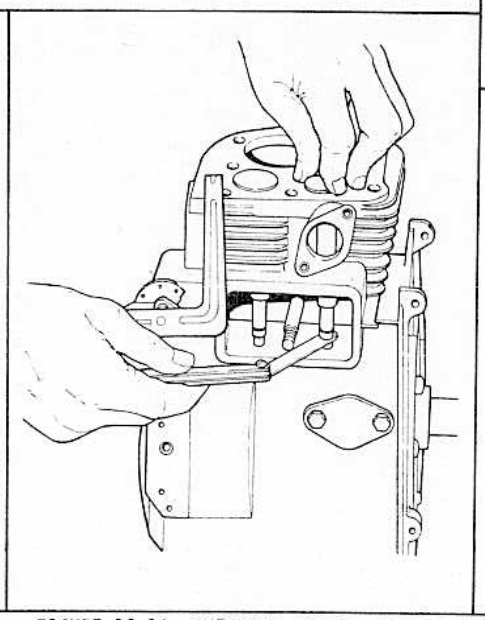


FIGURE 12-13 CHECKING VALVE - TAPPET CLEARANCE

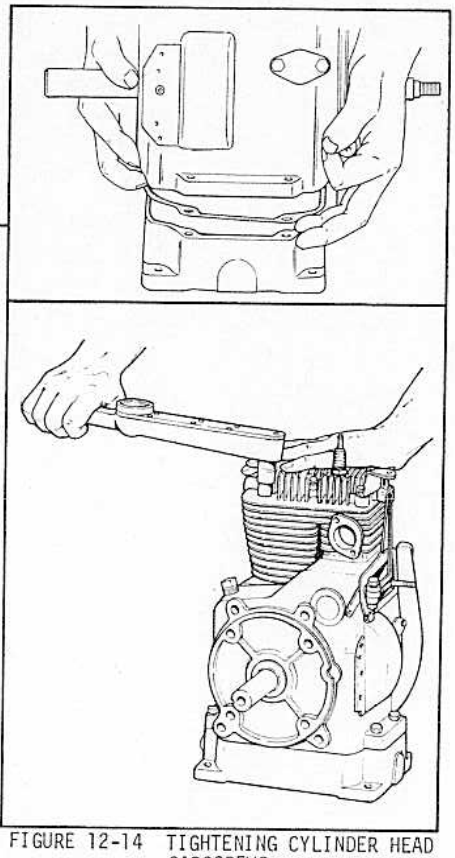


FIGURE 12-14 TIGHTENING CYLINDER HEAD CAPSCREWS

11. Installing and Setting Valves

a. Valves, valve seats and ports should be thoroughly cleaned. Valves should be ground and lapped-in to obtain a good valve seat. Keep valve seat from 1/32" to 1/16" in width.

b. Valve clearance should be checked cold. On K91, K141, K161, K181 with incorrect valve clearance, the valves must be removed and ends ground until proper clearance is obtained. ENDS MUST BE GROUND SQUARE AND ALL BURRS MUST BE REMOVED. On K241, K301, K321, adjust tappets to correct clearance.

c. After correct clearance is obtained, remove valves and install valve springs and retainers and rotators if used. Lubricate stems then replace valves, compress springs and place locking keys (pins on K91) 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 lubricated then tightened evenly and in sequence until proper torque is reached.

d. Install new spark plug and tighten to specified torque. Spark plug gap should be .025 or 020 for radio shielded spark plugs or .018" for gas operation.

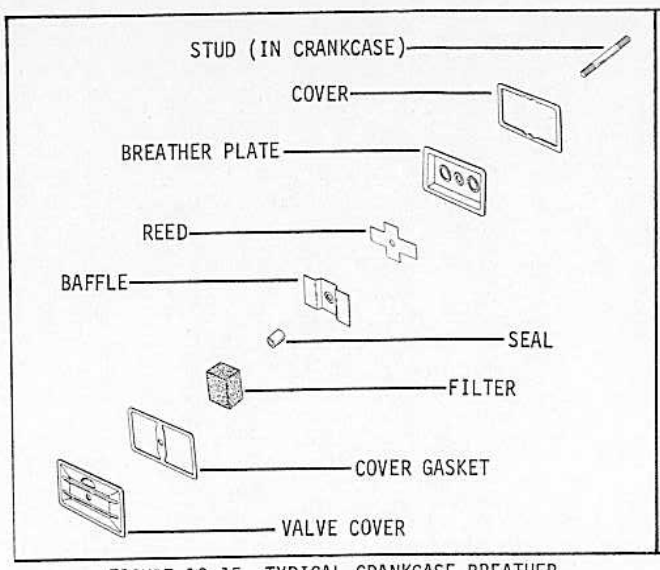


FIGURE 12-15 TYPICAL CRANKCASE BREATHER

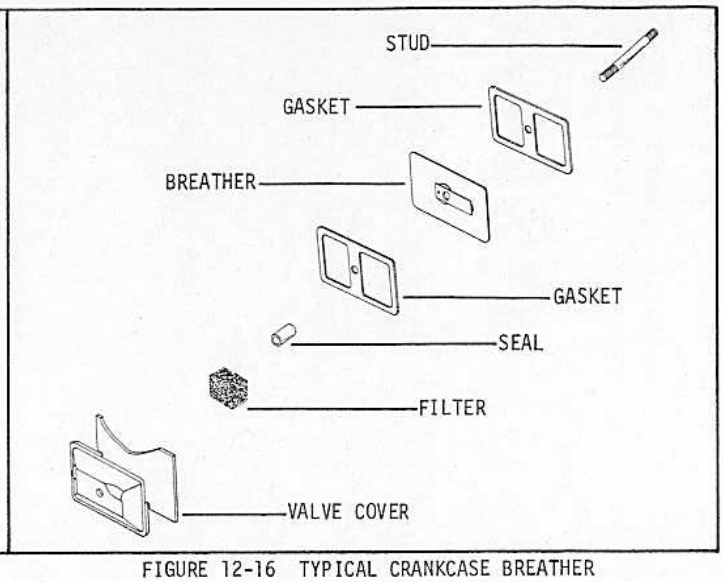


FIGURE 12-16 TYPICAL CRANKCASE BREATHER

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 illustrations show the correct order of assembly for two of the more common types. Most other types are assembled in the same general sequence. Make sure reed valve is installed properly.

c. Cover must be securely tightened to prevent oil leakage.

14. Magneto

a. On all magneto ignition systems the magneto coil - core assembly is secured in stationary position on the bearing plate. On the magneto - alternator system the coil is part of the stator assembly which is also secured to the bearing plate. Permanent magnets are affixed to the inside rim of the flywheel except in rotor type magneto systems. On these the magnet or rotor has a keyway and is press fitted on crankshaft -- magnet rotor is marked "engine-side" for proper assembly.

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

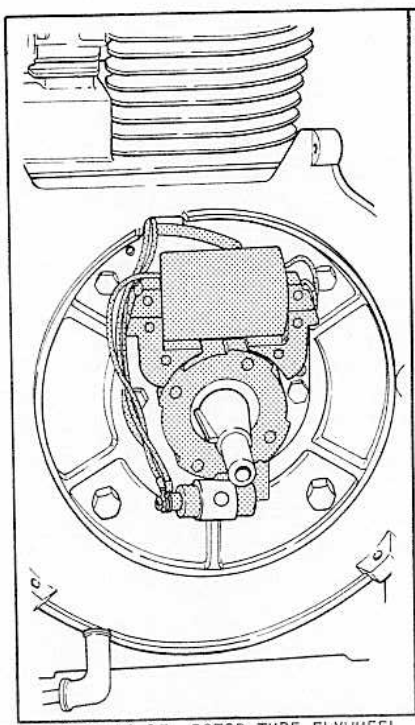


FIGURE 12-17 ROTOR TYPE FLYWHEEL MAGNETO

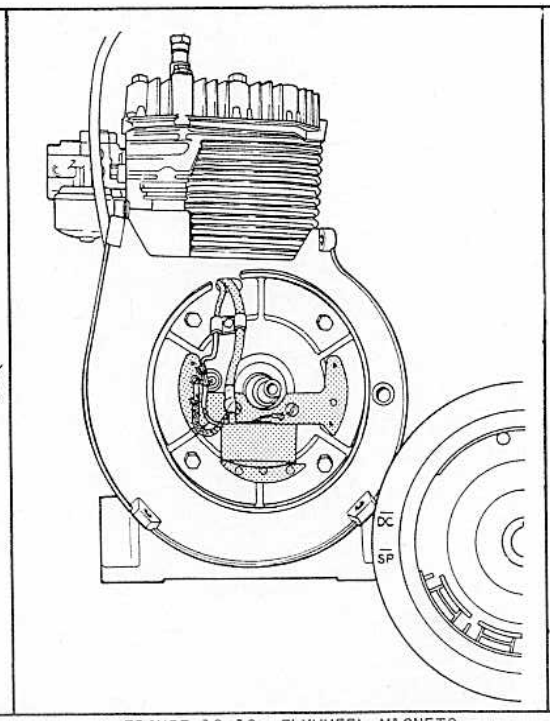


FIGURE 12-18 FLYWHEEL MAGNETO

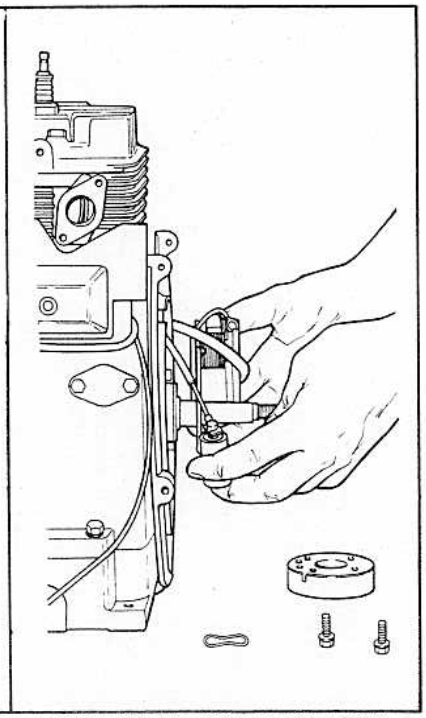


FIGURE 12-19 INSTALLING ROTOR TYPE MAGNETS

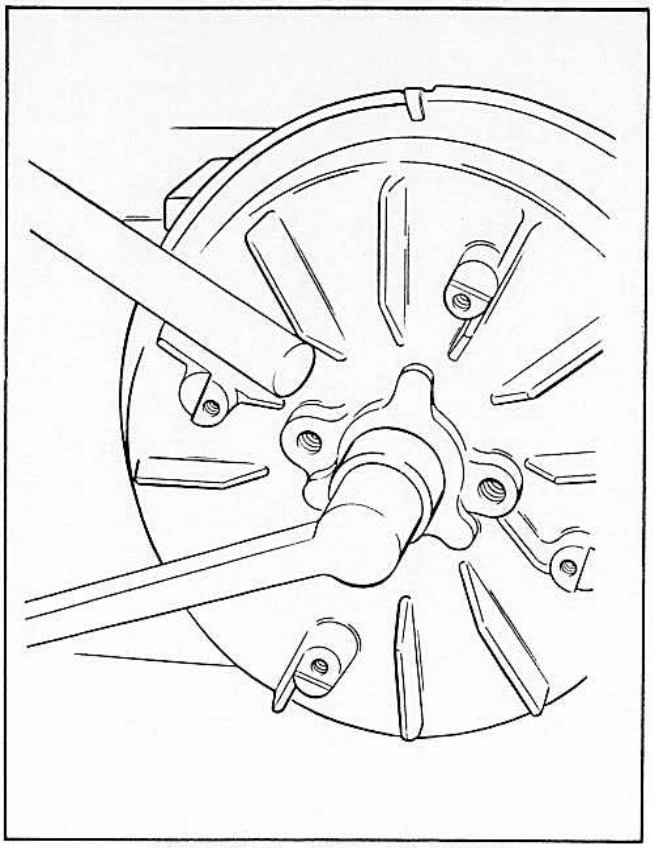


FIGURE 12-20 INSTALLING FLYWHEEL

15. Flywheel

a. Place wave washer on crankshaft and place flywheel in position. The square key holds flywheel on shaft.

b. Install starter pulley, lock washer and holding nut. Insert a bar between flywheel fins and tighten holding nut to torque value specified in Clearance Section.

c. The rotating screen is fastened to starter pulley with either screws and spacers or a wire retainer.

16. Breaker Points

a. Install push rod.

b. Fasten breaker in place with two screws.

c. Place cover gasket in position and attach magneto lead.

d. Set breaker gap at .020 full open. For 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. Position governor spring in speed control disc (K91, K141, K161, K181 only).

d. Before tightening clamp bolt, turn shaft counterclockwise as far as possible with a pair of pliers, pull arm as far as possible to left (away from carburetor), tighten nut and check for freedom of movement.

19. Blower Housing and Fuel Tank

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

b. Gasoline fuel tank and brackets (if used) are installed at the same time as baffles and shrouds.

c. Connect fuel line between filter and carburetor.

FINAL ADJUSTMENTS

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

RUN-IN PROCEDURES (RECONDITIONED ENGINES)

After an engine has been reconditioned and reassembled, it must be "run-in" on 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. (See Page 2.2) Do not continue using non-detergent oil after the first 5 hours of operation.

SPECIAL FUEL SYSTEMS

GAS SYSTEMS

Use of Liquified Petroleum Gas (LPG) requires sealed fuel system of special carburetion equipment. A sealed fuel system includes a special carburetor, primary regulator and secondary regulator, or a two-stage regulator which eliminates the two regulators previously listed. The primary regulator can be mounted on the engine but is usually mounted on equipment near the fuel supply tank.

LPG is stored in special containers under pressure up to approximately 200 psi depending on ambient temperatures. The gas is 80% liquid when stored at this pressure. Fuel is withdrawn under pressure from the top of the tank as vapor and the primary regulator reduces the pressure to 4 to 8 ounces per square inch or 7 to 11 inch water column.

Operation: The secondary regulator withholds gas until a vacuum, created by turning the engine over at a continuous rate, opens the regulator valve allowing fuel to enter the carburetor.

An idle line is used on some engines when engine is operating at idle speeds. At idle speed the velocity of air through carburetor may not be sufficient to draw enough fuel to sustain engine operation. For this reason, some carburetors use a separate idle fuel system. The idle line carries fuel from the secondary regulator to the air intake side of the carburetor where fuel is introduced at the lower idle speeds. When the fuel demand drops to a certain point, the regulator diverts fuel from the main fuel system into the idle fuel system. On systems having the idle line, the idle mixture adjustment is made at the regulator rather than at the carburetor.

On certain systems, a balance line is used to avoid the problem of an over-rich fuel mixture which can be caused by restricted air flow. The balance line is connected to the atmospheric side of the secondary regulator and to the carburetor air horn. This balance insures a constant ratio of fuel to air under varying degrees of air cleaner restriction.

