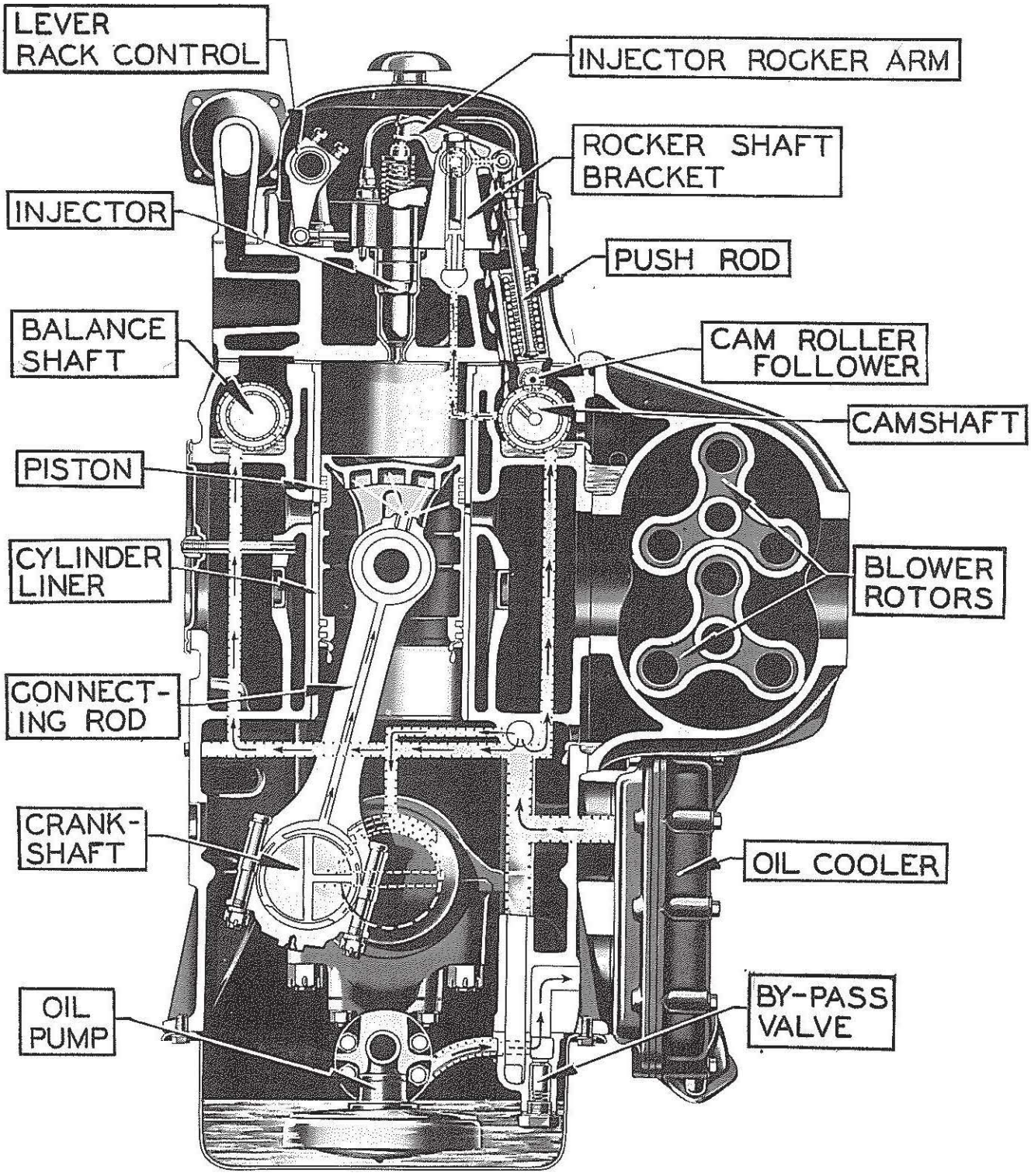


CROSS SECTION OF ENGINE, SHOWING LUBRICATION

1 -- Specifications of Lubricants

A. Engine Crankcase Lubricant:

USE NON-CORROSIVE HEAVY DUTY DIESEL ENGINE LUBRICATING OIL CONTAINING ADDITIVES WHICH WILL PREVENT SLUDGE OR GUM DEPOSITS. UNDER NO CIRCUMSTANCES SHOULD A CORROSIVE DIESEL ENGINE LUBRICATING OIL EVER BE USED.

Atmospheric Temperature	Viscosity
Above 32° F.	Use SAE 30
0° F. to 32° F.	Use SAE 20 W
0° F. and below	Use SAE 10 W

Manufacturers of lubricants recognize the importance of the qualities required for use in our equipment and they are cooperating fully to insure the use of only those oils which fulfill these requirements. The oil distributor and oil manufacturer are to be held responsible for the results obtained from their products.

The outstanding lubricating requirements for efficient operation of this engine are: The maintaining of piston rings in a clean, free condition; absence of hard carbon and "varnish" deposits on or within engine parts; the prevention of bearing corrosion and the promotion of general cleanliness within the engine.

Proper operation and maintenance of the engine is necessary to obtain the desired results from the lubricating oil. Operating and maintenance factors can be effectively controlled by the engine user.

B. Transmission and Final Drive Lubricant:

Lubricate these assemblies with motor oil. A list of the various brands of motor oils which have been tested and approved for use in these assemblies is shipped with each tractor and is also available from Allis-Chalmers dealers. Use only an oil shown on this list, as the use of untested oils may result in deterioration of the Neoprene boots and rings in these assemblies.

Use oils with the following viscosity:

Atmospheric Temperature	Viscosity
Above 32° F.	Use SAE 50
32° F. and Below	Use SAE 30

A revised list of approved oils and greases is issued every six months. New oils and greases which have been tested and approved during each period are added to the list. Ask your nearest Allis-Chalmers factory branch or authorized dealer for latest list.

C. Truck Wheel, Track Idler and Track Support Roller Lubricant:

Lubricate these assemblies with a grease that has been tested and approved by Allis-Chalmers Mfg. Co.

The type of grease used for lubricating these assemblies was selected because of its good pumpability and cold temperature characteristics and because of its having a minimum effect on the synthetic rubber seal boots. It is also an extremely stable grease and will not deteriorate excessively with long use.

Ask your nearest Allis-Chalmers factory branch or authorized dealer for the latest list of greases that have been found satisfactory.

D. Pressure Gun Lubricant:

Use a pressure gun lubricant with a minimum melting point of 300° F. This lubricant should be in a viscosity range so as to insure easy handling in the pressure gun at prevailing air temperature.

NOTE: In selecting the pressure gun lubricant make certain that it will not wash away in presence of water.

1E -- Specifications of Fuel Oil

Use No. 1 or No. 2 Diesel Fuel Oil purchased from a reputable oil company. This fuel must be within the classification limits as established by the American Society for Testing Materials.

For longer engine life and better performance, fuel oil requirements must comply with four basic qualifications.

1. Physical cleanliness
2. Absence of chemical contamination
3. Proper burning characteristics

4. Cold starting ability

Physical cleanliness means freedom from water, dirt and other incombustible ingredients. Since all present day high-speed engine fuels are completely distilled, they leave the refinery in clean condition. Transport and subsequent storage account for the addition of most foreign matter found in the fuel.

Of the chemical contamination, the most objectionable are free sulphur and gum, which, even in relatively small quantities, are largely responsible for harmful internal engine deposits. The fuel must also be free from alkali and mineral acids.

Proper burning characteristics are dependent upon ignition quality and volatility.

The ignition quality of a fuel is indicated by cetane numbers. Fuels with a low cetane number will not ignite as readily as fuels having a high cetane number. Use fuel with a cetane number of at least 40. For winter use, fuels with a higher cetane number are conducive to easier starting and shorter ignition delay.

Volatility is determined by the boiling temperature range. Fuels having a low final boiling point will vaporize and burn more completely than fuels with a high final boiling point.

The preferred high speed diesel fuels range in color from white to light amber.

2 -- Routine Service

The operating life of a tractor can be materially lengthened and fewer shut downs will be experienced if the unit is properly serviced at regular intervals. Often major repairs and shut downs can be avoided if the tractor is inspected regularly and any difficulties corrected when it is of a minor nature.

The following outline gives the operator the points that should be lubricated and inspected at each inspection period.

Ten (10) Hour Service

Lubricate:
- All Button Head Fittings—(Stabilizers Crank Assembly)
  - (a) Stabilizer Link
  - (b) Stabilizer Link Shaft
  - (c) Stabilizer Crank Support
- Bell Crank Thrust Pin ("HD 10" & "HD 14")
- Master Clutch Shifter Bearing
- Steering Clutch Release Bearings

Inspect:
- Crankcase Oil Level
- Air Cleaners
- Pre-Cleaners
- Cooling System
- Fuel Sediment Trap
- Batteries
- Transmission Case Oil Level
- Fuel Tank
- Final Drive Case Oil Level
- Inspect Tractor for Loose Nuts and Bolts
- Steering Clutch Throwout Adjustment
- Master Clutch Adjustment
- Brake Adjustment
- Front Idler and Track Adjustment

Sixty (60) Hour Service

Drain and refill crankcase. The oil should be changed every 30 to 60 hours, depending upon the quality of oil, the kind of fuel used and the working conditions.

Clean primary lubricating oil filter.

Install a new element in the secondary filter with every fourth oil change or every 240 hours.

One Hundred (100) Hour Service

Inspect:
- Generator Belt
- Fan Belts
- Wire Insulation and Connections
- Track Shoe Bolts
- Final Drive Packing Adjustments ("HD 14" only)

Lubricate:
- Brake Floating Bell Crank ("HD 10" only)

Two Hundred (200) Hour Service

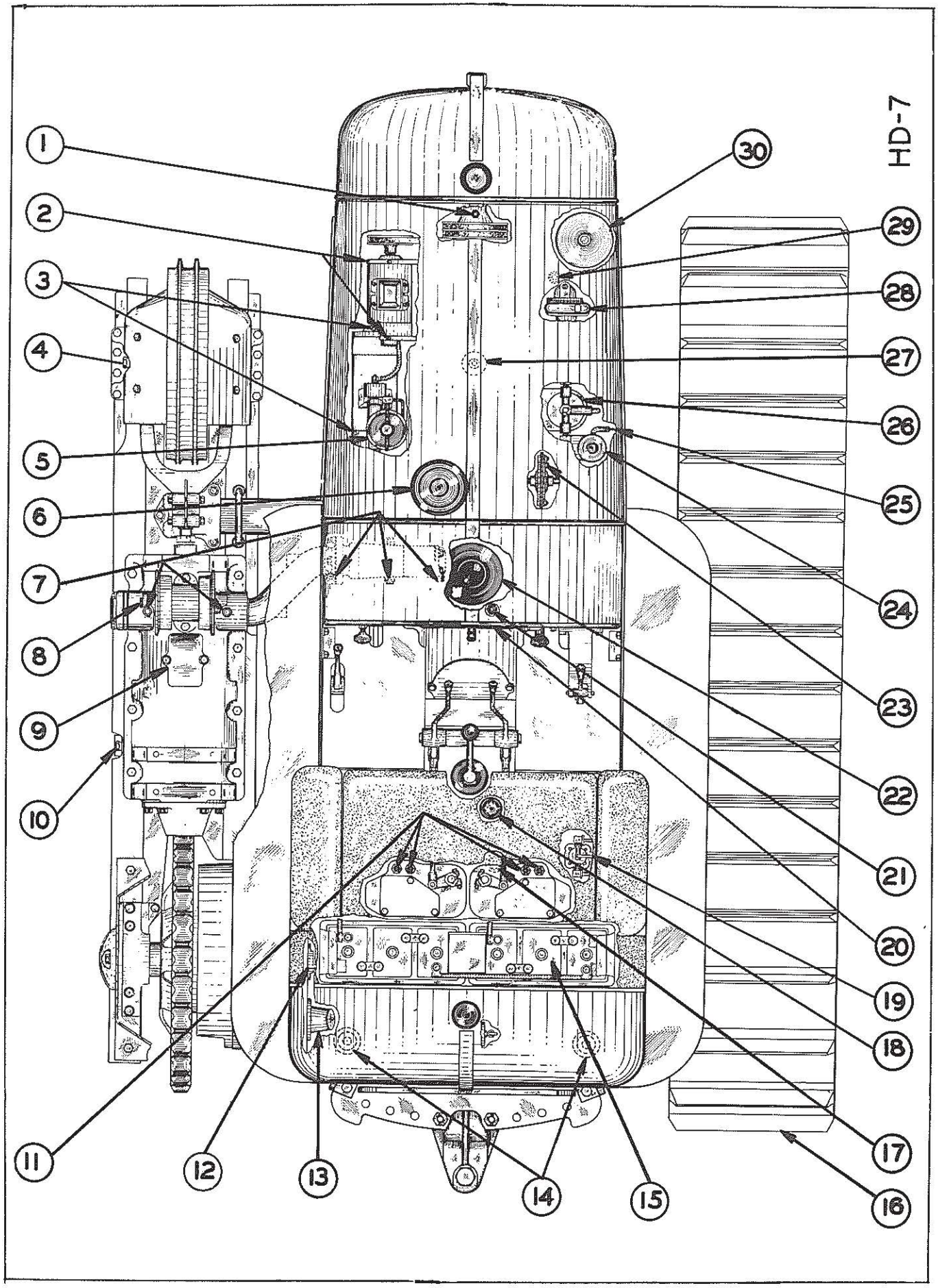
Lubricate:
- Truck Wheels, Front Idlers, Track Support Rollers } See 1000 HOUR SERVICE
- Fan
- Generator
- Starter
- Track Release Spring Mechanism
- Master Clutch Cams (HD-10 and HD-14)
- Drain, flush and refill cooling system.
- Drain, flush, and refill final drive cases. The oil in the final drive cases should be changed every 200 to 400 hours of operation, depending upon the operating conditions.

One Thousand (1000) Hour Service

Lubricate:
- Truck Wheels
- Front Idlers
- Track Support Rollers

These assemblies on tractors Serial Number HD-7 #12566, HD-10 #6163 and HD-14 #5614 and later are lubricated with grease and should be lubricated after every 1000 hours of operation.

These assemblies on tractors prior to Serial Number HD-7 #12566, HD-10 #6163, and HD-14 #5614 are lubricated with oil and should be lubricated after every 200 hours of operation. NOTE: These assemblies may be grease-packed if desired and then serviced after every 1000 hours of operation. (Refer to Topics 6, 7, and 8.)


HD-7
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3 -- "HD 7" Lubrication and Service Chart

1. FAN—One Lubrication point—Lubricate every 200 hours of operation with pressure gun lubricant.
2. GENERATOR—Two lubrication points—Lubricate every 200 hours of operation with light motor oil.
3. STARTER — Two lubrication points — Lubricate every 200 hours of operation with light motor oil.
4. FRONT IDLERS—Two lubrication points (one on each side of tractor).
   GREASE LUBRICATED IDLERS (On tractors, Serial Number 12566 and later). Lubricate every 1000 hours of operation. Using lubricating gun, pump grease in SLOWLY until clean grease can be seen coming out along the outside of the grease gun nozzle. Use an approved grease. Refer to Topic 7.
   OIL LUBRICATED IDLERS (On tractors, prior to Serial Number 12566). Lubricate every 200 hours of operation with 5 strokes of the gun. Use an approved motor oil. Refer to Topic 7.
5. SECONDARY OIL FILTER—Install a new element every 240 hours of operation or every 4th change of oil. Refer to Topic 10C.
6. PRE-CLEANER—Inspect and service every 10 hours of operation. Refer to Topic 12.
7. STABILIZER CRANK ASSEMBLY—Ten lubrication points. Lubricate every 10 hours of operation with pressure gun lubricant.
8. TRACK SUPPORT ROLLERS—Two Lubrication points (one on each side of tractor).
   GREASE LUBRICATED ROLLERS (On tractors, Serial Number 12566 and later). Lubricate every 1000 hours of operation. Using lubricating gun, pump grease in SLOWLY until clean grease can be seen coming out along the outside of the grease gun nozzle. Use an approved grease. Refer to Topic 8.
   OIL LUBRICATED ROLLERS (On tractors prior to Serial Number 12566). Lubricate every 200 hours of operation with 3½ strokes of the gun. Use an approved motor oil. Refer to Topic 8.
9. TRACK RELEASE SPRING MECHANISM—Inspect oil level every 200 hours of operation. Keep filled to filler plug with motor oil same viscosity as used in transmission. Drain, flush and refill with motor oil same viscosity as used in transmission every 800 hours of operation. Capacity 4 quarts.
10. TRUCK WHEELS—Ten lubrication points (five on each side of tractor).
    GREASE LUBRICATED WHEELS (On tractors, Serial Number 12566 and later). Lubricate every 1000 hours of operation. Using lubricating gun, pump grease in SLOWLY until clean grease can be seen coming out along the outside of the grease gun nozzle. Use an approved grease. Refer to Topic 6.
    OIL LUBRICATED WHEELS (On tractors prior to Serial Number 12566). Lubricate every 200 hours of operation with 4 strokes of the gun. Use an approved motor oil. Refer to Topic 6.
11. STEERING CLUTCH THROWOUT BEARING —Four lubrication points. Lubricate every ten hours of operation with pressure gun lubricant of high heat resistance.
12. FINAL DRIVE DRAIN PLUG—Drain, flush and refill every 200 to 400 hours of operation. Capacity 7 quarts each.
13. FINAL DRIVE FILLER PLUG—Inspect oil level every 10 hours of operation. Keep filled even with level plug with approved motor oil.
14. SEDIMENT TRAPS—Drain traps every morning before starting; more often if necessary. In freezing weather, drain after stopping, so water will not freeze in traps.
15. BATTERIES—Keep the tops and terminals clean. Keep filled with clean distilled water to ⅜" above separator plates; inspect water level daily. Test periodically with hydrometer.
16. TRACKS—Do not lubricate.
17. TRANSMISSION DRAIN PLUG—Drain, flush and refill every 800 hours of operation with approved motor oil. Capacity 26 quarts.
18. TRANSMISSION CASE FILLER PLUG AND OIL LEVEL BAYONET GAUGE—Inspect oil level every 10 hours of operation and keep the oil level between "Low" and "Full" on the bayonet gauge.
19. FIRST STAGE FUEL OIL FILTERS—Install element when necessary. Refer to Topic 11.
20. LUBRICATING OIL PRESSURE GAUGE—Normal operating pressure when the engine is warm and at full throttle, is 25 to 35 on the gauge; if gauge does not register, stop engine immediately and determine the cause.
21. MASTER CLUTCH SHIFTER BEARING — Lubricate every 10 hours of operation with pressure gun lubricant of high heat resistance.
22. AIR-CLEANER—Inspect and service every 10 hours of operation. Refer to Topic 13.
23. THROTTLE LEVER DISC—Lubricate when necessary for easy operation with pressure gun lubricant; do not over-lubricate.
24. CRANKCASE FILLER CAP—One filler point. Change oil every 30 to 60 hours of operation. USE A NON-CORROSIVE DIESEL LUBRICATING OIL CONTAINING ADDITIVES PREVENTING SLUDGE AND GUM DEPOSITS. Capacity 11 quarts.
25. CRANKCASE BAYONET GAUGE—Inspect oil level every 10 hours of operation.
26. SECOND STAGE FUEL OIL FILTER—Replace element when necessary, that is, when pressure drops below normal range — (25 to 65) due to filter clogging. Refer to Topic 11.
27. CRANKCASE DRAIN PLUG—One drain point. Drain and refill with new oil every 30 to 60 hours of operation. See Topic 1A. Capacity 11 quarts.
28. WATER PUMP DRAIN—Periodically drain and flush out system. Refer to Topic 18. Capacity 5¾ gallons.
29. RADIATOR DRAIN—Periodically drain and flush out system. Refer to Topic 18. Capacity 5¾ gallons.
30. PRIMARY OIL FILTER—Clean the oil filter element at each crankcase oil change. Refer to Topic 10.

wheels it is necessary to take the weight of the tractor off of them. Check each truck wheel support roller, and idler separately. If end play or up and down motion is present the assembly should be removed and repaired before serious damage or complete failure occurs. Packing an assembly with grease will not correct worn or broken parts.

After grease packing, paint the shaft plugs RED which will indicate they have been grease-packed. All grease packed assemblies coming from the factory will have the plugs painted red. Assemblies which have been packed with grease should never, at any time, be lubricated with lubricating oil.

9 -- Care of Pilot Bearing

The pilot bearing is lubricated through a wick in the end of the crankshaft. If the pilot bearing fails because of insufficient lubrication, a new wick must be installed in the crankshaft.

10 -- Lubricating Oil Filters and Oil Cooler

To provide a normal flow of clean, cool oil to the engine it is essential that both the primary oil filter, secondary oil filter and cooler be kept in good condition. Each of these units will be discussed separately in the following text.

A. PRIMARY OIL FILTER

1. The primary oil filter of the double screen type, is located in the lubricating system between the oil pump and the oil cooler. (See illustration). ALL THE OIL FROM THE PUMP PASSES THROUGH THE FILTER AND COOLER. The oil filter removes all larger particles from the oil and collects a portion of the sludge from the oil on the two screen elements. The filter removes particles from the oil larger than .005" in diameter. If the filter should become clogged, the by-pass valve will open and allow the oil to flow directly from the pump to the main oil gallery, This condition should, by no means, be tolerated since oil flowing by way of the by-pass will not have the benefit of being filtered or cooled, and continuous operation in this manner will cause unlimited damage to engine parts.

B. REMOVAL AND CLEANING OF PRIMARY FILTER.

1. Remove filter drain plug.
2. Remove the oil filter retainer bolt.
3. Remove the oil filter shell and filter elements from the oil filter and cooler adapter housing.
4. The filter elements must be washed every time oil is changed. Wash the elements in fuel oil with a soft brush. Do not scrape the elements with a sharp or metal instrument or wire brush. Wash the filter base and outer shell before assembling.

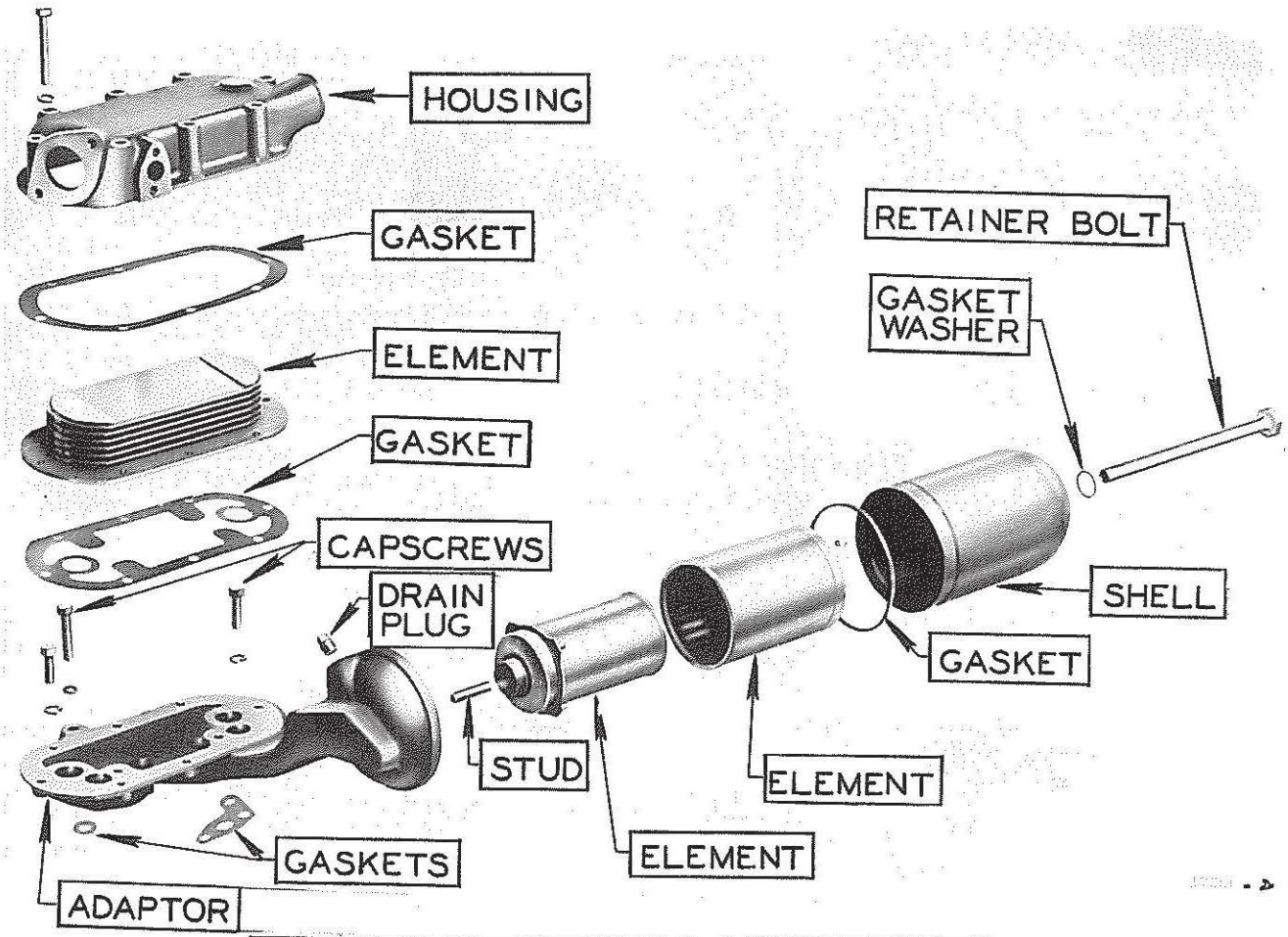
   After washing, reassemble the unit on the filter base. After assembling, check to see whether copper gasket under retainer bolt prevents oil leaks. Also be sure oil filter shell gasket fits properly. Run the motor for a few minutes and inspect for oil leaks.

C. CLEANING PRIMARY FILTER ELEMENTS AND OIL COOLER WITH SOLVENTS.

A strainer that has become loaded with impurities can usually be cleaned only through use of special solvents in conjunction with some type of circulating system that will create a flushing action. NOTE: When a filter element is removed from an engine it should be cleaned immediately. Do not allow a dirty element to dry, since this will cause lacquer or sludge deposits to harden. Keep submerged in a pail of fuel oil before cleaning.

1. EFFECTIVE SOLVENTS
   Excello Floor cleaning compound
   Bendix cleaning compound
   Turco cleaning compound
   #70 stripper

   A mixture of Oakite #7 and fuel oil; 3 parts Oakite and 5 parts of fuel oil.
   NOTE: The solvents listed above should be used according to the directions of manufacturer. After cleaning operation is completed all traces of the cleaning solution should be washed from the filter elements. In the event that the above procedure does not eliminate the clogged condition, a new element must be installed.
2. Another very effective solvent is the new Bendix cleaner which dissolves or loosens the sludge or other foreign matter that may be collected on the metal of the oil cooler or filter elements.
   Its application is very simple since all that is required is submersion of cooler or filter elements in solution for a sufficient length of time to allow the chemical action of the fluid to properly remove the impurities. The length of time for the submersion will depend upon the condition of the cooler or filter elements. The impurities, etc., removed from elements will settle in the bottom of the



PRIMARY OIL FILTER AND OIL COOLER

containers used for this cleaning operation.

3. After the above operation, the cooler or element should be left to drain for a few minutes, then followed with a thorough washing with live steam to remove all traces of the cleaning solution. If solution in container is properly covered to prevent evaporation, it may be used again.
   NOTE: The above information is submitted in a general manner in order to explain the principles of this cleaner. However, it is recommended that the more specific instructions supplied by the manufacturer of cleaner be studied carefully before using any cleaning solution

D. SECONDARY OIL FILTER

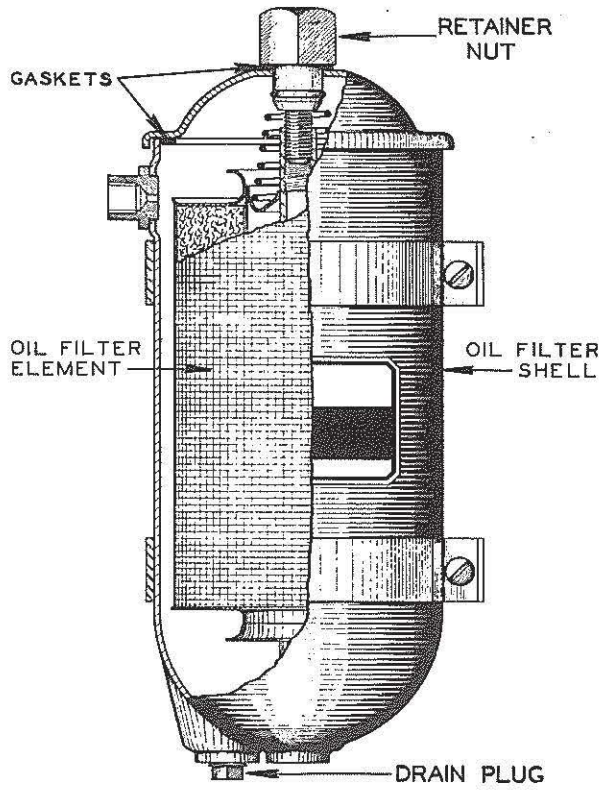
The secondary oil filter is located on the left side of the motor. The inlet line at the top of the filter body is connected to the main oil gallery in the cylinder block.

The outlet line from the filter body is at the bottom and drains back into the crankcase.

Only a portion of the oil flows through this filter. This filter has a replaceable element and must be changed every 4th oil change or every 240 hours of operation.

E. REMOVAL OF SECONDARY FILTER ELEMENT AND INSTALLATION OF A NEW ONE.

1. Remove the drain plug at the bottom of body and loosen the cover; let the oil drain out before removing the element.
2. Remove and discard the filter element.
3. Clean out the filter body and replace drain plug.
4. Install new element, new cover gasket and tighten cover securely.
5. When installing new element one extra quart of oil is required for crankcase filling. NOTE: When filling crankcase with oil fill only to "Full" mark on crankcase bayonet gauge.
6. Start motor, inspect for leaks and run for a few minutes. Then stop motor and let it stand long enough for the oil to drain back into crankcase. Test with crankcase bayonet gauge to see if more oil is needed.
7. In cold weather the motor should be run long enough to attain operating temperature before checking the oil level.



SECONDARY OIL FILTER

FIG. 2

F. OIL COOLER.

1. The lubricating oil cooler lowers the oil temperature as the oil travels through the small passages inside the cooling unit. If these passages become entirely clogged, no cooling of the oil can take place, and the oil is by-passed directly to cylinder block gallery. It is absolutely necessary that the oil cooler unit be kept clean for proper oil cooling.
2. Cleaning of a clogged cooler is sometimes very difficult. A cooler that has become loaded with impurities over a long period of operation can usually be cleaned only through use of special solvents in conjunction with some type of circulating system that will create a flushing action. However, in most cases, the use of any of the special solvents, as listed previously in a hand operated force pump will dislodge any accumulation. In the event that such treatment does not eliminate the clogged condition, a new cooler element must be installed. NOTE: A clogged oil cooler or filter is a contributing factor to low engine oil pressure which may be the cause of one or many operating difficulties. For further information on the effects of clogged oil cooler or filter element on engine oil pressure refer to Topic 25J "Low Oil Pressure."

11 -- Fuel System and Filters

DESCRIPTION:

Fuel is drawn from the bottom of the fuel tank, through the first stage filters, by the transfer pump. The transfer pump then forces the fuel through the second stage filter to the fuel intake manifold on the right side of the engine. The fuel then flows under pressure to the injectors. Note that the fuel entering the injectors is filtered through a porous bronze filter. The surplus fuel leaves the injectors through another porous bronze filter, flows into the return fuel manifold and back to the fuel tank through the return fuel line.

A. FUEL SYSTEM

NORMAL FUEL OIL PRESSURE IS 25 TO 65 ON GAUGE AT HIGH IDLE. DO NOT OPERATE ENGINE WHEN FUEL PRESSURE IS NOT WITHIN THIS RANGE.

The Diesel engine in this tractor depends upon the circulation of fuel oil through the injectors to keep the injectors cool. The transfer pump circulates approximately 30 gallons of fuel per hour through the injection system. If this quantity is allowed to decrease, serious damage to the injectors may result from over-heating. As the fuel filters begin to clog, the quantity of fuel circulating through the injectors diminishes. Although this flow may be sufficient to keep the engine operating normally, it may be reduced to the point where the injectors are becoming dangerously over-heated. Therefore, proper performance of the engine does NOT necessarily mean that enough fuel is being circulated, so we recommend that the fuel filtering system be inspected and the necessary filter elements replaced at the first indication of a deviation in fuel oil pressure from normal.

The first two or three times the operator has to change the fuel filter elements will give him a good indication as to about how often it will be necessary for the filter elements to be replaced thereafter. That is, if the filters clog on an average of every 450 hours for the first two or three times, the filter element should be changed, as an item of routine service, every 400 hours of operation thereafter without waiting for a drop in fuel pressure

The length of time that fuel filter elements will operate, of course, depends upon the type and kind of fuel being used and the care used to keep it clean in storage and handling. In accordance with the above

paragraphs, change the filter elements in the FIRST AND SECOND STAGE FUEL FILTERS after a reasonable number of hours of operation even though they are not completely clogged, in order to safeguard the injection system.

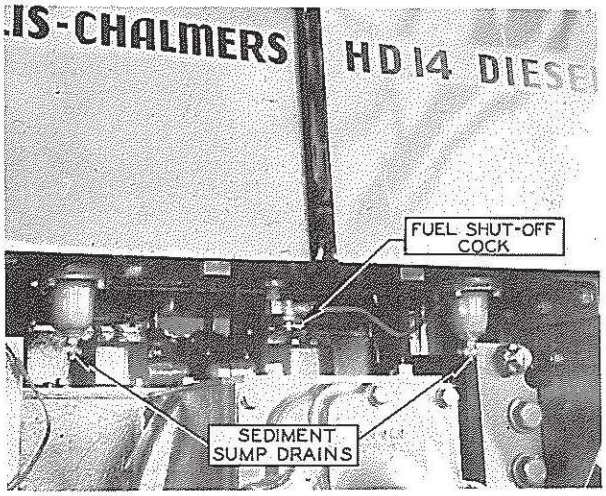


FIG. 1

B. FUEL SEDIMENT TRAPS

The sediment sumps on the fuel tank should be drained every 10 hours of operation or daily before starting engine at the beginning of the operating period. In freezing weather, drain at end of operating period as water might collect in traps and cause damage by freezing.

C. FIRST STAGE FUEL FILTER

Under normal operating conditions when using clean fuel, the FIRST STAGE FUEL FILTERS between sediment sump and transfer pump should operate without clogging for approximately 300 to 500 hours. The elements in these filters are replaceable. A drop in fuel pressure may indicate that the filter is clogged. Never attempt to clean the filter element. If clogging occurs, install a new element.

D. SECOND STAGE FUEL FILTER

The SECOND STAGE FUEL FILTER, between transfer pump and the injectors, is a replaceable element type. When clean fuel is used under normal operating conditions, the element should last from 300 to 500 operating hours. When clogging of this filter occurs, install a new element. Do not attempt to clean the clogged filter element.

Open the drain at the bottom of the SECOND STAGE FUEL FILTER every morning or every 10 hours of operation to drain off any water and sediment which may have accumulated.

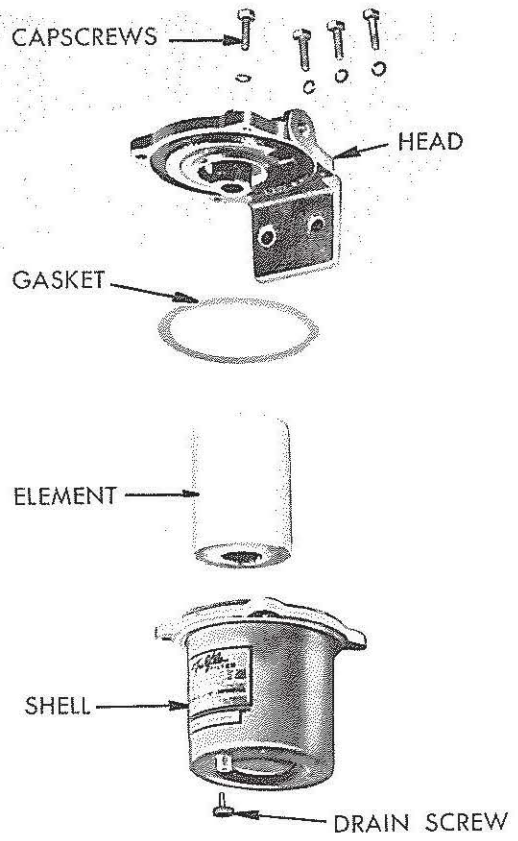


FIG. 2

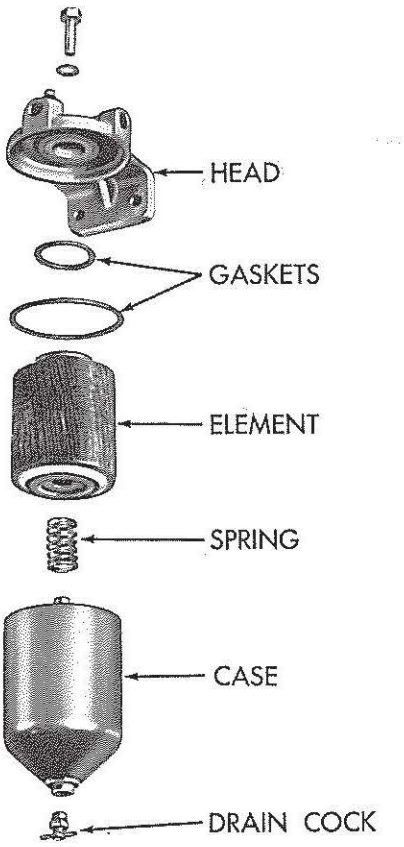


FIG. 3

12 -- Pre-Cleaners

DESCRIPTION:

The purpose of the pre-cleaners must not be underestimated, as their duty is to remove a large percentage of the foreign material before it enters the air cleaners. Dirt is trapped in the pre-cleaner shells where it can easily be removed. The pre-cleaners are provided with an eye glass through which the dirt accumulation may be seen. The pre-cleaners will not function properly if the dirt level in the shell covers over one-half the eye glass.

To service pre-cleaners remove wing nut and cap assembly. Lift pre-cleaner shell from cleaner body and remove dirt from shell by shaking. Be sure louvers on cleaner body are not bent or clogged with leaves or other foreign material.

CAUTION: When replacing cap and nut assembly be sure gasket is in good condition

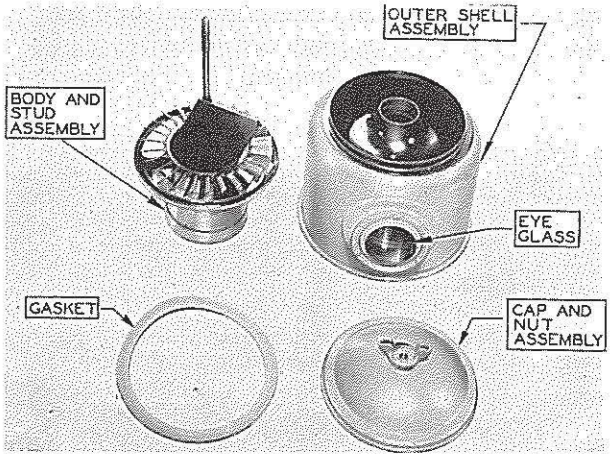


FIG. 1

and in proper place with wing nut tight to prevent leakage so purpose of pre-cleaner will not be defeated.

13 -- Care of Air Cleaner

The air cleaners must be inspected every ten (10) hours of operation. Remove the oil cups and inspect the amount and condition of the filtering oil. In extreme dusty conditions the oil will have to be changed every eight or ten hours. The oil must be kept level with the top of the cone in the oil cup. Use SAE 40 in the summer and SAE 30 in the winter. Do not use anything lighter and DO NOT USE A DIESEL ENGINE LUBRICATING OIL IN THE AIR CLEANER. These lubricating oils are likely to foam thus reducing air cleaner efficiency and possible oil pull-over with serious injury to the engine.

In extreme dusty conditions the air inlet tube of the air cleaner must be swabbed out every ten hours of operation. Oil from the oil cup splashes up on the inside of the tube and collects dust on the sides of the passage, this dust accumulates and reduces the volume of air going through the air cleaner.

A broken hose, loose clamps, or a leak of

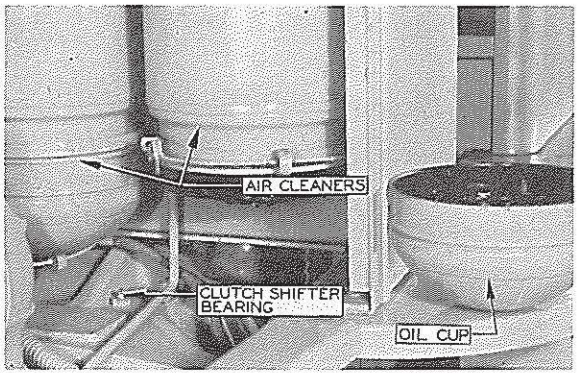


FIG. 1

any kind between the air cleaners and the blower will defeat the purpose of the cleaners. ALL CONNECTIONS MUST BE TIGHT. Improper care of the air cleaners will result in abnormal wear of blower. rings, pistons and cylinder liners.

19--Effects of Prolonged Engine Idling

Low operating temperatures cause the development of several conditions which can adversely affect operation or even result in serious damage to engine parts.

Because of the high thermal efficiency of a diesel engine, insufficient heat is dissipated to cylinder jackets during idling periods to maintain normal operating temperatures. Consequently, cylinders cool off or become "cold". Fuel injected into cold cylinders is only partially burned. Some is discharged as exhaust in a sharp, pungent vapor of blue-grey color. This vapor is the most volatile (low boiling point) fraction of the fuel. Unburned fuel of the least volatile (high boiling point) fraction will accumulate within the cylinder. Some of this fuel seeps past the pistons and dilutes the lubricating oil; the remainder decomposes into lacquers or tar-like substances which deposit on valves, pistons, cylinders, etc. Moreover, sludge accumulation in the lubricating oil is generally most rapid at sub-normal operating temperatures.

Development of the above conditions can be avoided if the engine operating temperature is kept above 175° F. It is preferable, whenever possible, to stop the engine if a long idling period would otherwise occur. If a stop is undesirable, idling speeds above 1000 r.p.m. should be maintained.

The effects of prolonged idling also greatly depend upon the characteristics of fuel or lubricating oil used. It is advisable to select lubricating oils which possess high oxidation resistance, a minimum tendency to leave hard deposits and of the correct viscosity. For severe idling conditions a fuel with a high cetane rating, a low boiling point, and a narrow distillation range will be most suitable. Consult a representative or an engineer from the oil company which supplies your oil and obtain his recommendation as to their grade of oil which conforms to the specifications in this manual.

20--Care of Generator and Battery

The generator is set to charge at the rate of 4 to 8 amperes when the tractor leaves the factory. This is sufficient to keep the batteries fully charged under ordinary operating conditions.

The storage battery simply stores electrical energy.

Battery failures are more numerous in cold weather. Because the required cranking torque of an engine is materially increased by low temperatures. To crank an engine at 5° F.requires approximately 4 times the torque that is necessary at 80° F. A battery which is fully charged at 80° F. has only about 60% capacity at 20° F. and only 20% capacity at -20° F. Thus, it is quite evident that batteries must be kept in top condition in cold weather. A start will not be obtained when a battery "grinds" the engine over; a cranking speed of 80 r.p.m. is prerequisite to good starting. Use of Air Heater will facilitate starting at temperatures under 40° F.

When weather temperature drops, more attention should be given to the hydrometer readings of the battery. The electrolyte in a fully charged battery should have a hydrometer reading of 1.280-1.300 when corrected to 60° F. When taking readings at temperatures other than the specified standard, it is necessary to make corrections. For every ten degrees above or below 60° F. 0.004 must be added or subtracted, respectively, to or from the observed reading. Specific gravity readings without corrections for temperature are practically meaningless. Thus, if the electrolyte reads 1.275 at 0° F. the following corrections must be made: 60/10 x .004 = .024, and 1.275 - .024 = 1.251 corrected reading. If the corrected reading falls below 1.225, the battery should be recharged from an outside source.

A low battery reading might indicate that attention should be given the generator or voltage regulator. If these units are within specifications and the battery is partially discharged, the wiring system should be inspected for shorts. The top of the battery should be flushed with a soda solution to prevent self-discharge. When all irregularities have been corrected battery should be fully charged.

If corrosion occurs, clean the posts and terminals with a strong soda solution and apply vaseline to post and strap terminals.

Filler plugs should be kept tight at all times and the top of the battery kept dry. The electrolyte should always be maintained at the proper level, and pure or distilled water added periodically to each cell until the solution is about ⅜" above the top of the plates. During freezing weather any addition of water should be made after starting the engine and the engine run for several minutes to thoroughly mix water and solution.

Inspect battery periodically.

21 -- Engine Pre-Heater Operation

If the engine, air heater and batteries are in good condition, the engine can be started in temperatures down to zero by using the air heater only.

In temperatures below zero, it may be necessary to use the engine Pre-Heater #042765, in conjunction with batteries which have been warmed sufficiently to produce enough current to crank engine at approximately 80 R.P.M.

Install the heater intake assembly on the engine in place of one of the air box inspection covers. This intake elbow is divided into two parts by a baffle. The heater extension tube will fit into upper part. The lower opening is for the exhaust of the heater gases after circulation through the air box.

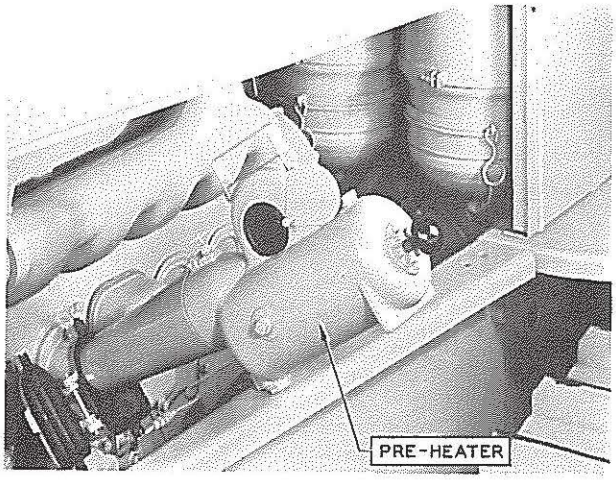


FIG. 1

A. OPERATING THE ENGINE PRE-HEATER:

1. Remove filler plug, and fill the case about 2/3 full of fuel oil, the same as is used in the fuel tank of the tractor. Replace the filler plug securely to prevent leakage.
2. Close the needle valve.
3. Pump up to about 120 pounds pressure, with the hand pump.
4. Close the air regulator plate next to the fan.
5. Connect the heater fan wire to the live starter switch terminal which is directly connected to the battery. Ground the heater body to the tractor. The heater fan should start immediately and run as long as the battery connection and good ground is maintained.
   NOTE: Some of the engine pre-heaters may have two fan wires. One wire is the fan wire and the other is the ground wire. As before, connect one wire to the live starter switch terminal. Connect the other wire securely to any metal part of the chassis. The fan should start running when both wires are connected. It does not matter which fan wire is connected to the live starter switch terminal as the fan will run in only one direction.
6. Raise the heater extension tube or spout and open the needle valve until a good spray or mist is ejected. Ignite the spray with a match or other means. Then lower the heater extension tube.
7. Loosen the wing nuts on top of the intake elbow and turn the cover back. Place the end of the heater extension tube into the intake elbow. Open the air regulator plate.

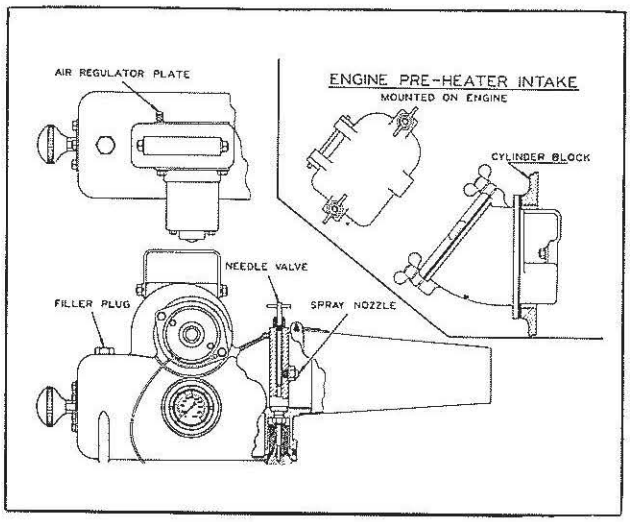


FIG. 2

The heater will blow hot gases into the engine air box which will circulate around all cylinders. For the proper length of time to leave the heater on, refer to the following chart. Caution: Do not attempt to start the engine until the engine pre-heater has been removed and the intake elbow cover has been securely replaced.

Atmospheric Temp.	Leave Heater On
+30° F.	7 min.
+20° F.	8 min.
+10° F.	9 min.
0° F.	10 to 15 min.
—10° F.	10 to 15 min.
—20° F.	10 to 20 min.
—30° F.	15 to 20 min.
—40° F.	15 to 30 min.

After the pre-heater has been in operation for the proper length of time, remove it, close the needle valve and the air regulator plate; disconnect the fan wire. Close the cover on the intake elbow and fasten it securely. Start the engine immediately, using the engine air

heater as for starting in mild cold weather.

The engine pre-heater is used to warm up the engine for easy cranking only and will not aid combustion by furnishing warm air to the cylinders. For this reason, it is necessary to use the engine air heater that is furnished as standard equipment with the tractor. This unit heats the cold air before it is drawn into the combustion chamber.

It is suggested that some thought be given to the method used to operate the air heater to get best results. To use the air heater, first turn on the primer switch then operate the pump with a smooth slow stroke while pressing the button switch and the starter button. THESE THREE OPERATIONS MUST BE PERFORMED SIMULTANEOUSLY. By doing this, practically all the fuel pumped through the air heater will be burned, reducing the collection of raw fuel in the air box to a minimum. If the starter is not used with the air heater the oxygen in the air box will soon be exhausted; then the flame will go out and raw fuel will be pumped into the motor. The air heater should be operated for a short period after the engine starts to keep the engine operating smoothly.

22 -- The Hour Meter

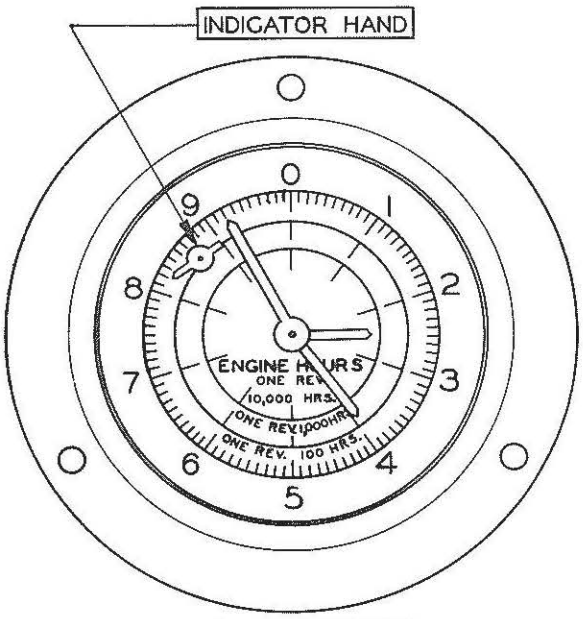
The hour meter, mounted on the right hand side of the dash, is spring driven and electrically wound. Winding is accomplished by an electromagnet or solenoid inside the clock which stretches the coil spring sufficiently to operate the clock for about three minutes. As the spring loses tension a pair of contact points within the clock approach each other. When they finally make contact, another electric impulse excites the solenoid and the clock is again wound, then the contacts separates.

Since this clock is intended to register the number of hours the tractor works, a pressure switch is installed in the engine oil system which breaks the clock-winding circuit whenever the oil pressure drops below 5 pounds. Therefore, the clock can not wind when engine is not running or when it is idling at a speed too low to maintain 5# pressure in the oil line. However, the clock may continue to run as much as 3 minutes after the tractor stops or until the spring has exhausted its energy. The clock has been adjusted to run a little slow to compensate for this overrun.

When reading the clock, read from the inside out, that is, read the short hand first, then the medium length hand and finally, the long hand.

The figures on the inside (short hand) scale, represent thousands of hours; figures on the middle scale, hundreds; and on the outside, tens.

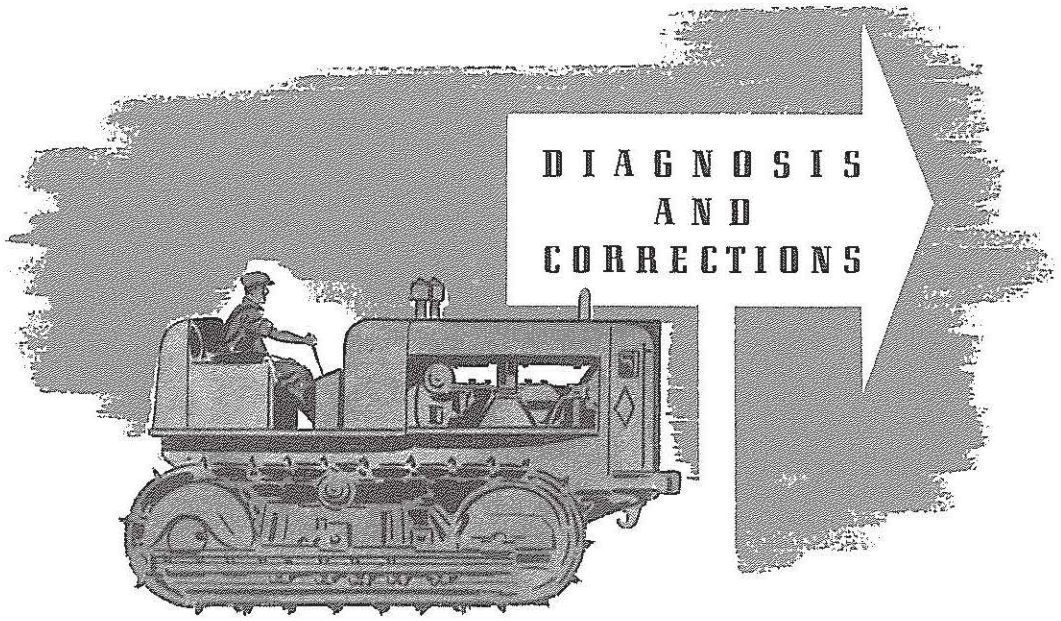
Therefore, when reading the dial read on each scale the number the hand has just passed setting the figures down from left to right. The fourth figure is obtained by counting the number of short marks between the long hand and the figure last passed by that hand.



HOUR METER
ABOVE READING
2392 HRS.

Refer to figure 1. Notice that the first three digits of the reading are the three figures just passed by the three hands reading from the inside out, 239. The fourth figure is obtained by counting the marks beyond nine, which gives "2" for the fourth place making the reading 2392 hours.

The indicator hand rotates slowly as visual indication that the hour meter is operating.



SAFETY:

Be sure of your footing before making a heavy lift.
Lift steadily; don't jerk.

DIAGNOSIS AND CORRECTIONS
25 -- Engine

Diagnosis	Corrections	Refer to Topic No.
A. FAILS TO START		
1. Battery too low to turn engine fast enough.	Charge battery or install battery that will crank engine at least 80 R.P.M.	20
2. Starting Motor switch defective.	Inspect starter switch shift lever capscrew. Adjust correctly.	95
3. Poor Connections.	Clean and tighten connections.	20-95
4. Fuel shut-off control not in proper position.	Place in forward position.	15-A
5. Insufficient fuel to injectors.	Inspect fuel supply, shut-off valve , filters, fuel pump and lines.	11
6. Cold weather.	Use air heater.	16
7. Fuel shut-off lever on governor loose on the shaft.	Tighten clamp bolt in proper position	46
8. Motor oil too heavy.	Use correct weight oil.	1
B. LOSS OF ENGINE POWER		
1. Fuel shut-off and air valve control linkage adjusted incorrectly.	Adjust linkage.	46
2. Insufficient fuel.	Check supply and lines.	11
3. Filters clogged.	Install new filters.	11
4. Improper fuel.	Obtain proper fuel.	1
5. Defective transfer pump.	Repair or install new pump.	91
6. Injectors not equalized.	Equalize injectors.	45
7. Injectors not timed properly.	Time the injectors.	42
8. Air cleaner clogged.	Remove and clean bowl.	13
9. Pre-cleaners clogged.	Clean pre-cleaners.	12
10. Air port holes plugged in cylinder sleeves.	Remove cylinder head, blower, inspection plates and clean port holes.	84-D
11. Worn governor parts.	Make repairs needed.	93
12. One or more cylinders misfiring.	Locate and correct cause.	11-19 & 42-44
C. POOR COMPRESSION		
1. Valves not seating.	Adjust valve lash, reface valves or install new and lap in.	44
2. Valves seats worn, pitted or cracked.	Grind valve seats, if cracked, install new ones.	78
3. Piston rings weak, broken, stuck or worn.	Install new rings and correct cause of sticking.	83
4. Bent valve.	Install new valve.	78
5. Sticking valve.	Free stem and correct cause.	
6. Broken valve spring.	Install new spring.	78
7. Valve lash too close.	Adjust to .012" lash.	44
8. Excessive valve guide wear.	Install new valve guide.	78

Diagnosis	Corrections	Refer to Topic No.
9. Leaky cylinder head gasket.	Install new gasket.	78
10. Worn cylinder liners.	Install new liners.	84
11. Worn pistons.	Install new pistons.	83
D. EXCESSIVE PISTON AND CYLINDER LINER WEAR		
1. Oil of unsuitable composition, grade or viscosity.	Change to oil of suitable specifications.	1
2. Carbon bulding up on pistons and rings.	Sometimes caused by motor running too cold, incorrect motor oil or fuel.	1-18-19
3. Dirty containers used for motor oil.	Motor oil should be kept in clean place, and clean containers used when filling motors.	1
4. Oil used more than the recommended length of time.	Change oil at the recommended intervals.	2-3-4
5. Lack of oil.	Keep oil at recommended level	2-3-4
6. Piston rings improperly fitted to piston and cylinder liner.	Install new rings and fit properly.	83
7. Piston rings stuck or broken.	Install new rings.	83
8. Foreign materials entering motor.	Service and inspect air cleaners and pre-cleaners. Proper care of these cleaners is very important.	12-13
9. Loose connections in air system.	All connections must be air-tight.	12-13
10. Loose valve cover.	Any dirt in the valve compartment may enter the crankcase.	
11. Improper fuel.	Use a suitable fuel.	1
E. BURNED PISTON HEADS		
1. Piston pin bushings come loose in connecting rods, closing off oil to spray tip in upper part of rod that cools the pistons.	Install new bushings, with proper fit.	83
2. Motor idles too slow to maintain 5 pounds minimum gauge pressure.	Set idling speed of motor to 450 R.P.M.	45
3. Clogged connecting rod spray nozzle.	Clean spray nozzle.	83
4. Low oil pressure.	Remedy cause of low oil pressure.	25-J
5. Inferior oil causing a deposit on under side of piston head. See Items D-2, 4 & 5 and E-1, 3 & 4 above before blaming oil for this condition.	Obtain satisfactory oil.	1
F. BEARING FAILURE		
1. Unsuitable lubricating oil.	Change to a suitable oil of non-corrosive type, correct grade and viscosity.	1
2. Lack of oil.	Maintain proper oil level.	2-3-4
3. Foreign materials entering motor.	Use clean oil containers when filling motor with oil, and see that air system and gaskets on motor are in good condition.	

Diagnosis	Corrections	Refer to Topic No.
4. Motor runs too hot.	Normal operating temperature 175° to 185° F.	18
5. Restrictions in oil passages.	Clean all oil passages.	85-C
6. Crankshaft bearing journal rough or out of round.	Grind or replace crankshaft.	81
7. Crankshaft out of alignment.	Straighten or install new shaft.	81
8. Bent connecting rod.	Align rod or install new.	83
9. Low oil pressure.	Minimum, 5 pounds at low idle, 25 to 35 at high idle.	25-J
10. Bearing loose.	Install new bearing and tighten cap	82-83
11. Sprung bearing insert.	Install new insert.	82-83
G. BURNED VALVES AND SEATS		
1. Improper (too little) valve lash.	Adjust to .012" lash.	44
2. Weak valve springs.	Install new springs	78
3. Valves sticking in guides.	Clean stems and guides. Install new parts if necessary.	78
4. Valve seats too wide.	Reseat to correct width.	78
5. Overheating motor.	See "Cooling Systems."	18
6. Unsuitable fuel.	Use a fuel of recommended specifications.	1
7. Excessive carbon deposits around seat and valve heads.	Clean and replace; reseat if necessary. All valves must be lapped in.	78
8. Warped valve head.	Install new valve.	78
H. VALVES STICKING		
1. Motor runs too cold.	Operate at 175° to 185° F. temperature.	18
2. Insufficient clearance between valve stem and guide.	Ream guides for proper clearance.	78
3. Weak valve springs.	Install new springs.	78
4. Broken valve springs.	Install new springs.	78
5. Valve stems scored or carboned.	Clean, if necessary install new valve.	78
6. Gummy deposits from inferior fuel or oil.	Clean and use suitable fuel or oil.	1
7. Clogged muffler.	Replace muffler.	
I. EXCESSIVE OIL CONSUMPTION		
1. Piston rings worn or broken.	Install new rings.	83
2. Crankcase gasket leaking.	Install new gasket.	89
3. Rear crankshaft seal leaking.	Install new seal.	81
4. Crankshaft wick carrying too much oil through.	Install new wick.	81
5. Front crankshaft seal leaking.	Install new seal.	81
6. Leaking blower gasket.	Install new gasket.	79
7. Leaking blower seals.	Install new seals.	79

Diagnosis	Corrections	Refer to Topic No.
8. Cylinder walls worn.	Install new liners.	84
9. Excessive ring gap.	Install new rings.	83
10. Overheating	See "Cooling System."	18
11. Rings not seating.	Install new rings.	83
12. Stuck oil rings, clogged drain slots.	Install new rings, clean drain slots in pistons.	83
13. Improper grade or viscosity of oil.	Obtain oil of proper grade and viscosity.	1
14. Oil level too high in crankcase.	Maintain proper oil level.	2-3-4
15. Loose fitting piston pin retainer.	Bend ends of piston pin lock ring to exert more pressure on retainer.	
J. LOW OIL PRESSURE		
1. Insufficient oil in crankcase.	Maintain proper oil level.	2-3-4
2. Motor oil diluted with fuel oil.	Change motor oil and inspect fuel connections on injectors and fuel manifold.	77
3. Clogged oil filter.	Remove and clean element.	10
4. Clogged oil cooler	Remove and clean or replace.	10
5. Clogged oil pump screen.	Remove and clean or replace,	10
6. Worn bearings.	Overhaul motor.	73
7. Defective oil pressure gauge.	Install new gauge.	
8. Defective oil line to pressure gauge.	Repair or install new line.	
9. Leaks—loose connections at oil line or filter.	Tighten connection.	
10. Worn by-pass valve assembly.	Install new parts.	89
11. Worn release valve or spring in oil pump.	Install new parts.	89
12. Defective oil pump or connections.	Repair and install new parts necessary.	89
13. Defective oil passage in motor.	Repair or install new motor block.	85-C
K. OIL AND ENGINE OVERHEATING		
1. Clogged primary oil filter, or clogged oil cooler.	Remove and clean out element with solvent, install new if unable to clean.	10
2. Water level low.	Keep radiator filled.	18
3. Ineffective cooling.	See "Cooling System."	18
4. Insufficient oil.	Maintain proper oil level.	2-3-4
5. Motor oil diluted with fuel.	Change oil and inspect fuel connections on injectors and fuel manifold.	77
L. EXCESSIVE BLACK SMOKE		
1. Improper fuel.	Obtain proper fuel.	1
2. Air cleaner clogged.	Clean central passage in air cleaner and service air cleaner.	13
3. Pre-cleaner clogged.	Remove and clean; if defective install new parts.	12

Diagnosis	Corrections	Refer to Topic No.
4. Too much or too heavy oil in air cleaner.	Fill with proper weight and amount of oil.	13
5. Air box inspection cover leaking.	Tighten or install new gasket.	
6. Plugged air port holes.	Remove cylinder head, blower, inspection covers and clean out port holes.	84-D
7. Air box drain plugged.	Open drain.	85-B
8. Incorrect injector timing.	Time injectors.	42
9. Injectors not equalized properly	Equalize injectors.	42
10. Incorrect valve lash.	Adjust valves .012" lash.	44
11. Defective injector.	Repair or install new injector.	77
12. Worn rings, piston, or liners.	Install new parts.	83-84
M. EXCESSIVE BLUE SMOKE		
1. Insufficient fuel to injector.	Inspect fuel supply to injectors.	11
2. Injectors not equalized.	Equalize the injectors.	43
3. Cylinder misfiring.	Locate and correct the cause.	11-19, 42-43
4. Defective injectors.	Repair or install new injector.	77
N. IMPROPER FUEL PRESSURE		
1. Fuel pressure too low.	Check for clogged filters or defective fuel pump and repair.	10
2. Fluctuating fuel pressure.	Inspect gauge, dampener and fuel pump.	49, 91
O. ENGINE DETONATES —KNOCKS		
1. Incorrect injector timing.	Time the injectors correctly.	42
2. Injectors not equalized correctly.	Equalize the injectors.	43
3. Incorrect valve lash.	Adjust valve lash to .012"	44
4. Incorrect motor temperature.	Keep temperature 175° to 185° F.	18
5. One or more cylinders misfiring.	Locate and correct cause.	11-19-42-43-44
P. OIL IN AIR BOX		
1. Blower gasket leaking.	Install new gasket.	79
2. Blower seals leaking.	Install new seals.	79
3. Piston pin retainers loose.	Lock-ring not tight against retainer.	83
4. Piston rings worn or broken.	Install new parts.	83
5. Air box drain tube clogged.	Clean tube.	85
Q. NOISY OPERATION		
1. Worn blower drive shaft.	Install new drive shaft.	80
2. Loose rotor shafts (Blower).	Install new rotors.	79
3. Worn bearings (Blower).	Install new bearings.	79
4. Scored lobes and housing (Blower).	Remove and repair blower.	79
5. Worn blower gears.	Install new gears.	79
6. Worn or broken timing gears.	Install new.	80
7. Broken piston.	Install new.	83
8. Burned or warped valve.	Install new.	78

Diagnosis	Corrections	Refer to Topic No.
R. FLUCTUATING FUEL PRESSURE		
1. Dirt in relief valve.	Remove and clean relief valve.	91
2. Insufficient fuel supply.	Fill fuel tank.	
3. Worn body, rotor or vanes.	Install new parts.	91
S. NO SPARK AT THE ELECTRODES OF AIR HEATER		
1. Ignition switch defective.	Install new switch.	
2. Wiring defective.	Install new.	
3. Coil points defective or burned.	Condition with ignition file.	48
4. Coil points stuck.	Free points.	48
5. Ignition points shorted, porcelain cracked or broken.	Install new porcelain.	48
6. Improper gap.	Adjust gap to 1/8"	48
7. Sludge or oil on points.	Clean points.	48
T. FUEL NOT DELIVERED TO IGNITION CHAMBER — AIR HEATER		
1. Spray nozzle clogged	Clean nozzle.	48
2. Pump piston leather dry.	Install new leather.	48
3. Pump piston leather worn.	Install new leather.	48
4. Pump inlet line cracked or broken.	Repair or install new.	48
U. ENGINE RUNS UNEVENLY AND VIBRATES EXCESSIVELY		
1. Incorrect injector timing.	Time injectors.	42
2. Injector not equalized.	Equalize the injectors.	43
3. Spray tip burned off—not atomizing fuel properly.	Install new spray tip.	77
4. Spherical valve and spring assembly inoperative.	Repair, install new parts needed.	77
V. LOW ENGINE R.P.M.		
1. Governor control rod improperly adjusted.	Adjust rod to proper length.	46
2. Fuel and air shut-off improperly adjusted.	Make proper adjustment.	46
3. Binding or damaged linkage.	Repair, install new parts needed.	46-93
W. POOR BURNING FUEL. (PRE-HEATER)		
1. Spray tip clogged.	Remove and clean.	47
2. Needle valve clogged.	Remove and clean.	47
3. Improper fuel.	Use a good clean fuel, same as used in tractor.	1
4. Low air pressure.	Operating pressure is from 80 to 100 pounds.	47
5. Not the right air mixture.	Regulate intake air cover for proper burning.	47
6. Filter clogged.	Install new filter.	47
7. Water in fuel and frozen.	Thaw out and drain, fill with proper fuel.	47
X. LOW FUEL PRESSURE		
1. Clogged line.	Clean or install new line.	

Diagnosis	Corrections	Refer to Topic No.
2. Broken line.	Repair or install new line.	
3. Fuel low in tank.	Fill tank.	
4. Damaged gauge.	Install new gauge.	
5. Air leak in fuel system, between fuel tank and fuel pump.	Tighten all connections. (Do not overlook this kind of leak. When motor is not running it will not leak fuel, but air will be drawn in when motor is running.)	
6. Damaged restriction unit.	Install new unit.	
7. Wornor sticking by-pass valve in transfer pump.	Repair.	91
8. Worn transfer fuel pump.	Repair.	91
9. Clogged filters.	Install new filters.	11
10. Improper fuel.	Use correct fuel.	1
Y. HIGH FUEL PRESSURE		
1. Damaged gauge.	Install new gauge.	
2. Transfer pump by-pass assembly is improperly installed.	Change to opposite side.	91
3. Transfer pump by-pass spring damaged.	Install new spring.	91
4. Clogged fuel return elbow.	Remove and clean.	
Z. PRESSURE HAND VIBRATES EXCESSIVELY		
1. Damaged gauge.	Install new gauge	
2. Damaged dampener.	Install new unit.	46
3. Worn transfer pump assembly.	Repair.	91
4. Air leak in fuel line or in filters between transfer pump and fuel tank.	Tighten all connections. (Do not overlook this kind of leak. When motor is not running it will not leak fuel, but air will be drawn in when motor is running.)	