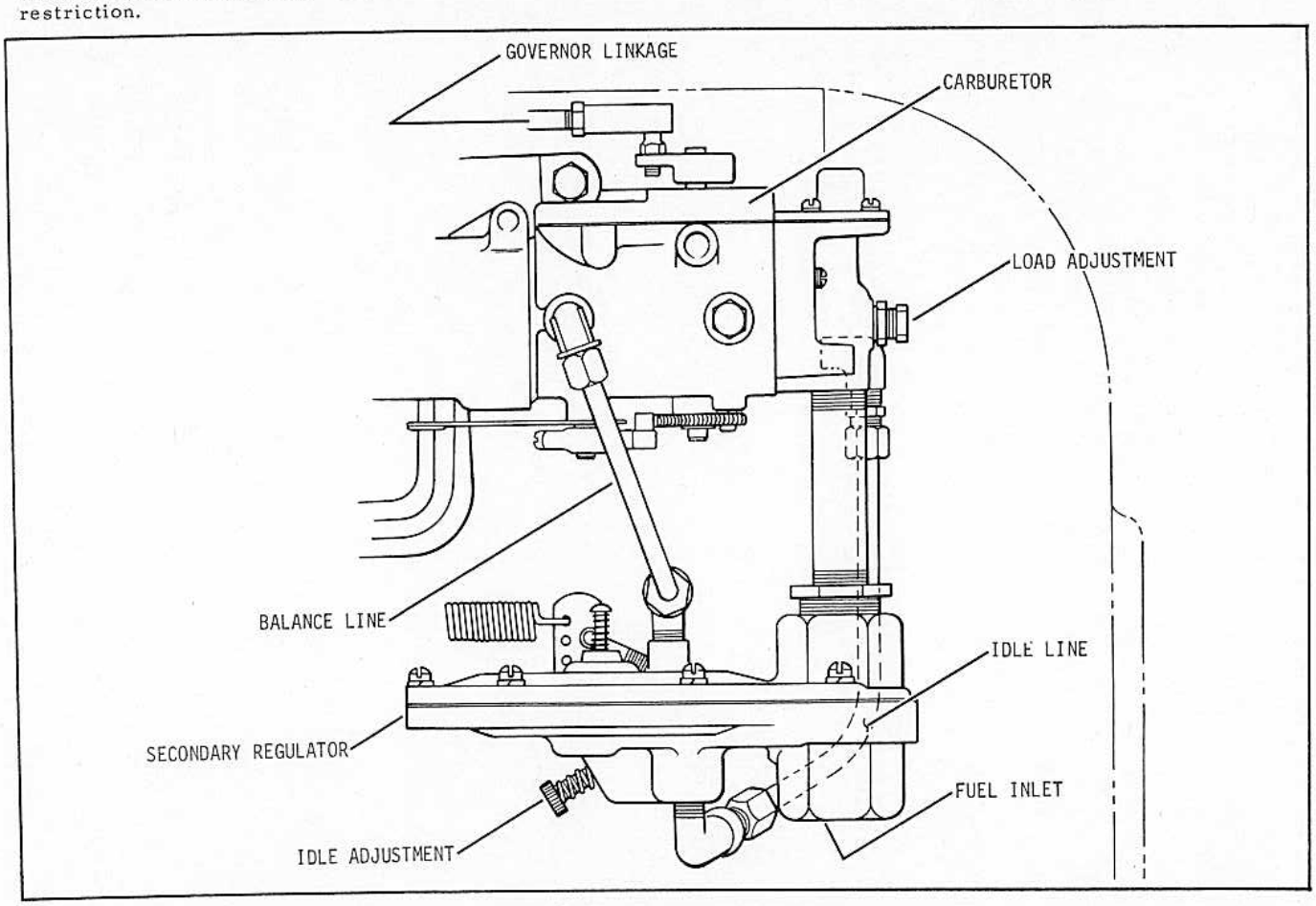


FIGURE 13-1 GAS SYSTEM COMPONENTS

Starting Engine: The carburetor is adjusted at the factory and under normal operating conditions will require no readjustment. If adjustment is necessary because of gas values or air conditions, refer to the Carburetor Adjustment Section.

a. Open fuel supply valve.

b. On carburetors having a choke, close choke. If carburetor does not have a choke, depress the primer button on the secondary regulator for an instant so that enough fuel will enter the carburetor for starting. Some gas fuel systems use a very sensitive secondary regulator and therefore can be started without priming or choking.

c. Start engine.

d. Open choke after engine has come up to governed speed. Adjust the load adjustment until the engine runs smoothly at governed speed and no load.

e. After engine has been allowed to warm up, return throttle to idle position and adjust idle setting. On gas systems using an idle line, the adjustment must be made on the secondary regulator. Set the idle stop adjustment for the proper idle speed. On those engines that do not use a balance line and the idle adjustment is made on the carburetor, set the idle adjustment needle.

f. Set engine at full throttle and put under full load and readjust the load adjustment screw for maximum engine RPM. If possible, a tachometer should be used for the final power adjustment.

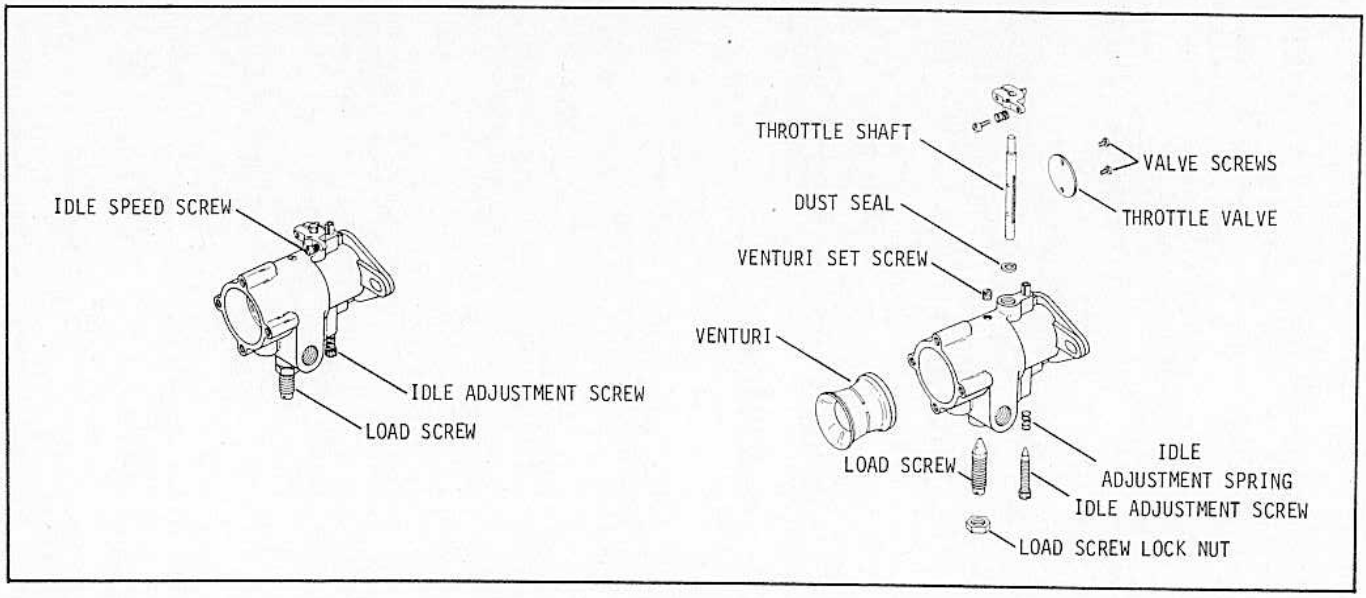


FIGURE 13-2 GARRETSON CARBURETOR

GAS CARBURETORS

Description: Gas carburetors used on Kohler Engines are the horizontal type. The carburetors either have the venturi cast in the body making it an integral part or a replaceable venturi. Due to simplicity in design and few moving parts, the gas carburetor rarely needs attention. A gas carburetor therefore serves to control the ratio of gas to air under varying load and speed conditions.

Operation: As the engine is cranked, gas enters the carburetor and passes through the fuel inlet where a load adjustment screw controls the flow of fuel to the venturi nozzle. Air enters the air horn and mixes with the gas entering the venturi at the nozzle. The mixing point of gas and air is located at the point of greatest pressure drop inside the venturi. This creates a suction within the nozzle that varies with the changing rate of air flow and thus meters a greater volume of gas at heavier loads and a decreased value at lighter engine loads. The volume of gas/fuel mixture entering the engine is controlled by the throttle valve (disc).

Disassembly: When it is necessary, the carburetor should be cleaned thoroughly and worn parts be replaced. NOTE: A different type of carburetor is used on the K181. See special instruction for K181 gas carburetor on following pages. To disassemble carburetor, the following procedure should be followed:

1. Remove air cleaner from carburetor.
2. Disconnect governor arm from carburetor.
3. Disconnect fuel line.
4. Remove carburetor from engine.
5. Remove load screw assembly and spring (if used).
6. Loosen venturi set screw(s) and remove venturi (removable type).
   Note: Heavy end of venturi is toward air intake.
7. Remove throttle valve (disc, screws, throttle valve and throttle shaft).
8. Remove idle adjustment screw and spring.

Inspection of Parts: Clean all parts and wipe free of oil and grease. With an air hose, blow out all internal openings and passageways. Inspect all areas subject to wear and make sure all areas are free from dirt.

Reassembly:

1. Install idle adjustment screw and spring.
2. Install throttle shaft, throttle valve and throttle valve screws.
3. Place venturi in carburetor with heavy end of venturi toward air intake side of carburetor and secure set screw(s).
4. Install load adjustment screw assembly and spring or load adjustment screw lock nut when used.
5. Install carburetor on engine.
6. Connect fuel line.
7. Connect governor arm to carburetor.
8. Install air cleaner on carburetor.

Adjustment: Ensign Model CBM Gas Carburetor

1. Set starting adjustment 1-1/4 turns open.
2. Set load adjustment 4 turns open.
3. Set idle adjustment on regulator 1-1/2 turns open.
4. Close choke all the way.
5. Open throttle at least halfway.
6. Crank engine.
7. When engine starts, adjust the starting adjustment first for maximum engine speed then leaner until speed drops slightly. Tighten starting adjustment screw, lock nut.
8. Open choke and close throttle simultaneously.
9. Make temporary adjustment of load screw for highest RPM while holding throttle at about 2/3's rated speed.
10. With engine warm, set idle stop screw for correct idle speed and adjust idle screw for the best idle.

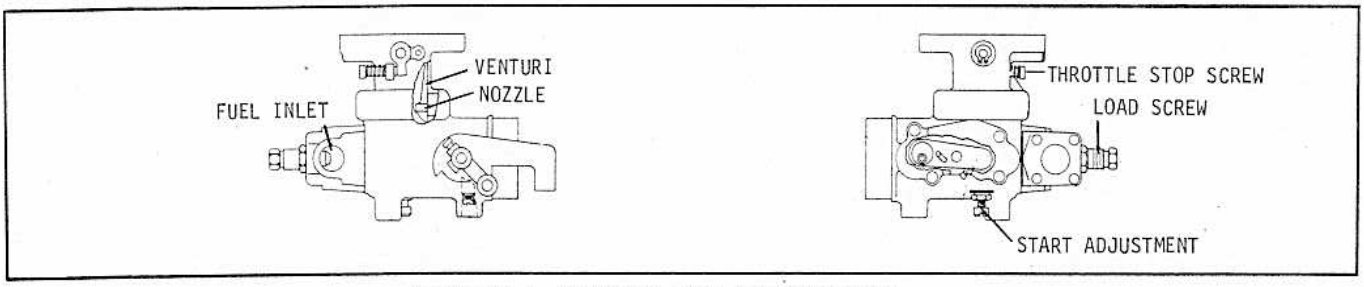


FIGURE 13-3 ADJUSTING MODEL CBM CARBURETOR

11. Open throttle fully and load engine to obtain an engine speed of 1/2 to maximum operating speed. Find the two positions of the load screw setting where the engine speed begins to drop, when going richer and leaner, then set screw at midpoint.

    To set load screw without load: A reasonable adjustment can be made when it is not possible to load the engine, as follows: Disconnect economizer and plug intake manifold connection. Bring engine to a high speed. Adjust load screw for maximum RPM then carefully turn in to where the RPM just begins to fall. Set load screw to the midpoint of these two positions and tighten lock nut. The idle adjustment must be carefully made before using this method as it influences the mixture under this engine condition.

Adjustment: Garretson Carburetors

1. Check the throttle shaft to make sure it turns freely from closed to open position.
2. Mount carburetor on engine attaching fuel line, governor linkage and air cleaner.
3. Turn in the idle stop adjusting screw approximately 2 turns, so that the throttle valve is held slightly open.
4. Using a screwdriver, close the idle fuel adjusting screw completely.
5. Completely close the load adjustment screw. Open load adjustment screw approximately 5 turns on K91, K141, K161, 3-1/2 turns on K241 and K301 models.
6. Start engine.

7. Adjust load adjustment screw until engine runs smoothly at governed speed and no load.

8. If engine is required to idle, slowly return the engine speed to idle and adjust the idle adjustment screw for best or smoothest idle. Set the idle stop adjustment for the proper idle speed. Do not attempt to control the idle speed with the idle fuel adjustment.

9. If the engine is not required to idle, leave the idle fuel adjustment screw completely closed. The idle stop adjusting screw on the throttle arm may then be used to adjust for the minimum speed desired.

10. Put the engine under its normal load and readjust the load screw for maximum engine RPM. Tighten load adjustment lock nut if used. Use tachometer if possible for this final load adjustment.

K181 GAS CARBURETOR

Disassembly:

1. With carburetor inverted, loosen load adjustment lock, remove load adjustment screw with nut from fuel metering block. Then remove fuel block screws, fuel block and gasket.

2. Remove the adapter plate screw and lockwashers, then remove adapter plate and gasket from throttle body.

3. Remove idle adjustment needle with spring from throttle body.

4. Mark position of choke plate in throttle body and position of choke lever with choke plate in a closed position.

5. Remove choke plate screws and choke plate. Loosen choke shaft collar set screw and remove choke shaft collar. Remove choke shaft and lever.

6. Remove throttle plate screws, throttle plate and throttle shaft-lever assembly. Then remove seal retainers with seals.

Cleaning and Inspection: Thoroughly clean all metal parts with cleaning solvent. Blow out all passages and channels with compressed air. Never use a wire or drill to clean out jets. Inspect throttle shaft for wear or damage. Inspect choke shaft for wear or damage. Replace when damaged or worn excessively. Inspect idle needle valve, replace if grooved or damaged.

Reassembly:

1. Place adapter plate gasket on throttle body and attach adapter plate to throttle body using two short screws and lock washers. Place lock washer on medium length screw before assembly. Long screw goes in raised portion of adapter. Tighten screws uniformly.

2. Place metering block gasket on adapter and attach fuel metering block with screw and lock washers. Assemble check nut on main adjustment screw and thread screw into fuel block until screw just contacts seat, then back out screw two full turns and tighten check nut.

3. Place spring on idle needle valve and assemble idle needle valve in throttle body. Turn idle needle valve in lightly against its seat, then back out valve on turn.

4. Place seal washers in seal retainers and assemble in throttle shaft retainer bores from opposite sides. Insert throttle shaft in throttle body and attach throttle plate to throttle shaft with screws. Leave screws loose. Make sure throttle plate and throttle shaft are assembled in same way as before disassembly. Close throttle, align for best closing and then tighten screws.

5. Place choke shaft and lever in throttle body and attach choke plate with screws. Leave screws loose. Make sure choke plate is assembled in original position. Close choke plate for best closing and securely tighten screws. Assemble collar over end of choke shaft and tighten set screw.

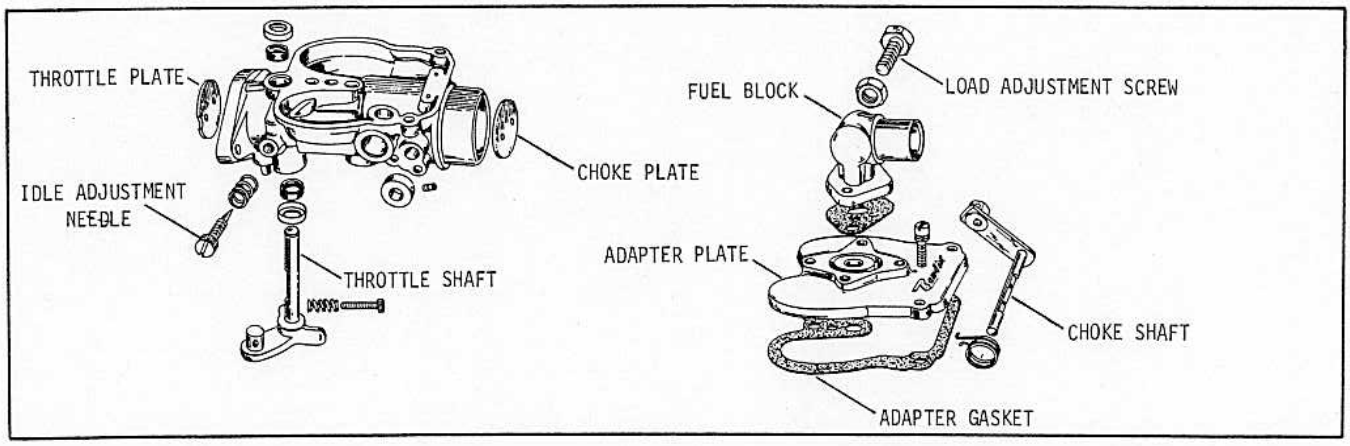


FIGURE 13-4 K181 CARBURETOR ADJUSTMENTS

PRIMARY REGULATORS

Description: The function of the primary regulator is to provide initial control of the fuel under pressure as it comes from the fuel supply tank. The inlet pressure for the primary regulators used on Kohler Engines should never exceed 250 psi. The primary regulator is adjusted for an outlet pressure of approximately 6 ounces or 11 inches water column.

Operation: Upon demand for fuel, a pressure drop occurs on the fuel outlet side of the regulator diaphragm. At this pressure drop, the gas inlet valve begins to open and allows fuel to pass through the primary regulator to the secondary regulator. As the need for more fuel increases, the fuel inlet valve opens more and allows more fuel to pass through until the valve is completely open.

Disassembly:

1. Remove assembly screws.
2. Remove housing cover and adjustment spring.
3. Remove diaphragm.

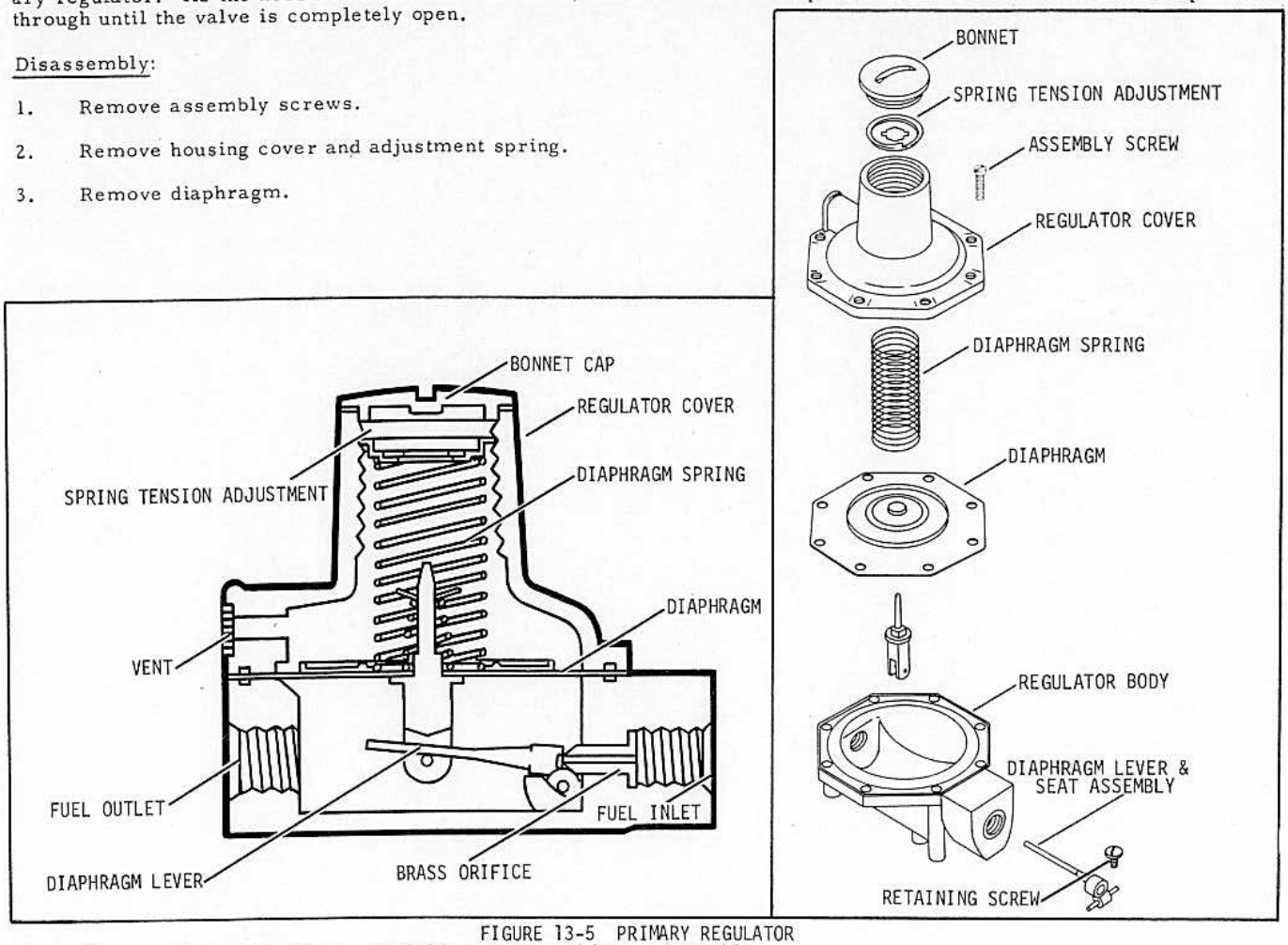


FIGURE 13-5 PRIMARY REGULATOR

4. Remove diaphragm lever, retaining screws and lever assembly.

Inspection of Parts:

1. Inspect diaphragm for breaks, cracks or weak areas. Replace if necessary.
2. Inspect brass orifice seating area for nicks. Do not remove unless replacement is necessary.
3. Inspect rubber seat for foreign material or excessive seat indention. Replace diaphragm lever and seat assembly if necessary.

Reassembly:

1. Make sure all parts are clean and free from dirt.
2. Insert diaphragm lever and seat assembly and secure with retaining screws.
3. Place diaphragm into position making sure that diaphragm lever and diaphragm are properly engaged.
4. Place adjustment spring on top of diaphragm in proper position. Place housing cover in position making sure that the housing vent is above the outlet of regulator. Start all assembly screws and tighten evenly.

Adjustment: After reassembly it will be necessary to check the outlet pressure. The outlet pressure should be approximately 6 ounces or 11 inches water column. If adjustment is necessary, remove the bonnet cap. Using a large screwdriver, adjust the spring tension to vary the pressure. Turning in or clockwise increases the outlet pressure and turning out decreases the outlet pressure.

It is important that the inlet be kept clean when mounting or servicing the regulator. Pipe dope should be used on the inlet fitting but care should be taken that no pipe dope enters into the regulator for it can lodge on the seat and orifice.

TROUBLE SHOOTING PRIMARY REGULATOR

TROUBLE	CAUSED BY
Outlet pressure over 11 inches water column.	Dirt on fuel inlet valve seat.
Fuel leaking from regulator vent and outlet pressure does not rise.	Improper pressure adjustment.
	Ruptured or defective diaphragm. Dirt on valve seat.

SECONDARY REGULATORS

Description: The secondary regulators used on Kohler Engines are compact single diaphragm type. This regulator will regulate the flow of gas to the carburetor accurately and will shut the gas off automatically when the engine demand ceases.

Operation: With the engine shut off, the diaphragm spring holds the fuel inlet valve against the fuel inlet valve seat. The diaphragm spring tension is transferred to the fuel inlet valve by the diaphragm lever. Upon cranking the engine, a pressure drop occurs on the fuel outlet side of the regulator diaphragm. Since one side of the diaphragm is exposed (vented) to atmospheric pressure while the outlet side is exposed only to the pressure drop (vacuum) from cranking, the diaphragm pushes against the diaphragm lever and spring. At this pressure drop, the gas inlet valve begins to open and admits fuel to the engine for starting. As the engine accelerates and pulls more and more air through the regulator, the pressure drop in the regulator increases until the fuel inlet valve is completely open.

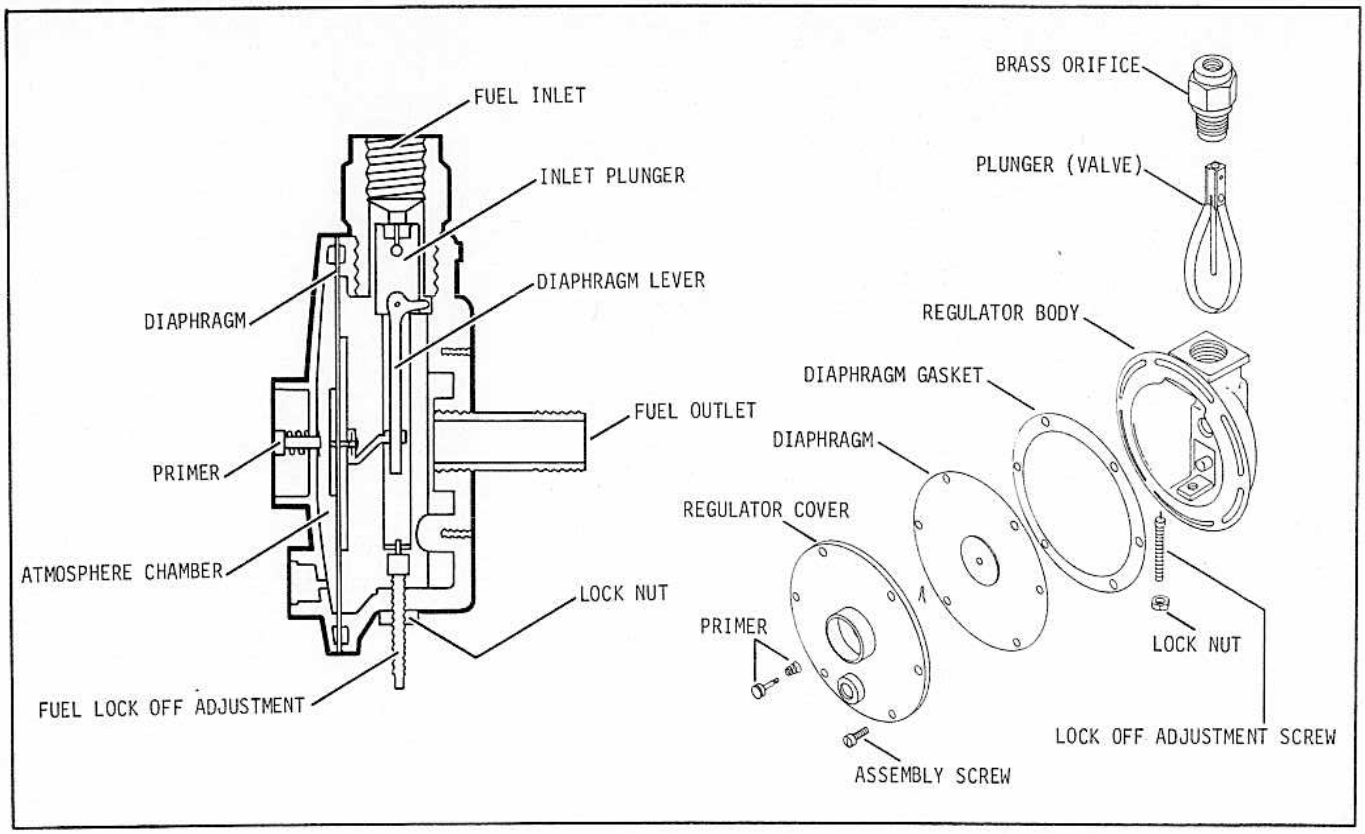


FIGURE 13-6 MODEL S OR SD REGULATOR

Disassembly:

1. Remove assembly screws.
2. Remove housing cover.
3. Remove diaphragm and gasket(s). Some diaphragms are attached to the diaphragm lever. To remove diaphragm, put a knife under the retainer clip on the end of the lever assembly so that the end of the pusher pin will come up and slide out the end of the retainer clip.
4. Remove diaphragm lever and spring. NOTE: On the model S and SD regulators, the inlet plunger or valve must be removed through the fuel inlet fitting hole by first removing the brass orifice. The brass orifice should not be removed unless absolutely necessary; it should, however, be inspected for dirt or nicks on the seating surface.

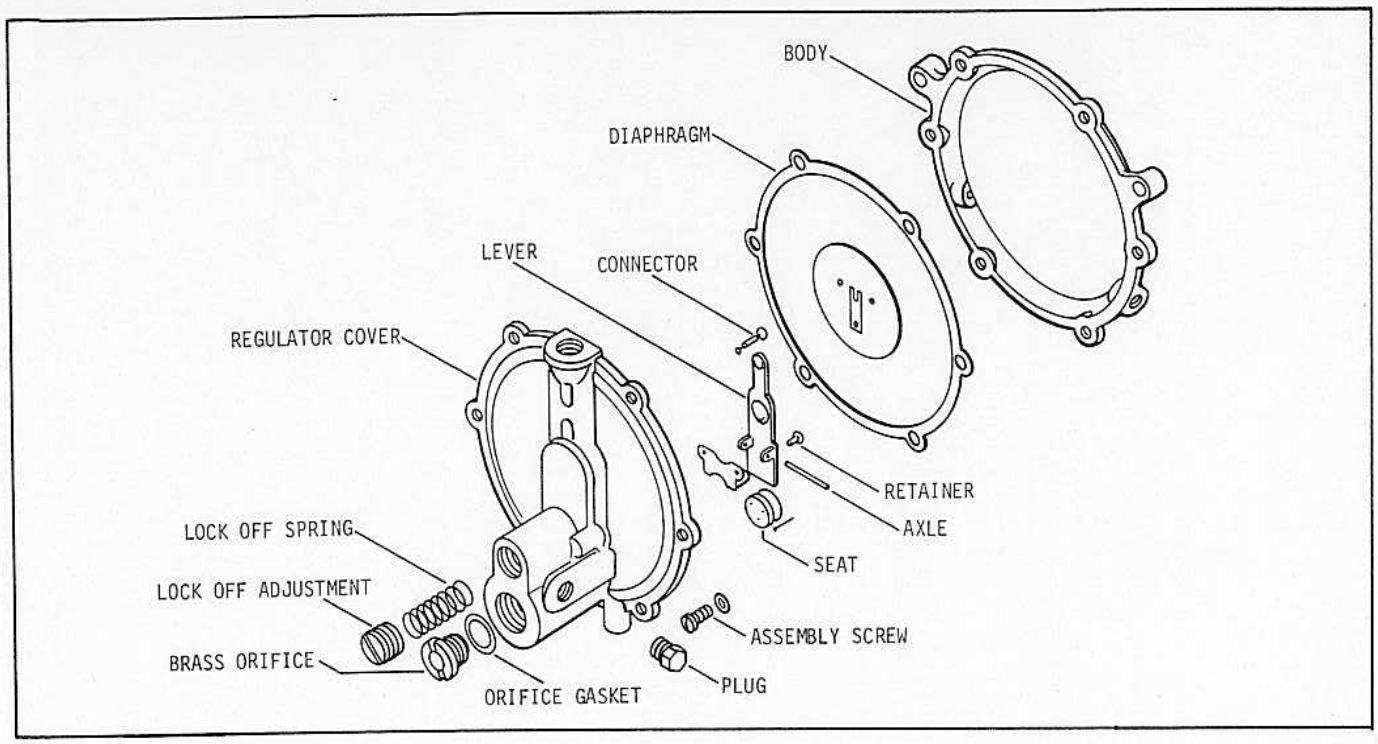


FIGURE 13-7 DISASSEMBLY MODEL KN REGULATOR

Inspection of Parts:

1. Inspect diaphragm and gasket areas for breaks and cracks. Replace if damaged.
2. Inspect brass orifice for nicks. Replace if damaged.
3. Inspect rubber seat for foreign material or excessive seat indentation. Replace if necessary.
4. Replace or repair all other parts which appear to be worn or damaged.