26 -- Ammeter

A. DOES NOT REGISTER		
1. Damaged ammeter.	Install new ammeter.	
2. Loose connections.	Tighten connections.	
3. Generator brushes sticking.	Free brushes or install new ones.	96
4. Generator brushes worn.	Install new brushes.	96
5. Voltage regulator defective.	Repair or install new regulator.	96
6. Dirty generator armature.	Clean armature.	96
7. Worn or burned commutator.	Turn down and undercut armature or install new.	96
8. Worn armature shaft.	Have shaft built up or install new.	96
9. Short or open circuits in field or armature of generator.	Have generator rewound or install new.	96
10. Generator belt off or too loose.	Install new belt or adjust.	50

Diagnosis	Corrections	Refer to Topic No.
B. REGISTER TOO HIGH		
1. Generator field grounded.	Locate for external ground; and correct.	96
2. Regulator defective.	Repair or install new regulator.	96
C. UNSTEADY HAND		
1. Low brush tension.	Adjust or install new brush spring.	96
2. Brushes sticking	Clean brushes.	96
3. Burned commutator bars.	Recondition in lathe, undercut commutator, solder loose connections.	96
4. High mica on commutator.	Undercut mica.	96
5. Commutator out of round.	Recondition in lathe.	96
6. Rough, dirty or greasy commutator bars.	Clean commutator bars.	96
7. Loose connection at terminal post.	Tighten connection.	96

27 -- Air Heater

A. INOPERATIVE		
1. Worn contact points in switch.	Check for loose connections or install new switch.	48
2. Leak at heater pump.	Install new leathers.	48
3. No fuel from pump.	Loose lines or defective leathers. Install necessary new parts.	48

28 -- Temperature Gauge

A. INOPERATIVE		
1. Broken.	Install new gauge.	

29 -- Hour Meter

A. DOES NOT REGISTER		
1. Loose wire connection from ammeter, ground or pressure switch.	Tighten connections	66
2. Pressure switch out of adjustment.	Adjust switch.	66
3. Defective works in meter.	Install new meter.	66

30 -- Final Drive

A. OIL LEAK, OUTER SEAL		
1. Bearing out of adjustment.	Adjust bearing.	109-B
2. Defective boot.	Install new boot.	108-109
3. Seal boot torn loose.	Remove and repair.	108-109
4. Seal ring worn.	Install new seal ring.	108-109
5. Seal ring stuck on hub.	Clean and replace.	108-109
6. Bearing plate worn.	Install new bearing plate.	108-109-110

77 -- Unit Injector

IDENTIFICATION OF INJECTORS

The injectors used in the HD7, HD10 and HD 14 tractors can be identified either by the letter "A" stamped on the injector body, or by the number "60" stamped on a "BLUE" metal tag pressed into the injector body. Also make sure the end of the spray tip is marked "6-.006-155" or "6-.006-155-O".

Installation of any injector assembly other than the ones described above will result in serious damage to the engine.

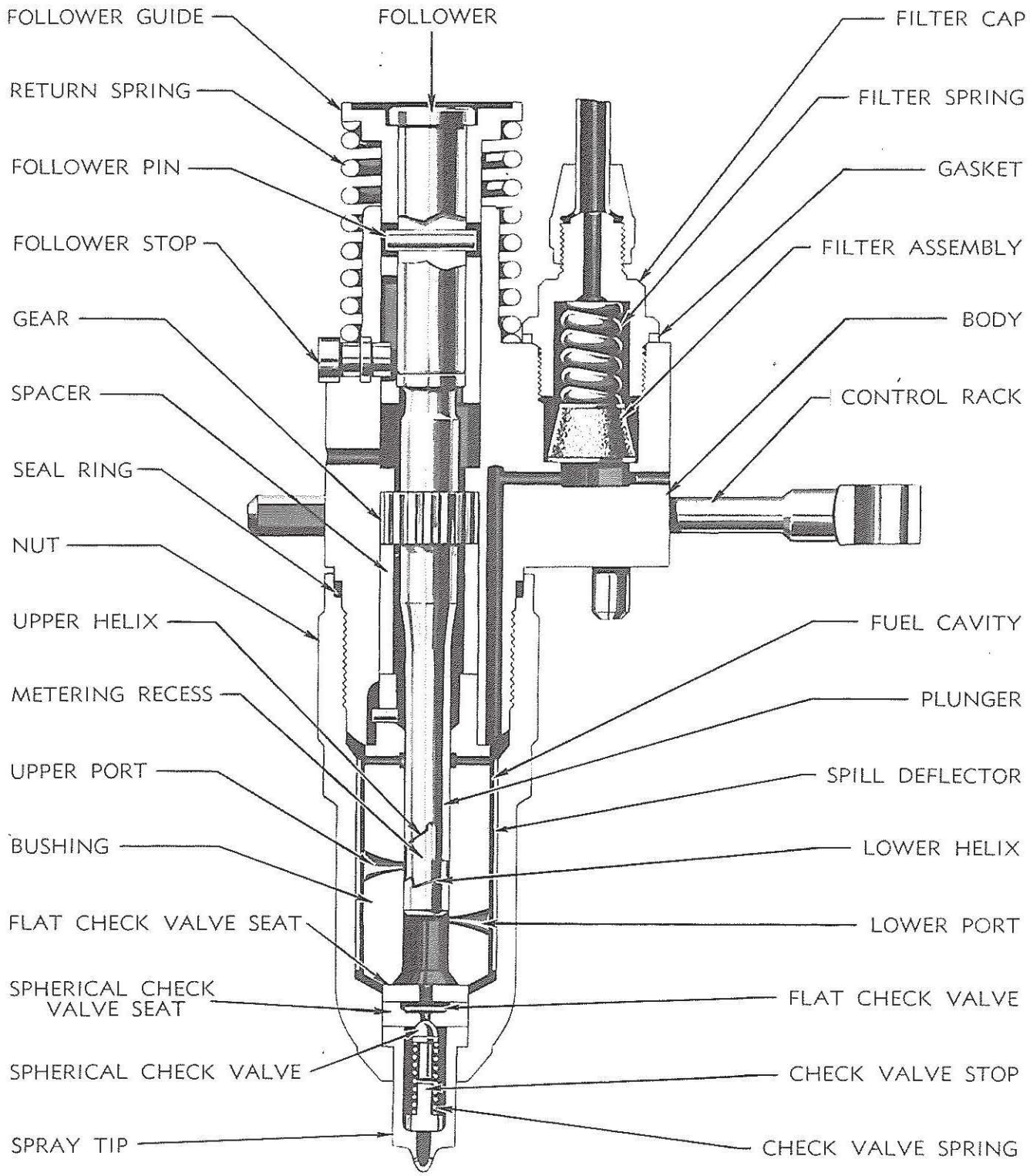


FIG. 1

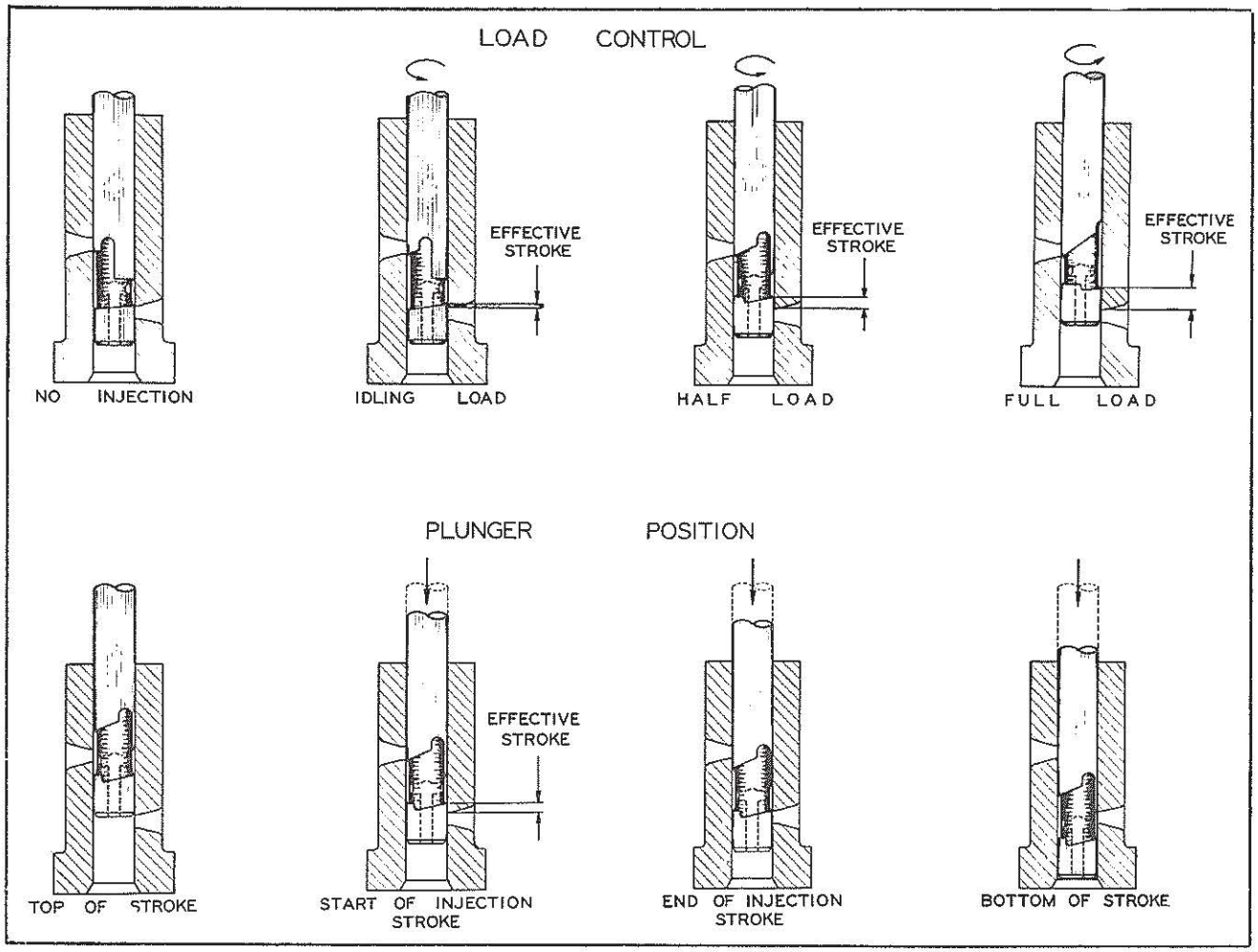


FIG. 2

DESCRIPTION—The cross section of the Model 71 Injector, illustrated in Fig. 1 shows the fuel injector parts. Fuel oil is supplied to the injector at a pressure between 25-65 pounds per square inch and enters the steel body at the top through the filter. After passing through the fine-grained filter element in the inlet passage, the fuel oil fills the annular supply chamber between the bushing and the spill deflector. The plunger operates up and down in this bushing, the bore of which is connected to the fuel supply in the annular chamber by two funnel-shaped ports.

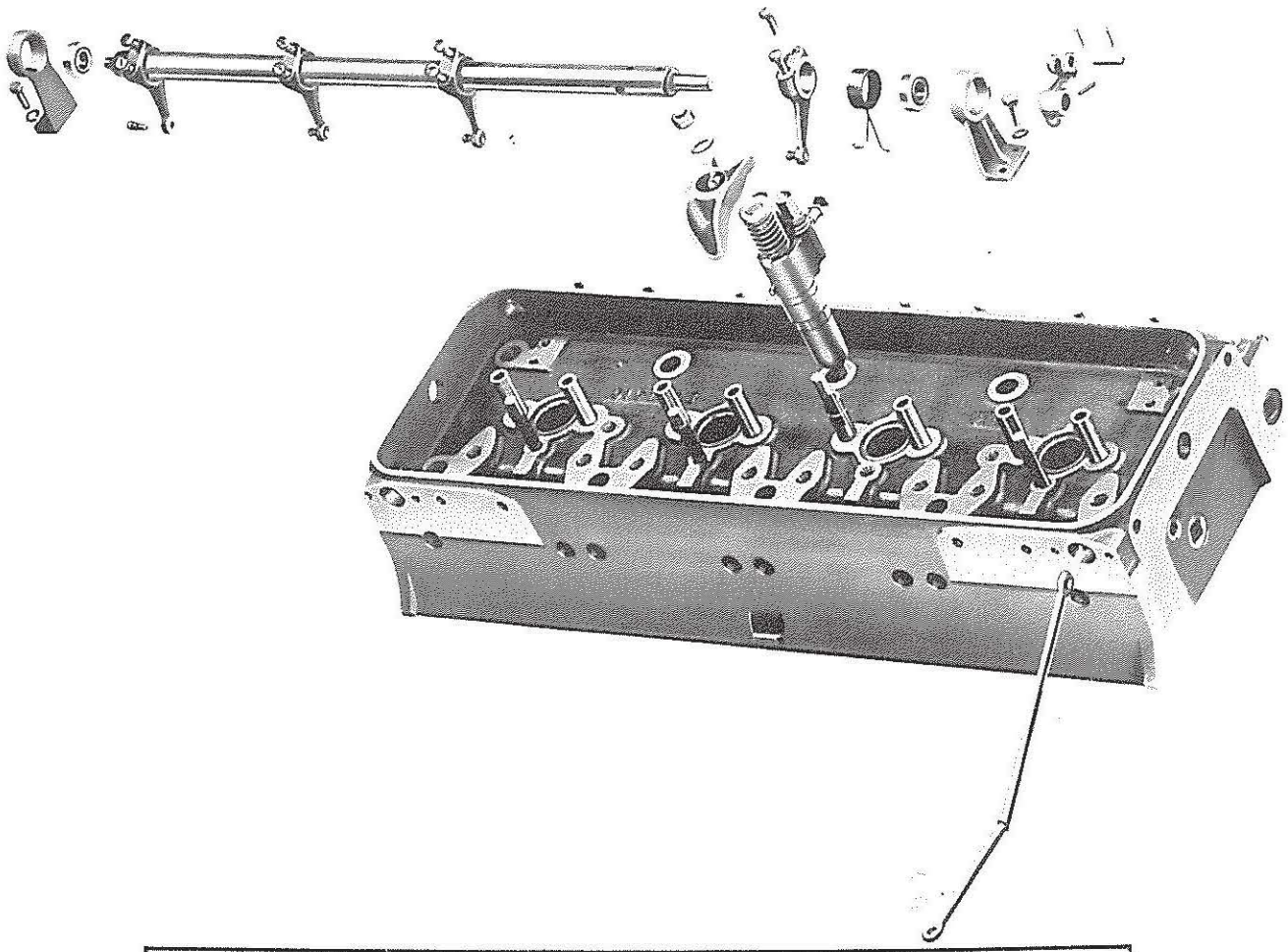
The motion of the injector rocker arm is transmitted to the plunger by the follower which bears against the return spring. In addition to this reciprocating motion, the plunger can be rotated, in operation, around its axis by the gear, which is in mesh with the control rack. An upper helix and lower cut-off are machined into the lower end of the plunger for metering purposes. The relation of this helix and cut-off to the two ports changes with the rotation of the plunger. As the plunger moves downward, the fuel oil in the high-pressure cylinder or bushing is first displaced through the ports and back into the supply chamber until the lower edge of the plunger closes the lower port. The fuel oil is then forced upward through the center passage in the plunger into the recess between the upper helix and the lower cut-off from which it can still flow back into the supply chamber until the helix closes the upper port. When the upper port closes, injection starts and continues until the plunger moves down and uncovers the lower port at the lower helix, which is the end of injection period. When the lower helix uncovers the lower port, the pressure is released through the center passage in the plunger into the recess of the helix and out through the lower port into the supply chamber. The rotation of the plunger, by changing the position of the helix, retards or advances the closing of the ports and the beginning and ending of the injection period, at the same time increasing or decreasing the desired amount of fuel which remains under the plunger for injection into the cylinder.

Fig. 2 shows the various plunger positions from FULL INJECTION to NO INJECTION. With the control rack pushed IN com-

pletely (full injection), the upper port is closed shortly after the lower port has been covered, thus producing a full effective stroke and maximum injection. With the control rack pulled OUT completely (no injection), the upper port is not closed by the helix until after the lower port is uncovered. Consequently, with the control rack in this position, all of the fuel charge is forced back into the supply chamber, and no injection of fuel takes place. From this NO INJECTION position to FULL INJECTION position (full rack movement) the contour of the helix advances the closing of the ports and the beginning of injection.

Fig. 2 shows four positions for the downward travel of the plunger. On the downward travel of the plunger, the metered amount of fuel is forced through the center passage of the valve assembly, past the flat check valve, shown in Fig. 1, and against the spherical check valve. When sufficient fuel pressure is built up, the spherical check valve is lifted off its seat and the fuel is forced through 6 small orifices in the spray tip and atomized in the combustion chamber. The check valve prevents air leakage from the combustion chamber into the fuel system in case the valve is accidentally held open by a small particle of dirt, thus allowing the injector to continue to operate until the particle works through the valve. On the return upward movement of the plunger, the high-pressure cylinder is again filled with fuel oil through the ports. The constant circulation of fresh, cool fuel through the injectors, which renews the fuel supply in the chamber, helps to maintain even operating temperature of the injectors, and also effectively removes all traces of air which might otherwise accumulate in the system and interfere with the accurate metering of the fuel. NO VENTING OF THE FUEL LINES OR INJECTORS IS REQUIRED AT ANY TIME, EVEN WHEN STARTING FROM "EMPTY."

The fuel injector outlet opening, which returns the excess fuel oil supplied by the fuel pump, is directly adjacent to the inlet opening, and is protected against dirt or other foreign matter by a fine-grained filter element, exactly like the one on the inlet side.



EXPLODED VIEW OF INJECTOR AND CONTROL RACK

FIG. 3

A. REMOVAL OF INJECTOR FROM HEAD

CAUTION: Cleanliness must be maintained at all times during the dismantling and assembling of the injector.

1. Remove hood from tractor.
2. Thoroughly clean cylinder head cover before removing. Remove cylinder head cover.
3. Disconnect fuel lines at injector and cylinder head fittings, placing them in a clean pan.
4. Place injector shipping caps on fuel openings in order to prevent any dirt from entering.
5. Turn engine over until rocker arms at cylinder from which the injector is to be removed are free (valves closed) and injector is at its highest point. Otherwise an undue strain will be put on push rods when rocker arm assembly is laid back out of the way.
6. Remove the 2 capscrews holding the rocker arm shaft brackets to cylinder head and fold back the rocker arms, rocker arm shaft and rocker arm shaft brackets.

   CAUTION: In laying the assembly back, care must be exercised to prevent bending a push rod. Lift up on entire assembly to compress the springs on lower end of push rods to allow assembly to be laid back properly.

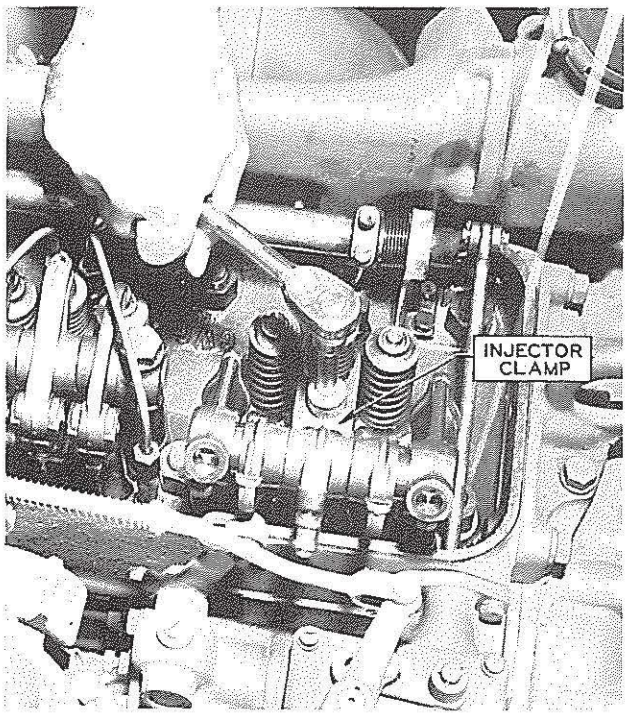


FIG. 4

7. Remove the injector hold down nut and clamp.
8. Pry injector from it's seat by means of the injector puller tool.

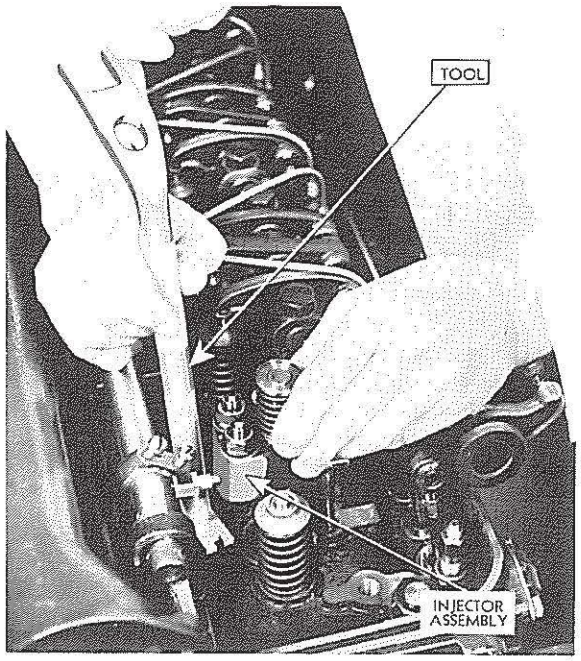


FIG. 5

9. Lift injector from seat at the same time disengaging the control rack linkage.
10. Replace cylinder cover to prevent any dirt entering the motor.

B. DISMANTLING THE INJECTOR

Before attempting to do any work on the injectors, it is very necessary that certain preparation be made. BE SURE to have a clean place to work. Have 2 small pans of clean fuel oil. As the injector is dismantled insert each part in the clean pans of fuel. Dismantle the injector as follows:

1. Support the injector right side up in a vise with the fixture as shown in Fig. 7 and loosen (not remove) the 2 fuel connections.

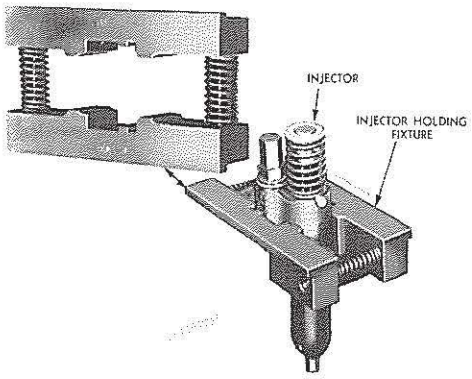


FIG. 7

2. Insert the tool beneath the spring as shown in Fig. 8 and raise spring away from follower stop; compress the spring

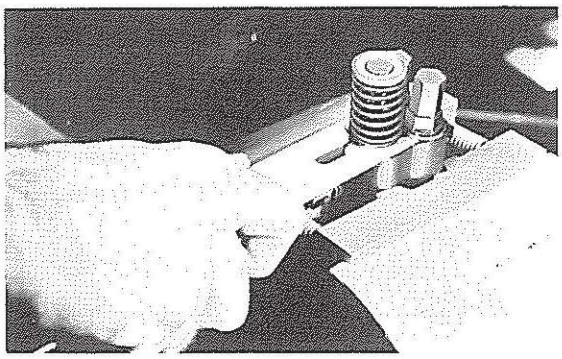


FIG. 8

and withdraw the follower stop.

3. Remove the plunger, follower guide, and follower pin from the injector body. Remove the follower pin from the follower guide and separate the parts.
4. Invert the injector in holding fixture. Clamp in vise and loosen (not remove) nut with special wrench as shown in Fig. 9.

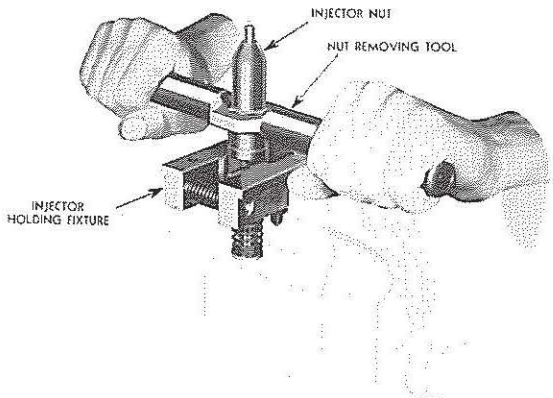


FIG. 9

5. Holding the injector in an inverted position, unscrew nut and lift away from the injector body, being careful not to dislodge the spray tip and the other small parts resting on the end of the plunger bushing.
6. Carefully lift the spray tip, spherical check valve, spherical valve spring, spring stop, flat check valve, check valve seat, and spherical valve seat away from the plunger bushing.
7. Jar the spill deflector from the nut.
8. Jar the spacer and gear from the inpector body.
9. Pull the rack from the injector body.
10. Remove the 2 fuel connections, 2 filters, and the 2 springs from the injector body.

NOTE: Should more than one injector be dismantled BE SURE that all parts for each injector are kept together.

C. INSPECTION

Many of the close fittings parts in the injector are very carefully lapped. If any of the internal working parts of the injector become scored these parts are unfit for further use and new parts must be installed.

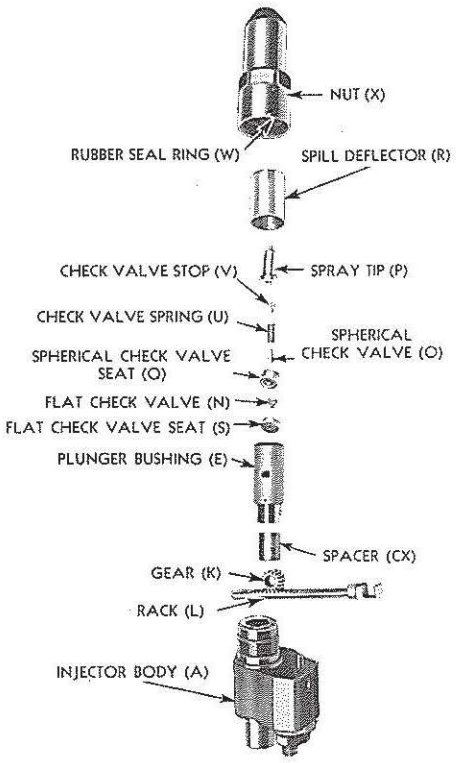


FIG. 10

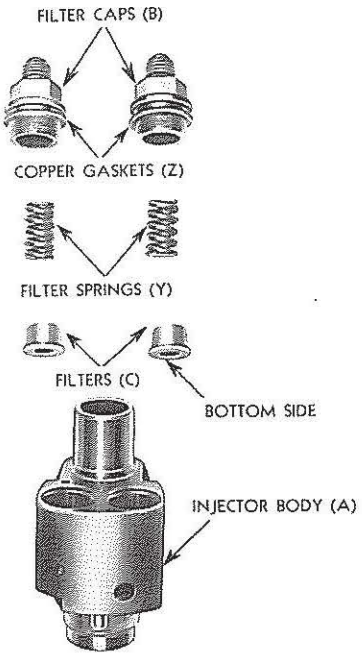


FIG. 11

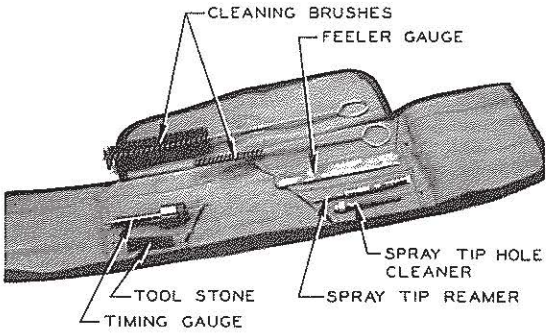


FIG. 12

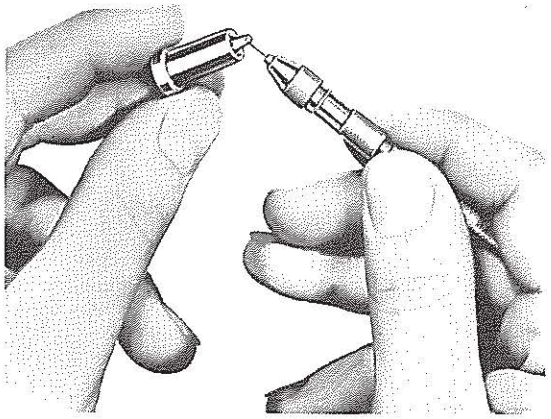


FIG. 13

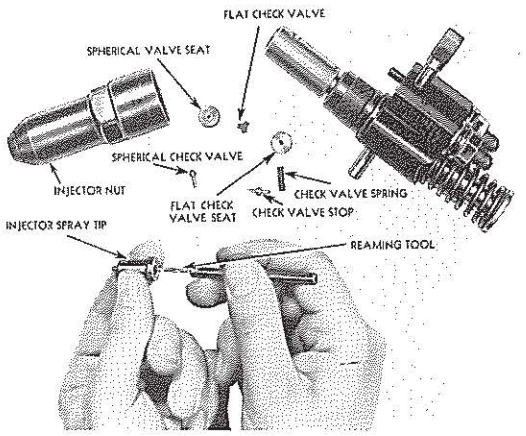


FIG. 14

After the injector has been disassembled all parts must be carefully protected from dirt and stored so that parts will not be misplaced until used. Note the caution on cleanliness at the beginning of this section. Having cleaned all parts thoroughly examine all mating parts for free movement then clean the injector tips as shown in Figs. 13 and 14.

D. INJECTOR TIP AND VALVE ASSEMBLY

Effective on engine serial Nos. 371429, 4716652 and 67120871, a new spray tip and flat check valve assembly are used in the injectors. These injectors can be identified by the letter "O" stamped on the end of spray tip.

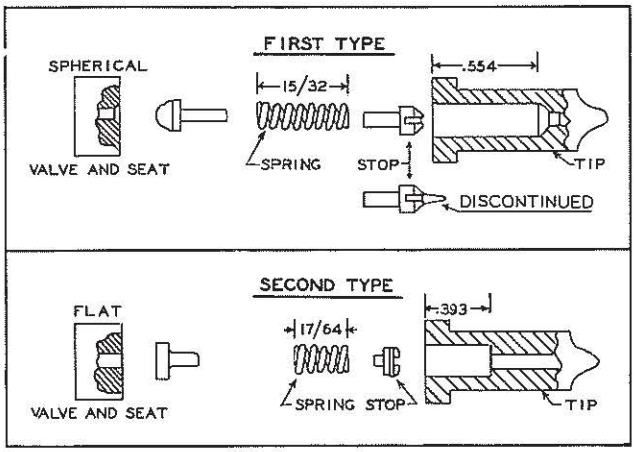


FIG. 15

1. The 2nd type parts as shown cannot be used in injectors built previous to this change, unless all the new parts as listed in the parts book supplement are used. This spray tip and valve assembly service unit is carried under part No. 5227324. The 1st type parts are still serviced separately for the first type injectors.
2. The 2nd type injector check valve, as shown in Fig. 15, has a flat surface contact with the double check valve seat, whereas the former valve, as shown, 1st type, was spherical and seated accordingly. The 2nd type valve may require occasional lapping, and this lapping can be accomplished in the field successfully; whereas the spherical check valve could not.
3. Because of its size, the 2nd type injector check valve requires extreme care in servicing. When lapping the check valve, a perfectly flat surface is necessary. Either a lapping block or a piece of first grade plate glass at least four inches long may be used.

   NOTE: In lapping the check valve, Carborundum H-40 lapping cream, or equivalent, should be used with either the lapping block or the piece of plate glass.
4. The following steps must be followed for the correct lapping of the injector check valve:
   a. Put a small spot of cream on the lapping block.
   b. With check valve held between the thumb and the middle finger, apply a light pressure on the check valve while drawing the check valve across the lapping block in a straight line.
   c. After each stroke, thoroughly clean the valve with fuel oil, dry and in-

spect by holding to the light to observe differences of light reflection as an indication of valve flatness.

d. If valve is perfectly flat, it will present a uniform appearance when held to the light and rotated.

5. The surface of the check valve seat must be lapped as carefully as the check valve. This is done in the same manner, using the same lapping block and cream.
6. The second type injector has all of the same operating characteristics as the injector equipped with the spherical valve except when the new injector is tested by "popping the injector" it will not make the chirping sound.

E. ASSEMBLING THE INJECTOR

Before starting to assemble an injector, it is necessary to have an extremely clean work bench on which to work and store the parts. Care must be taken when assembling, to place the various parts in their proper relative position. The accompanying figures should be thoroughly studied before attempting the assembly.

1. To assemble filter, hold the injector body Fig. 11 right side up, place one of filters in each of the fuel cavities in the top of the injector body. When assemblying the filters always have the washer at the bottom as shown in Fig. 11. Whenever the injector is dismantled install new filters. Place a spring above each filter, a copper gasket up against the shoulder of each filter cap, lubricate the threads and tighten the filter caps in place in the injector body. Whenever a filter cap is removed from the injector body use a new copper gasket under each cap.
2. Rack and gear assembly. Note that two of the teeth of the injector rack have a drill spot mark on the one end; also one tooth of the mating gear is similarly marked. When the rack and gear are assembled, the marked tooth of the gear engages between the two marked teeth on the rack. This relation of rack and gear must be maintained for proper timing of the injector.
3. Hold the injector body bottom end up and slide the rack through the 1/4 inch (approx.) hole in the body so the two marked teeth can be observed when looking from the bottom into the bore of the gear. See Fig. 10. The injector rack can be placed in the injector body in only one position and have the teeth marks show in the opening of the gear.
4. Now, holding the rack in position so the teeth marks show, slide the gear into the proper engagement with the rack.
5. Slide spacer down on top of gear. Slide plunger bushing down onto spacer with locating pin in bushing guided into slot of injector body.

NOTE: The flat check valve seat and spherical check valve seat should be lapped on both sides (Fig. 16) before being put into the injector assembly. Also the flat side of the injector tip and the end of the plunger bushing that butts up to the flat check valve seat must be lapped.