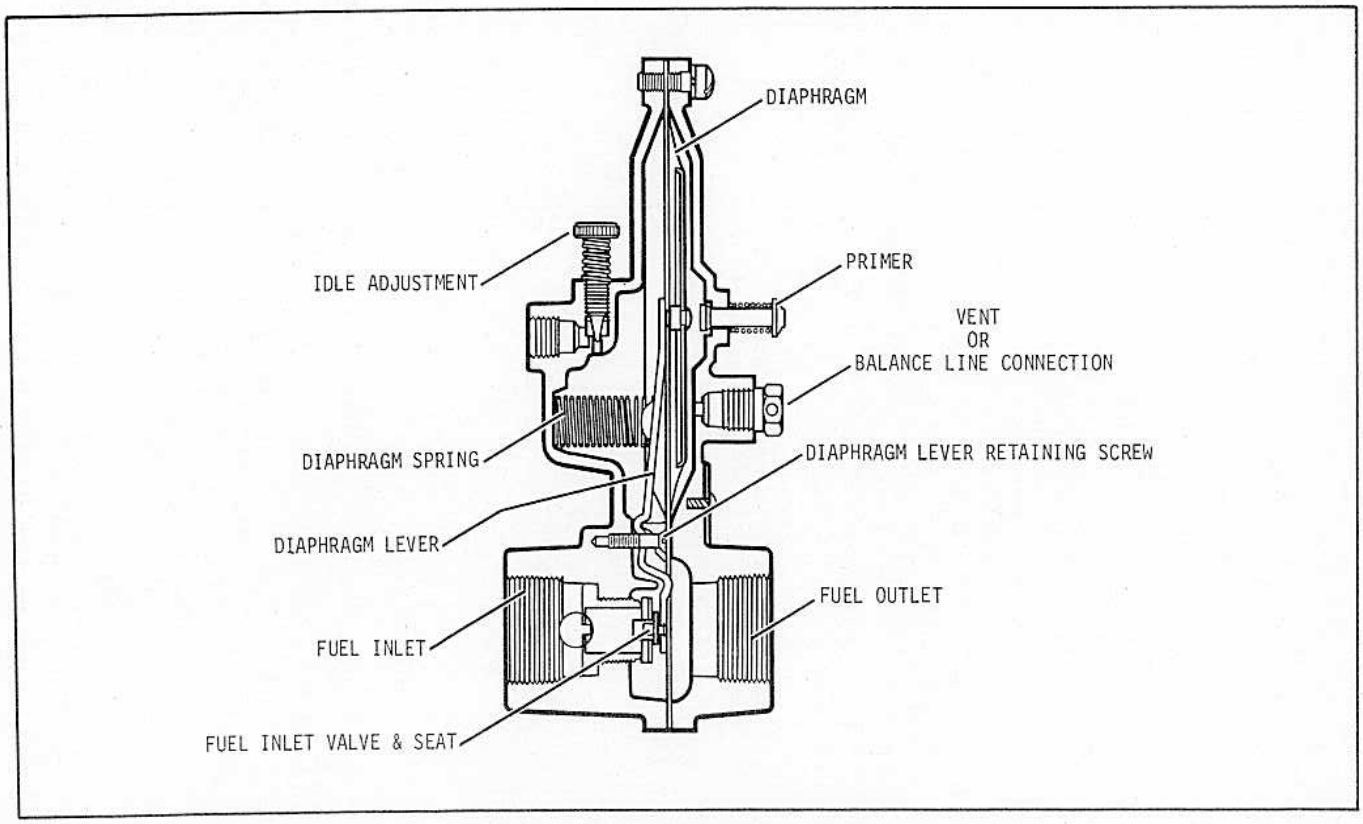


FIGURE 13-8 MODEL F OR F1 REGULATOR

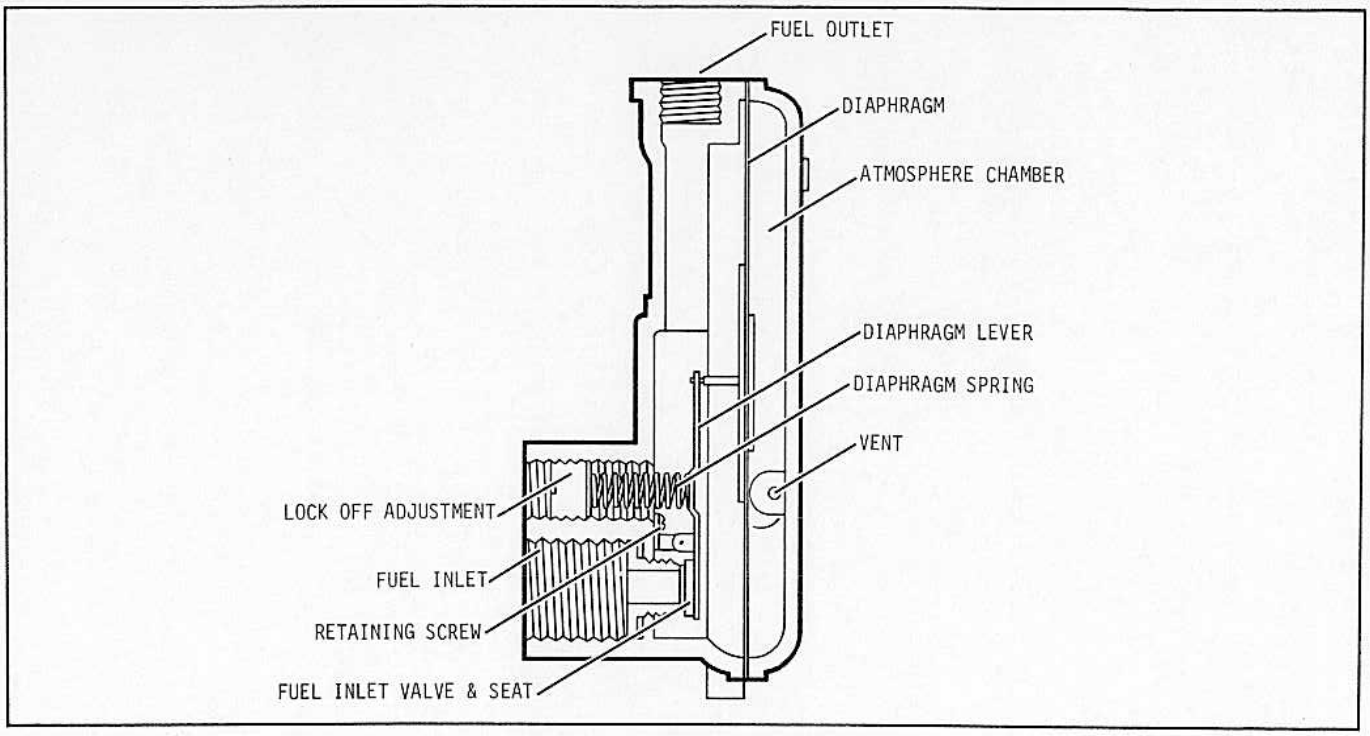


FIGURE 13-9 MODEL KN REGULATOR

Reassembly:

1. Make sure all parts are clean and free from dirt.

2. Insert diaphragm lever and spring and secure with retaining screw. Do not tighten the retaining screw more than enough to hold the lever in place. If it is too tight, it will bind the lever. On the model SD regulator, the inlet plunger (valve) is inserted through the fuel inlet fitting hole.

3. Place leaf spring on tip of adjusting screw. Tighten fuel inlet fitting. (model SD regulator only)

4. Place gasket/diaphragm into position. Make sure diaphragm is engaged with diaphragm lever. (models KN, S & SD only)

5. Place regulator housing in position and tighten assembly screws evenly. On the model S and SD regulators, only start screws. Before tightening, it is necessary to blow in the outlet fitting to set the diaphragm slack. Tighten screws.

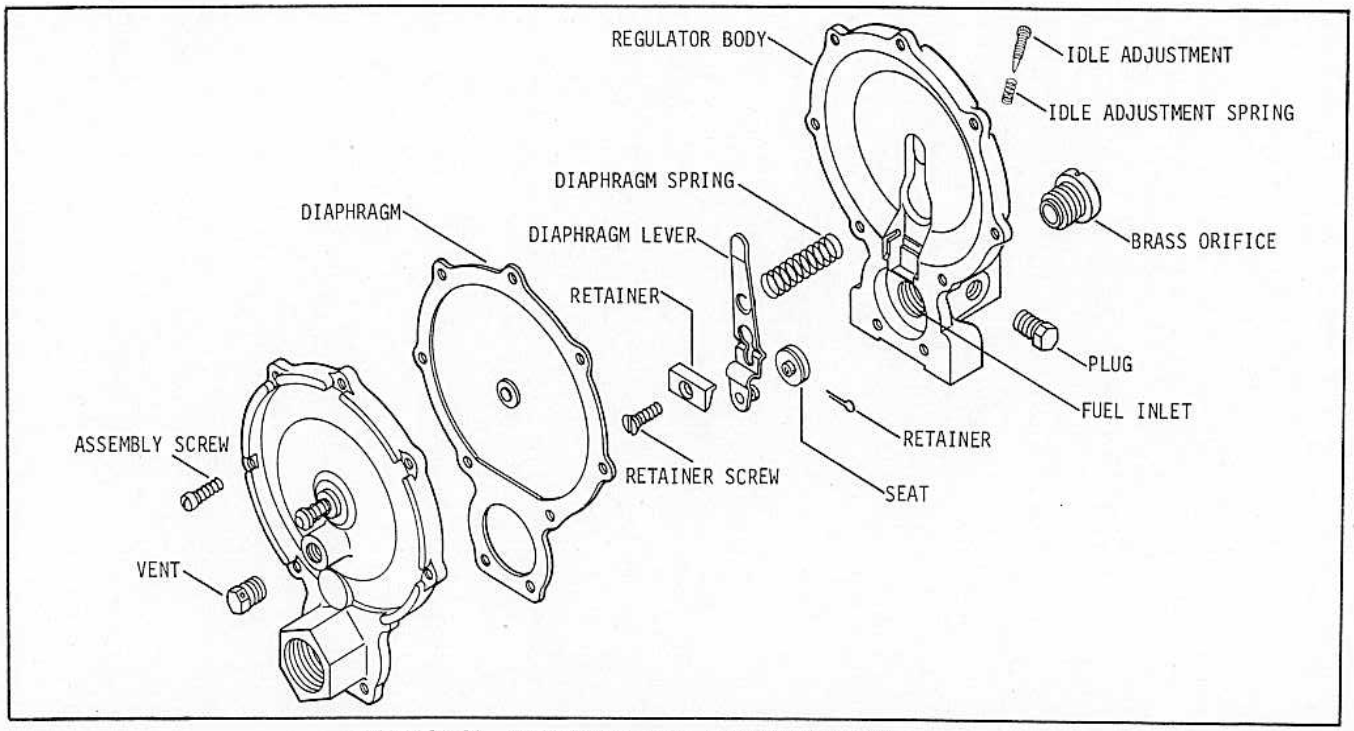


FIGURE 13-10 DISASSEMBLY MODEL F OR F1 REGULATOR

Adjustment: Secondary regulators used on Kohler Engines require only one adjustment. Engines using the Ensign model F or F1 regulator have an idle adjustment. This adjustment should be made while the engine is running. The Garretson S, SD & KN regulators require the lock off or fuel control adjustment. When making this adjustment, the following procedure should be followed: NOTE: Regulators should be mounted as close to a vertical position as possible and adjusted in the position that it will be mounted on the engine.

1. Connect regulator inlet to a source of compressed air or gas, but not over 10 psi. If gas is used, adjustment should be made in a well-ventilated room or preferably outside.

2. Turn fuel supply on.

3. On the model KN regulator, open the lock off adjusting screw until fuel comes through the regulator. Turn screw in slowly until fuel flow stops completely. A soap bubble can be used to check fuel shut off. If bubble increases in size and breaks, fuel is not shutting off properly and adjustment is necessary. Turn in one more additional turn after fuel is completely shut off. The adjustment screw may be turned in from the normal position to set the idle mixture if it is too rich. Never use the lock off adjusting screw in an attempt to adjust the fuel mixture at any speed except idle. Never attempt to set engine speed with this adjustment. The model S and SD regulators must be adjusted by depressing the primer button for an instant. This will allow fuel to flow from the outlet. When the primer is released, the fuel flow should stop. (Use soap bubble as discussed previously) If soap bubble breaks, loosen the adjustment screw lock nut and turn adjustment screw in until fuel flow stops -- then turn in one additional turn. Check the adjustment several times by depressing the primer. After proper adjustment is reached, tighten lock nut.

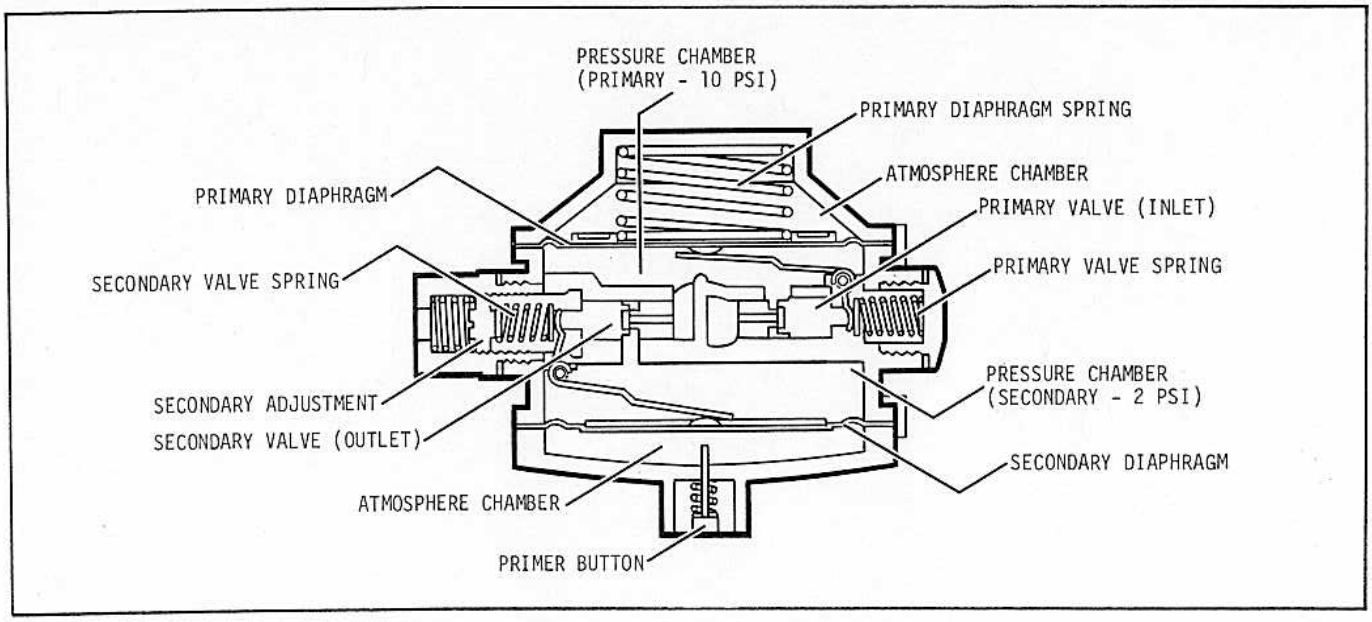


FIGURE 13-11 TWO STAGE REGULATOR

TWO STAGE REGULATOR (ZENITH)

Description: The two stage regulator used on Kohler Engines is a double diaphragm type regulator designed specifically for use with small air-cooled engines. It combines both primary and final secondary stage regulation into a single compact unit. The regulator is simple to mount on the engine. The regulator fuel inlet is connected to the fuel tank with the fuel outlet connected to the carburetor.

Operation: Vaporized fuel is admitted to the regulator inlet at tank pressure (up to 250 psi). Since the secondary valve is closed, the pressure on the internal side of the primary diaphragm builds up until the pressure overcomes the spring acting on the opposite side of the diaphragm. This primary diaphragm spring has sufficient tension to require approximately 10 psi pressure on the internal side of the diaphragm to counteract the opening force due to the spring. When the pressure reaches this level, the valve is closed, preventing further pressure rise. The secondary diaphragm acts against the secondary valve spring. Its action results from vacuum obtained from the carburetor. As this vacuum begins acting on the diaphragm, the diaphragm is moved nearer the center of the regulator, which opens the secondary valve, until an equilibrium is reached. As more fuel is required, vacuum from the carburetor increases, causing the secondary valve to open further, admitting more fuel. When fuel is flowing, the pressure on the primary diaphragm is lowered slightly, permitting the spring to open the primary valve to attempt to bring the pressure back to 10 psi.

Service Procedure: Special Tools Required

* C161-199 Easy-Out Tool

* C161-198 Valve Seat Inserting Tool

* C166-53 (6) Aligning Studs

* See Tool List

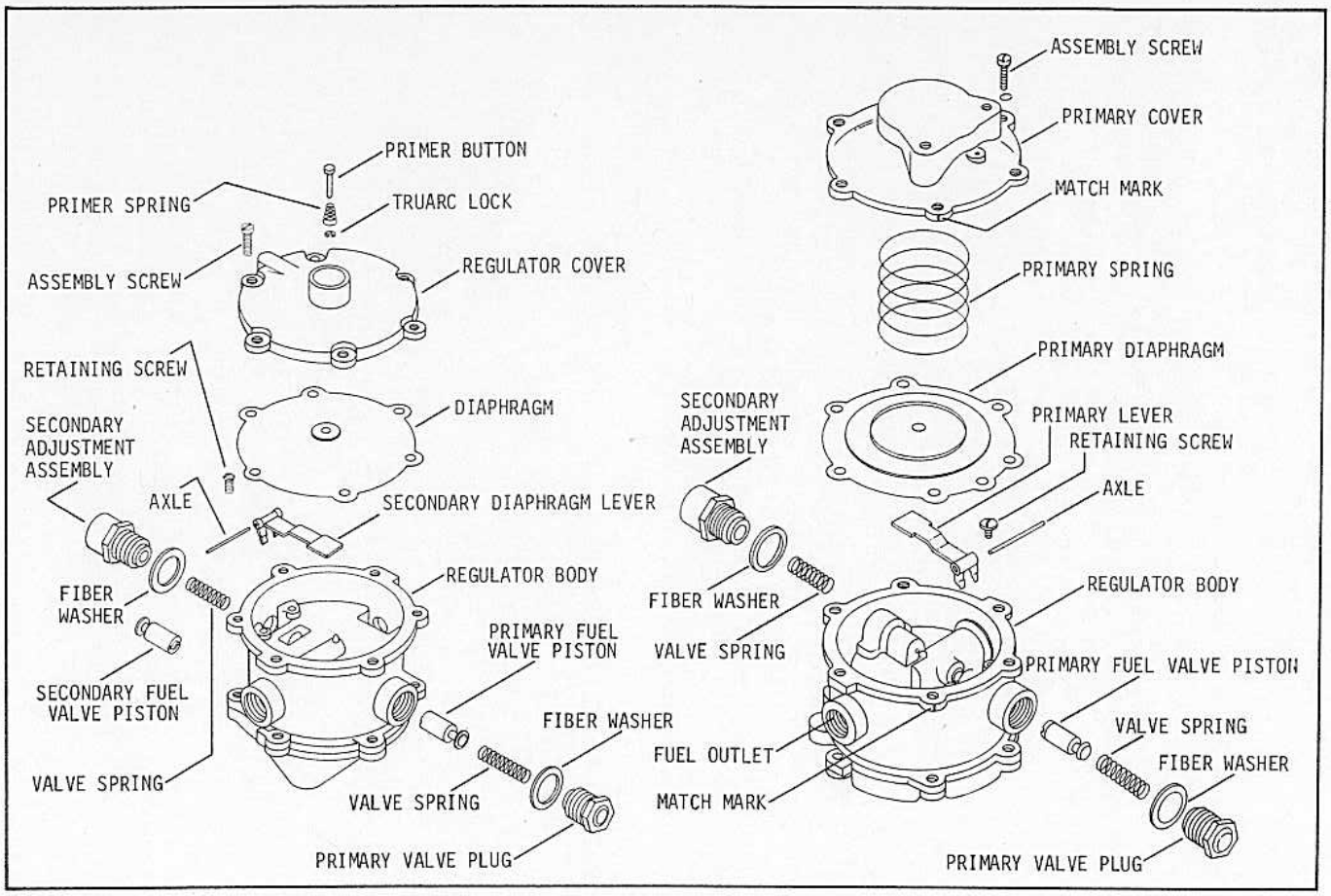


FIGURE 13-12 DISASSEMBLY TWO STAGE REGULATOR

Disassembly: Follow the sequence of operations as listed in the service procedure, failure to do so could result in damage to certain parts.

1. Place regulator on bench with primary side up and fuel outlet boss toward operator.

2. Scribe a match mark from primary diaphragm cover to regulator body casting so that upon reassembly, these parts can be replaced in their original position. Figure 13-12.

3. Use a 13/16" wrench and remove the primary valve plug, secondary adjustment assembly, valve springs and fiber washers. Notice that secondary adjustment assembly is toward operator's left and contains a spring loaded adjusting screw. Also note that primary valve plug is not adjustable and contains a much heavier spring.

4. Remove the six assembly screws that secure the primary cover and diaphragm assembly to regulator body.

5. Remove the primary cover, spring and diaphragm.

6. Remove the primary diaphragm lever by taking out the two axle retaining screws and lifting out the lever and axle. Tilt the casting and primary fuel valve piston will fall out. Use a paper clip or similar tool and remove the rubber valve disc.

7. Turn regulator over and remove the secondary cover assembly screws.

8. Remove secondary cover and diaphragm.

9. Remove the diaphragm lever and valve piston assembly by following procedure outlined in Step 6.

10. Carefully examine the orifices of the primary and secondary valve seats. These seats are located in the valve channels of the regulator body. If either seat is scratched or imperfect and must be replaced, see next step.

11. Clamp casting in vise. Place old fiber washer on shoulder of puller nut, part of tool C161-199. Insert tapered end of tool C161-199 in orifice of valve seat. Align easy-out with valve seat orifice by adjusting puller nut until half of its shoulder has entered fuel valve channel. Turn easy-out to left (counterclockwise) until tapered threads are firmly engaged in valve seat orifice. Hold easy-out handle to prevent its rotating while turning puller nut to right (clockwise) to extract valve seat. Discard old valve seat.

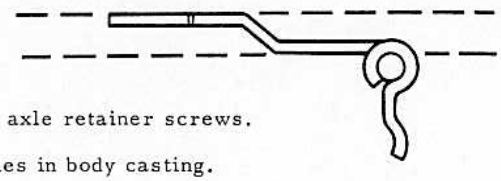
12. Examine primer button located in the center of the secondary diaphragm cover. Depress the button and then release it. The button should return to its original position. If primer is operating normally, no further service is required. Should a part be rusted or corroded, remove the truarc lock and replace parts as needed, then secure by replacing truarc lock. This completes disassembly.

Cleaning and Inspection: After disassembly, clean all parts in alcohol and air dry. Inspect all parts for wear or damage. Replace any questionable parts with new parts.

Reassembly

NOTE: The following parts are interchangeable: Primary and secondary valve seats, primary and secondary valve pistons and discs, primary and secondary diaphragm levers and axles.

1. If valve seats have been removed, replace them with new seats as follows: Hold body casting with valve channel in a vertical position. Place a new valve seat, orifice down, on inserting tool (C161-198). Insert tool and valve seat in valve channel. Use a small hammer and seat the valve by driving it in with a series of light taps.
2. Install primer button assembly in secondary diaphragm cover by inserting plunger through small end of spring and depressing plunger far enough to secure with truarc lock.
3. Install new rubber valve discs in valve pistons (no tools required).
4. Place regulator body on bench with side marked "secondary" up and fuel outlet boss toward operator.
5. Insert a valve piston, the end with rubber disc first, in valve channel on operator's right.



6. Examine both diaphragm levers. Surfaces should be parallel.
7. Install diaphragm lever and axle assembly and secure with two axle retainer screws.
8. Install five aligning studs (C166-53) in five assembly screw holes in body casting.
9. Install secondary diaphragm, place with valve button down. NOTE: Disregard 7th hole in diaphragm.
10. Install secondary cover.
11. Install one assembly screw finger tight and then remove one aligning stud and replace it with another screw. Continue in this manner until all six assembly screws have been installed, then tighten all assembly screws evenly.
12. Turn regulator over and position it on bench so that the word "primary" is up and fuel outlet boss is toward operator.
13. Insert a valve piston, the end with rubber disc first, in valve channel on operator's right.
14. Install diaphragm lever and axle assembly and secure axle with two retainer screws.
15. Insert six aligning studs (C166-53) in the six assembly screw holes in body casting finger tight, then install primary diaphragm, plates up. NOTE: Disregard 7th hole in diaphragm.
16. Place primary diaphragm spring on small diaphragm plate.
17. Align match marks on primary diaphragm cover and regulator body.
18. Depress diaphragm cover all the way, remove one aligning stud, and replace it with an assembly screw, tighten screw moderately tight.
19. Remove remaining aligning studs one at a time and replace them with assembly screws while maintaining pressure on the cover. Tighten all screws evenly.
20. Place regulator on bench, primary side up and fuel outlet boss toward operator.
21. Place a new fiber washer on the primary valve plug (the one without the spring loaded adjusting screw and the one having the heavier of the two springs).
22. Install primary valve plug, fiber washer and spring assembly in the right hand piston channel. Tighten securely with a 13/16" wrench.
23. Use a new fiber washer and install secondary adjustment assembly in left hand channel.

Testing and Adjusting:

1. Turn the secondary adjusting screw to left (counterclockwise) as far as it will go. Now, turn it to the right (clockwise) three (3) turns.
2. Connect regulator inlet to a source of compressed air or gas in excess of 25 psi, depress primer button two or three times, connect a 0-15 lb. pressure gauge to fuel outlet and hold primer button in a depressed position. Pressure gauge should read approximately 2 psi and remain steady. If pressure creeps up, primary valve is leaking. Clean or replace parts as necessary.
3. Keep regulator inlet connected to a source of compressed air or gas in excess of 25 psi. Remove pressure gauge from fuel outlet channel and cover opening with a film of bubble solution. If secondary regulator valve is leaking, a bubble will begin to expand. Clean or replace valve parts as needed and recheck for leak.

4. Keep regulator fuel outlet covered with a bubble film and slowly turn secondary adjusting screw to left (counter-clockwise) until a bubble begins to form at outlet, then turn adjusting screw one turn to the right (clockwise).

5. Regulator is now ready to be placed in service. Further adjustments should be made at the carburetor ONLY.

COMBINATION GAS — GASOLINE

This system allows the engine to be operated on either gas or gasoline fuel and is generally used on a constant speed application, such as an electric plant.

When installing the combination system, the type of fuel to be used must be considered. Vendors of LPG (Butane and Propane) and natural gas can supply information on connections. It will be necessary for the vendors to supply or recommend a primary regulator to be used with the system to reduce line pressure.

The engine will require a pressure of from 4 to 8 ounces per square inch to be supplied to the connection at the secondary regulator. Pressure may be checked with a manometer. The reading for correct pressure would be 7 to 12 inches water column.

Gas fuel is supplied directly to carburetor air intake through a secondary regulator mounted on engine. By turning engine over at a continuous rate, engine vacuum will open regulator and allow fuel to enter combustion chamber. The secondary regulator has a priming button which allows gas to flow into system for quicker starting.

Gas Operation

1. Close shut-off valve on gasoline filter.

2. Open gas cock in gas supply line.

3. Start engine. If unit has not been previously adjusted for correct fuel - air mixture, loosen lock nut on mixture jet and turn jet until engine runs smooth under load. Retighten lock nut. If engine runs unevenly with no load, regulate air adjustment by turning until operation is smooth. It may be necessary to regulate gas adjustment jet to insure proper performance under load.

Changeover: Gas to Gasoline

1. Shut off gas cock in fuel supply line (normally located ahead of gas filter and gas regulator).

2. Open shut-off valve on gasoline filter.

3. Refer to Carburetor Adjustment Section, if any adjustment is necessary.

KEROSENE SYSTEM

Description: Kerosene operation is available on most Kohler Engines. The lower cost of kerosene and longer valve life make this fuel attractive; however, the reduction in horsepower (25 - 30%) limits its uses.

The volatility (ability to vaporize) and octane rating of kerosene is lower than gasoline. For this reason, kerosene powered engines are equipped with lower compression cylinder heads and fuel cups for starting on gasoline. To further aid operation, the K241 and K301 engines use an air restriction inlet ring on the flywheel so that the operating temperature of the engine increases and aids vaporization of kerosene. The K241 and K301 engines also have special piston rings to keep the crankcase oil dilution at a minimum.

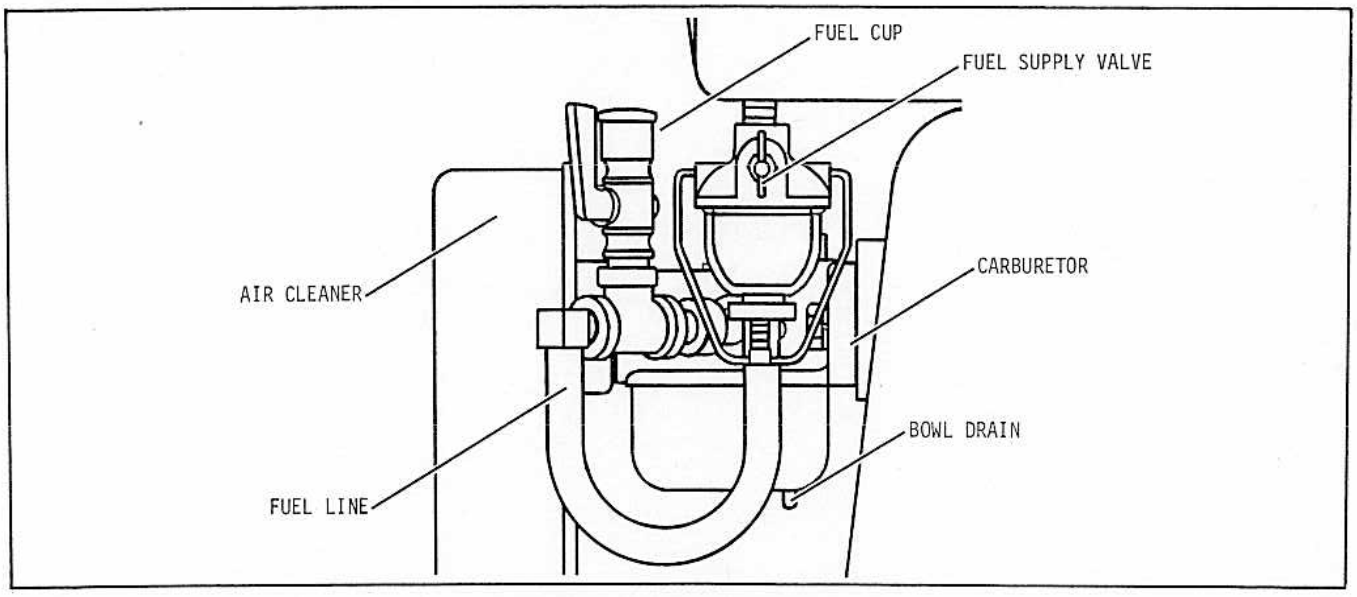


FIGURE 13-13 KEROSENE SYSTEM

The carburetors used for kerosene operation are similar to those used for gasoline except a bowl drain is included so that the kerosene can be drained before starting the engine. Note: Kerosene operated engines must be started on gasoline.

Starting Kerosene Equipped Engines: Before starting engine, the fuel supply valve must be closed to prevent kerosene from flowing to the carburetor. The carburetor must be drained of all kerosene. The carburetor drain is provided for this purpose.

Open gasoline fuel cup lever, fill cup and close lever. Start engine. After engine has started, open fuel supply valve to permit kerosene to flow from fuel tank to carburetor.

NOTE: For carburetor adjusting and repair, see Carburetor Adjustment in Gasoline Carburetor Reconditioning Section.

Always use

MODIFICATIONS & ACCESSORIES

CLUTCH

CLUTCH -- WET TYPE

To avoid overloading shafts or bearings, install sheave or sprocket as close to housing as possible. Center of sheave or sproket must be located within 1/2 the length of the shaft extension.

Lubrication

Oil bath type lubrication is used. Keep housing filled to oil level hole with nondetergent engine oil of proper grade.

ABOVE 50° F.	SAE 30
0° TO 50° F.	SAE 20
BELOW 0° F.	SAE 10

Change oil in PTO after each 100 hours of engine operation.

Adjustment

Clutch adjustment is necessary when it slips, heats or when the shifting lever jumps out. A new clutch may require adjustment to compensate for normal function surface wear-in.

To adjust clutch, remove nameplate and proceed as follows: Turn adjusting ring* in clockwise direction (use screwdriver blade) until force of 40 - 45 pounds is required at finger position on shifting lever to engage clutch.

*NOTE: Adjusting ring is spring loaded and need not be loosened. Do not pry or force spring lock away from ring.