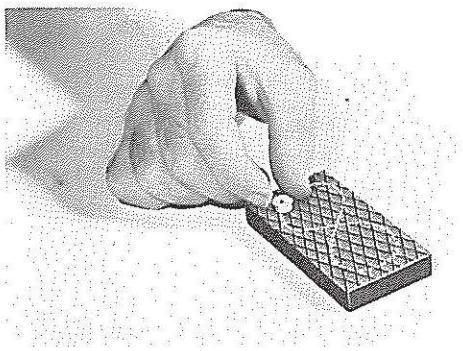


FIG. 16

6. Slide rubber seal ring down over threads to shoulder of injector body. Slide the spill deflector down over the plunger bushing.
7. Place flat check valve seat flat down on clean piece of paper, place flat check valve on seat and spherical check valve seat cupped side down over check valve. Note that one surface of the check valve seat is cupped for the check valve and the other surface has a small conical seat at the center for the spherical valve.
8. Holding the spray tip point down, place the check valve stop, (small end down), into the injector tip. Place spring over end of stop and drop spherical check valve down into spring with the spherical end up.
9. Hold injector body in the vise bottom end up, then centrally place the check valve assembly on the end of the plunger bushing and place the tip assembly and spherical seat down on the top of the check valve assembly.
10. Lubricate the threads on the nut; put a piece of 1/4" or 5/16" copper tubing through the hole in the nut. Place the copper tubing over the end of the injector tip and slide the injector nut down into place.
11. Screw the nut in place BY HAND and at the same time move the copper tubing up and down and around in a circle so the spherical valve assembly will fit into the injector nut correctly. As long as the injector tip will move up and down do not put a wrench on the nut.

When everything is in place the injector nut will hold the tip assembly down firm when tightened by hand.

12. Tighten the injector nut with special wrench. Fig. 9.
13. Plunger and Follower Assembly: Insert the plunger large end up into follower guide. Insert follower, large end up into follower guide. Slide follower pin through hole in follower guide and follower; drop this assembly through follower spring so head of follower seats into counterbored head of follower guide.
14. Invert the position of the injector in the vise (right side up). Hold the control

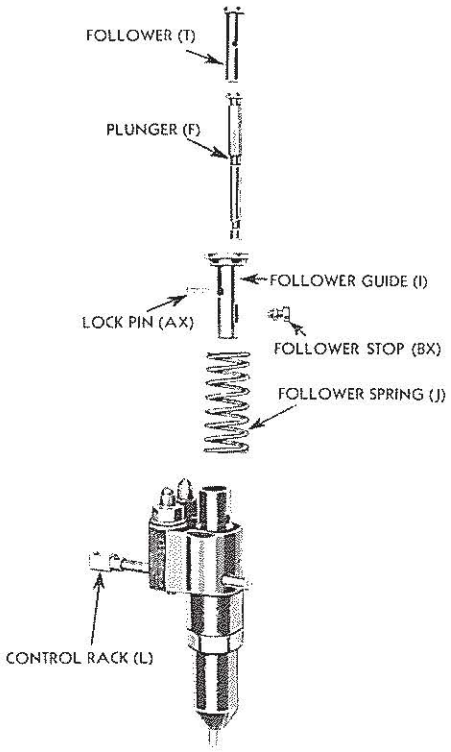


FIG. 17

rack in; slide the plunger assembly in top of injector body, so the flat side of the plunger will engage the flattened side of gear.

15. Align holes in the follower guide and injector body for the follower stop beneath the return spring, then insert slotted wedged end of injector spring lifter tool beneath the spring end, push down on top of the follower and insert the follower stop pin. Fig. 8. When the injector spring lifter tool is removed, the spring will hold the follower stop in place.

NOTE: Try injector rack; if it works hard the injector must be dismantled and the parts inspected for burrs.

F. TESTING INJECTOR

1. After an injector has been rebuilt it should be tested before it is installed in the engine. This test is known as "Popping the Injector," and is accomplished with tool as shown in Fig. 18.

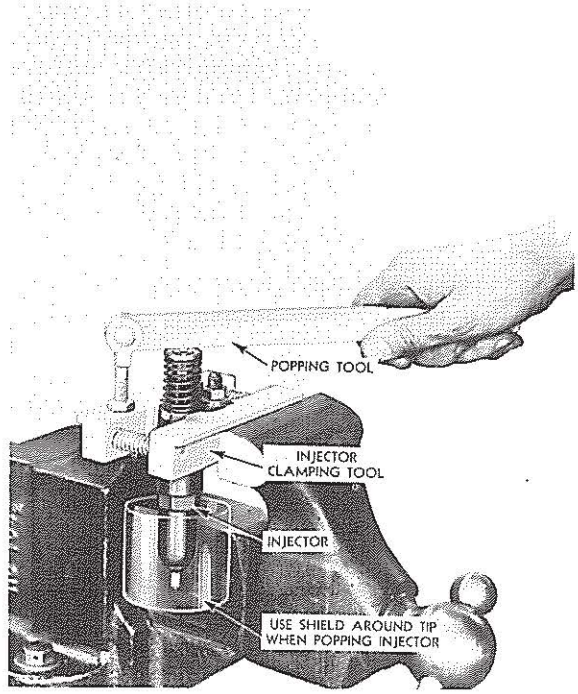


FIG. 18

2. To test you may also try depressing the plunger follower with the thumbs and fore fingers in order to find out if there is any sticking or binding which can be more easily detected than if a tool were used.
3. If plunger follower and spray tip are in good working order, the failure of an injector may be due to one or both of two causes.
   a. Clogged fuel passages in spray tip.
   b. Inoperative spherical valve.
4. Place injector in test fixture as shown and by means of an oil can, introduce fuel into one of the injector openings until fuel flows from the other opening. Set a beaker under and surrounding injector spray tip so fuel injected from tip hits inside of beaker.

   CAUTION: Always use beaker and keep hands away from spray tip when "popping" injector; otherwise the fuel from spray tip will penetrate the skin and may cause blood poisoning.
5. To determine if all six holes in tip are open, take a piece of paper and roll it similar to a 2" mailing tube and place over spray tip; press the handle down on plunger follower with a quick motion after which withdraw paper roll

and count the spots on the paper.

6. If the check valve opening pressure is satisfactory, considerable downward pressure will be required on the fixture handle to open the check valve and discharge the fuel through the six holes. If considerable pressure is not required on the fixture handle to open the check valve so the fuel is discharged in a fog from the spray tip, the valve opening pressure is too low.
7. To test for a check valve leak, wipe or blow all fuel from spray tip and press down firmly on fixture handle to the point where check valve is about to open. (Do not force valve open). Continue to hold handle down against check valve pressure and observe whether or not dribble of fuel occurs at spray tip. If dribble occurs, check valve is not seating properly. If the injector does not pass the above three tests satisfactory, it should be disassembled, carefully and thoroughly cleaned and new parts installed for any worn or corroded parts.

G. INSTALLING THE INJECTOR

1. The injector is installed in the cylinder head by reversing the sequence of operations for removal. A dowel provided on the injector body registers with a hole in the cylinder head so the injector can be located in only one position. After locating the injector tighten in place with the hold-down clamp and nut and attach fuel lines to injector and fuel connections.
2. Every time an injector is removed from the engine it must be timed and equalized. See Topics 42 and 43.

78 -- Cylinder Head

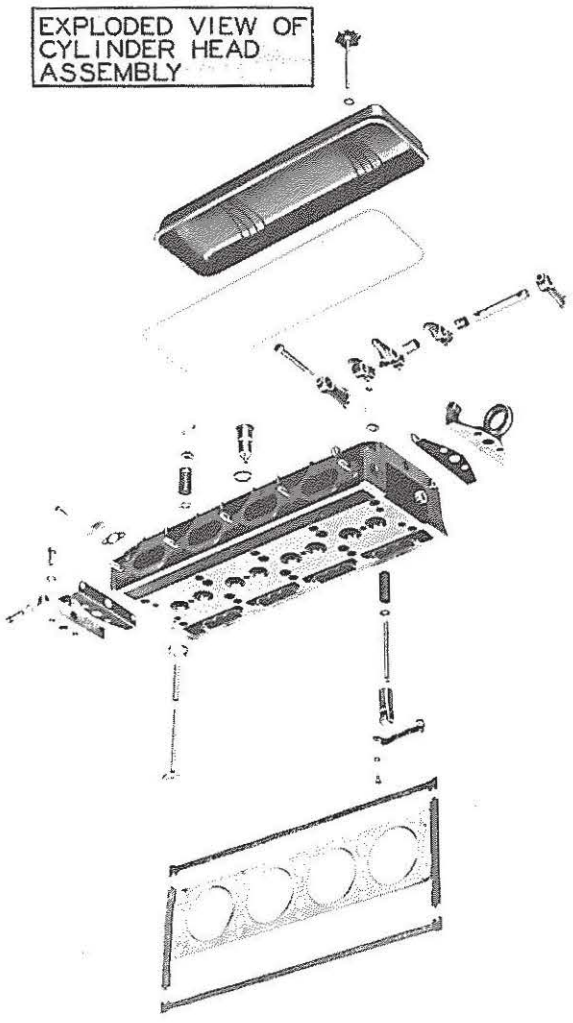


FIG. 1

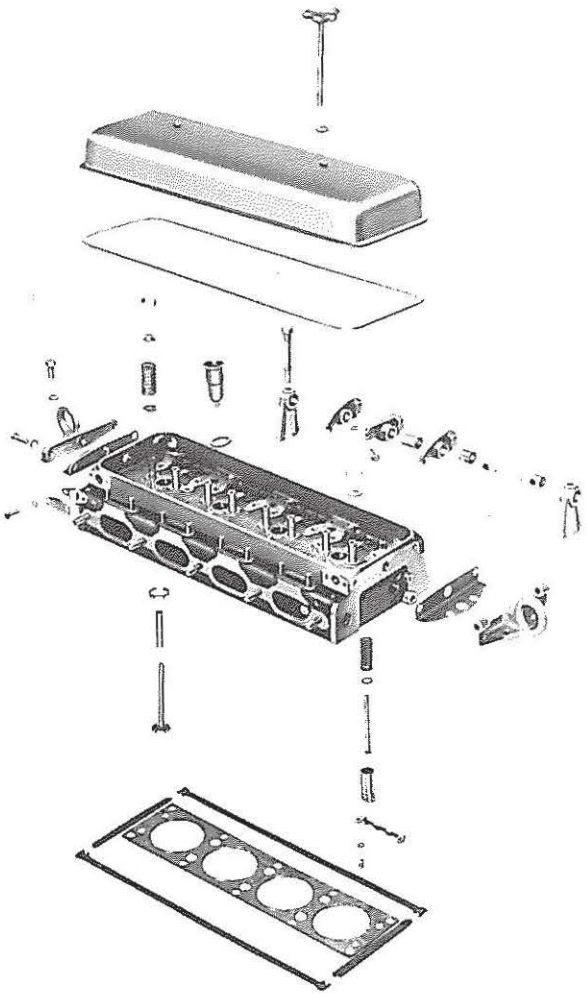


FIG. 2

DESCRIPTION — The cylinder head is a one-piece casting which can be removed from the engine as an assembly containing cam followers, guides, rocker arms and valves. The head is securely held to the cylinder block by heat-treated alloy steel studs.

Located in the head are two exhaust valves, a fuel injector, and three rocker arms, for each cylinder. The middle rocker arm operates the injector plunger; the other two operate the exhaust valves.

Hardened exhaust valve seats are expanded into the cylinder head. These seats furnish accurate seating of the valves under varying conditions of temperature, and materially prolong the life of the cylinder head. The hardened seats are accurately ground to very close limits and their freedom from warpage, under ordinary working conditions, reduces valve grinding to a minimum.

To insure efficient cooling, each fuel injector is inserted into a thin-walled copper tube passing through the water space in cylinder head. The lower end of the copper tube is pressed into the cylinder head and spun over; the upper end is flanged and sealed with a Neoprene seal. The spun-over lower end and sealed upper end, prevent any water leaks around the copper tube.

Two exhaust passages from each cylinder lead through a single port to the exhaust manifold. The exhaust passages, exhaust valve seats, and injector tubes are completely surrounded by cooling water.

To seal compression, a flat laminated gasket composed of steel sheets is provided between the cylinder head and top of cylinder block. A cork gasket around outer rim of head seals against oil leaks.

The top of the cylinder head is completely enclosed by an easily removable pressed steel valve rocker cover, which is held in place by screws fitted with hand knobs. The cover is sealed against leakage by a gasket which is held in place by a retainer and flanged edge of the cover.

A. REMOVAL OF CYLINDER HEAD

1. Loosen clamp nut and precleaner.
2. Remove hood by loosening a bolt at each corner.
3. Wash all dirt from top of motor.
4. Drain cooling system by opening petcock at lower side of water pump.
5. Remove 2 capscrews and separate water by-pass pipe from bottom of thermostat housing at front end of water manifold.
6. Loosen hose clamps on top radiator hose.
7. Loosen and remove water temperature fitting from rear end of water manifold.
8. Remove valve cover.
9. Remove 2 screws that hold breather pipe to governor control housing.

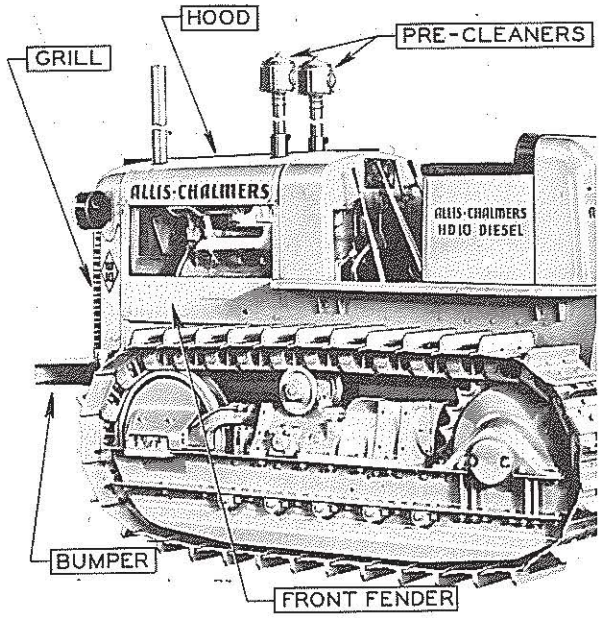


FIG. 3

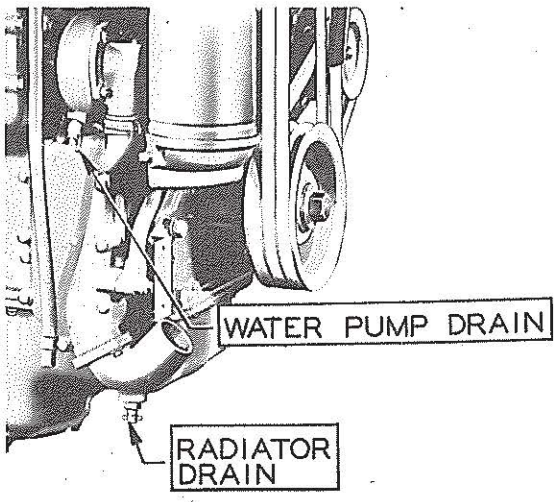


FIG. 4

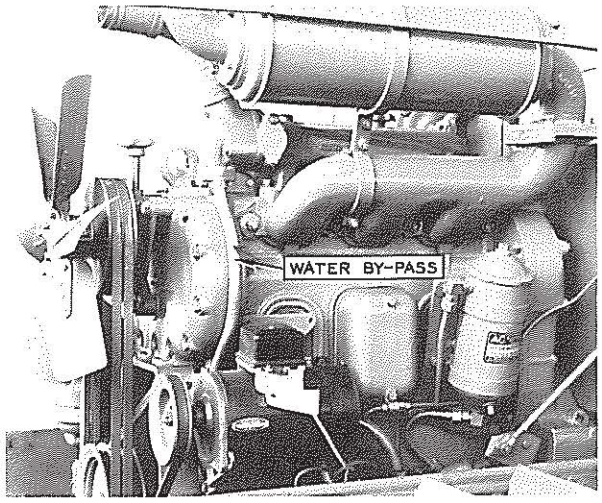


FIG. 5

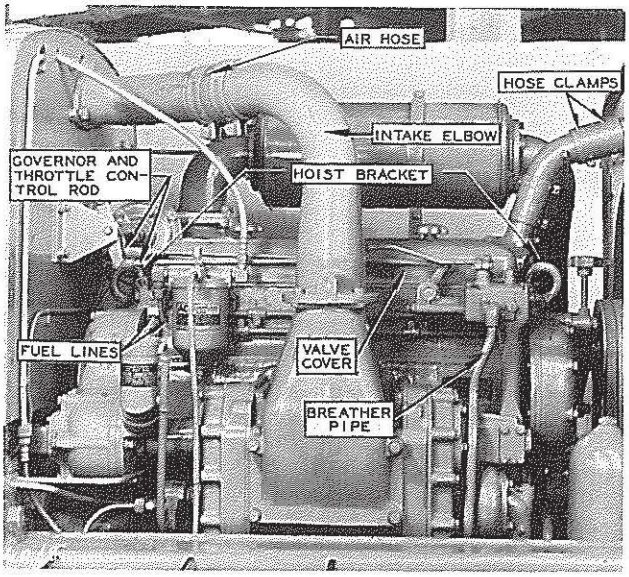


FIG. 6

10. Remove 4 capscrews from governor control housing cover, and remove cover and gasket.
11. Detach governor control rack link from governor and control rack shaft; remove link.
12. Remove 2 capscrews which attach governor control housing to cylinder head.

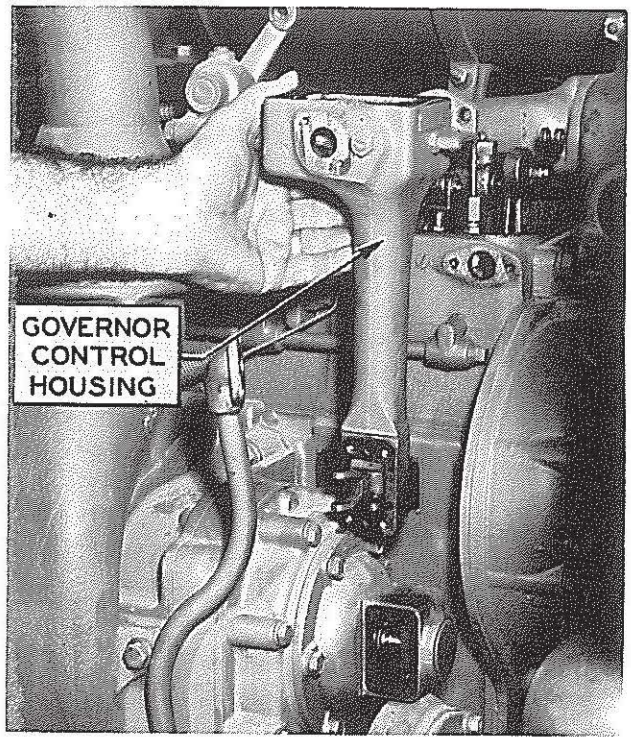


FIG. 7

13. Remove 2 pins in throttle control and shut off lever. Remove governor control housing assembly.
14. Loosen fuel line connections at return fuel manifold on the cylinder head.
15. Disconnect fuel line from pump to filter at filter—remove filter bowl and take out two capscrews holding filter bracket to head.
16. Remove the front injector control tube bracket and remove the control rack.
17. Remove all injector fuel lines. Injector fuel opening should be protected with shipping caps after disconnecting the fuel lines.
18. Remove 2 capscrews at each end of cylinder head that secure cylinder head lifting brackets to the flywheel housing and balance weight covers.
19. Loosen hose clamps on hose connecting air intake pipe and intake elbow.
20. Remove intake elbow by taking out 4 capscrews, which hold it to blower housing.
21. Remove pins from rear ends of governor and throttle control rods.
22. Remove the nuts from the cylinder head studs and, by means of the lifting brackets remove the cylinder head.

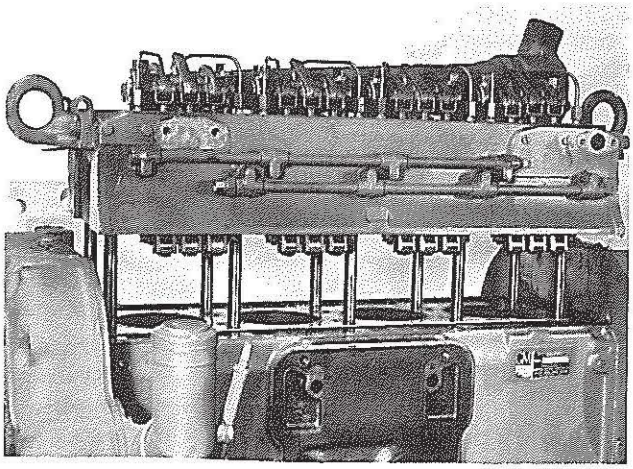


FIG. 8

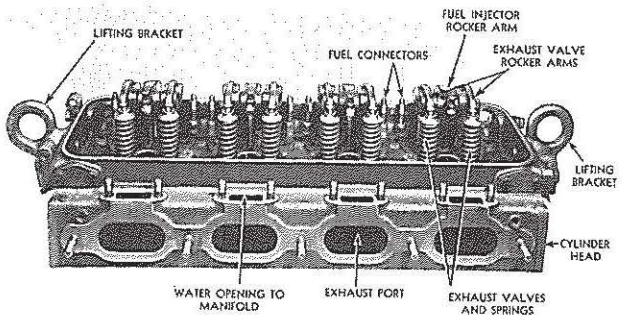


FIG. 9

B. INSTALLING CYLINDER HEAD

Before replacing cylinder head, clean tops of pistons and inspect the cylinder head gasket. If the gasket is damaged install a new gasket.

1. Remove the old cork oil seal gasket from the top of the cylinder block, clean the surface well and install a new gasket;

use shellac on both sides of gasket.

2. Wipe upper surface of cylinder block clean and install cylinder head gasket. The gasket surface next to cylinder head is marked "Top;" also the bead around openings for combustion chambers is toward the cylinder head.
3. Wipe under side of cylinder head clean, and by means of the lifting brackets, set cylinder head in place on block.
4. Loosen capscrews that attach lifting brackets to cylinder head so brackets can shift; starting from the center of the cylinder head and working toward each end, tighten all cylinder head stud nut as tight as possible with an 18" wrench. If torque wrench is used see Topic 68.
5. Replace and tighten the 2 capscrews at each end of cylinder head and attach lifting brackets to flywheel housing and balance weight cover. Tighten the 2 screws that attach lifting brackets to cylinder head. Be sure gaskets are in place.
6. From this point on, reverse dismantling procedure. See instructions, Topics 42 and 43, for injector timing and balancing; also Topic 44 for valve lash instructions.

NOTE: Before replacing valve cover, start the motor and run motor at half speed. Inspect all fuel connections for leaks.

Be sure that valve cover makes air tight joint at cylinder head and is tightened down evenly.

C. CYLINDER HEAD REPAIRS

1. Dismantle engine as outlined in Topic 78A.
2. Remove the two cap screws holding the rocker arm brackets to the cylinder head and remove the brackets from the shaft. Slide the shaft from the rocker arms, and fold the arms back.

   CAUTION: When removing the rocker arm shaft, fold back the three rocker arms and shaft just far enough so shaft can be pulled endwise. DO NOT FORCE THE ROCKER ARMS BACK WITH SHAFT IN PLACE AND IMPOSE A LOAD ON THE ROCKER ARM PUSH ROD.
3. Remove Injectors:

   NOTE: Removal of injectors is unnecessary unless work is to be done on the cylinder head. IF INJECTORS ARE REMOVED, PROTECT THE SPRAY TIPS FROM DAMAGE. Remove injectors as follows:

   a. Remove the injector hold-down nut and clamp.
   b. Using special tool, pry the injectors straight up and remove. After removing the injectors, wash the outside exposed portion in clean fuel and blow off with compressed air.

      If injectors are to be left out of the engine any length of time, they should be filled with a 50-50 mixture of mineral seal oil and kerosene and packed in the air tight containers the new ones came in. Test pop each injector as described in Topic 77E before installing the injector in the engine.
4. Remove nuts from cylinder head studs and by means of lifter brackets remove the cylinder head.

D. REMOVAL OF EXHAUST VALVES

1. Place the clyinder head on the work

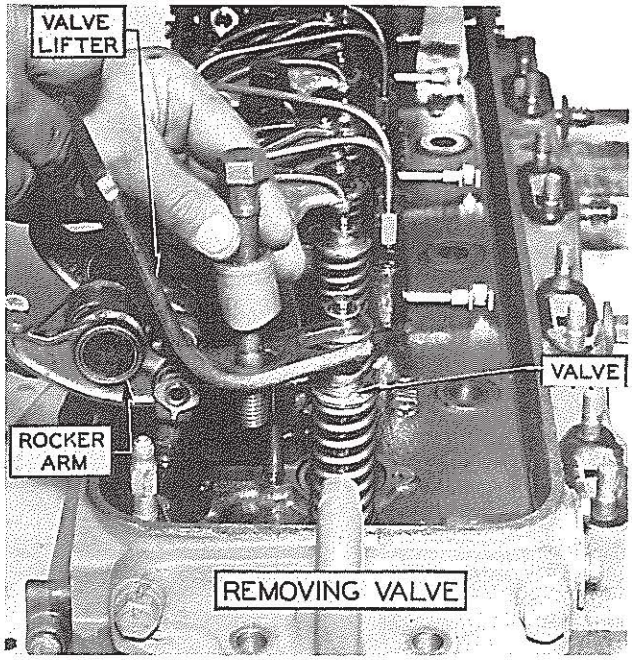


FIG. 10

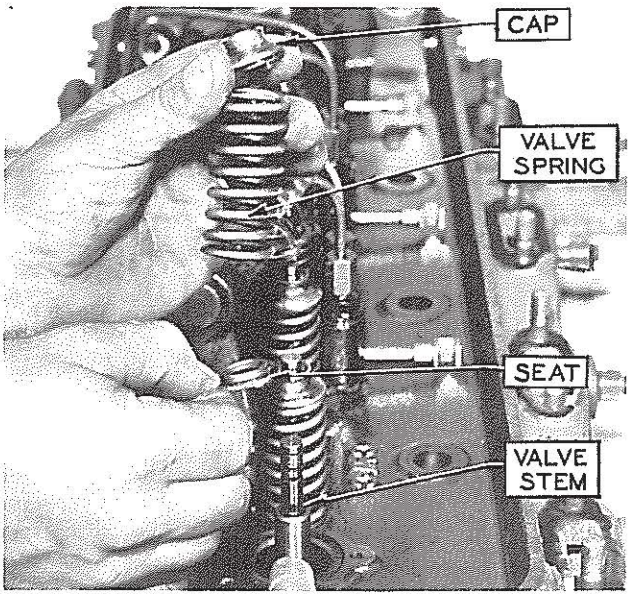


FIG. 11

bench right side up, with the valve heads resting on a 2" thick block of wood, and release the valve spring by removing the tapered seat lock with special tool shown in Fig. 10. The 2" thick block is used to protect the valve followers which project through the lower side of the cylinder head.

2. Turn the cylinder head over and withdraw the valves from the bottom.

E. NEW EXHAUST VALVE SPRING, SPRING SEAT, AND SPRING CAP

Effective with Engine Serial Nos. 3714457, 4716024, and 6712481, the subject new parts which formerly were used only on high and medium high output engines were incorporated in all other 3, 4, 6-71 engines, replacing the parts formerly specified.

1. The new exhaust valve parts, as they apply to the 3, 4, 6-71 engines, provide an anti-spin feature which prevents the valve from turning or spinning when engine is operated at higher speeds.
2. In line with the valve spring and parts change on the 3, 4, 6-71 engines, the cylinder heads for these engines have been revised to add 1/8" drilled holes as required for seating the pin which is part of the new valve seat assembly. See sketch, Fig. 12, showing section of cylinder heads where the 1/8" drilled holes were added.
3. The new valve spring is identical with former spring except that it has the tapered ends cut back from end coils to give a 1/16" step for locking in the new cap and new seat assembly. The new seat assembly provides for a locking pin which fits into the hole drilled in the cylinder head as mentioned in preceding paragraph. See Fig. 12 for details of old and new valve parts.

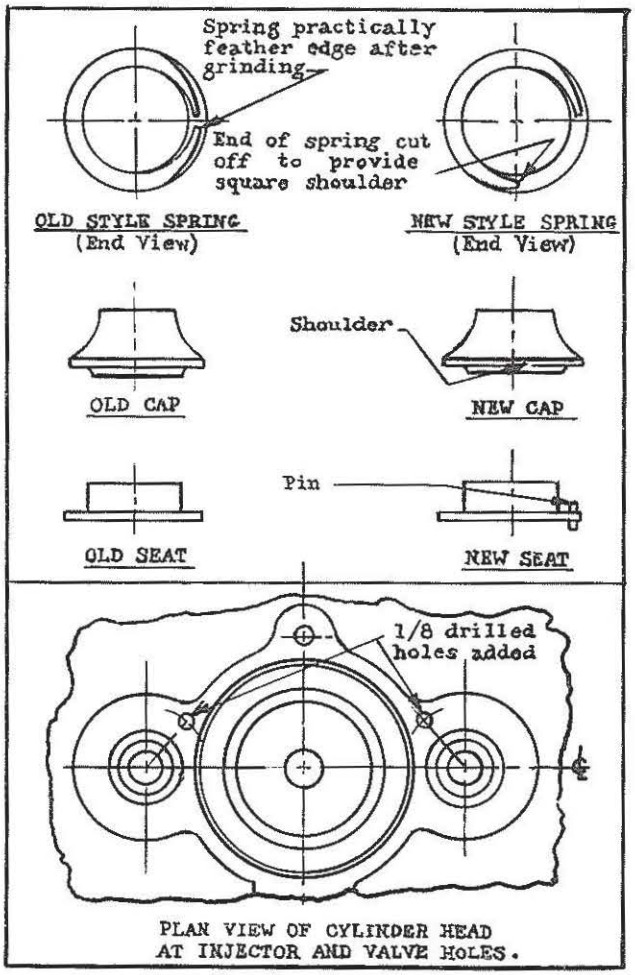


FIG. 12

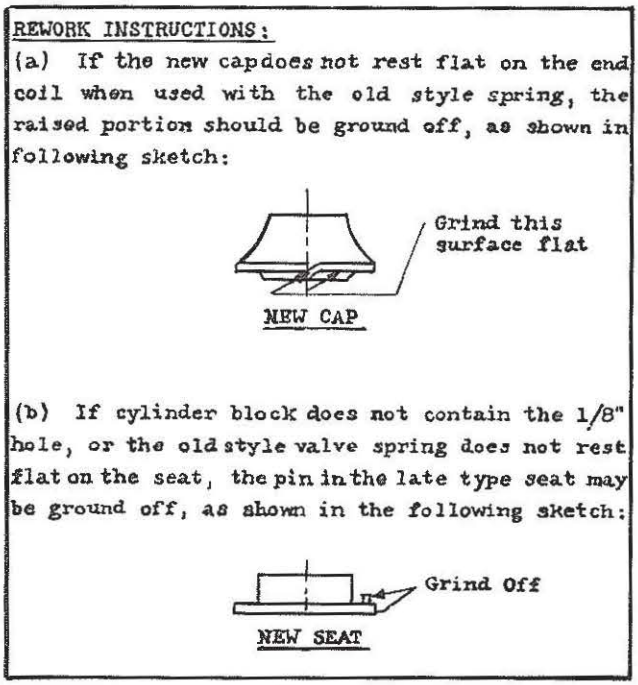


FIG. 13

4. INTERCHANGEABILITY
   a. Valve Spring. The new spring may be used with either old or new correlated parts.
   b. New Valve Spring Cap. The new cap may be used on engines with old style spring. However, care should be taken that the cap rests flat on the end coil of spring. If a rocking condition exists follow rework instructions shown in Fig. 13.
   c. New Valve Spring Seat. The new seat is only released for the 3, 4, 6-71 engines and can only be used on those engines with cylinder heads that include the 1/8" drilled hole for seating the pin, unless the pin on the new seat is ground off, as shown in rework instructions, Fig. 13.
5. PARTS NOTE:

Both old and new valve spring seats will be available for service, and replacement orders should specify the old or new part numbers

indicated in parts list below. However, in the case of valve spring and cap, only new numbers will be available for service replacement. Parts books should be marked for reference purposes.

6. IDENTIFICATION:

The new spring may be identified by the square cutoff at the end coils. The new seat has a pin and the cap has a step added to prevent spring from turning.

PARTS LIST

Old Part No.	New Part No.	Part Name
5150289	5155209	Valve Spring
5150291	5155210	Valve Spring Cap
5150292	Same	Valve Spring Seat
	5155207	Valve Spring Seat

F. REMOVE AND INSTALL VALVE GUIDES

The valve stem diameter is from .3425" to .3414" and the clearance of the stem in the guide should be from .001" to .002". If this clearance is greater than .005" the guide should be replaced.

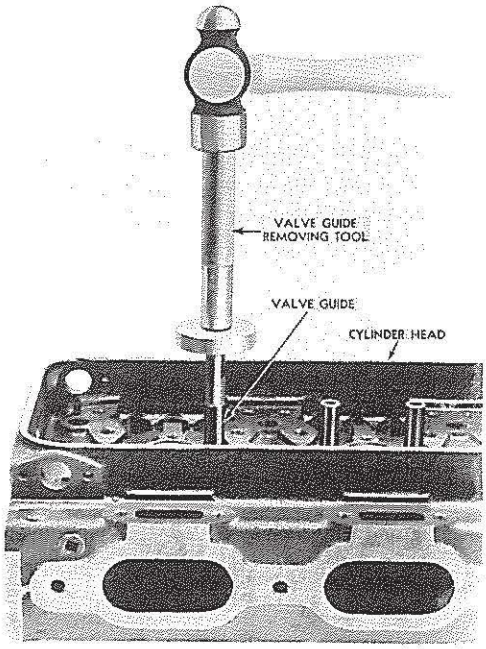


FIG. 14

1. Drive valve guide out from top with special driver shown in Fig. 14.
2. To install valve guide, drive in from bottom of cylinder head with driver and then ream with special reamers shown in Fig. 15.

G. REMOVE AND REPLACE VALVE SEAT INSERTS

1. With cylinder head removed, wash in clean fuel oil and dry with compressed air.
2. Lay cylinder head on bench and insert the collet inside of the valve; insert so

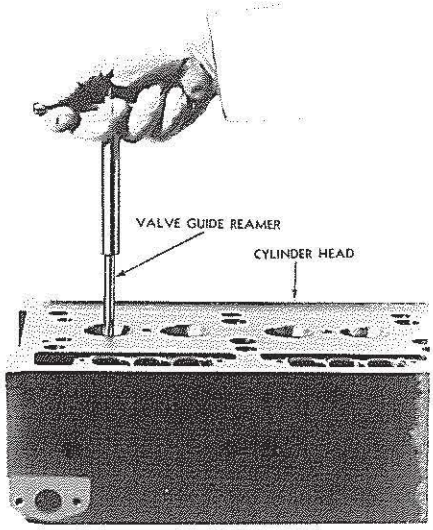


FIG. 15

that lip at bottom of collet flange is flush with bottom side of valve insert. While holding collet in this position, expand same by turning nut at top of tool. Be sure that flange of collet is firmly entered just below valve insert.

3. Slide tool body over top of collet with Allen screw of body in line with slot below threads on collet. Turn Allen screw IN to engage slot and lock screw on collet relative to body.
4. Put thrust bearing over top of collet and on top of body.
5. Start screw thread of tool head onto collet and continue to turn until valve insert is pulled from cylinder head.

NOTE: Particular care must be exercised when replacing valve seat inserts. The inserts are installed into the cylinder head with drive-shrink fit, and must

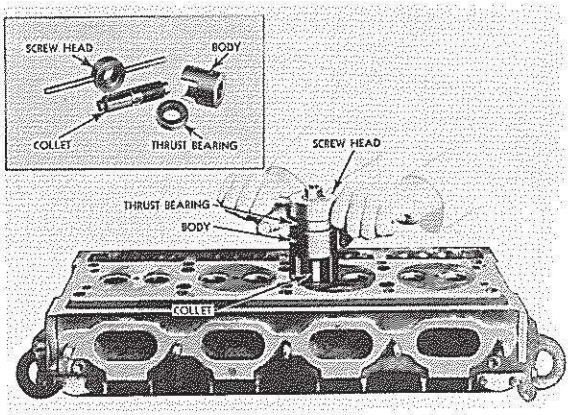


FIG. 16

be started in place true with counterbore in head.

6. See that cylinder head is perfectly clean, particularly the counterbore for inserts.
7. Immerse cylinder head for 30 minutes in water at temperature of 180 to 200 degrees F.
8. Cool inserts on dry ice for 45 minutes.
9. Place cylinder head bottom-side-up on bench, blow out counterbore for inserts with air, and lay one insert at each insert counterbore—valve side up.

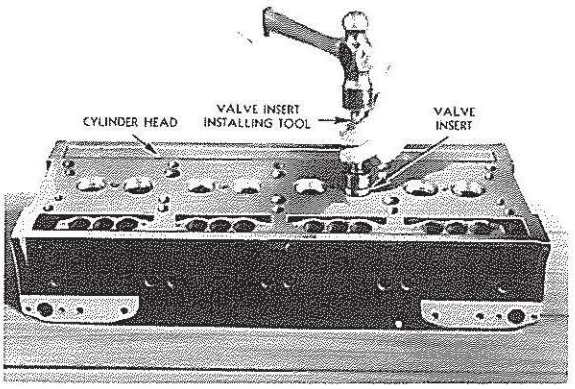


FIG. 17

10. Using special locating and driving tool, shown in Fig. 17, insert pilot end of driver into valve guide and drive insert down tight into counterbore.
    This operation must be done quickly, while the valve seat inserts are cold.
11. Inspect valve seat for concentricity with valve guide and, if necessary, recondition seats as directed.

H. RECONDITIONING VALVES AND VALVE SEATS

Before either a new or used valve is installed, the seat in the cylinder head for the valve should be examined for proper valve seating. Furthermore, if valve once used is to be installed again, the valve stem should be cleaned, and the seat reground to the recommended angle of 45 degrees. The valve guide should be thoroughly cleaned with reamer recommended in conjunction with other Diesel Engine tools. If bore in valve guide is worn oblong, or if valve heads are warped relative to the stem, new parts should be installed. The width of the valve seats in the cylinder head is 5/64". When new valve inserts are installed, or old inserts refaced, the work must be done with a grinding wheel. The ordinary method of reaming valve seats is ineffective for this operation because of the very hard valve insert material.

The complete equipment for valve seat grinding should include:

1. Eccentric valve seat grinder.
2. Dial gauge.

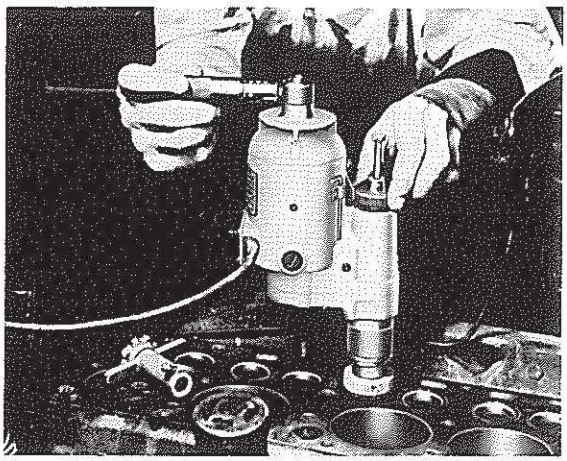


FIG. 18

FIG. 19

3. Pilot.
4. 45 deg. grinding wheel.
5. 70 deg. grinding wheel.

The 45 deg. grinding wheel is used for refacing the valve seats, and the 70 deg. wheel is used for narrowing the seats to the standard 5/64" width. After the valve seats have been dressed with the grinding wheel, the dial gauge, shown in Fig. 19, is used to

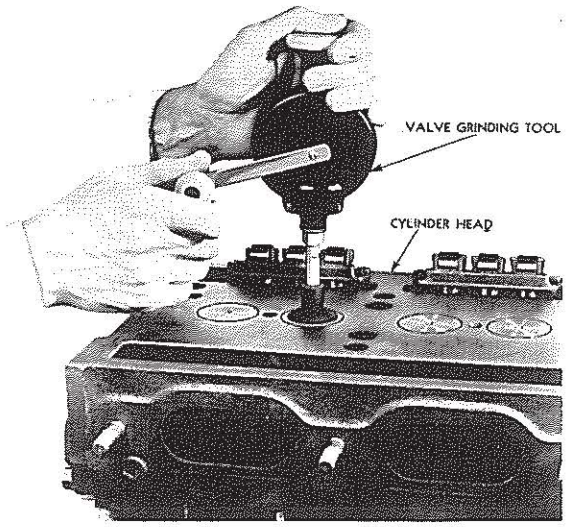


FIG. 20

check the concentricity of the valve seats relative to the valve guides.

After the valve seats have been ground with tool shown in Fig. 18, the valves should be put in place and lapped to perfect seats in the regular manner, as shown in Fig. 20. After lapping, contact between valves and seats may be checked by wiping a thin film of Prussian blue on the valve seats, setting valves in place, and bouncing valve on seat.

I. REMOVAL OF CAM FOLLOWERS AND PUSH RODS

The cam followers may be removed from either the top or bottom of the cylinder head. When they are removed from the bottom, the cylinder head must first be removed from the motor, and when they are removed from the top, the cylinder head need not be removed. If, for any reason, the cylinder head is off the engine, the cam followers can best be removed from the bottom of the head as shown in Fig. 21.

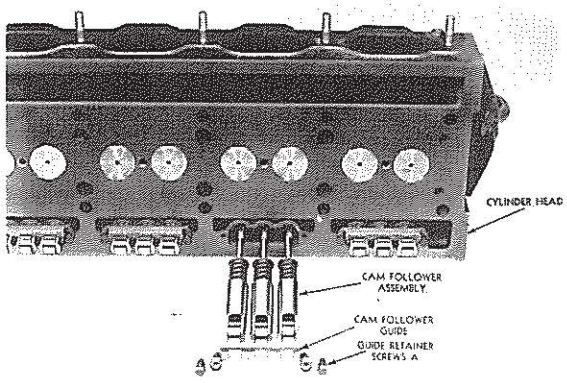


FIG. 21

1. TO REMOVE THE CAM FOLLOWERS AND PUSH RODS FROM THE LOWER SIDE OF THE CYLINDER HEAD:
   a. Cylinder head removed.
   b. Remove the rocker arms by loosening lock nuts and unscrewing from push rods.
   c. Lay the cylinder head edgewise on the bench, as shown in Fig. 21, and remove the 2 screws "A" that attach the cam follower guides to cylinder head and remove guides.
   d. Pull the cam followers, retainer springs, spring retainers and push rods as an assembly from lower side of cylinder head.

The valve follower retainer spring lock wires, shown in Fig. 22, still remain in the cylinder head. If the head is to be changed, these springs must be removed; if not, they may be left in place.

It may be desirable, at times, to change a push rod without removing the cylinder head.

2. TO REMOVE CAM FOLLOWERS AND PUSH RODS FROM UPPER SIDE OF CYLINDER HEAD:

To use the tool illustrated in Fig. 22 re-

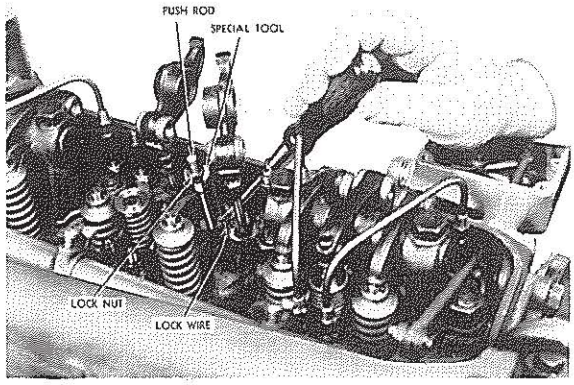


FIG. 22

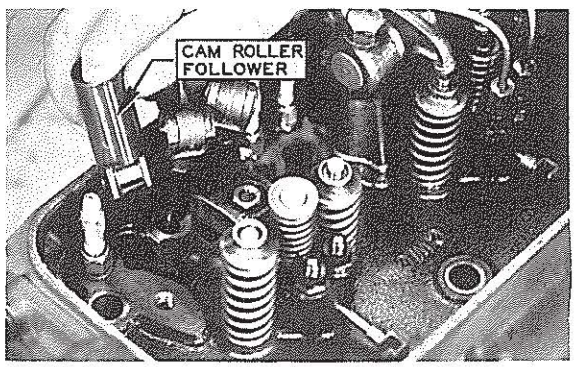


FIG. 23

move the rocker arm, insert the special tool between the upper surface of the cam follower retainer spring and the lock nut on the push rod, then screw the nut down to compress the spring. With the spring compressed, use a screw driver and dislodge the lock wire from the groove in the cylinder head. With lock wire dislodged, the push rod may be removed. Cam follower may now be pulled out of cylinder head.

J. INSPECTION OF CAM FOLLOWER ASSEMBLY

After the cam followers have been removed they should be cleaned in fuel oil, blown off

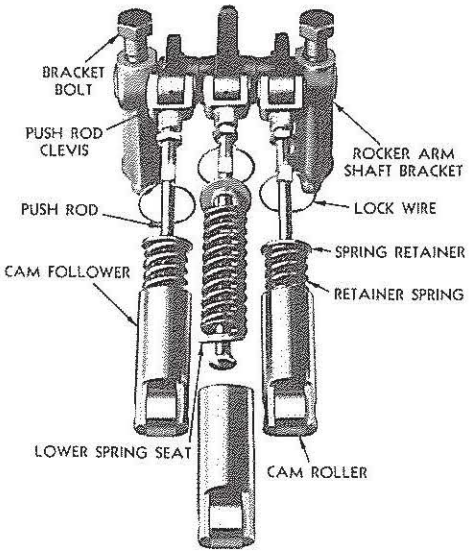


FIG. 24

with dry compressed air, and inspected before being assembled into the cylinder head. The cam rollers must rotate smoothly and freely on their bearings. If cam rollers, bearings, or pins are worn sufficiently to allow more than .005" radial movement of roller, or if pins are loose in the cam followers, the follower assemblies should be renewed. Rollers must be free from flat spots or scuff marks. If these exist, or if rollers have not been rotating freely, examine the cams on which rollers have operated; if scuffed or noses of cams are worn down, install a new camshaft.

Rapid change in valve lash, if such condition has existed, may be due to cam follower assemblies because of the above reasons.

K. REPLACING CAM FOLLOWERS

1. To assemble cam followers and push rod assemblies from the bottom of the cylinder head.
   a. See that the spring seats, push rods, and retainer springs are set down into the hollow followers as shown in Fig. 24. Then with the lock wires in place in the cylinder head, slide the follower assemblies into the cylinder head. When installing the followers, see that the oil holes in the lower end of the followers point away from the valves, so that the holes are not covered with the follower guides.
   b. Attach the follower guide retainers to the cylinder head, to hold the followers in place.
   c. Provide a 2" thick strip of wood on which to rest cylinder head and protect valve followers, then invert the head and run the lock nuts down onto upper end of push rods.
   d. Note that the injector rocker arm—the center arm—is different from the exhaust valve rocker arms; also that the boss for the shaft on the valve rocker arm is longer on one side than on the other. The long side of the boss must face the injector rocker arm.

   With the rocker arms selected as above, screw the upper end of each push rod into the rocker arm clevis so the end of the rod is just flush with the top of the threaded portion of the clevis. Do not tighten the lock nuts yet.

CAUTION: Whenever a push rod has been disconnected from the push rod clevis, the rod must be screwed back into the clevis flush with the top of the threaded portion of the clevis before the valve lash is checked. If this is not done, the piston may hit the head of the valve when the engine is being turned, owing to the small clearance between the valves and piston head at the piston's upper position.

2. To replace cam followers and push rod assemblies from the top of the cylinder head.
   a. Replace the cam follower. Point the oil holes in the lower end of the followers away from the valves so that the holes will not be covered by the follower guides.
   b. Install the push rod assembly.
   c. Install the lock wires in place.

L. REMOVAL OF INJECTOR COPPER TUBING

1. Turn the cylinder head bottom side up and drive the copper tube from position by shearing the flange at the bottom of the tube with the special tool as shown in Fig. 25.

M. INSTALLING INJECTOR COPPER TUBE

1. The copper tube is installed in the cylinder head by inserting a rubber ring into counter-bore of cylinder head at open-

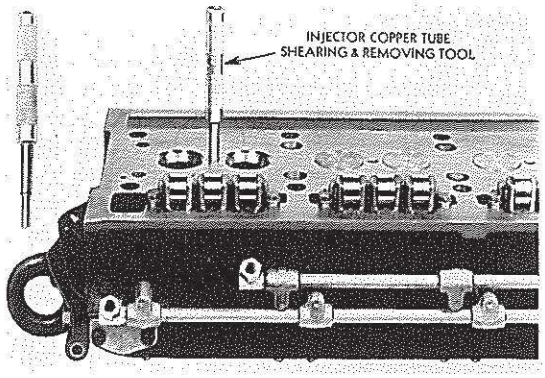


FIG. 25

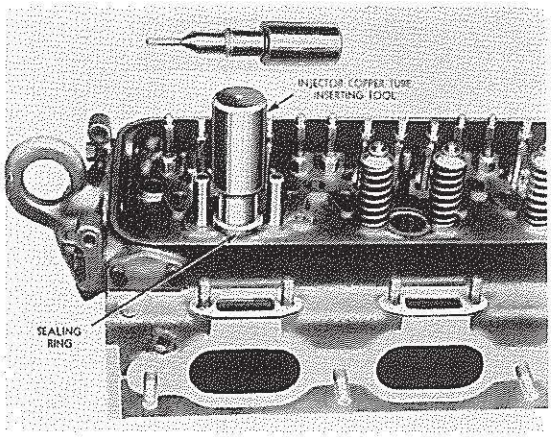


FIG. 26

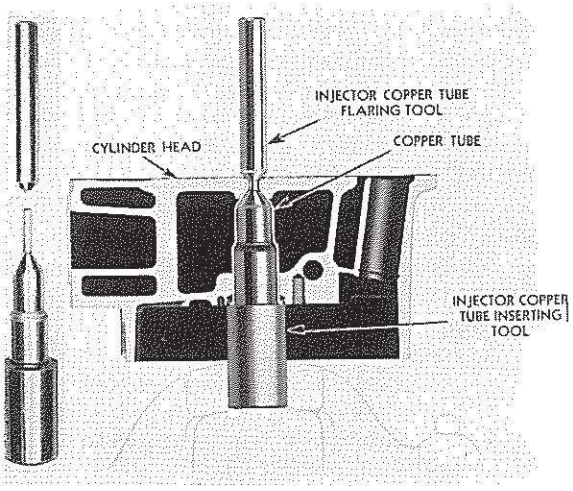


FIG. 27

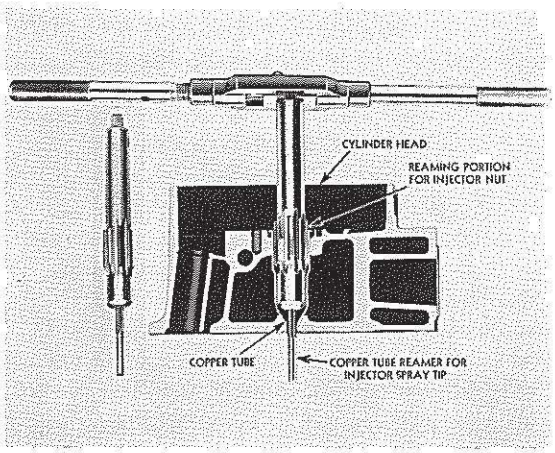


FIG. 28

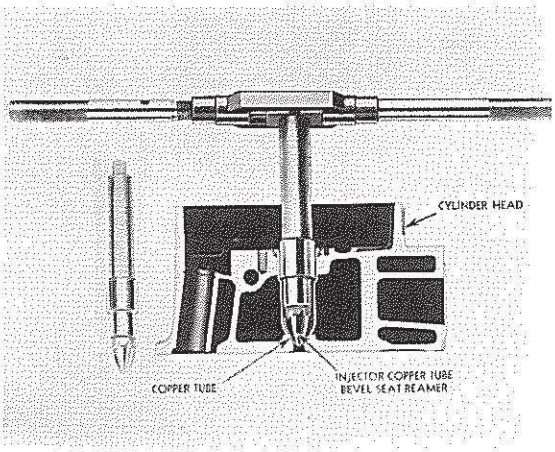


FIG. 29

ing for injector tube and crowding tube through ring and into position in cylinder head. The flange at upper end of tube will seat on rubber ring and into counter-bore when copper tube is in position.

2. Drive tube into position with special tools as shown in Fig. 26, taking great care that the small end of copper tube enters the hole without striking the edge. If this happens the copper tube will be damaged.
3. After driving tube into position, support driving tool in vise, point up and inside of tube. Slide flaring tool down over small end of driver tool and peen lower end of tube into flare of cylinder head by rotating the flaring tool. See Fig. 27.
4. After copper tube has been installed in the cylinder head, it must be reamed first to receive the injector spray tip; and second, for good seating of bevel on lower end of injector nut. The reaming for the injector and spray tip is done by a special tool as shown in Figs. 28 and 29.

NOTE: When using injector hole tube reamers use a mixture of one-half cutting oil and one-half kerosene. This will produce a smooth finish and preserve cutting edges of reamers. Time can be saved when reaming injector hole tube bevel seat by use of the injector feed clamp Fig. 31. Besides cutting reaming time in half, use of feed clamp also produces a smoother seat. Feed clamp can

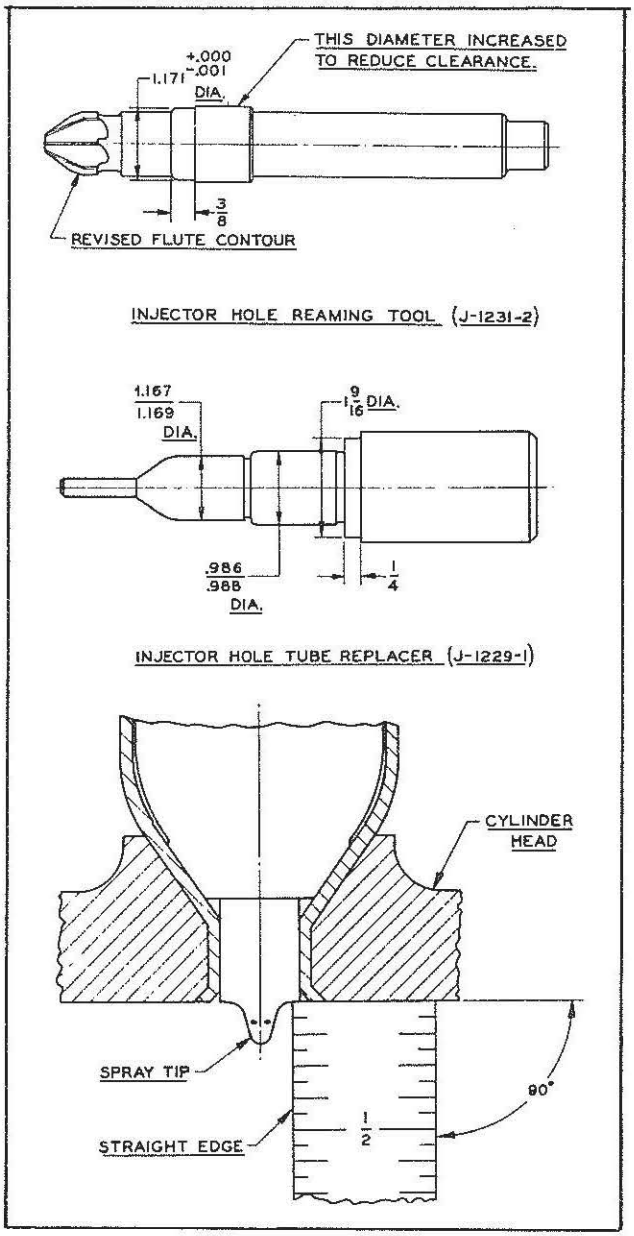


FIG. 30

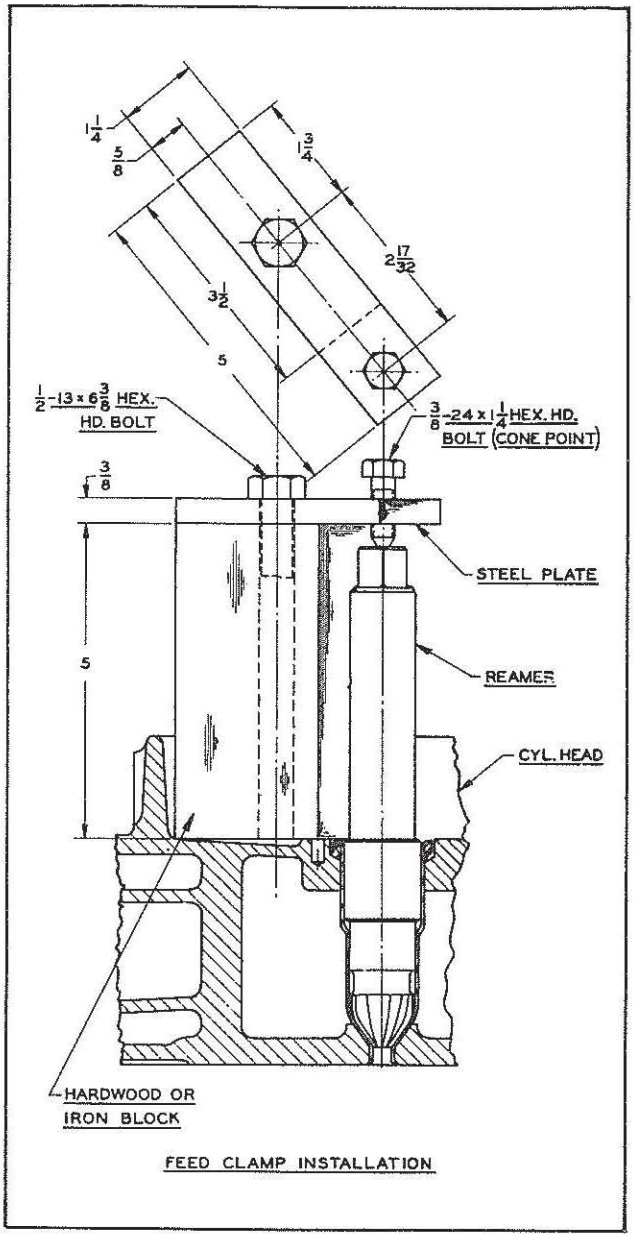


FIG. 31

be made up as shown, or purchased.

CAUTION: Injector tube bevel seat should be reamed so that shoulder on spray tip is just flush with face of cylinder head, Fig. 30. This relation should be checked with a straight edge as it is important to hold the tip in this position. Check depth with an injector during reaming operation.

5. In order to withstand the high compression pressure, the beveled seat at lower end of injector nut must fit true in the copper tube.
6. After the reaming operations, daub a thin film of Prussian blue at lower end of injector nut and insert injector down in the tube and lock in position with injector clamp.
7. Remove the injector and see if the injector has a good bearing at the bevel seat; if bearing is poor at this point, chances are the tube has been improperly installed in which case install another tube and again proceed with reaming operations as outlined above.

N. REMOVAL OF FUEL OIL MANIFOLD

1. Remove valve cover.
2. Remove fuel oil lines from injector to fuel connectors. Place shipping caps over openings in injector to keep dirt from getting in the injector.
3. Remove fuel connectors and fuel manifolds.

NOTE: The connectors must be removed before the manifold can be removed. The T connectors on the manifold leading into

the cylinder head are on the top side of the lower manifold and on the bottom side of the upper manifold.

O. INSTALLING FUEL OIL MANIFOLD

1. After the manifolds have been set in position, replace the fuel oil connectors.
2. Connect fuel oil lines to manifold.
3. Attach fuel oil line at injectors and fuel connectors.

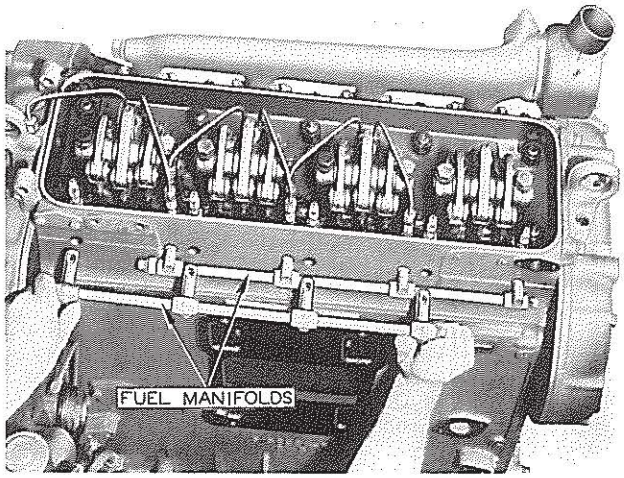
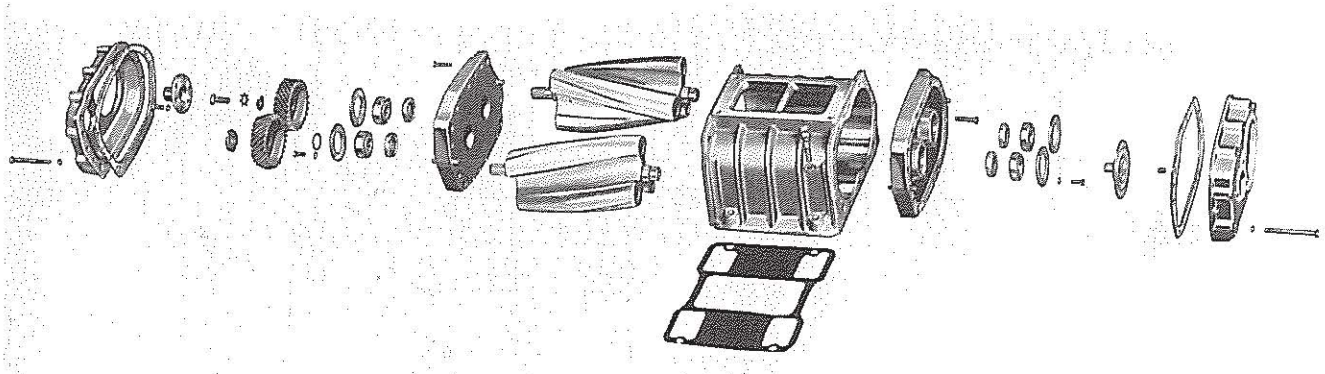


FIG. 32

79 -- Blower



EXPLODED VIEW OF BLOWER ASSEMBLY

FIG. 1

In the scavenging process employed in these two-cycle engines, a charge of air, which is forced into the cylinders by the blower, thoroughly sweeps out all of the burnt gases through the exhaust valve ports and also helps to cool the internal engine parts, particularly the exhaust valves. At the beginning of the compression stroke, each cylinder is filled with fresh, clean air, which permits highly efficient combustion.

DESCRIPTION—The blower, designed especially for efficient Diesel operation, supplies the fresh air needed for combustion and scavenging. Its operation is similar to that of a gear-type oil pump. Two hollow rotors, each with three lobes, revolve with very close clearances in a housing bolted to the side of the engine. To provide continuous and uniform displacement of air, the rotor lobes are made with a twisted or helical form.

The air entering the blower inlet from the air cleaner is picked up by the lobes and carried to the discharge side of the blower as indicated by the arrows. The continuous discharge of fresh air from the blower creates an air pressure of about seven pounds per square inch in the air chamber of the cylinder block at maximum engine speed. This air swirls through the intake ports, which start to open at 48° before bottom dead center and close at 48° after bottom dead center.

The angle of the ports in the cylinder liners imparts a rotational motion to the intake air as it enters the cylinder. This rotation persists throughout the compression stroke and improves the combustion.

Two timing gears on the drive end of the rotor shafts space the rotor lobes with a slight clearance. Consequently, due to the fact that the rotors do not touch each other at any time, they require no lubrication. Highly effective seals prevent air leakage at the ends of the lobes, and also keep the oil used for lubricating the timing gears and rotor shaft bearings from entering the rotor compartment. The upper rotor is driven 1.95 times engine speed by the

blower driveshaft and the lower rotor is driven from the upper rotor through the timing gears. The flexible coupling attached to the blower drive gear, which prevents the transmission of torque fluctuations to the blower, is formed by an elliptical cam driven by two bundles of leaf springs which ride on four semi-cylinderical supports. Each rotor is supported on the doweled end plates of the blower housing by a single-row radial ball bearing at the front, and a two-row pre-loaded radial and thrust ball bearing at the gear end.

A. REMOVAL OF BLOWER

1. Disconnect the governor control housing assembly from the blower and the block. Remove this housing.
2. Remove the flywheel housing star cover and remove the blower drive shaft.
3. Disconnect the fuel lines from the fuel pump.
4. Disconnect the water pump at the oil cooler and cylinder block.
5. Remove the air intake elbow and air inlet housing.

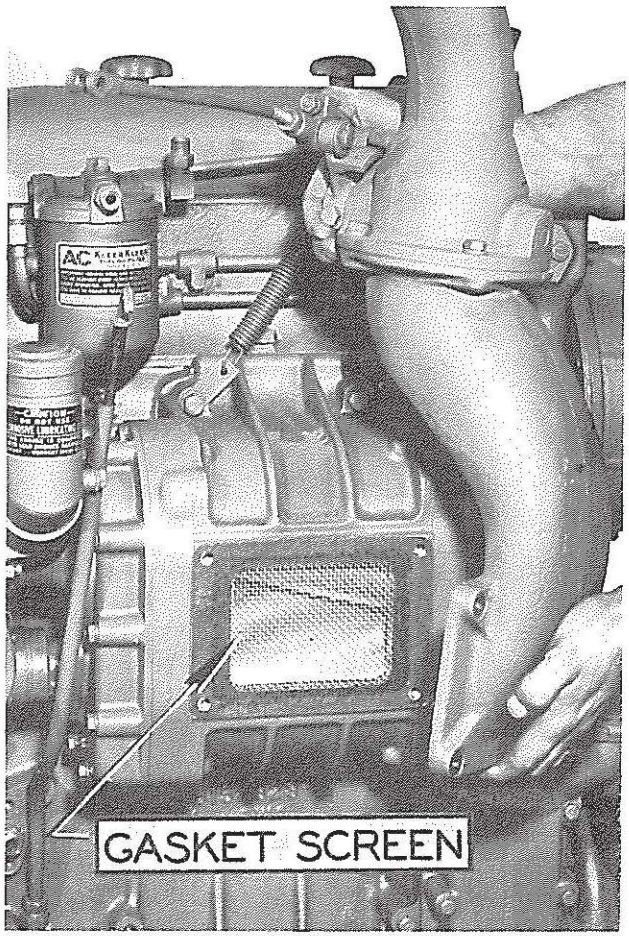


FIG. 2

6. Remove the capscrews at the top and bottom of the blower that holds it to the cylinder block.
7. Raise the front end of blower slightly to clear water pump to oil cooler connection, and pull blower assembly (including accessories) forward, withdrawing blower drive shaft cover from grommet on drive gear housing.
8. Remove the fuel oil pump, water pump, blower drive shaft covers, and governor weight housing from the blower.

B. DISASSEMBLY

1. Remove 10 capscrews in each end cover and pull cover off dowels at top and bottom of bolt flange. Do not pry between cover and end plate or gasket surfaces will be damaged.

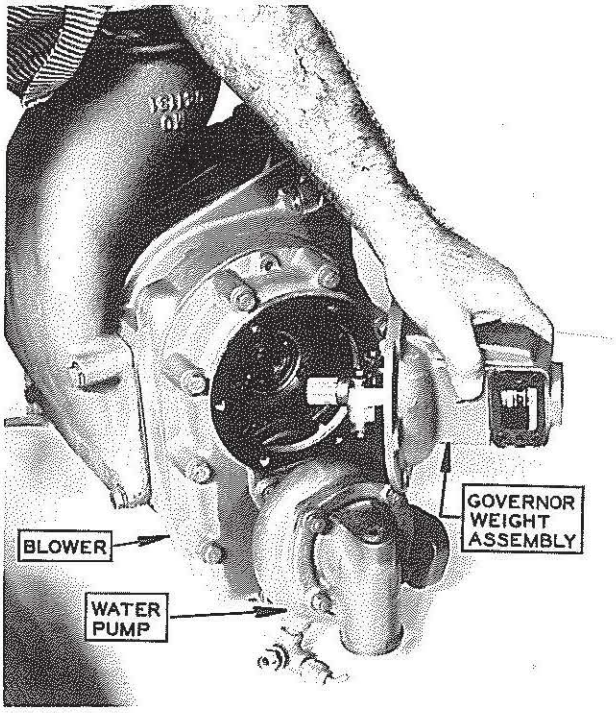


FIG. 3

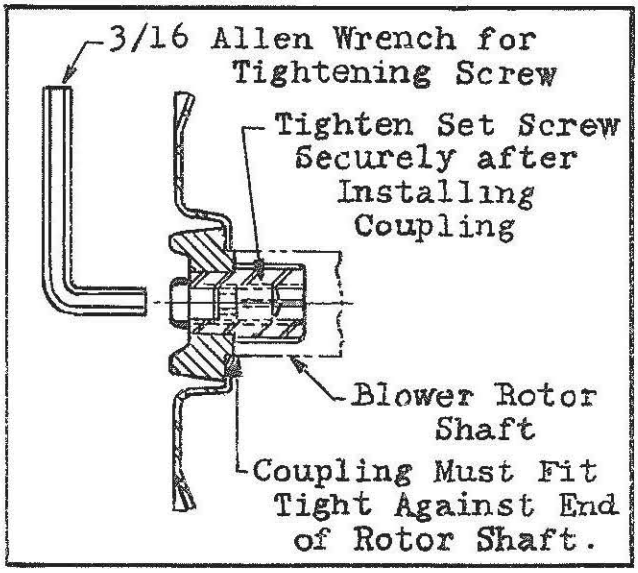


FIG. 4

2. Using a $\frac{3}{16}$" Allen wrench, loosen expander screw at center and front end of

blower lower rotor shaft, and withdraw water pump intermediate coupling from shaft.