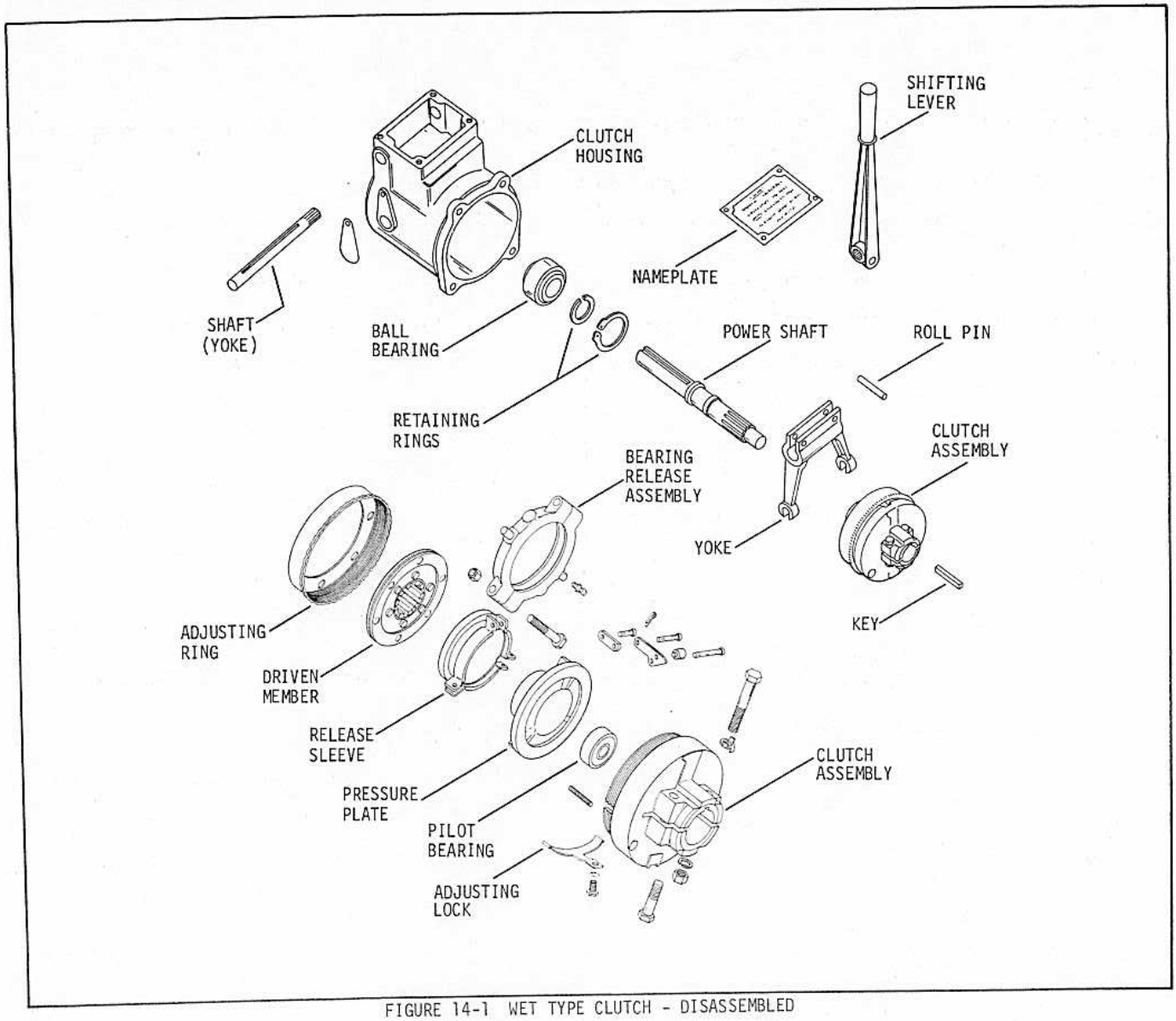


FIGURE 14-1 WET TYPE CLUTCH - DISASSEMBLED

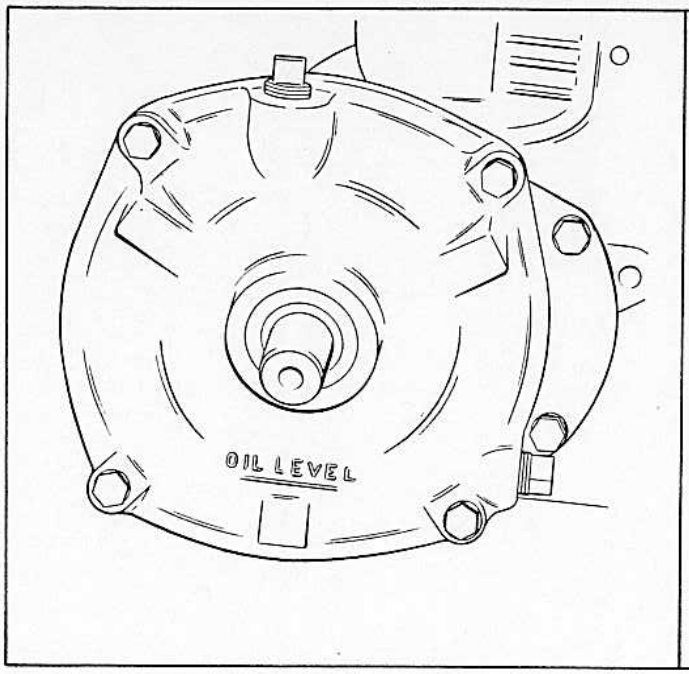


FIGURE 14-2 GEAR REDUCTION

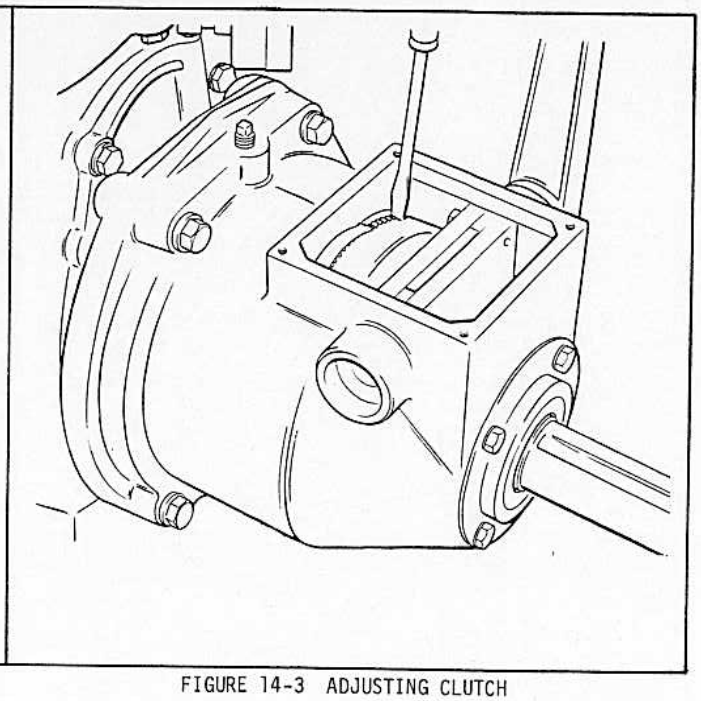


FIGURE 14-3 ADJUSTING CLUTCH

CLUTCH -- DRY TYPE

A firm pressure should be required to engage clutch. Adjustments should be made if slipping or overheating is noticed.

1. Remove inspection plate and locate adjustment lock by turning flywheel.
2. Release clutch and with a large screwdriver turn clutch collar clockwise, one notch at a time, until a firm pressure is required to engage clutch.
3. On final engagement, rollers should go over center to lock or clutch will release under load.
4. Every 50 operating hours lubricate clutch bearing collar through inspection plate on clutch housing.

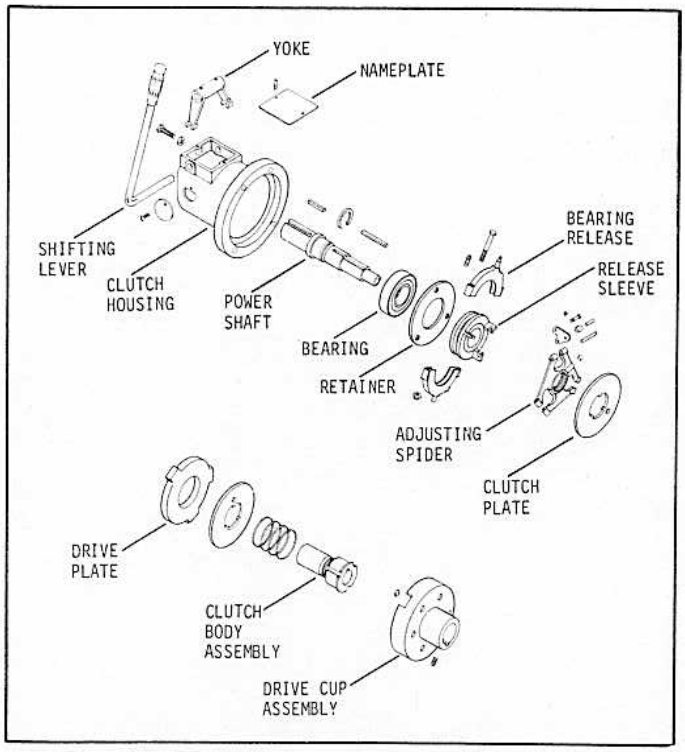


FIGURE 14-4 DRY TYPE CLUTCH - DISASSEMBLED

Service on Clutch

1. Remove cover plate and release clutch.
2. Remove two cap screws from clutch yoke and take out spacers.
3. Pull out clutch cross shaft.
4. Take out four housing bolts and slide off clutch housing.
5. Remove lock bolt and back out key lock screw in clutch assembly.
6. Pull assembly unit off of engine crankshaft.
7. If clutch plate replacement is necessary, clutch assembly should be bolted to crankshaft, unscrew adjustment collar and replace the plate.
8. Reverse the above procedure for reassembly.

GEAR REDUCTION

The reduction unit consists of a driven gear which is pressed on the power take off (P. T. O.) shaft. The drive gear is an integral part of the engine crankshaft. The P. T. O. shaft is supported by two bearings - one in the cover and the other in the housing. Oil seals are provided at both ends of the shaft. Unit must be disassembled for removal. The following procedure is used:

STEP A - Removal

1. Drain lubricating oil from unit.
2. Remove four cap screws from gear housing and slide cover off along with driven gear.
3. Remove four cap screws holding gear housing to engine.
4. Wash all parts and inspect shaft, bushing and gear for wear. Replace worn parts.
5. Remove old oil seals and install new seals (flat side out) in the gear housing and cover.

STEP B - Installation

1. Wrap piece of tape or roll paper around crankshaft gear to protect the oil seal, slide housing over the shaft and attach to the block. Two lock washers are used on the outside of housing and copper washers inside.
2. Tape or paper should be wrapped around the shaft to prevent the keyway from damaging the cover oil seal. Install the gasket(s) and reduction gear cover and tighten cap screws.
3. Adjust shaft end clearance to .001/.006 inches by varying the total gasket thickness, adding or removing gaskets as required.
4. Remove oil fill plug and oil level plug, fill unit to the oil level hole. (Same grade as used in engine.)

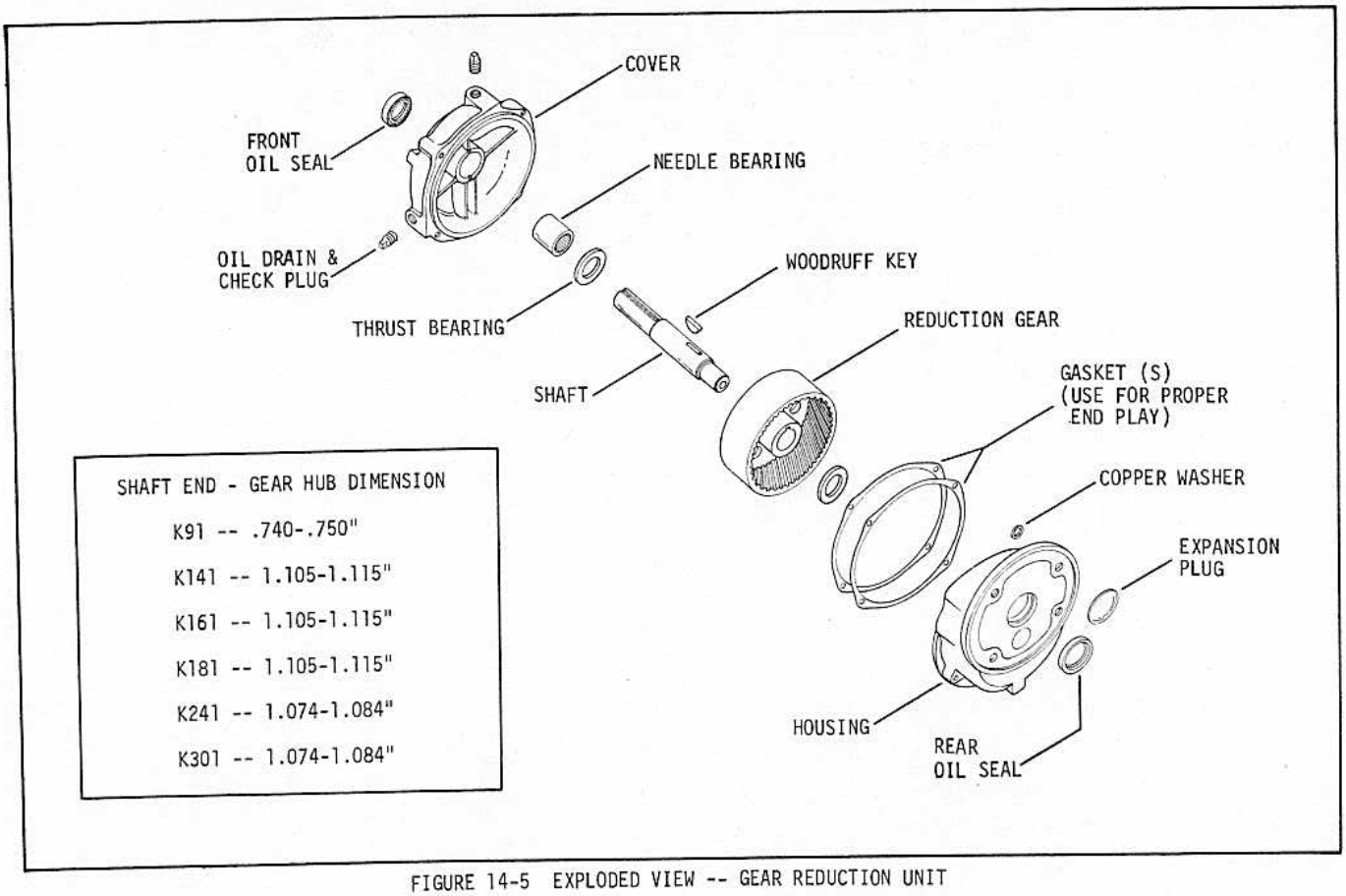


FIGURE 14-5 EXPLODED VIEW -- GEAR REDUCTION UNIT

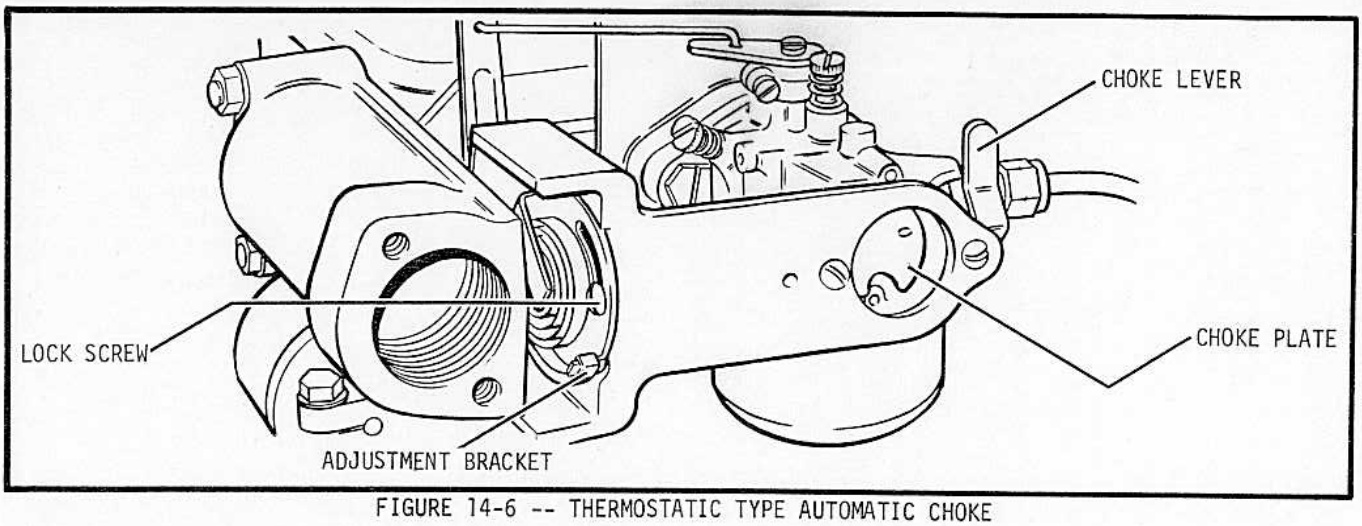


FIGURE 14-6 -- THERMOSTATIC TYPE AUTOMATIC CHOKE

AUTOMATIC CHOKES

Thermostatic Type: The automatic choke is a heat sensitive thermostatic unit. At room temperature, choke lever will be set in a vertical position. If engine should fail to start when cranked, adjust choke lever by hand to determine if choke setting is too lean or too rich. Once this has been established, adjustment can be made to remedy situation. Proceed as follows:

1. Loosen adjustment lock screw on choke body. This allows the position of adjustment bracket to be changed.
2. Moving adjustment bracket downward will increase the amount of choking. Upward movement will result in less choking.
3. After adjustment is made, tighten adjustment lock screw.

Electric-Thermostatic Type: Remove air cleaner from carburetor to observe position of choke plate. Choke adjustment must be made on cold engine. If starting in extreme cold, choke should be in full closed position before engine is started. A lesser degree of choking is needed in milder temperatures. If adjustment is needed, proceed as follows:

1. Move choke arm until hole in brass shaft lines up with slot in bearings.
2. Insert #43 drill (.089) and push all the way down to engine manifold to engage in notch in base of choke unit (See Figure 14.7).
3. Loosen clamp bolt on choke lever, push arm upward to move choke plate toward closed position. After desired position is attained, tighten clamp bolt then remove drill.
4. After replacing air cleaner, check for evidence of binding in linkage--correct if necessary. Be sure chokes are fully open when engine is at normal operating temperature.

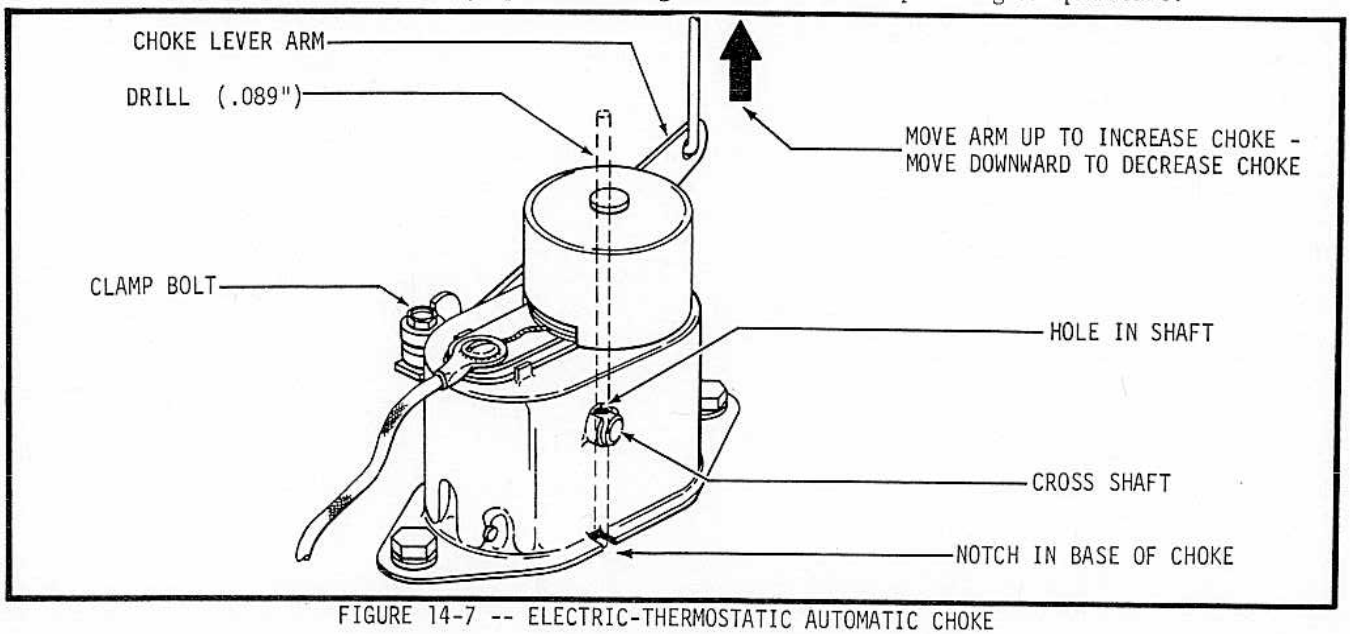


FIGURE 14-7 -- ELECTRIC-THERMOSTATIC AUTOMATIC CHOKE

WINTERIZED ENGINES

Engines used for winter or cold weather operation are supplied with special equipment. This special equipment is designed to gain optimum performance at low temperatures. The equipment affected is primarily the air intake system, the ignition system and the governor.