3. Remove 6 capscrews attaching blower drive shaft flange to rear face of blower upper rotor timing gear, and tap flange free of gear.
4. Remove the capscrews and washers at center of rear end timing gears that lock the gears in place.
5. The two timing gears must be pulled from the rotor shafts at the same time.

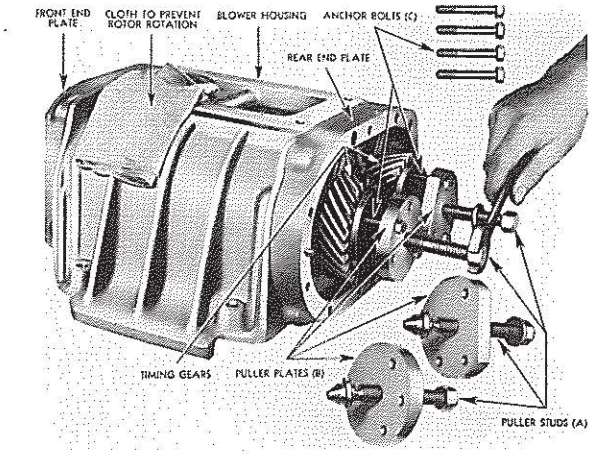


FIG. 5

   a. Back out puller studs (A) in puller plates (B) as far as possible.
   b. Install two anchor bolts (C) in diametrically opposite holes of puller plates and screw anchor bolts into gears as far as possible so faces of plates are parallel with face of blower.
   c. Turn the two puller studs (A) UNIFORMLY clockwise and withdraw gears from rotor shafts.
      Note number and thickness of shims on each rotor shaft, if any are used, remove from shafts and replace accordingly when assembling blower.
6. Back out 3 capscrews at each bearing and remove rotor shaft bearing retainers at both ends of blower.
7. Remove rotor shafts from rear bearings and front end plate from blower housing. This procedure applies to blowers on which the rotors and housing have not been scored to the extent that withdrawal of rotors assembled to the front end plate will not further damage rotors. If rotors and blower housing are badly scored, rotor shafts should be pushed from bearings in front end plate before withdrawal, as outlined in item (8).
   a. Remove two countersunk fillister head screws from end plate, and loosen about three turns the two countersunk fillister head screws in REAR end plate.

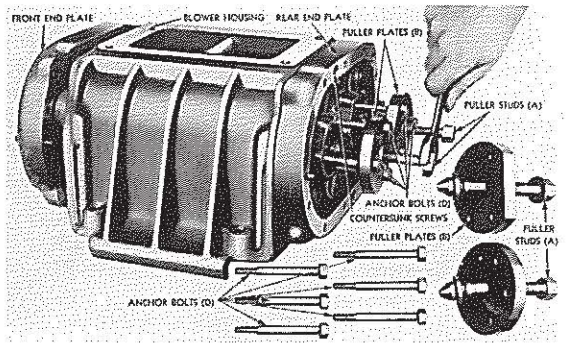


FIG. 6

   b. Back out puller studs (A) in puller plate (B) as far as possible.
   c. Install the 3 anchor bolts (C) in the three equally spaced holes of each puller plate and screw anchor bolts in holes from which bearing retainer screws were removed so faces of plates are parallel with face of blower.
   d. Turn the two puller studs (A) uniformly clockwise and push rotor shafts from bearings in REAR plate. FRONT plate, with rotor shafts still assembled in bearings, will be pushed away from blower housing, simultaneously.
   e. Remove tool from rear end plate and the two fillister head retaining screws, then pull plate from position by hand. Withdraw rotors and front end plate assembly from blower housing, IF ROTORS ARE NOT SCORED. If rotors are scored, remove front end plate from rotor bearings before withdrawing rotors; as outlined in item (8).
8. Remove rotor shafts from front end plate bearings. The rotor shafts are removed from the FRONT end plate bearings with the same tool and in exactly the same manner as from the REAR plate, as follows:
   a. Attach puller plates (B) to blower front end plate with anchor bolts (C) screwed into holes from which bearing retainer bolts were removed—the same as in 7-C.
   b. Turn the two puller studs (A) uniformly clockwise and push rotor shafts from bearings.
9. Remove rotor shaft bearings from blower end plates. Insert bearing removing tool through oil seal from inner face of blower end plate, as shown in Fig. 7 so pilot of tool enters bore in inner race of bearing and shoulder of tool rests against face of bearing inner race. Support end plate approximately two inches off bench and drive bearing from position. Follow this same method on all

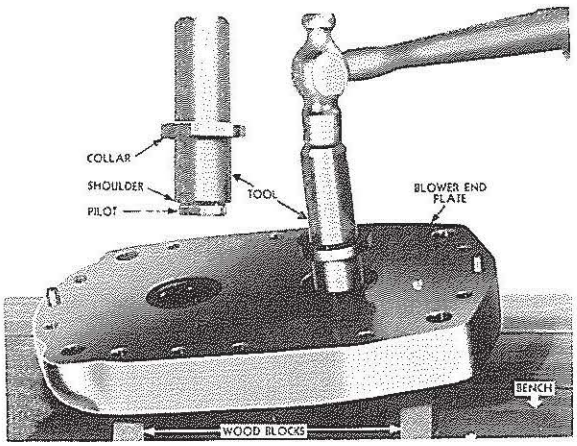


FIG. 7

four bearings.

10. Remove bearing oil seals from blower end plates. Inspection of oil seals for leaks while the blower was running on the engine largely determined if they should be changed. A further inspection may be conducted after blower has been disassembled. If the leather is scored so that a tight seal on shafts is impossible or the leathers have become charred and hard, the seals should be changed. If change is necessary, the seals may be removed from the end plates at the same time the individual bearings are removed. This is done by continuing to drive down on the tool, shown in Fig. 7 until collar on tool rests on and forces seal down and out of plate.

C. INSPECTION

After the blower has been disassembled all parts should be washed thorougly, blown dry with compressed air, and inspected before assembly.

1. Ball bearing inspection
   a. Wash the ball bearings by rotating the bearings by hand in clean kerosene or fuel oil until free from grease and oil.
   b. Clean the balls and races by directing air through the bearing, at the same time rotating the bearing by hand. Do not spin the bearing with air pressure.
   c. If necessary, repeat cleaning operation to be sure all foreign substance is removed.
   d. After cleaning thoroughly, lubricate with clean engine oil and rotate by hand and inspect for rough spots. The bearing should run free and show no indication of roughness. The double-row bearings are pre-loaded and have no end play; in fact, a new double-row bearing will seem to have considerable resistance to motion when revolved by hand.
2. Inspect the oil seals in the end plates and if necessary, install new seals. Oil seals that have been used should be lubricated with clean engine oil at time of assembling blower; new oil seals should be soaked for at least 60 minutes in thin, clean, engine oil before assembling.
3. Inspect blower rotor lobes for smoothness. and shaft serrations and bearing surfaces for wear or burrs.
4. See that end plate finished faces are smooth and flat.
5. See that finished ends of blower housing, which receive the end plates, are flat and free from burrs. The end plates must set flat against the blower housing.
6. Inspect blower gears for wear.
7. Inspect the inside of the housing to see that the surfaces are smooth.

D. ASSEMBLY

1. Install oil seals in blower end plates. The oil seals should be assembled into the end plates with flat face of seals flush with inner finished face of plates and sealing edge of leather pointing toward rotor bearings, as shown in Fig. 9. The seals may be installed properly with the tools shown in Fig. 8.
   a. Support end plate between soft jaws in bench vice. Back out puller stud (A) as far as possible and push stud through bore for bearing in end plate from the outer face (rib side with puller plate 'B') resting against outer face of blower end plate.

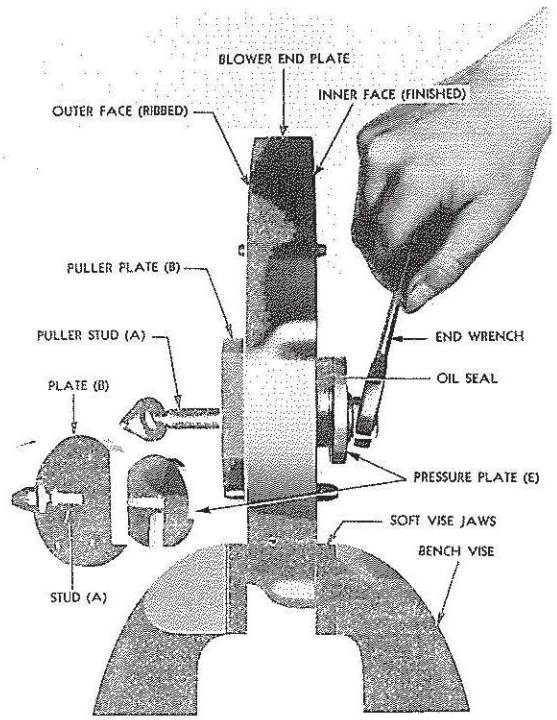


FIG. 8

b. With flat face of oil seal facing head of puller stud. slide seal over head of stud and start into bearing bore by hand.
c. Slip pressure plate (E) over body and next to head of puller stud and turn puller stud (A) clockwise forcing oil seal into seat until pressure plate (E) sets tight against inner face of blower end plate. Remove tool and install remainder of seals in the same manner.

2. Install blower front end plate. The top of the blower may be identified by the flange which carries the entire length of the housing and provides a rest on top of the cylinder block. The end plate is semicircular at the top, as shown in Fig. 10 and is also marked "TOP" on outer, ribbed side.

Even though the blower end plate is interchangeable front and rear, the plate at the front end of the blower should be assembled to the blower housing before the rear plate is assembled.

When viewing blower housing as on engine, the end plate for the front will be assembled to the right-hand end of the housing.

With these identifications clearly in mind, attach end plate to front end blower housing, as follows:

a. Start end plate dowels in dowel holes of blower housing. Rap dowels and end plate lightly with babbitt hammer to fit end plate to housing.
Note that no gaskets are used between end plates and housing, therefore, mating surfaces must be perfectly flat and smooth.
b. Lock end plate securely to housing with two fillister head screws. NO LOCKWASHERS.
c. Inspect and see that dowels project 3/8" beyond outer face of end plate.

3. Before further assembly of the blower, certain inspection operations are necessary to insure the proper relation of parts. The lobes on one of the blower rotors and the teeth on one of the timing gears form a right-hand helix and on the mating parts a left-hand helix.

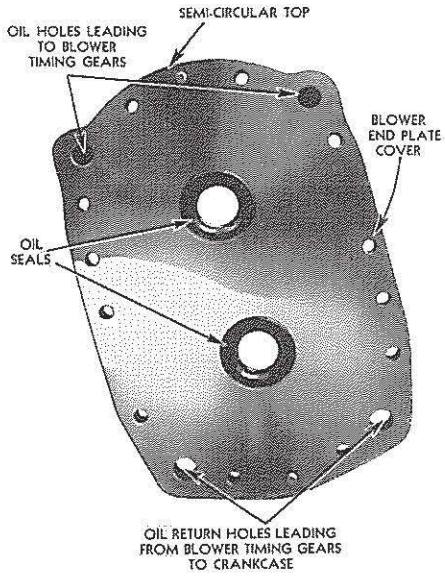


FIG. 9

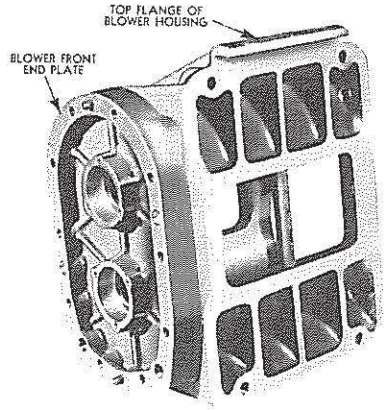


FIG. 10

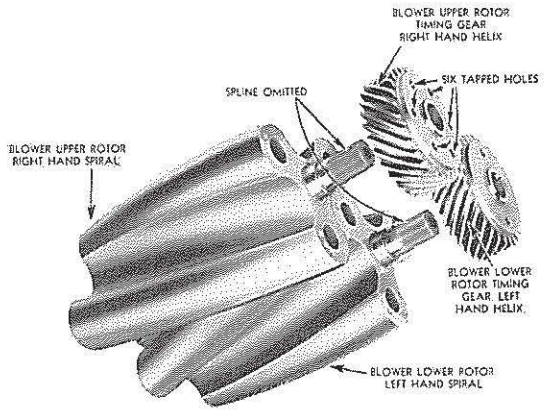


FIG. 11

The rotor with the right-hand helix must be used with gear having right-hand helical teeth and vice-versa. Rotor and gear with RIGHT-HAND helices are the upper units in the blower; and these parts with left-hand helices the lower units. Furthermore, for convenience in blower timing, one serration is omitted on the drive end of each blower shaft with corresponding omissions in the gear hubs. Gears must be placed on

the shafts with the serrations in registration. Rotors must be assembled with the omitted serrations toward top on both rotor shafts.

To avoid confusion when assembling, place the right-hand rotor and right-hand gear together on the bench; likewise the left-hand rotor and gear, as shown in Fig. 11.

NOTE: Effective on motors serial number 371-4353, 471-6022 and 671-11907. Rotors and gears are marked as follows: Upper rotor and upper gear are marked "Upper."

Lower rotor and lower gear are marked "Lower."

4. Assembling rotors into housing. With this in mind, as outlined in item (3).
   a. Install one oil seal pilot (F) over short end (non-splined) of each rotor shaft and with rotors in mesh and omitted serrations toward top of blower housing, slip rotors into housing. (See Fig. 12).
   b. Remove oil seal pilots.

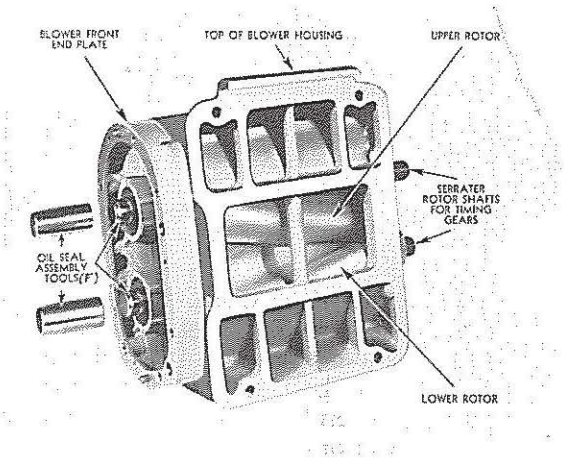


FIG. 12

5. Install blower rear end plate. With rotors positioned in housing as per item (4).
   a. Install one oil seal pilot (F) over serrated end of each rotor shaft.
   b. Identify top and bottom of end plate as described in item (2) and shown in

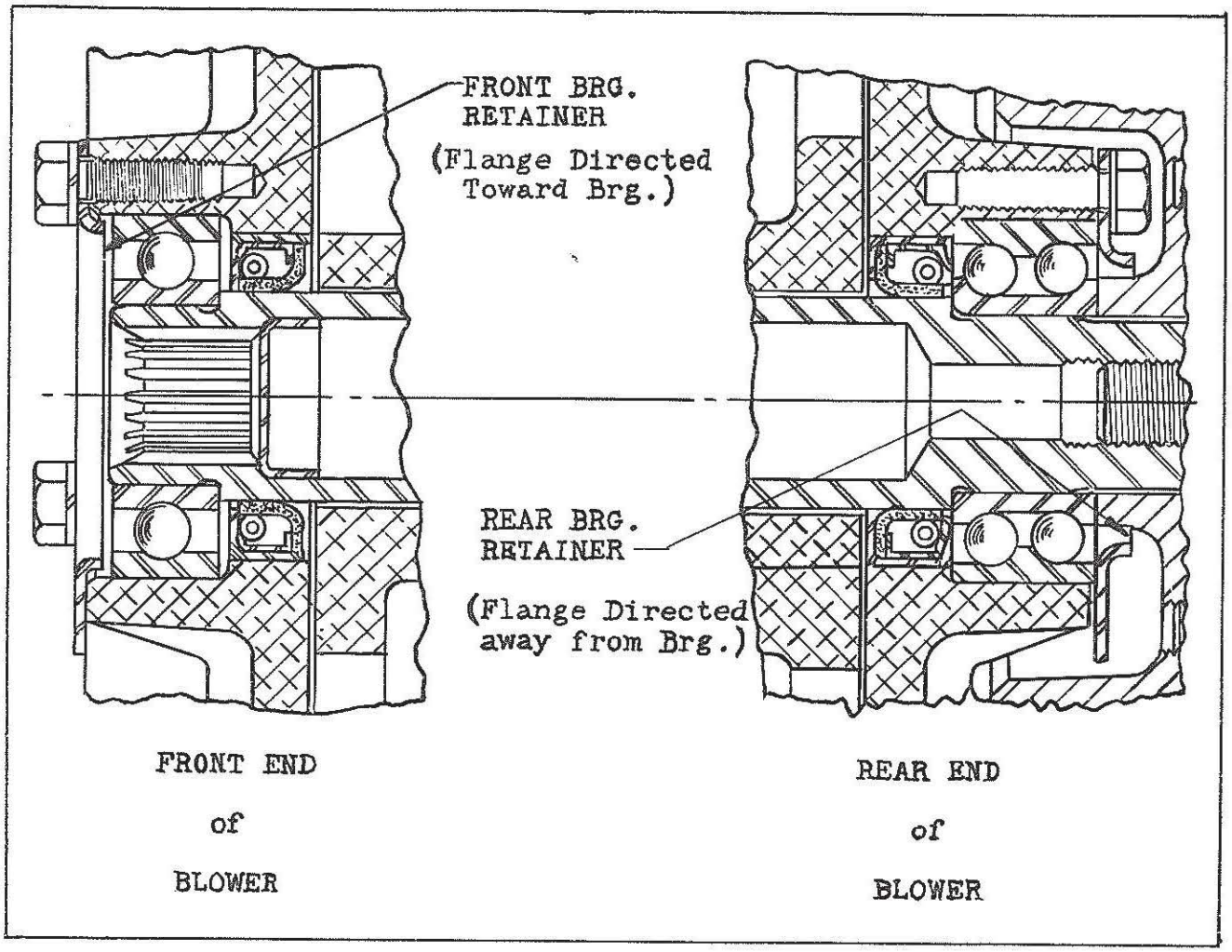


FIG. 13

Fig. 10 and start end plate dowels into dowel holes in blower housing. Tap dowels lightly to fit end plate to housing.

c. Lock end plates securely to housing with two fillister head screws. NO LOCKWASHERS.
d. Inspect and see that dowels project ⅜" beyond outer face of end plate.
e. Remove oil seal pilots.

6. Install rotor shaft front bearings. Single-row ball bearings are used at the front end of the blower rotor shafts and double-row ball bearings at the rear (serrated) end. The bearing number is stamped at one end of the ball race only. When assembled, the markings are toward the outside face of the end plate. With these identifications in mind:
   a. Start the single-row bearings onto front end of rotor shafts (short end with internal splines.)
   b. Using tool (G) shown in Fig. 14, tap bearings into end plates.

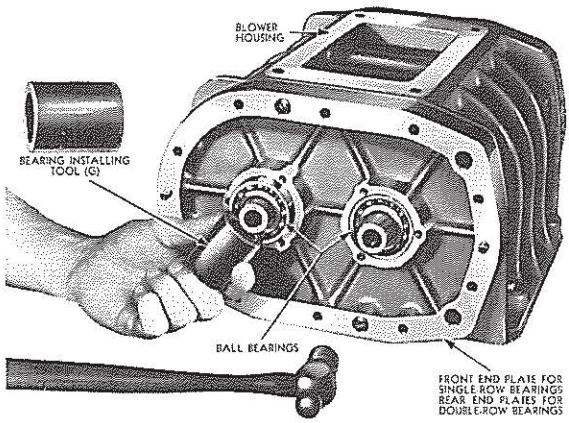


FIG. 14

NOTE: Bearing retainers for single-row bearings have 1 13/16" inside diameter and for double-row bearings 1-9/16" inside diameter.

   c. Install front bearing retainers with flange at inner diameter of retainer directed toward bearing. Lock each retainer with three capscrews and lock washers.

7. Install rotor shaft rear bearings. Install the rear rotor shaft bearings exactly the same way the fronts were installed and using the same tool, except, flange at inner diameter of retainer is directed away from bearing. Be sure markings on bearing race are toward blower end plate.
8. Press timing gears onto rotor shafts. If blower once used is being reassembled —shims were no doubt used back of one, or perhaps both blower timing gears— they should be installed in their original positions before pressing gears onto shafts. If new gears and shafts are used, install without shims, and use shims later if necessary when timing rotors.

Being sure that both rotor shafts with the omitted serrations, as shown in Fig. 11 point toward top of blower; that the drive gear (timing gear) with 6 tapped holes in hub, is located on the upper rotor shaft; that original shims are placed on their respective shafts, start both gears onto shafts and gears registering. An "O" mark is indented into end of shaft at omitted serration to assist in locating gears properly.

Apply some engine oil at shaft serrations and proceed to press gears onto shafts with tool, shown in Fig. 15.

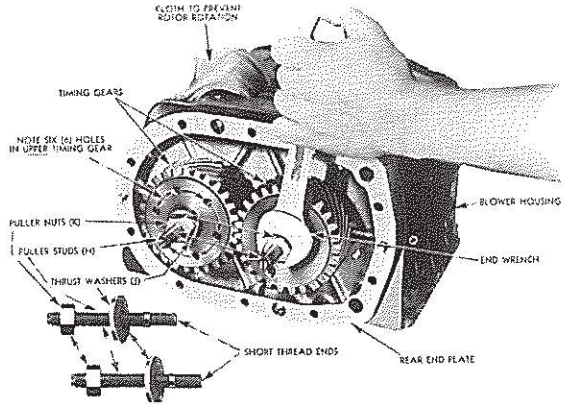


FIG. 15

   a. If blower is equipped with ⅜" diameter timing gear retainer bolts, put thrust washers (J) on puller studs (H), insert short threaded end of studs through holes in gear hubs and screws into rotor shafts as far as possible.
   b. Turn puller nuts (K) UNIFORMLY clockwise and press gears tight against shoulders or shims on shafts. Caution! Gears must be pressed to position at the same time to avoid damage to gears and rotors. Do not pull gears up tight if rotors are in contact.
   c. If blower is equipped with ½" diameter timing gear retainer bolts, use these bolts, together with the small washer at upper shaft and large washer with driving lugs at lower shaft, to press the gears uniformly onto shafts.
   d. If ⅜" timing gear retainer bolts are used, lock gears in place with capscrews and lockwashers, noting that small flat washer is located on upper shaft, and large washer, with driving

lugs for fuel pump, is located on lower shaft. See that locking ears on fuel pump coupling engage slots in gear hub.

e. If ½" timing gear retainer bolts are used, install special lockwasher and pierced retainer washer on bolt for upper gear so that retaining washer pierced lugs engage slots in gear hub, and lockwasher ear engages slot in retaining washer.
For lower gear lock, install special lockwasher and fuel pump coupling disc on retainer bolt so lock tangs of disc engage slots in gear hub and lockwasher ear engages slot in coupling disc. Draw retainer bolts reasonably tight, but not enough to bend fuel pump coupling disc.

9. Blower rotor timing. At this stage of the blower assembly, the blower rotors must be "timed."
The three lobes on each blower rotor are located spirally (helical) relative to the center line of the rotor shaft. The teeth on the timing gears are also helical, and as previously stated, the rotor with the right-hand helical lobe is driven with a gear having right-hand helical teeth. The blower rotors, when properly positioned in the housing, run with a slight clearance between the lobes. This clearance may be varied by moving one of the helical gears in or out on the shaft relative to the other gear.
If the upper gear is moved out, the upper rotor will turn counter-clockwise when viewed from the gear end. If the lower gear is moved out, the lower rotor will turn clockwise when viewed from the gear end. This positioning of the gear, to obtain the proper clearance between the rotor lobes, is known as blower timing.
Moving the gears out or in on the rotors is accomplished by adding or removing

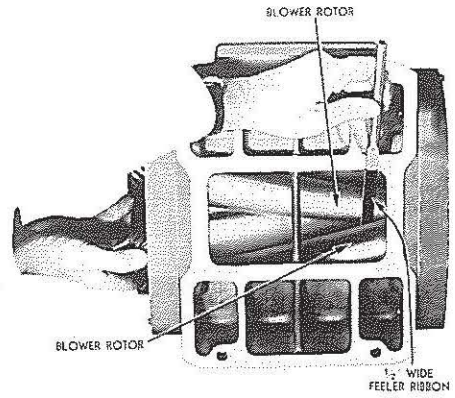


FIG. 16

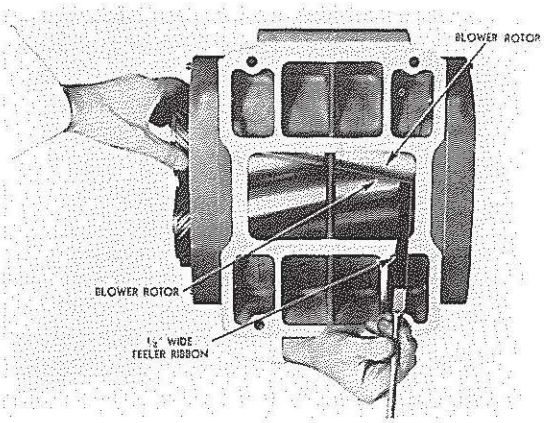


FIG. 17

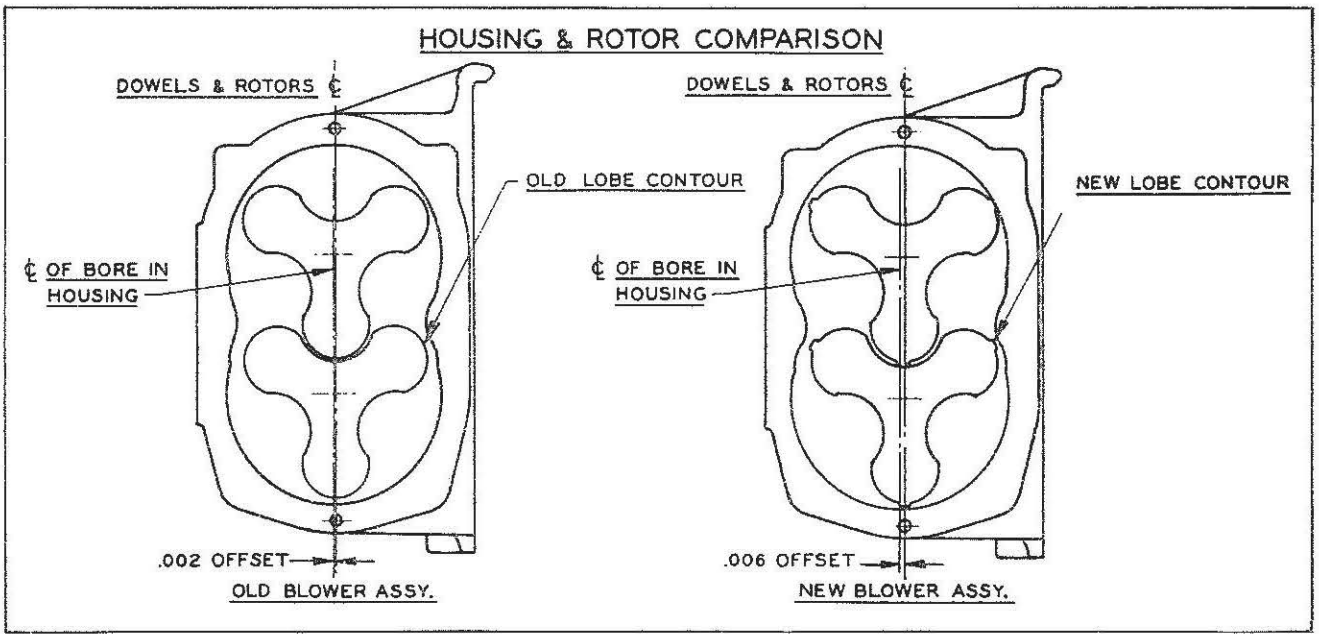


FIG. 18

shims between the gear hub and the bearing back of the gears.

10. Rotor lobe clearance. The clearance should be the same between the leading and trailing sides of individual rotor lobes with their mating lobes.
11. Inspect rotor lobe clearance. The clearance between rotor lobes may be inspected with various thickness feeler ribbons ½" wide. When measuring clearances more than .005" laminated feelers made up of .002", .003" or .005" are more practical and suitable than one single thick feeler.

    The clearance between rotor lobes must be taken between two of the lobes at one end of the blower while revolving the rotors to the right, and also between the same two lobes at the same end while revolving the rotors to the left. This double inspection must be made between each pair of mating lobes at each end and at the mid-section for the three and four cylinder engines, and at several intermediate points on blowers for the six cylinder engine. Always determine point of minimum clearance and adjust for that point.

    Inspection for clearance shows:
    .004" existing on leading side
    .012" existing on trailing side

    .016" total both sides
    ½ total = .008" desired each side.
    Desired minus existing = .008" — .004" =.004" or the amount one rotor must be revolved to produce proper clearance both sides of each lobe.

    A .001" shim back of the blower gear will revolve the rotor .001". Having determined the amount one rotor must be revolved to produce the proper clearance —same as the thickness of shims required—add shims back of either the upper or lower gears, to produce the desired results. Note that adding shims back of the UPPER gear will increase the clearance between the leading and trailing sides of the lower and upper rotor lobes.

    When additional shims are required, both gears must be pulled from the rotors, as directed under "Disassembly of Blower," Topic 79B.

    Install the required thickness of shims back of the proper gear and next to the bearing inner race, and again press the gears tight in place. Re-inspect clearances between rotor lobes.

E. MEASURING ROTOR TO ROTOR CLEARANCE (LATE TYPE ROTORS)

A change has been made in the rotor contour and housing clearance on the blowers used on "HD" series tractor engines. These changes are effective on production tractors. After the present stock of blower parts are used, only new type parts will be available for service.

New housings can be identified by the part number stamped on the upper face of the housing. The first new housings are stamped with a letter "H." Housings used in service that have neither of these markings can be identified by the part number cast on the inside of the housing.

New type rotors can be identified by their revised contour (see illustration). Fig. 18. New type rotors can be used in old housings, but the clearances will be different to those formerly used. Use the new clearances as listed below.

Old rotors can be used in new type housings for the 6-cylinder engine, but not on the 3 and 4-cylinder engines because the clearances obtained are insufficient. Follow instructions previously given to adjust rotor to rotor clearance when old rotors are used in new type housing on 6-cylinder engines. When a blower is rebuilt for service using new type rotors and an old housing or new type rotors and new type housing, the new clearances should be used.

1. Set blower rotors in position as shown in drawing with one lobe of upper rotor pointing straight down.
2. Inspect dimension CC (see Fig. 19) from outlet side of blower. Check this dimension for full length of lobe. This dimension is the same for the 3, 4 and 6-cylinder engines. Set rotor clearance .002" to .006'.
3. Inspect dimension C (see drawing) from inlet side of blower. Check this dimension for full length of lobe. On the 3-cylinder engine, the clearance is .012" to .018", on the 4-cylinder .014" to .020", and on the 6-cylinder .016" to .022".
4. Rotate rotors 60° from location shown in step No. 1 or until one lobe on lower rotor points straight up. Check CC from inlet side of blower. Check this dimension for full length of lobe.
5. Inspect dimension C from outlet side of blower. Check this dimension for full length of lobe.

    These steps must be performed on all three lobes of the blower.

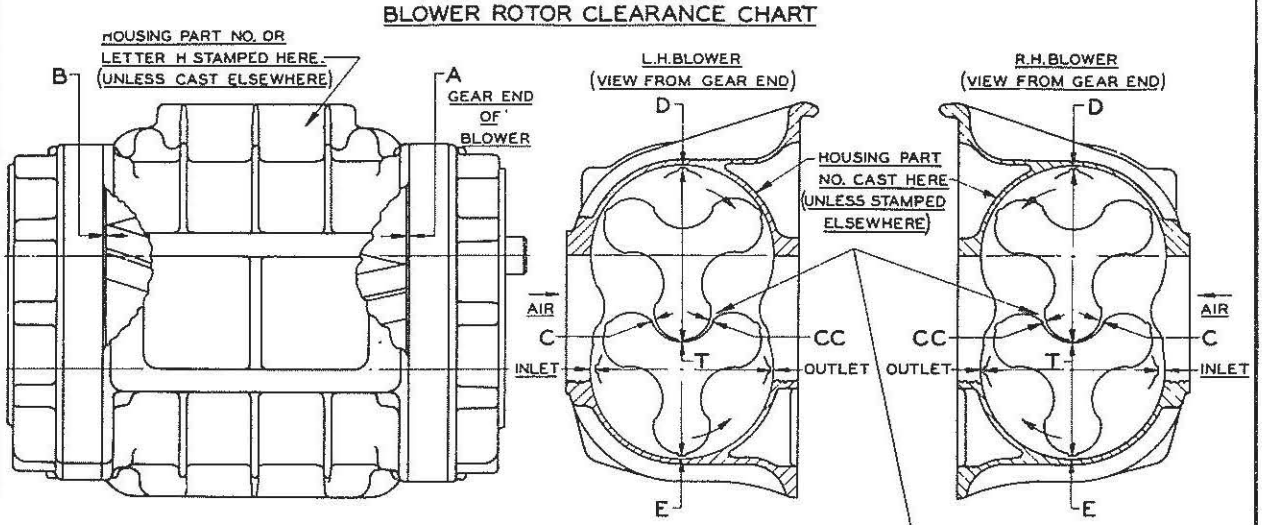
    These clearances are obtained by adding or removing shims from the end of the blower rotors as described in Topic 79-D-11.

    If inspections were carefully made, shims correctly installed, and gears tight in place, the clearances should be correct. If work was done carelessly, the operation will have to be repeated.

After correct clearances are obtained, lock gears in place.

6. Using the 6 capscrews and lockwashers attach blower drive shaft flange to outer face of upper rotor timing gear.
7. Insert splined end of water pump intermediate shaft and coupling into front end of lower rotor shaft and hold coupling shaft while tightening Allen screw securely with $\frac{3}{16}$" wrench.
   Some water pump couplings are not provided with expander screw, in which case, simply insert coupling into engagement with rotor shaft inner serrations.
8. If gasket is unsatisfactory in any way, shellac a new gasket to each blower end

BLOWER ROTOR CLEARANCE CHART



		A		B		C		CC	D		E		INLET		OUTLET		T	
		OLD	NEW	OLD	NEW	OLD	NEW	NEW	OLD	NEW	OLD	NEW	OLD	NEW	OLD	NEW	OLD	NEW
3-71	MIN.	.007	.007	.007	.007	.008	.012	.002	.008	⊕	.008	⊕	.009	.017	.005	.004	.010	⊕
	MAX.	.009	.009	.009	.009	.010	.018	.006	.010	⊕	.010	⊕	.011	.019	.007	.007	.012	⊕
4-71	MIN.	.007	.007	.009	.009	.008	.014	.002	.008	⊕	.008	⊕	.009	.017	.005	.004	.010	⊕
	MAX.	.009	.009	.011	.011	.010	.020	.006	.010	⊕	.010	⊕	.011	.019	.007	.007	.012	⊕
6-71	MIN.	.007	.007	.014	.014	.008	.016	.002	.013	⊕	.013	⊕	.014	.017	.010	.004	.010	⊕
	MAX.	.009	.009	.016	.016	.012	.022	.006	.015	⊕	.015	⊕	.016	.019	.012	.007	.012	⊕

⊕ - CHECKING DIMENSION NOT REQUIRED ON NEW ASSEMBLY.

CLEARANCE COMPARISON CHART

	—3-71—		— 4-71—		— 6-71—	
	Inlet	Outlet	Inlet	Outlet	Inlet	Outlet
Old Rotors & Old Housing	.009-.011	.005-.007	.009-.011	.005-.007	.014-.016	.010-.012
Old Rotors & New Housing	.0135-.0155	.0015*-.0035	.0135-.0155	.0015*-.0035	.0185-.0205	.0065-.0085
New Rotors & Old Housing	.0125-.0145	.0085-.0105	.0125-.0145	.0085-.0105	.0125-.0145	.0085-.0105
New Rotors & New Housing	.017-.019	.005-.007	.017-.019	.005-.007	.017-.019	.005-.007

*This clearance insufficient and to correct remove .004 from diameter of rotors.

End clearances have not been changed on the new assembly. (See Chart above.)

An old rotor and a new rotor can be used together; however, maintain these minimum clearances:

See Chart above		3-71	4-71	6-71
CC		.004 Min.-.006 Max.	.004 Min.-.006 Max	.004 Min.-.006 Max.
C		.010 Min.	.011 Min.	.012 Min.

FIG. 19

plate cover, supply a lockwasher and plain washer in turn, on the 10 cap-screws and attach both end plate covers.

NOTE: Foreign matter inside the blower is apt to ruin the unit. After blower has been assembled, attach the gasket and cover over the air inlet on the outer face of the blower housing to prevent foreign matter entering housing.

F. BLOWER ROTOR GEAR CLEARANCES

1. Previous instructions specified to replace blower rotor timing gears if the blacklash was .002" or more. With the new blower assemblies and also on old asemblies having the revised rotor clearances, a maximum of .004" backlash will be permissible. Gears should be inspected for roughness or uneven wear; if any is apparent, new gears must be installed.

G. INSTALLING BLOWER ON ENGINE

1. Attach the fuel pump, water pump, etc. to the blower before installing it on the engine.

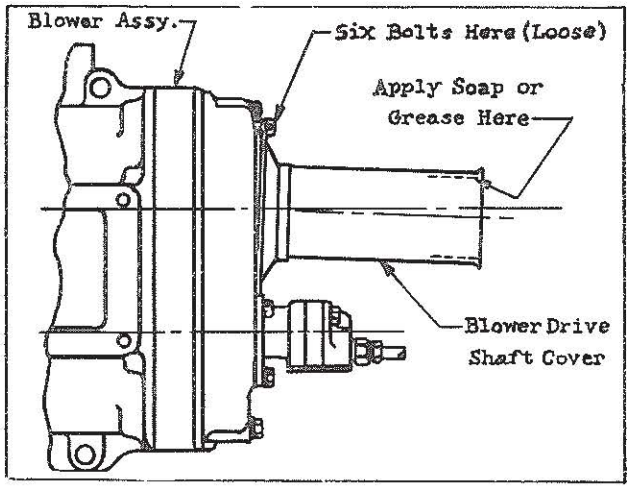


FIG. 20

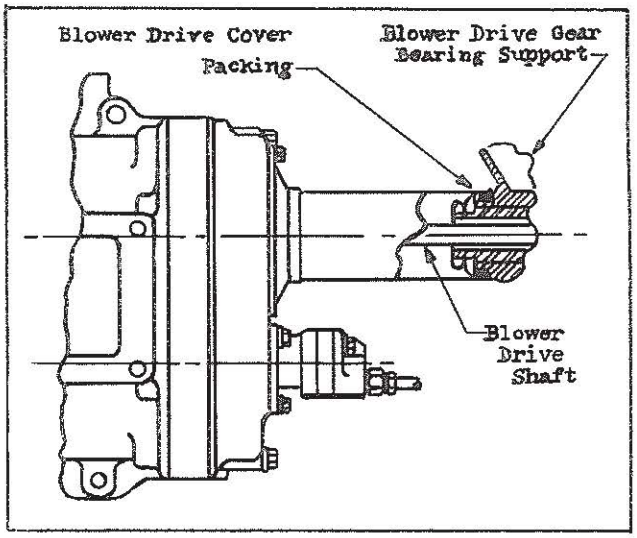


FIG. 21

2. Reverse the removal procedure and attach blower to engine.

H. GASKET SEALING

When replacing worn gaskets on engine repair or inspection work, it is advisable to use a good non-hardening gasket sealing cement to insure improved gasket sealing. It is recommended that cement be used on both sides of principal gaskets, such as cylinder block end plate and cylinder head oil gasket. As for the blower housing gasket, is it necessary to use the cement on the blower only, the side which faces the cylinder block use a thin coat of oil.

The laminated metal cylinder head gasket, however, should be installed DRY, since this insures proper sealing for this type gasket.

I. BLOWER ROTOR HELIX ANGLE CHANGED (SERIES 3-71 AND 4-71 ENGINES)

Blower Rotor Assemblies for Series 3-71 and 4-71 have been changed to incorporate the same helix as used on the Series 6-71 engines. This change in angle of lobe helix is illustrated in the accompanying sketches.

The new rotors are not interchangeable with the earlier parts due to the difference in angularity. Therefore, replacements of old or new rotors must be made in pairs. (For this purpose a part number has been assigned to each pair of rotors.)

OLD STYLE PARTS WILL NOT BE MAINTAINED FOR SERVICE.

Rotors otherwise are interchangeable. Blower rotor clearances given in Topic No.79-E apply to all assemblies. This change became effective in production with Engine Nos. 3715308 and 4716969.

The new part numbers are inked on the end of the rotors to aid in identification of the assemblies.

NOTE: The new Rotor Sets include one L.H and one R.H. Rotor Assembly — MATCHED.

Couplings and retainers are no longer attached to the rotors included in the new sets.

SPECIAL NOTE CONCERNING 6-71 ROTORS

The 6-71 Blower Rotor Assemblies will also be furnished as MATCHED SETS only for service replacement.

The new set includes one L.H. and one R.H. Rotor Assembly — MATCHED.

Blower Rotors and Rotor Gears are now marked "upper" and "lower", as shown in the accompanying sketches. The right-hand helix rotors and gears are marked "upper". whereas the left-hand helix rotors and gears are marked "lower". This identification feature will assist considerably in identifying spare parts in stock and also in actual assembly in field service.

Interchangeability is not affected; likewise part numbers remain the same. This change became effective in production beginning with Engine Nos. 3714353, 4716022, and 67111907.

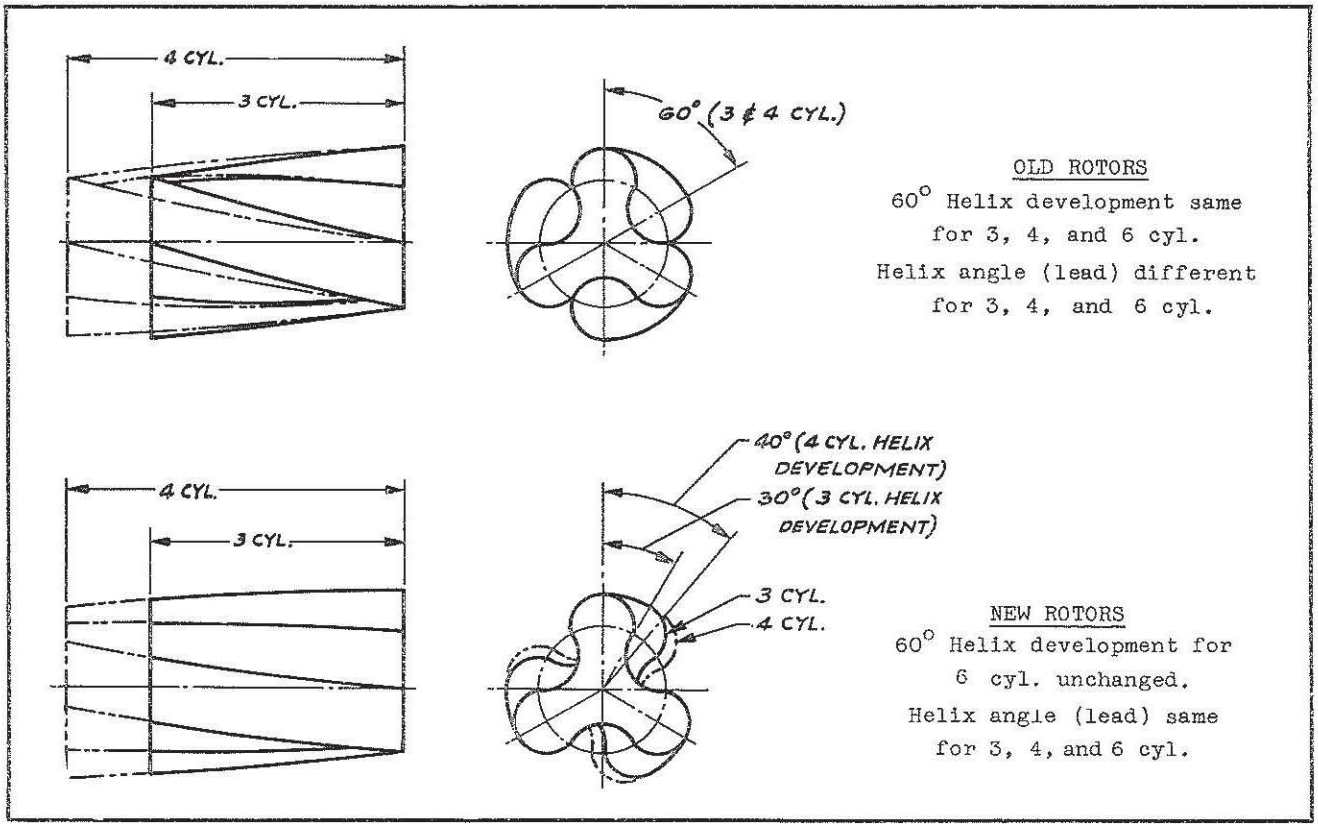


FIG. 1

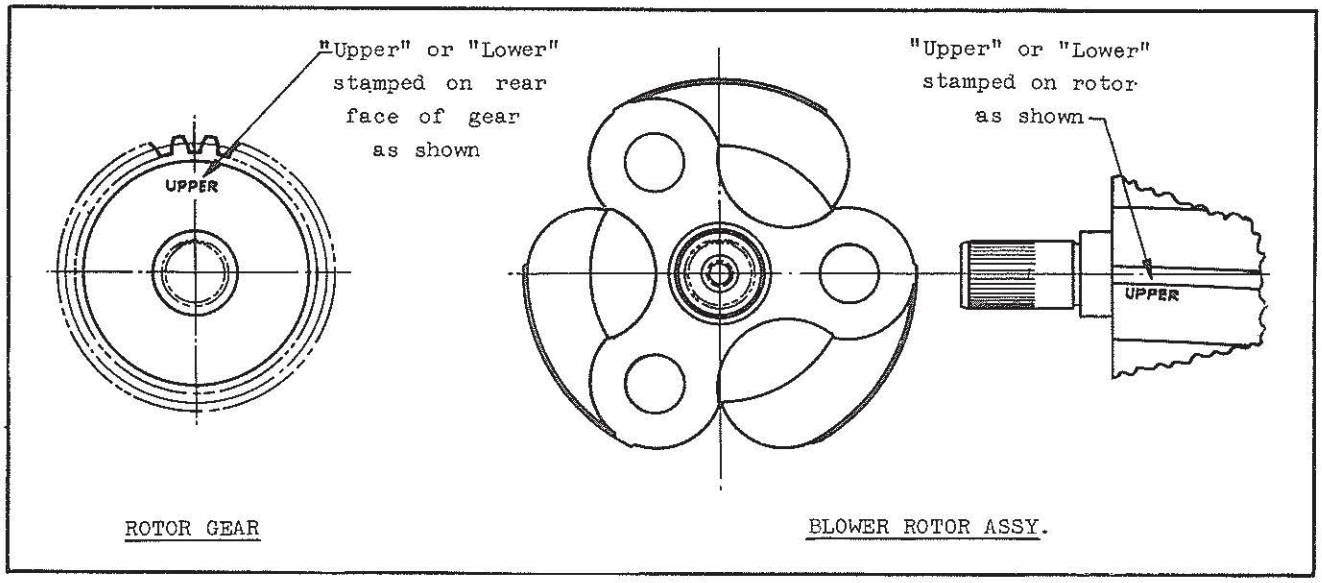

"Upper" or "Lower"
stamped on rear
face of gear
as shown
UPPER
"Upper" or "Lower"
stamped on rotor
as shown
UPPER
ROTOR GEAR
BLOWER ROTOR ASSY.

FIG. 2

80 -- Gear Train

The gear train, as assembled for use in our tractors, comprises five principal gears meshed in sequence as follows: crankshaft gear, idler gear, balance shaft gear camshaft gear, and blower drive gear. The camshaft and balance shaft gears are counterweighted so that the inertia effect of the two, which are meshed together, exactly counterbalance each other. In addition, there are weights on the front ends of these shafts which perform this same function and in addition, with the help of the counterbalances in the camshaft and balance shaft gears, tend to overcome the inertia effect of the reciprocating parts of the engine. It is through this system that the designers have been able to produce a practically vibrationless engine.

The idler gear is provided with a bushing of the same lead bronze material as is used in the main and connecting rod bearing shells. This bushing is permanently installed in the gear so that if it ever should become necessary to replace the bushing, the entire gear must be replaced. Corrosive oil will damage the lead bronze material of this bushing sufficiently to necessitate its replacement. The idler gear runs on a renewable hardened steel hub and normal wear will generally show on the hub instead of in the bushing.

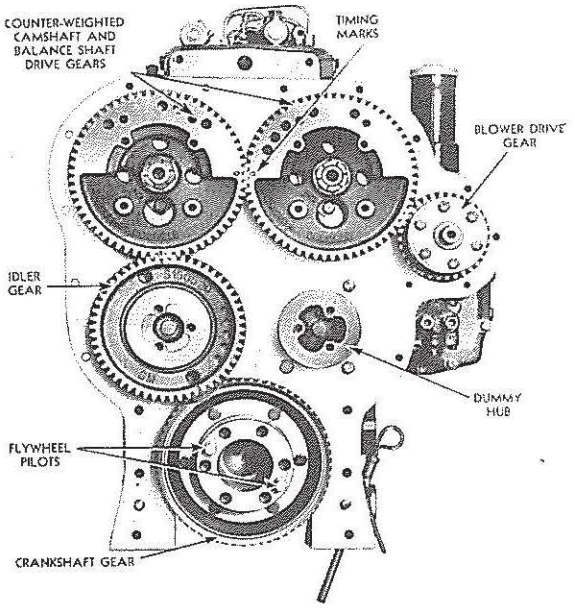


FIG. 1

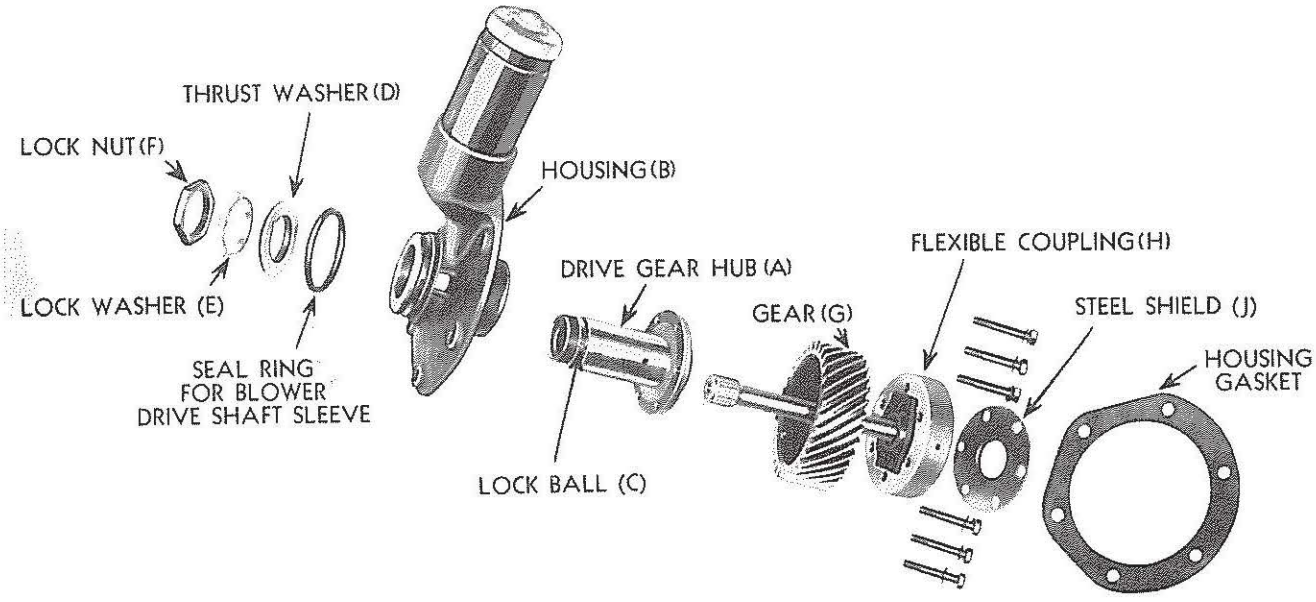


FIG. 2

A. REMOVAL OF BLOWER DRIVE GEAR HUB

1. Remove the blower from the side of the block.
2. Before loosening lock nut on gear hub, an inspection should be made for end clearance between gear hub bushing and thrust washer. If end clearance is excessive, this condition alone is sufficient reason for renewing the housing and inner babbitt bearing assembly.

The specified end clearance between gear hub and thrust shoulder of hub housing is from .003" to .006" and should not exceed .010".

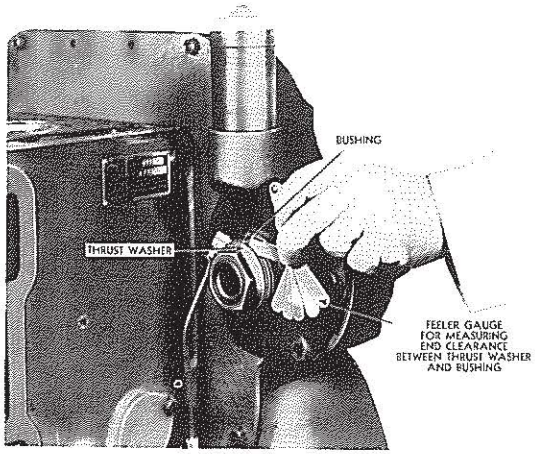


FIG. 3

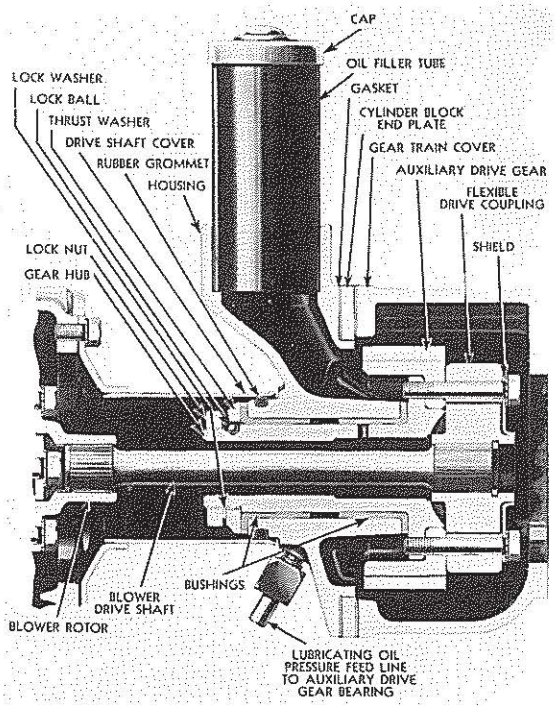


FIG. 4

3. If gear has not been removed from hub and still engages either the camshaft or balance shaft gear, the ears on lockwashers may be straightened and lock nut loosened before housing is completely loosened from cylinder block end plate. If the gear was previously removed, loosening of the lock nut may follow removal of housing, by holding the assembly in a bench vise.
4. Loosen nuts at each end of oil line leading from cylinder block to blower drive gear bearing. The oil line will be freed from the connectors when gear housing is withdrawn.
5. Remove the 2 remaining capscrews holding gear bearing housing to cylinder block end plate, and tap the assembly forward away from the plate.

B. DISASSEMBLING BLOWER DRIVE GEAR UNIT

1. Remove the 6 capscrews securing drive gear, drive coupling, and stamped retainer from gear hub and remove drive coupling.
2. Press drive gear from the gear hub.
3. Remove the previously loosened lock nut, lockwasher, lock ball, and thrust washer, from rear end of the gear hub and withdraw hub from housing.
4. If occasion requires, the rubber grommet may be removed from the front end of bearing housing.
5. If bearing housing is to be changed, remove oil line connection from the housing.

C. INSPECTION OF PARTS

Before assembling blower drive parts into housing, all parts should be inspected for wear.

1. Inspect the inside diameter and thrust faces of bushings inside blower drive gear hub. If bushings show score marks that would affect bearing efficiency, a new housing and bushing assembly must be installed. These bushings are diamond bored in place; therefore, in case of bushing failure, new housing and bushing assembly must be installed.
2. Inspect inside diameter of bushings for wear and roundness, also outside diameter of hub at bearing surfaces (journals) for wear. The proper clearance between bushings and hub journals is from .001" to .002" and must not exceed .005". Should inspection show bushings or journals worn to exceed .005" clearance, a new housing and bushing assembly should be installed.
3. Inspect serrations on blower drive shaft and if worn so that appreciable back lash is felt when shaft is inserted into flexible coupling or blower timing gear drive flange, a new shaft should be used.
4. Inspect driving springs and cams of flexible couplings to see that springs are intact and cams not worn.
5. See that all oil holes are open and cavities free from dirt.
6. Install a new rubber grommet around front end of housing nub over which blower drive shaft housing fits.

D. ASSEMBLY OF BLOWER DRIVE GEAR UNIT

The relative position of all parts constituting the blower drive gear assembly is shown in Fig. 2. All parts having been cleaned and inspected, they may be assembled as follows:

1. Spread some engine oil on outside diameter of drive gear hub "A" and slide hub

into housing "B" from rear of housing.
2. Install locking ball "C" into gear hub and slide thrust washer "D" in place over ball, with large diameter flat face of washer next to thrust face of bushing.
3. Prevent hub from turning by inserting bolts in 2 holes in hub and holding with a bar. Install a new lockwasher "E" next to thrust washer and tighten lock nut "F." Bend the ears of lockwasher against flats on nut to prevent nut from loosening.
4. Tap gear "G" into place on hub with flat finish face of gear away from housing.
5. The outer end of flexible coupling "H" is counterbored for about ¼" on the inside diameter of the hub. With this counterbore away from face of gear, place the stamped steel shield "J" against outer face of coupling, with flange at center of shield pointing away from coupling, and lock in place with lockwashers and capscrews.
6. Install blower drive shaft ring either on shaft or inside of cam coupling and slide shaft into serrations of cam coupling.
7. Apply some engine oil at each thrust shoulder of bushing and again inspect end clearance, as shown in Fig. 3.

E. INSTALLING BLOWER DRIVE GEAR ASSEMBLY TO ENGINE

The blower drive gear assembly may be attached to front face of cylinder block rear end plate by sliding gear and hub through the hole in end plate with finished face of housing up against end plate, install a new paper gasket between end plate and housing. Then place oil line from gear bearing to cylinder block into its 2 connections.

Install the 2 capscrews next to engine. The 4 bolts will be put in place when flywheel housing is installed. The 2 capscrews specified for this position must be used. If the capscrews are too long and project inside of the gear housing they will interfere with the gears.

The blower may be installed at this time without interfering with any other work to be performed on the gear train.

F. REMOVAL OF IDLER GEAR ASSEMBLY

1. Remove the motor from the tractor as described in Topics 74, 75 and 76.
2. Drain the oil and remove oil pan.
3. Remove master clutch from flywheel.
4. Remove flywheel.
5. Remove the combination gear train cover and flywheel housing.
6. Remove the capscrew and lockwasher from center of idler gear hub and withdraw hub, and gear assembly from cylinder block rear end plate.
7. If there is any need for doing so, the spacer and dowel assembly may also be removed at this time by removing the one center retaining capscrew and lockwasher.

G. INSPECTION OF IDLER GEAR AND HUB ASSEMBLY PARTS

Before the parts of idler gear assembly are put back in position, each part should be washed clean, inspected for wear and, if necessary, new parts installed.

1. Inspect the journal on gear hub for scoring and also for wear. Inspect inside diameter of gear bearing for scoring. The clearance between bearing in the gear and the journal should be from .002" to .003" and should not exceed .006". If the clearance exceeds .006", either the gear and bearing assembly or the gear hub or both should be changed, depending on which part or parts are worn.
2. Examine the face of the steel washer, the wearing face of the gear hub, both thrust faces and inside diameter of the gear bushings for scoring and wear. If necessary install new parts. The end play of the idler gear assembly is from .003" to .006" and should not exceed .008".

NOTE: The idler gear bushings are not removable; therefore, in case of bushing failure, a new idler gear assembly must be installed.

H. INSTALLATION OF IDLER GEAR ASSEMBLY

1. Having determined the relative positions of all parts, apply a small amount of cup grease to one face of the steel washer

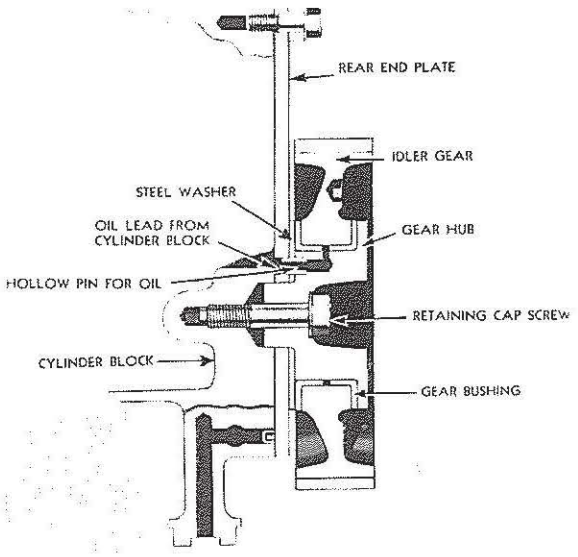


FIG. 5

and set against the cylinder block end plate, with hole in steel washer in line with oil hole. Grease is used on steel washer to hold it in place until hub and gear is installed.

2. Position crankshaft gear, and balance shaft gear so marks align with those on idler gear, and roll idler gear into position, then slide gear hub into place through bore in gear. Special care must be taken to have hollow pin in inner face of gear hub register in hole in end plate which carries oil to idler bearing. Fig. 5.
3. Be sure gear hub is tight against end plate and then lock in place with lockwasher and capscrew in center of gear hub.
4. Attach dummy hub on side of engine opposite to idler gear.
5. Inspect backlash between the various mating gears in the train, which should show from .004" to .006" between each set of gears and not to exceed .010".

I. REMOVAL OF CRANKSHAFT TIMING GEAR

The crankshaft timing gear is attached to crankshaft flange with 6 capscrews. To remove gears, with gear train cover removed, remove the 6 capscrews and slide gear from crankshaft flange.

J. INSTALLATION OF CRANKSHAFT TIMING GEAR

With oil deflector positioned so it can be bolted to hub of gear, and outside diameter lying against rim of gear, slide the crankshaft gear and oil deflector onto the crankshaft with the flat finished face of the gear toward the cylinder block. Position the gear teeth so timing mark "R" on gear teeth aligns with the corresponding mark on the idler gear, and slide gear up against flange on crankshaft. Fig. 1. Due to one off-set hole in crankshaft flange, the crankshaft gear can be located in only one position on flange. Turn either the crankshaft or gear train so bolt holes in web of gear align with the 6 holes in crankshaft flange and install lockwashers and capscrews, drawing gear into place.

FIRST TYPE GEARS.

NOTE: The crankshaft, camshaft and balance shaft gears each have 62 teeth. The idler gear has 54 teeth. Examine gear train for proper timing, note that timing marks on camshaft and balance shaft gears will coincide each complete revolution of the crankshaft. However, when timing is correct, all timing marks coincide at the same time, only once in 27 revolutions of the crankshaft. This must be borne in mind in examining the timing of these gears and the crankshaft rotated till this relation of timing marks is accomplished. FOR THE SECOND TYPE GEARS see Specifications. Topic 67-I.

81 -- Crankshaft

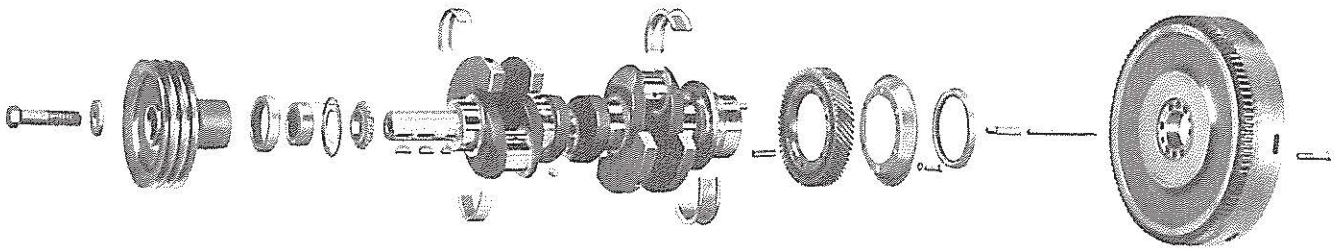
DESCRIPTION—The rigid crankshaft is a high-carbon steel drop forging, carefully heat-treated to insure ample strength and durability. All main and connecting rod bearing journal surfaces are electrically hardened by the Tocco process.

Complete static and dynamic balance of the rotating parts has been achieved by counterweights incorporated with the crankshaft.

Crankshaft thrust is taken through the rear main bearing. Full pressure lubrication to all connecting rod and main bearings is provided by drilled passages within the crankshaft and cylinder block.

Two dowels are provided in the crankshaft flange at the rear for locating the flywheel on the shaft. Six tapped holes, one unequally spaced, are provided for attaching the flywheel. Owing to this feature, a flywheel can be attached in only one position.

SERVICE—Since bearing loads take place on the lower half of the main bearing shells



EXPLODED VIEW OF CRANKSHAFT AND FLYWHEEL

FIG. 1

and the upper half of the connecting rod bearing shells, wear on the shell will take place at these points first. If therefore, main bearings or connecting rod bearing trouble is suspected, the oil pan and the main bearing caps as well as the connecting rod bearing caps should be removed, one at a time, and the lower half of the main bearing shells and the upper half of the connecting rod bearing shells inspected for scoring, corrosion, chipping, cracking, or signs of overheating. If crankshaft has been overheated, examine the journals for cracks. The backs of the bearing shells should also be inspected for any bright spots. Bright spots on backs of the shells will indicate that the shells have been shifting in their supports and are unfit for further use.

If the crankshaft journals do not show signs of scoring, overheating, or abnormal wear, it will be unnecessary to remove the crankshaft as the condition may be corrected by changing the worn half of the bearing shell only, providing the opposite half is in usable condition

Loose main bearings will be evidenced by the wobbling of the flywheel or a drop in oil pressure.

If the crankshaft journals show signs of overheating, or are badly scored, then the crankshaft must be removed and a new shaft installed.

A. REMOVAL

1. Remove the motor from the tractor as outlined in Topics 74, 75 and 76.
2. Drain oil from motor and remove the oil pan. (Two on HD14).
3. Remove the lubricating oil pump driven sprocket and bearing assembly from the front main bearing cap on the 3 and 4-cylinder engines. On the 6-cylinder engine, the sprocket is keyed to the pump shaft and will be removed together with the oil pump assembly. Refer to Topic 89 "Oil Pump Removal."
4. Remove the master clutch from the flywheel.
5. Remove the flywheel.
6. Remove the combination gear train cover and flywheel housing.
7. Remove the fan drive pulley.
8. Remove the crankshaft front cover from cylinder block end plate.
9. Remove the spacer (next to oil slinger) from front end of crankshaft.
10. Remove the oil pump drive sprocket and chain.
11. Remove the crankshaft timing gear and oil slinger.
12. Remove the connecting rod bearing caps.
13. Remove the main bearing caps.
14. Remove the crankshaft from the block.

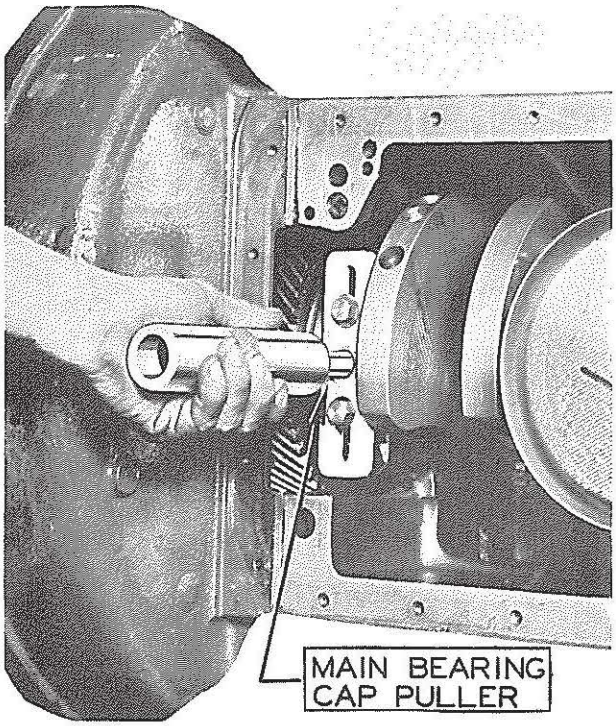


FIG. 2

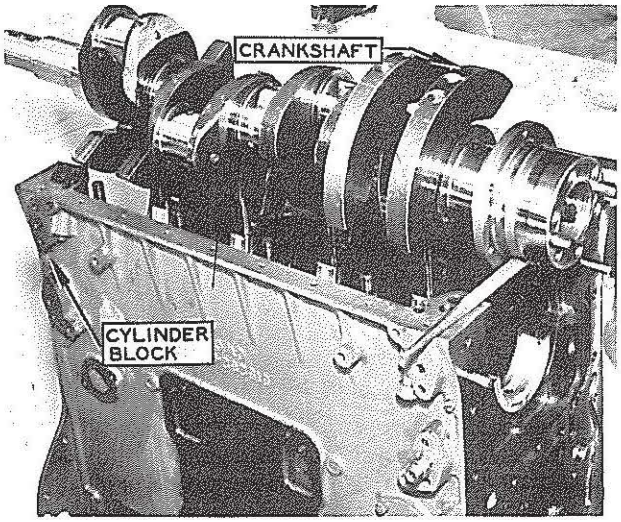


FIG. 3

B. GRINDING OF CRANKSHAFT JOURNALS

CAUTION: All main and connecting rod bearing journal surfaces are electrically hardened by the Tocco process. If regrinding becomes necessary work should be accomplished by some reputable machine works who have suitable equipment to handle precision work of this type. Bearing inserts of .010, .020 and .030 undersize can be obtained. Depth of Tocco hardening approximately .0625.