The special air intake system may consist of a duct assembly which is mounted on the carburetor and is generally used on engines exposed to ice and snow accumulations. The duct draws heat from the muffler and preheats the air entering the carburetor. Inside the duct assembly is an aluminum foil filter that filters the air passing through. This filter should be washed every 8 hours running time and oiled with SAE 30 oil. CAUTION: This system must not be used in areas where there is no snow or where high dust conditions are prevalent. In areas where high dust is encountered, the air intake heater should be removed and replaced with the Kohler approved dry type air cleaner.

For certain snowmobile applications or for engines to be used where air intake is protected from snow and ice accumulations, a special intake system is used. This system does not include an air cleaner and should never be used in anything but snow conditions.

For certain applications, a second duct is installed adjacent to the preheater duct which covers the governor. This duct protects the working exterior parts of the governor from snow and ice accumulations and furnishes sufficient heat while the engine is running to keep these parts operative.

A resistor type spark plug is normally used for cold weather applications. This plug minimizes fouling and assures better starting characteristics.

Engine users or owners should be cautioned against using certain winterized engines during the hot summer months since these engines may overheat.

TOOL LIST

Common Tools

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

DESCRIPTION	SIZE	DESCRIPTION	SIZE
Combination Wrench	3/8"	3/8" Socket	7/16" Hex. Standard
Combination Wrench	7/16"	3/8" Socket	1/2" Hex. Standard
Combination Wrench	1/2"	3/8" Socket	1/2" Deep
Combination Wrench	9/16"	3/8" Socket	9/16" Deep
Combination Wrench	5/8"	3/8" Socket	13/16" Deep
Screw Driver	5/16" x 6"	Ft. Lb. Torque Wrench	
Screw Driver	3/8" x 10"	In. Lb. Torque Wrench	
Screw Driver	#1 Phillips x 3"	Ring Compressor	
Pliers	6"	Ring Expander	
Ball Peen Hammer	12 oz.	Valve Spring Compressor	
Feeler Gauge	25 Blade	Needle Nose Pliers	
Drift Punch	5/16"	Timing Light	
Ratchet	3/8" Drive	Tachometer	
3" Extension	3/8" Drive		

Special Tools

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

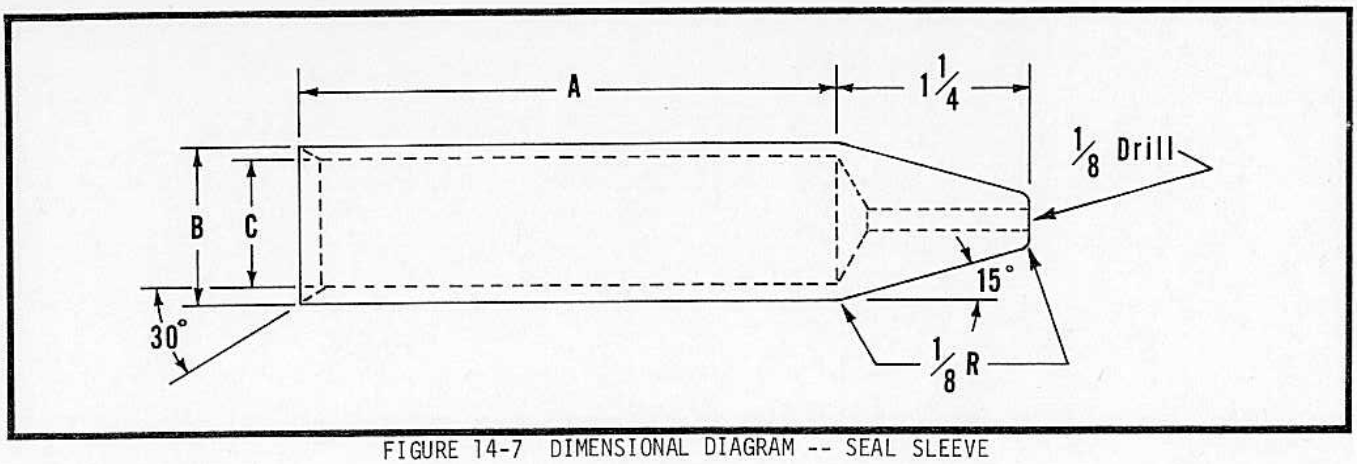


FIGURE 14-7 DIMENSIONAL DIAGRAM -- SEAL SLEEVE

SEAL SLEEVE DIMENSION (FIG. 14-7)	K91	ENGINE MODEL K141, K161, K181	K241, K301, K321
A	3-3/4"	4-3/4"	7-5/16"
B	.902/.903" .902/.907" .930/.935"	1.125/1.120"	1.245/1.250" 1.495/1.500"
C*	.7510/.7515"	1.002/1.003"	1.002/1.003" 1.252/1.253"

* *C dimension for standard crankshafts. On some applications, special sleeves will be needed. To determine C dimension, use diameter of crankshaft plus .002/.003".*

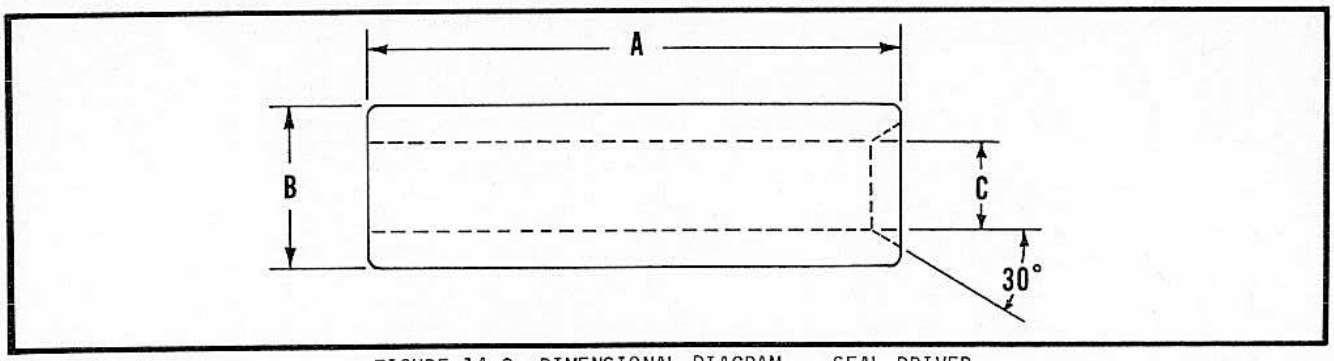


FIGURE 14-8 DIMENSIONAL DIAGRAM -- SEAL DRIVER

SEAL DRIVER DIMENSION (FIG. 14-8)	K91	ENGINE MODEL K141, K161, K181	K241, K301, K321
A	5-1/4"	6-1/4"	8-13/16"
B	1-3/4"	2"	1-11/16"
C	.905/.906" .905/.910" .933/.938"	1.123/1.128"	1.248/1.253" 1.498/1.503"

Tools required for special equipment are as follows:

PART NO.	PURCHASED FROM	DESCRIPTION
C-161-199	The Bendix Corp.	Easy-Out
C-161-198	The Bendix Corp.	Valve Seat Inserting Tool
C-166-53	The Bendix Corp.	Aligning Stud (6 Rqd.)

SPECIFICATIONS

TORQUE SPECIFICATIONS

ENGINE MODEL	GOV. ARM LOCK SCREW	CYLINDER HEAD*	CONNECTING ROD*	FLYWHEEL NUT	SPARK PLUG
K91	35 in. lbs.	200 in. lbs.	140 in. lbs.	40-55 ft. lbs.	18-22 ft. lbs.
K141	35 in. lbs.	15-20 ft. lbs.	200 in. lbs.	50-60 ft. lbs.	18-22 ft. lbs.
K161	35 in. lbs.	15-20 ft. lbs.	200 in. lbs.	50-60 ft. lbs.	18-22 ft. lbs.
K181	35 in. lbs.	15-20 ft. lbs.	200 in. lbs.	50-60 ft. lbs.	18-22 ft. lbs.
K241	----	25-30 ft. lbs.	300 in. lbs.	60-70 ft. lbs.**	18-22 ft. lbs.
K301	----	25-30 ft. lbs.	300 in. lbs.	60-70 ft. lbs.**	18-22 ft. lbs.
K321	----	25-30 ft. lbs.	300 in. lbs.	60-70 ft. lbs.	18-22 ft. lbs.

**Lubricate with oil at assembly.*
***On earlier K241, K301 Models with 3/4" - 16 thread tighten nut to 100 ft. lbs.*

STANDARD BOLTS, SCREWS & NUTS

Size	Tightening Torque		
	Grade 2	Grade 5	Grade 8
1/4-20	70 in. lb.	115 in. lb.	165 in. lb.
1/4-28	85 in. lb.	140 in. lb.	200 in. lb.
5/16-18	150 in. lb.	250 in. lb.	350 in. lb.
5/16-24	165 in. lb.	270 in. lb.	30 ft. lb.
3/8-16	260 in. lb.	35 ft. lb.	50 ft. lb.
3/8-24	300 in. lb.	40 ft. lb.	60 ft. lb.
7/16-14	35 ft. lb.	55 ft. lb.	80 ft. lb.
7/16-20	45 ft. lb.	75 ft. lb.	105 ft. lb.
1/2-13	50 ft. lb.	80 ft. lb.	115 ft. lb.
1/2-20	70 ft. lb.	105 ft. lb.	165 ft. lb.
9/16-12	75 ft. lb.	125 ft. lb.	175 ft. lb.
9/16-18	100 ft. lb.	165 ft. lb.	230 ft. lb.
5/8-11	110 ft. lb.	180 ft. lb.	260 ft. lb.
5/8-18	140 ft. lb.	230 ft. lb.	330 ft. lb.
3/4-10	150 ft. lb.	245 ft. lb.	350 ft. lb.
3/4-16	200 ft. lb.	325 ft. lb.	470 ft. lb.

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

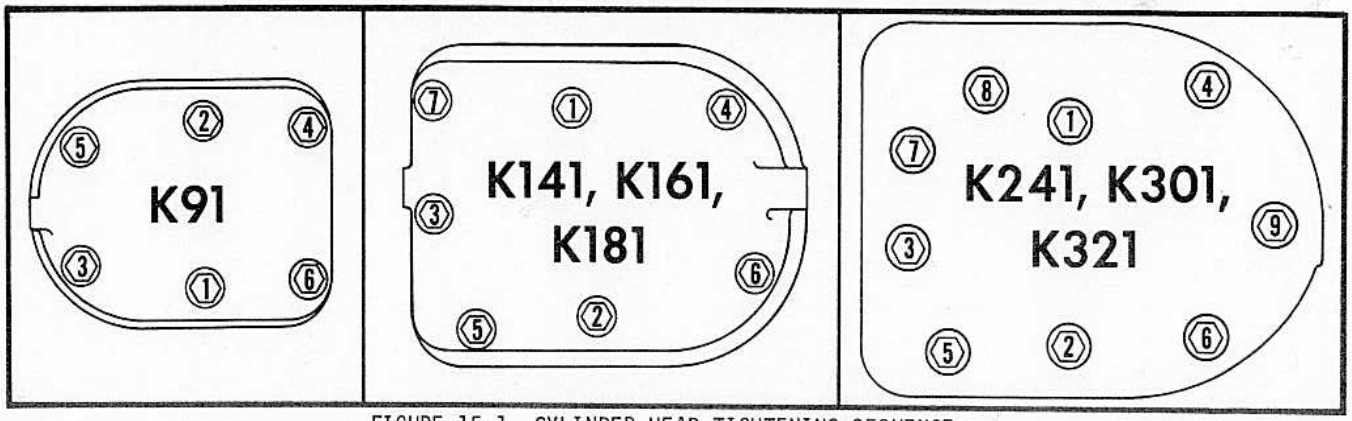


FIGURE 15-1 CYLINDER HEAD TIGHTENING SEQUENCE

SPECIFICATION	ENGINE MODEL						
	K91	K141-161 BEFORE SPEC. # *	K141-161 AFTER SPEC. # *	K181	K241	K301	K321
Bore and stroke	2-3/8x2	2-7/8x2-1/2	2-15/16x2-1/2	2-15/16x2-3/4	3-1/4x2-7/8	3-3/8x3-1/4	3-1/2x3-1/4
Bore diameter, new	2.375	2.875	2.9375	2.9375	3.250	3.375	3.500
Crankshaft end play (free)	.0038/.0228	.002/.023	.002/.023	.002/.023	.003/.020	.003/.020	.003/.020
Crankshaft - conn. rod journal size (Std.)	.9360/.9355	1.1860/1.1855	1.1860/1.1855	1.1860/1.1855	1.5000/1.4995	1.5000/1.4995	1.5000/1.4995
Crankpin - conn. rod side clearance	.005/.016	.005/.016	.005/.016	.005/.016	.007/.016	.007/.016	.007/.016
Crankpin length	.875	1.125	1.125	1.125	1.187	1.180	1.180
Main bearing journal diameter	.984	1.181	1.181	1.181	1.575	1.575	1.575
Connecting rod to crankpin running clearance	.001/.0025	.001/.002	.001/.002	.001/.002	.001/.002	.001/.002	.001/.002
Connecting rod to piston pin clearance	.0005/.0010	.0006/.0011	.0006/.0011	.0006/.0011	.0003/.0008	.0003/.0008	.0003/.0008
Piston pin to piston boss	.0002 Int. to .0002 Loose	.0001 Int. to .0003 Loose	.0001 Int. to .0003 Loose	.0001 Int. to .0003 Loose	.0000/.0003 Select Fit	One Thumb Push Fit	One Thumb Push Fit
Piston to cylinder bore (thrust face)	.003/.004	.0045/.0065	.0045/.0070	.0045/.0070	.003/.004	.003/.004	.0035/.0045
Piston to cylinder bore (top of skirt)	.0035/.0060	.006/.0075	.0060/.0080	.006/.0080	.0075/.0085	.0065/.0095	.007/.010
Piston pin diameter (Std.)	.5624	.6248	.6248	.6248	.8592	.8753	.8753
Ring side clearance, top ring	.002/.004	.0025/.0040	.0025/.0040	.0025/.0040	.002/.004	.002/.004	.002/.004
Ring side clearance, middle ring	.002/.004	.0025/.0040	.0025/.0040	.0025/.0040	.002/.004	.002/.004	.002/.004
Ring side clearance, oil ring	.0015/.0035	.001/.0025	.001/.0025	.001/.0025	.001/.003	.001/.003	.001/.003
Ring end gap	.007/.017	.007/.017	.007/.017	.007/.017	.010/.020	.010/.020	.010/.020
Ring width, top ring	.093	.093	.093	.093	.093	.093	.093
Ring width, middle ring	.093	.093	.093	.093	.093	.093	.077
Ring width, oil ring	.187	.187	.187	.187	.187	.187	.187
Gear reduction shaft end play	.005/.010	.001/.006	.001/.006	.001/.006	.005/.010	.005/.010	.005/.010

Camshaft pin to camshaft clearance	.0010/.0025	.0010/.0035	.0010/.0035	.0010/.0035	.001/.0035	.001/.0035	.001/.0035
Camshaft pin to block (Bearing plate end)	.0005/.0012	.0005/.0020	.0005/.0020	.0005/.0020	.0005/.002	.0005/.002	.0005/.002
Camshaft pin to block (P.T.O.E.) (Int.)	.0055/.002	.0015/.003	.0015/.003	.0015/.003	.0015/.003	.0015/.003	.0015/.003
Camshaft pin to breaker cam	.001/.0025	.0010/.0035	.0010/.0035	.0010/.0035	.0010/.0025	.0010/.0025	.0010/.0025
Camshaft end play	.005/.020	.005/.010	.005/.010	.005/.010	.005/.010	.005/.010	.005/.010
Valve stem clearance in guide, intake	.0005/.0020	.0010/.0025	.0010/.0025	.0010/.0025	.0010/.0025	.0010/.0025	.0010/.0025
Valve stem clearance in guide, exhaust	.0020/.0035	.0025/.0040	.0025/.0040	.0025/.0040	.0025/.0040	.0025/.0040	.0025/.0040
Valve guide in block (Interference)	Not Used	.0005/.0020	.0005/.0020	.0005/.0020	.0005/.0020	.0005/.0020	.0005/.0020
Valve seat in block (exhaust) (Interference)	.002/.005	.002/.004	.002/.004	.002/.004	.003/.005	.003/.005	.003/.005
Valve clearance, intake (cold)	.005/.009	.006/.008	.006/.008	.006/.008	.008/.010	.008/.010	.008/.010
Valve clearance, exhaust (cold)	.011/.015	.015/.017	.015/.017	.015/.017	.017/.019	.017/.019	.017/.019
Valve seat angle	44.5	44.5	44.5	44.5	44.5	44.5	44.5
Valve face angle	45	45	45	45	45	45	45
Valve seat width	.037/.045	.037/.045	.037/.045	.037/.045	.037/.045	.037/.045	.037/.045
Valve tappet clearance in block	.0005/.002	.0005/.002	.0005/.002	.0005/.002	.0008/.0023	.0008/.0023	.0008/.0023
Governor bushing to gov. cross shaft clear.	.0012/.0027	.0005/.002	.0005/.002	.0005/.002	.001/.0025	.0010/.0025	.0010/.0025
Governor gear to governor shaft	--	.0025/.0055	.0025/.0055	.0025/.0055	.0005/.0020	.0005/.0020	.0005/.0020
Governor cross shaft end play	--	.005/.030	.005/.030	.005/.030	.005/.030	.005/.030	.005/.030
Ball bearing to cylinder block (Interference)	.007/.0022	.0014/.0029	.0014/.0029	.0014/.0029	.0006/.0022	.0006/.0022	.0006/.0022
Ball bearing to bearing plate (Interference)	.0007/.0022	.0014/.0029	.0014/.0029	.0014/.0029	.0012/.0028	.0012/.0028	.0012/.0028
Ball bearing to crankshaft (Int. to loose)	.0004/.0003	.0005/.0002	.0005/.0002	.0005/.0002	.0004/.0005	.0004/.0005	.0004/.0005
Sleeve bearing to crankshaft (K141 only)	--	.0010/.0025	--	--	--	--	--
Sleeve bearing to bearing plate, K141 (Int.)	--	.0020/.0045	--	--	--	--	--

Specification number for K141 Spec. 29356; for K161 Spec. 281162.

WEAR TOLERANCES & CLEARANCES (MAX.)

SPECIFICATION (INCHES)*	K91	K141 & K161		K181	K241	K301	K321
		2-7/8" BORE	2-15/16" BORE				
CYLINDER BORE							
Maximum Oversize Diameter	2.378	2.878	2.9405	2.9405	3.2545	3.3785	3.503
Maximum Allowable Taper	.0025	.0025	.0025	.0025	.0015	.0015	.0015
Maximum Out of Round	.005	.005	.005	.005	.005	.005	.005
CRANKSHAFT CRANKPIN							
Maximum Out of Round	.0005	.0005	.0005	.0005	.0005	.0005	.0005
Maximum Taper	.001	.001	.001	.001	.001	.001	.001
CONNECTING ROD							
Maximum Wear Diameter-Big End	.9385	1.1885	1.1885	1.1885	1.5025	1.5025	1.5025
Rod to Crankpin-Max. Clear.	.0035	.0035	.0035	.0035	.0035	.0035	.0035
PISTON - THRUST FACE							
Maximum Wear Diameter	2.359	2.866	2.9305	2.9305	3.2445	3.7025	3.4945
PISTON RING							
Maximum Side Clearance	.006	.006	.006	.006	.006	.006	.006
VALVE STEM TO GUIDE**							
Exhaust - Maximum Clearance	.006	.006	.006	.006	.0065	.0065	.0065
Intake - Maximum Clearance	.004	.0045	.0045	.0045	.0045	.0045	.0045

**Maximum allowable before replacement, reboring, regrinding--see page 15.1-15.2 for new dimensions.*
***Measure at top of guide with valve closed.*

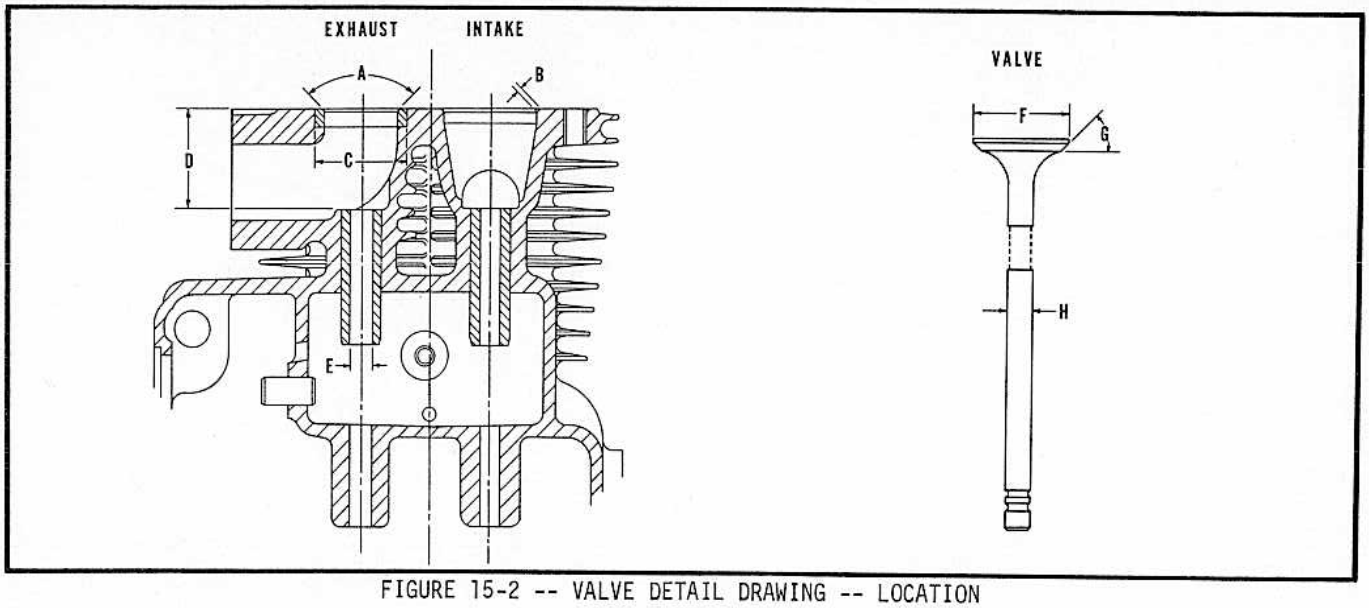


FIGURE 15-2 -- VALVE DETAIL DRAWING -- LOCATION

VALVE DETAILS

DIMENSION (SEE FIG. 15-2)	MODEL K91		MODEL K141, K161, K181		MODEL K241, K301, K321	
	INTAKE	EXHAUST	INTAKE	EXHAUST	INTAKE	EXHAUST
A SEAT ANGLE	89°	89°	89°	89°	89°	89°
B SEAT WIDTH	.037/.045	.037/.045	.037/.045	.037/.045	.037/.045	.037/.045
C INSERT O. D.	------	.972/.973	------	1.2535/1.2545	------	1.2535/1.2545
D GUIDE DEPTH	NONE	NONE	1-5/16	1-5/16	1-15/32	1-15/32
E GUIDE I. D.	NONE	NONE	.312/.313	.312/.313	.312/.313	.312/.313
F VALVE HEAD DIAMETER	.979/.989	.807/.817	1-3/8	1-1/8	1.370/1.380	1.120/1.130
G VALVE FACE ANGLE	45°	45°	45°	45°	45°	45°
H VALVE STEM DIAMETER	.2480/.2485	.2460/.2465	.3105/.3110	.3090/.3095	.3105/.3110	.3090/.3095

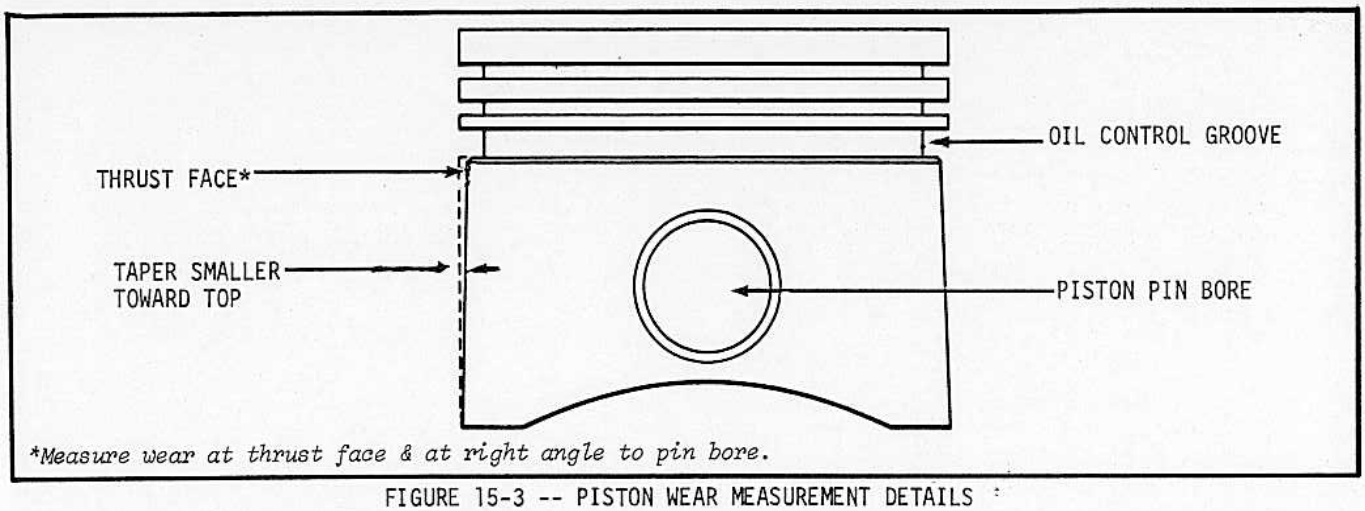


FIGURE 15-3 -- PISTON WEAR MEASUREMENT DETAILS

OIL SEAL INSTALLATION

When installing new oil seals, apply a liberal amount of light grease such as lubriplate on the seal lip area. Use seal driver and seal sleeve of appropriate size and install carefully to prevent the seal lip from rolling and creasing. Press against outer edges of seal--press squarely into position and to the depth specified in the chart below. Note that the front oil seal depth varies with engine model and type of bearing plate used--bearing plate configuration differs with type of ignition system used--these differences are shown in the cutaway views in Figure 15-4 to help identify the various bearing plate types. Rear oil seal installation details are shown in Figure 15-5 on the next page.

ENGINE MODEL	FRONT OIL SEAL LOCATION					
	MAGNETO ROTOR	FLYWHEEL MAGNETO	3 AMP ALTERNATOR	10 AMP ALTERNATOR	BREAKERLESS	BATTERY
K91	1/32"	1/32"	--	--	--	1/32"
K141	--	1/32"*	Full In	1/32"	--	Full In
K161	1/32"	1/32"	--	1/32"	--	1/32"
K181	1/32"	1/32"	1/32"	1/32"	.486"	1/32"
K241	--	1/2"	1/2"	1/2"	.73"	1/2"
K241A	--	.52"	--	1/2"	.52"	.12"
K301	--	1/2"	1/2"	1/2"	.73"	1/2"
K301A	--	.52"	.52"	1/2"	.52"	.12"
K321	--	1/2"	1/2"	1/2"	.73"	1/2"

With sleeve bearing-drive seal in until it bottoms against shoulder.

REAR OIL SEAL DEPTH: 1/32" for K91 thru K181, 1/8" for K241 thru K321. Depth measured in from crankcase face at PTO end.

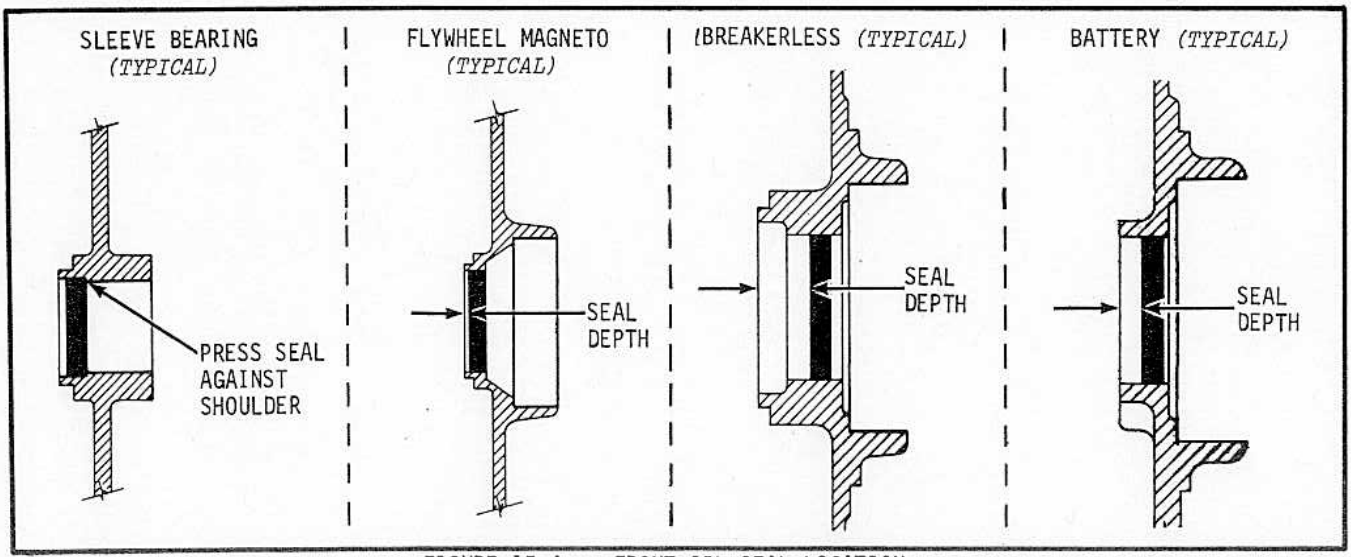
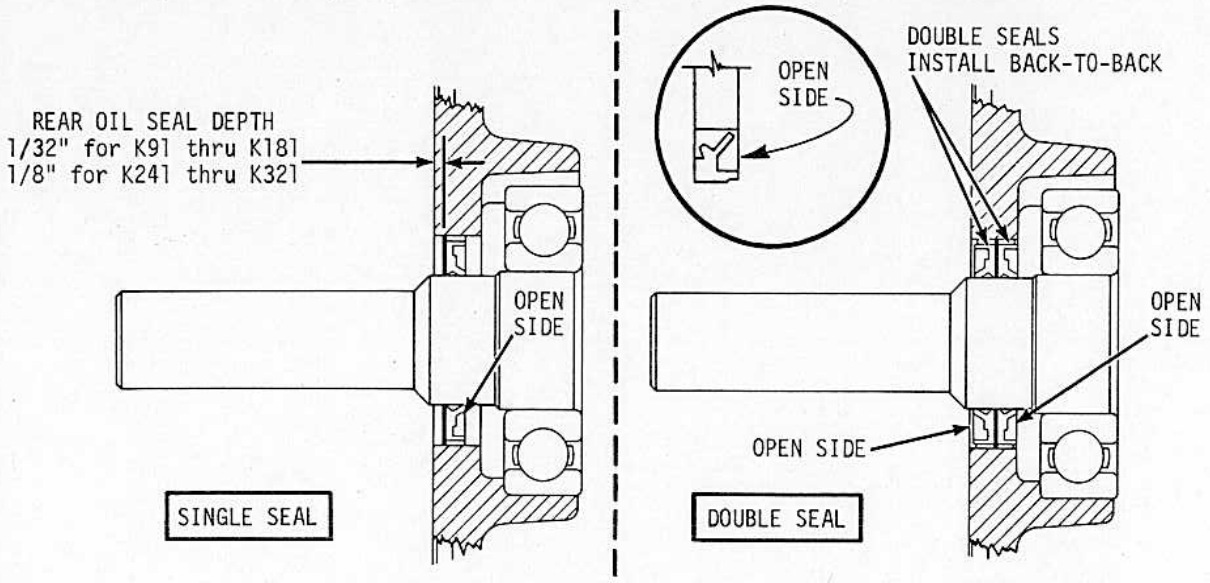


FIGURE 15-4 -- FRONT OIL SEAL LOCATION



NOTE: In applications using an oil reservoir outside the PTO end of block, two seals are installed back to back to provide sealing both ways--on these, install seals with lips facing direction shown in the cutaway view on the right.

FIGURE 15-5 -- REAR OIL SEAL INSTALLATION DETAILS

MARCH 13/76 BORE NOMINAL 3.25"

Top

" Down.	Ga.	Corrected	ø+ in Thousandths
0"	4	0	0
1/2"	38	34	10.4
1"	28	24	7.6
1 1/2"	29	25	7.9
2 1/2"	26	22	7.0
3 1/2"	18	16	5.1
4 1/4	6	2	0.6
5 1/2	4	0	0