The crankshaft journals may be inspected for scoring or over-heating without removing the crankshaft. To measure journal diameters, however, removal of the crankshaft is necessary.

C. INSPECTION

When a crankshaft has been removed for any reason, a thorough inspection should be carried out before the shaft is again installed in the engine. Such a check should include the following:

1. Blow out all oil passages with air.
2. Measure the main bearing and connecting rod journals. The journals should be measured at several places on the diameter in order to show the smallest diameter in case the journal has worn out of round. See Specifications. Topic 67-E.
3. Measure the thickness of the main bearing and connecting rod bearing shells as described under "Main Bearing Inspection." The specified clearance on the main and connecting rod bearing is from .002" to .004". Install new bearings when clearance exceeds .008". If the journals are worn excessively a new crankshaft should be installed, or for regrinding see Topic 81-B.
4. If the pilot bearing in the flywheel shows lack of lubrication, a new oil wick must be installed in crankshaft. If the oil wick shows that too much oil is coming through, (which can be determined by the amount of oil in master clutch compartment and on master clutch disc, which will cause it to slip) a new wick must be installed.

D. INSTALLATION OF PILOT BEARING OIL WICK

1. Run a fine wire through one end of wick. ½" from the end, lap back, and twist over.
2. Now run the wire through the crankshaft from the outer end, and pull wick in place leaving the same amount extending through each end, and remove wire.
3. Use a punch, approximately $\frac{3}{16}$", and a small hammer and work as much of the wick in, at each end as possible, to make a good tight job. Care must be used when driving wick in.
   CAUTION: Do not attempt to twist the wick in place as this will leave a groove around wick and will cause it to leak. After working as much of the wick in as possible with a punch and hammer the wick can be trimmed off at each end, leaving ¼" to ⅜" extend through.
4. If the rear crankshaft oil seal becomes worn to the point that excessive oil leaks into the flywheel housing, a new seal must be installed. Refer to Topic 87-C. Main bearings also must be inspected for maximum wear before a new seal is installed. Refer to Topic 82-B.

E. INSTALLATION

The crankshaft is installed by reversing the sequence of operations for removal as described above. The crankshaft main bearing upper shells are grooved for lubrication. The lower shells are not grooved. Also, the shells are marked upper and lower. When replacing the bearing shells, preliminary to setting the crankshaft in place, see that the grooved shells are placed in the cylinder block as shown.

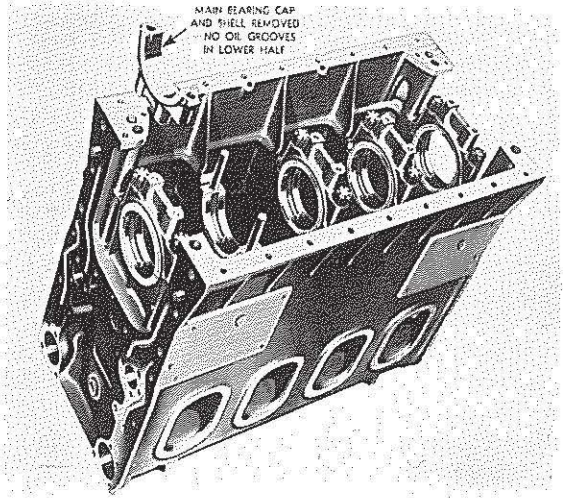


FIG. 4

1. After the bearing upper shells have been placed in the block, apply some clean NON-CORROSIVE DIESEL OIL on crankshaft before it is installed.
2. The main bearing caps are numbered 1, 2, 3, etc. indicating their respective positions. The marked side is always to ward the blower side of the cylinder block. Heeding the marks, place the bearing lower shells in the bearing caps and install caps, locking in place with nuts and cotter pins. When tightening bearing cap bolts, rap caps 2 or 3 light blows with a hammer to assist in positioning shells.
   NOTE: If bearing has been properly installed the crankshaft will turn freely with all main bearing caps bolted tight. Front and rear main bearing caps on all production engines have machined recesses to accommodate flange type thrust bearings. All other bearing caps are plain. Any replacement cap supplies will have the recess and can be used to replace any cap. Replacement caps are not numbered. To position in block see that insert tang groove is toward blower side of engine. On late motors the main bearing caps are made heavier, ½" in the stud boss height. The stud is also made longer ½". INTERCHANGEABILITY IS EFFECTED. The former service bearing cap and short stud will

be maintained for service requirement. However, the new service bearing can also may be used on motors built prior to this change providing the new longer studs also are used.

3. The connecting rods and caps are numbered 1, 2, 3, etc., indicating their respective positions. The marked side is always toward the blower side of the cylinder block. Heeding the marks, install the connecting rod bearing caps with shells in place and lock with nuts and cotter pins.
4. Shellac new gasket to bolting flange of crankshaft front cover and attach to cylinder block with lockwashers and capscrews, finger tight only. Do not tighten capscrews until after front spacer is put in position as shown in Fig. 5.
5. Install the spacer on front end of crankshaft next to oil slinger, as shown. NOTE: This spacer must not be put in place until front cover is put in place, otherwise the oil seal in the cover may be damaged.
6. Install the crankshaft timing gear. Be sure the timing mark coincides with that on the idler gear. Topic 80. Figure 1. NOTE: The holes in the gear and crankshaft are offset so that the gear fits on the crankshaft in only one position.
7. Install the combination gear train cover and flywheel housing. NOTE: Refer to Topic 87-C.
8. Install the flywheel.
9. Install lubricating oil pump. Refer to Topic 89-E.
10. Install oil pan.
11. Install motor in tractor as described in Topics 74, 75 and 76.

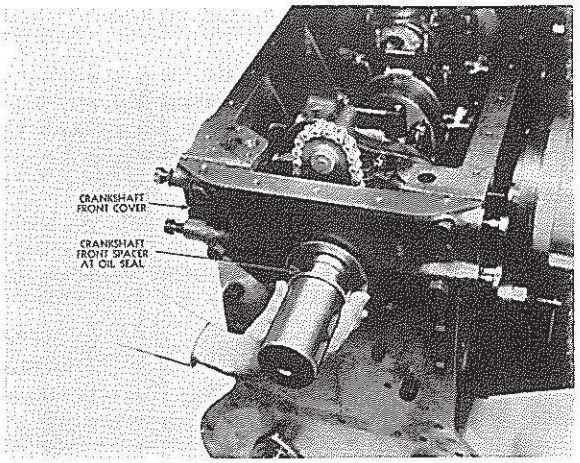


FIG. 5

82 -- Main and Connecting Rod Bearings

DESCRIPTION—Large copper-lead-bronze main bearing shells of the precision type are readily replaceable without machining. The main bearing caps are attached to the crankcase and carefully machined in place to receive the precision bearing shells. Each bearing cap is marked 1, 2, 3, etc., on blower side, and when removed should always be replaced in its respective position.

Crankshaft thrust loads are taken by the rear main bearing. The upper halves of the main bearing shells are seated in the cylinder block. The lower halves are held in place by the main bearing caps, each of which is bolted to the cylinder block by two special steel studs. Each half of the bearing shell is prevented from endwise or radial movement by a tang at the parting line on one side of the bearing. Each bearing cap is locked from sidewise movement by a milled seat in the cylinder block.

All upper halves of the main bearing shells carry a circular groove midway between the bearing edges which runs from parting line to parting line, and furnishes registration with the oil holes in the crankshaft journals at all times. An oil hole in this groove midway between the parting lines, provides oil registry with holes in the cylinder block, by way of the bearing shells, to the drilled passages in the crankshaft leading to the various connecting rod bearings.

All lower halves of the main bearing shells have no oil grooves; consequently, the upper and lower halves of these bearing shells are not interchangeable.

A very effective oil seal has been incorporated at the rear main bearing. This seal consists of a special treated leather ring (seal) in a stamped retainer pressed into the flywheel housing and an oil slinger attached to the rear face of the crankshaft timing gear. The rolled-over inner diameter of the leather is held snugly against the crankshaft journal by a coil spring, to prevent oil from creeping along the journal into the flywheel compartment. The slinger, attached to the gear, traps and throws the surplus oil from the gear teeth back into a cavity adjacent to the gear. The oil from this cavity flows back into the oil pan. The leather ring and coil spring constitute the oil seal assembly, which is readily replaceable.

An oil seal of the same design is used forward of the front main bearing. This seal is pressed into the crankshaft front cover.

A. REMOVAL OF MAIN BEARINGS

1. Remove the engine support cover and drain the oil from the engine.

2. Remove the oil pan (upper and lower on the "HD 14").
3. On the 3 and 4 cylinder engines, the lubricating oil pump assembly is bolted to one of the main bearing caps and the pump drive sprocket and bearing assembly is bolted to the front main bearing cap. If necessary, remove the oil pump and discharge pipe assembly, or the drive sprocket bearing, and then remove the bearing cap.
4. The bearing cap having been removed, insert a ¼" x 1" bolt with a ½" diameter and 1/16" thick head into the crankshaft main bearing oil hole, then rotate the shaft to the right (clockwise) and roll the bearing shell out of position as shown in Fig. 1. The head of the bolt should

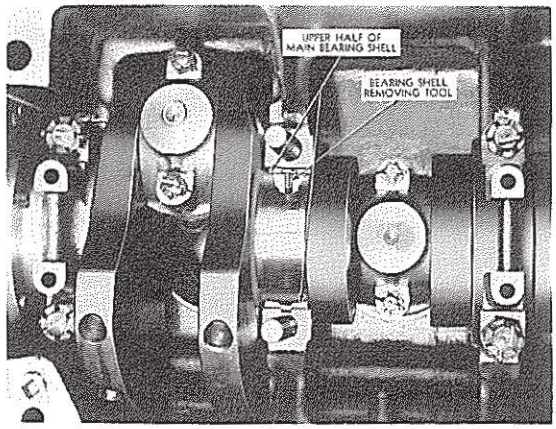


FIG. 1

not extend beyond the outside diameter of the shell. The upper half of all the main bearing shells may be removed in this manner except the rear main. On this bearing, the upper shell must be removed by driving on the edge of the bearing shell with a small curved rod, at the same time revolving the crankshaft, thus rolling the shell from position. Fig. 2.

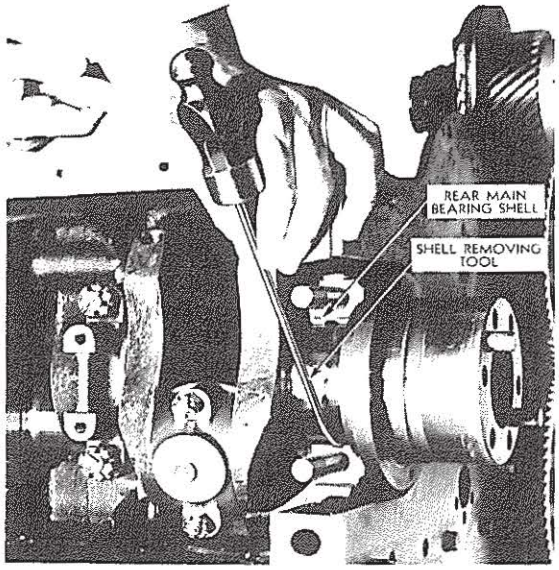


FIG. 2

B. INSPECTION OF MAIN BEARINGS

As stated above, the main bearing shells are of the precision type and are replaceable without machining. The clearance between the main bearing shells and the crankshaft journals is from .002" to .004" and should not exceed .008". Bearing shells when in place have .001" larger diameter at the parting line than at 90° from the parting line. The thickness of the bearing shells 90° from the parting line is .155".

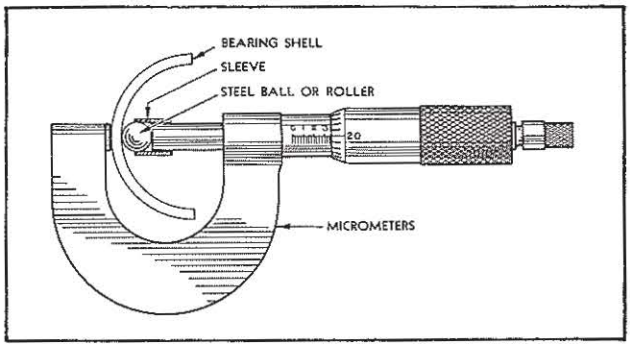


FIG. 3

The 2 shells do not form a true circle when not installed and when measured for inside diameter should be installed in the caps and block, with caps bolted in place. Fig. 4. The 2 halves of the shells have a squeeze fit in the case and cap, and must be tight when the cap is drawn down. The shells may be measured with micrometers at the points marked "C", and any variation from .155" will show the amount of wear on the particular shell being measured. Fig. 4.

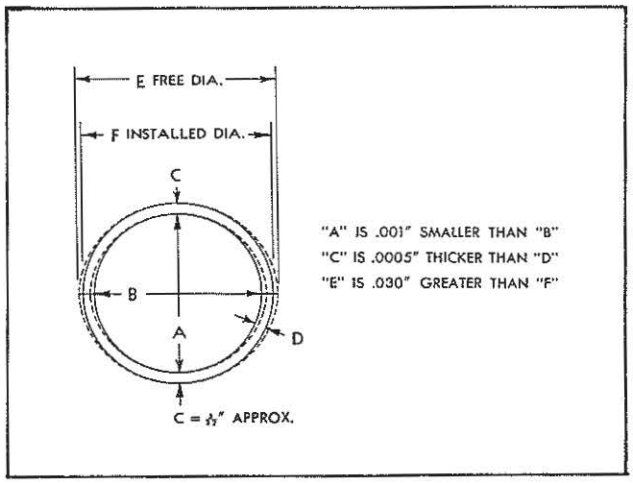


FIG. 4

(NOTE: All the main bearing load of these engines is carried on the lower half of the bearings only. Any chipping, pitting, scor-

ing, or overheating, of the main bearing shells may be observed by removing the main bearing caps.)

If main bearing trouble is suspected from the running of the engine, remove the oil pan; remove the main bearing caps—one at a time—and examine the bearing shells. As no load is imposed on the upper half of the shell, this half may not require changing. Bearing shells are furnished as upper or lower halves separately.

In cases of main bearing shell changes, the crankshaft journal should be examined for over-heating, scoring, or excessive wear. If crankshaft journals have been overheated, a new crankshaft should be installed. If they have been scored or worn and not overheated, they may be reground, and undersize bearing shells installed. See Topic 81-B.

C. INSTALLATION OF MAIN BEARINGS

To install a main bearing shell with the crankshaft in place, reverse the sequence of operations for removal. The upper and lower halves of the main bearing shells are not alike. The UPPER half IS GROOVED for lubrication and the LOWER half IS NOT. Always be sure to install the grooved shell in the cylinder block and the non-grooved shell in the bearing cap, otherwise the oil supply to the connecting rod bearings will be cut off.

1. When installing the upper half of main bearing shells with crankshaft in place, start the end of the shell having no tang around the crankshaft journal, so that when shell is in place tang will fit into groove in the shell support. NOTE: Main bearing caps are bored in position and marked 1, 2, 3, etc. Whenever bearing caps are removed, they should be replaced in their original positions with marked side of caps toward blower side of cylinder block.
2. With lower half of bearing installed in bearing cap, replace cap and draw up evenly. The cap stud nuts may then be tightened and locked. NOTE: Since the bearing shells have a squeeze fit in the cap and block, bearing cap nuts should be drawn tight so shells will not shift. If bearings have been installed properly, the crankshaft will turn freely with all main bearing caps bolted tight.

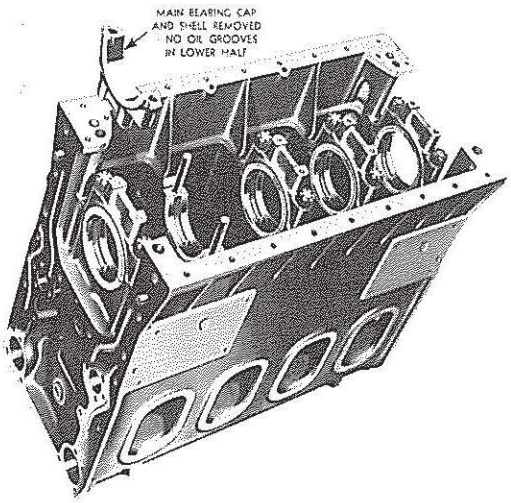


FIG. 5

D. REMOVAL OF CONNECTING ROD BEARINGS

1. Remove the cotter keys, nuts, and bearing caps.
2. Push the piston up in the cylinder and remove the upper half of the bearing.

E. INSPECTION OF CONNECTING ROD BEARINGS

All the connecting rod load of these engines is carried on the upper halves of the bearings only. Any chipping, pitting, scoring, or over-heating of the connecting rod bearing shells can be determined by taking off the rod caps, one at a time, and pushing the piston up in the cylinder so that the top half of the bearing can be observed.

F. INSTALLATION OF CONNECTING ROD BEARINGS

The upper and lower halves of the connecting rod bearing shells are not alike. The LOWER half has ONE CONTINUOUS groove from parting line to parting line for lubrication and UPPER half has one short groove at each parting line.

1. Place the correct half of the rod bearing in the connecting rod and install it on the crankshaft.

   NOTE: When the bearing is in place, a tang on the bearing shell will fit in a groove in the connecting rod.
2. Place the LOWER bearing shell in the connecting rod cap and install. Draw the cap up snug then the nuts can be tightened and locked.

   NOTE: The connecting rods and caps are all marked 1, 2, 3, etc., when they are removed they should be replaced with the marked side towards the blower.

   If bearings have been installed properly, the crankshaft will turn freely with all main bearing caps and connecting rod caps bolted tight.
3. Install oil pan and engine support cover.

83 -- Piston and Connecting Rod

DESCRIPTION—Each connecting rod is made of drop-forged heat-treated carbon steel, and forged to an "I" section with a closed hub at the upper end and an integral cap at the lower end. The rod is rifle-drilled for lubrication to the upper end, and is equipped with an oil spray jet for cooling of the piston head.

The lower end of the connecting rod shank is fitted with an orifice which meters oil to the rifle-drilled connecting rod. The crankpin bearings are steel-backed lead-bronze-lined shells of the precision type, without shim adjustments. The upper and lower halves of the connecting rod bearing shells (crankpin-big end) are different; therefore, are not interchangeable, but are replaceable without machining.

The upper bearing shell is grooved midway between the bearing edges, part way up from each parting line, with an oil hole through the shell at the termination of each groove. The lower shell has an oil groove in line with that of the upper shell and circling the shell from parting line to parting line. These grooves maintain a continuous registry with the oil holes in the crankpins, thereby providing a constant supply of cooling oil through the hollow connecting rod to the piston pin bearings and the spray jet.

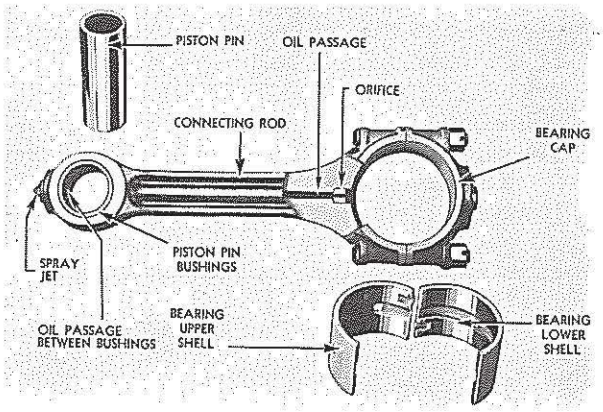


FIG. 1

A helically-grooved steel-backed bronze bushing is pressed into each side of the connecting rod upper end for the piston pin bearings. A cavity of approximately $\frac{3}{16}$" between the inner ends of these bushings, registering with the oil passage in the connecting rod, forms a duct around the piston pin whereby the pin bearing is lubricated and oil also is forced to the spray jet for piston cooling. The piston pin floats in the bushings of both the piston and connecting rod.

DESCRIPTION — Malleable iron pistons with extra long skirts, accurately ground the full length, are plated with a protective coating of either tin or Parco Lubrite, which permits close fitting. The top of the piston forms the combustion chamber and is designed to displace the air into close proximity to the fuel spray.

To add strength, rigidity, and cooling effect the head of each piston is cast with ribs on the inside. The ribbed head is cooled by lubricating oil forced from a spray jet on the top of the connecting rod.

Two steel-backed bronze bushings, with helical grooved oil passages, are pressed into the piston to provide a bearing for the hardened, floating piston pin. After the piston pin has been installed, the hole in the piston at each end of the pin is sealed with a tight steel cap and locked in place with a lock ring. Thus, lubricating oil returning from the sprayed piston head and working through the grooves in the piston bushings is prevented from reaching the cylinder walls.

A balancing rib is provided on the inside at the bottom of the piston skirt. Because of this design, all pistons are balanced to close limits.

Each piston is fitted with six cast iron rings of conventional cut-joint type. Four $\frac{1}{8}$" wide, tin-plated grooved compression rings are placed above the pin and two $\frac{3}{16}$" wide special oil-control rings scrape off the excess lubricating oil thrown onto the cylinder walls.

A. MOTOR RUN-IN SCHEDULE

After installation of new motor kits or piston rings, the motor must be run to allow rings to seat and avoid the possibility of liner scoring and excessive oil consumption. When motors are first started after installation of motor kits or piston rings, excessive smoking and raw fuel and lubricating oil may appear in the exhaust. This condition will correct itself as the motor is run in.

Before starting motor after overhaul inspect motor oil, fuel oil, and cooling system and see that air cleaners have been properly serviced. Close radiator shutters and start motor allowing it to run at $\frac{1}{2}$ throttle. See that all instrument panel gauge readings are normal.

The most important factor in running in a new engine or one which has just been overhauled is OPERATING TEMPERATURE. The engine temperature must be brought to normal, 175° to 185°, as soon as possible and carefully maintained as nearly as possible within this range. Temperatures of 150° and below are conducive to the formation of gum and sludge, both highly detrimental to an engine. DO NOT, THEREFORE EVER IN THE LIFE OF A TRACTOR, ALLOW IT TO OPERATE AT LOW TEMPERATURE.

The following run-in schedule is recommended:

$\frac{1}{2}$ hr. at half throttle
3 hrs. at two-thirds throttle
3 hours at full throttle

After this run-in, inspect engine lubrication

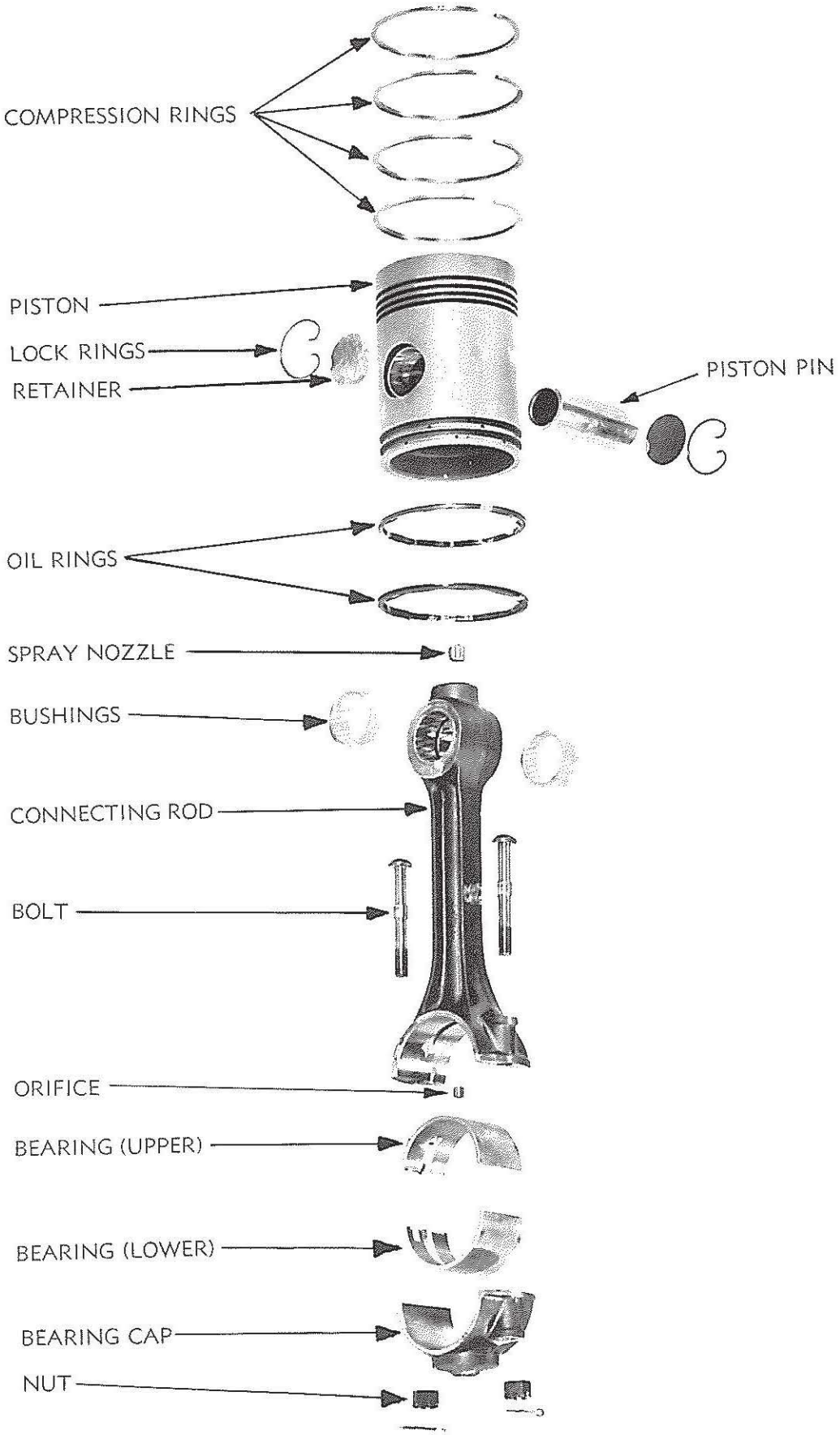

COMPRESSION RINGS
PISTON
LOCK RINGS
RETAINER
PISTON PIN
OIL RINGS
SPRAY NOZZLE
BUSHINGS
CONNECTING ROD
BOLT
ORIFICE
BEARING (UPPER)
BEARING (LOWER)
BEARING CAP
NUT

FIG. 2

and all points of adjustment, making any necessary minor corrections.

Tractor can then be put to work but should operate only under light load for the next 24 hours. Use a gear that will move the load without reducing engine speed. After another examination and necessary adjustments tractor is ready for full load.

B. PISTONS: LUBRIZING REPLACES TIN PLATING

1. The new lubrizing process replaces the tin plate on pistons for production and service. "Lubrizing" is effective with engine serial numbers 3713858, 4715786, and 67110126.
2. PISTONS WITH THE NEW TREATMENT WILL BE JET BLACK IN APPEARANCE, and easily identified from the former bright tin plated pistons. The process is a chemical treatment which converts the finish ground surface to a friction-free black coating providing a scuff-resistent surface for break-in purposes. However, interchangeability is in no way affected by this change since dimensionally the piston remains unchanged.

C. REMOVAL

1. Remove cylinder head. Refer to Topic 78-A.
2. Remove engine support bottom cover, drain the oil and remove the oil pan. (On HD-14, 2 Pans.)
3. Remove the lubricating oil pump (Only necessary when working on a piston directly over the oil pump assembly.)
4. Remove the carbon from the upper inside circumference of the cylinder liner.
5. Remove the cotter pins, nuts and bearing cap from the lower end of the connecting rod and push the piston and rod assembly out through the top of the cylinder block. PISTONS CANNOT BE REMOVED FROM BOTTOM OF CYLINDER BLOCK.
6. The piston rings may be inspected and changed and measurements taken on the outside diameter of the piston skirt without further disassembly.

D. INSPECTION

As the gummy deposits are not always easily removed from the piston walls and ring grooves with fuel oil or solvent, these parts may be cleaned by using Simonize-Chrome cleaner or its equivalent, and then blowing dry with compressed air. After cleaning, the piston skirt, the piston rings and ring grooves should be thoroughly inspected.

The tin coating on the skirt is less than .0007" thick and the presence of this coating of soft metal will indicate the practical absence of wear. If the tin is worn off in spots, a careful examination should be made for score marks or other indications of lack of proper piston clearance.

A scored piston should not be re-used. Install new piston.

The clearance between cylinder liner and piston skirt should be from .006" to .008".

E. FITTING PISTON

Measurement of piston and cylinder liner bore should be taken at room temperature (70 deg. F.).

Measurements should be taken on the piston skirt lengthwise and crosswise of the piston pin.

Cylinder bores should be measured with the gauge shown in Fig. 3 both lengthwise and crosswise of the cylinder block throughout the entire length of the cylinder liner.

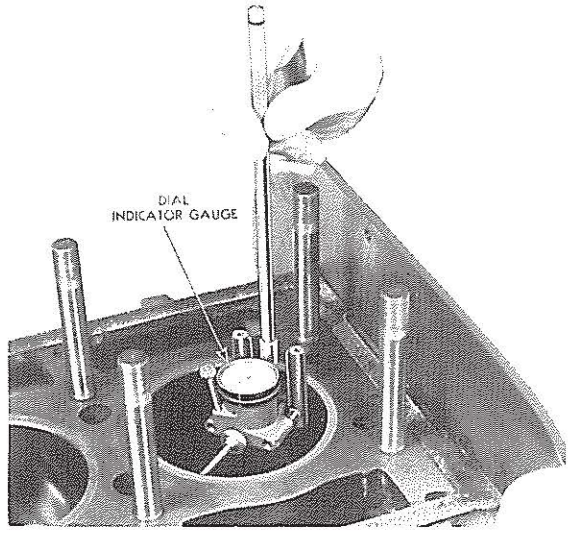


FIG. 3

The piston should be round within .001". The cylinder bore should be round and straight within .001".

The clearance of the piston in the bore may be checked crosswise of the pin by using a

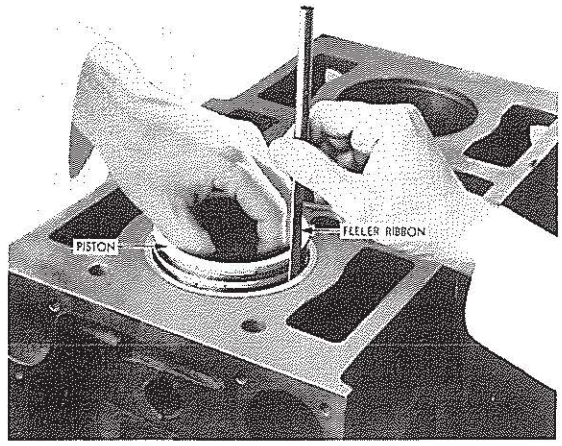


FIG. 4

½ inch wide feeler ribbon between the piston and cylinder liner. Fig. 4.

With a .006" clearance between piston and liner, a .005" feeler may be moved freely.

Since cylinder liners are furnished in standard size only, pistons are furnished in standard size only. The upper part of the piston (above the upper compression ring) is not tinplated and does not touch the cylinder wall. If this part of the piston shows any coating of hard carbon, the rings must be removed and the piston surface, as well as the ring grooves, thoroughly cleaned. The piston head should be absolutely clean outside as well as the cooling ribs inside. Any thick coating of carbon inside the piston head indicates failure of cooling oil supply and necessitates the cleaning of orifice at lower end of connecting rod, spray jet at upper end of connecting rod, oil passage in the connecting rod. Piston pin bushings in connecting rod may have become loose and worked toward each other, blocking oil supply.

Before disassembling the rings, they should be inspected for free fit in the grooves, side clearance, and wear. The presence of the original tool marks on the piston ring surfaces indicates the practical absence of wear. To avoid any breakage use special tool, Fig. 5 when removing or replacing piston rings. Care must be taken not to over-stress the piston rings by spreading the ends more than necessary to slip ring off and on the piston.

New piston rings should always be used with new pistons; furthermore, if the engine has been in service for some time, even though the same pistons are again used, it is advisable to use new rings.

NOTE: In some instances, replacement pistons and liners in the field have been improperly fitted, resulting in premature failure of these parts.

Pistons and liners are marked "A" - "AA" - "AAA" on the upper rim of each of these parts to denote their actual manufacturing limits, principally, to allow closer selection of correct parts in production. Even with these markings, it is production practice to use feeler checking across the pin and also at the thrust surface for the full length of the bore with liners installed and using the piston attached to the connecting rod inverted to insure proper fit before assembly. SERVICE SHOULD USE SAME METHOD TO INSURE PROPER FIT.

According to the markings of the pistons and liners, their use in the various mated sets would be approximately as listed below:

"A" Piston with "A" Liner — .0065" - .0075" Permissible

"A" Piston with "AAA" Liner—.0070" - .0080" Permissible

"AA" Piston with "A" Liner—.0055" - .0065" (Use only .006 or over)

"AA" Piston with "AAA" Liner — .0065" - .0075" Permissible

"AAA" Piston with "A" Liner—.0050" - 0060" Not Permissible

"AAA" Piston with "AA" Liner — .0055" - .0065" (use only .006 or over)

It is extremely important that PISTONS BE FITTED WITH NOT LESS THAN .006 RUNNING CLEARANCE. Bores in a tapered or out-of-round condition should be corrected by honing out the cylinder block slightly to insure loose fit of cylinder liners. A Sunnen hone or equivalent is recommended for this purpose since the stones can be adjusted, so removal of high spots is possible. Slightly scuffed liners, if usable, should be polished or lapped to remove surface irregularities. Pistons should not be fitted to cylinder bores with excessive out-of-round or taper. Do not confuse wear with out-of-round or taper. To obtain a satisfactory running clearance, pistons and liners should be selected for fit in the following manner·

1. Clean cylinder block and assemble liner in place.
2. Clean pistons and bores thoroughly.
3. Place a ½" wide .005" thick feeler ribbon in cylinder bore. Feeler ribbon should extend full length of bore.
4. Assemble piston in running position in cylinder with piston pin boss axis parallel to crankshaft axis.
5. Pull on feeler ribbon must not exceed 6 lbs. at room temperature when properly used as indicated below.
   a. With feeler inserted in bore at 90° to axis of crankshaft and pistons located first at top then at bottom of bore.
   b. As above with feeler ribbon inserted in a position parallel to axis of crankshaft.
6. Mark piston and assemble in cylinder bore in which it has been fitted.

When checking with feeler, if bind exists in one place only when fitting piston in new liner, remove liner and rotate part 90°. Reassemble liner and check again. (Due to the thin wall, it is possible for liners to go slightly out of round while in stock. Liners should be stocked standing on end).

After assembly of pistons and liners, proper run in schedule should be followed to insure proper seating of parts.

Above procedure with .005 feeler provides an actual running clearance of .006. For an

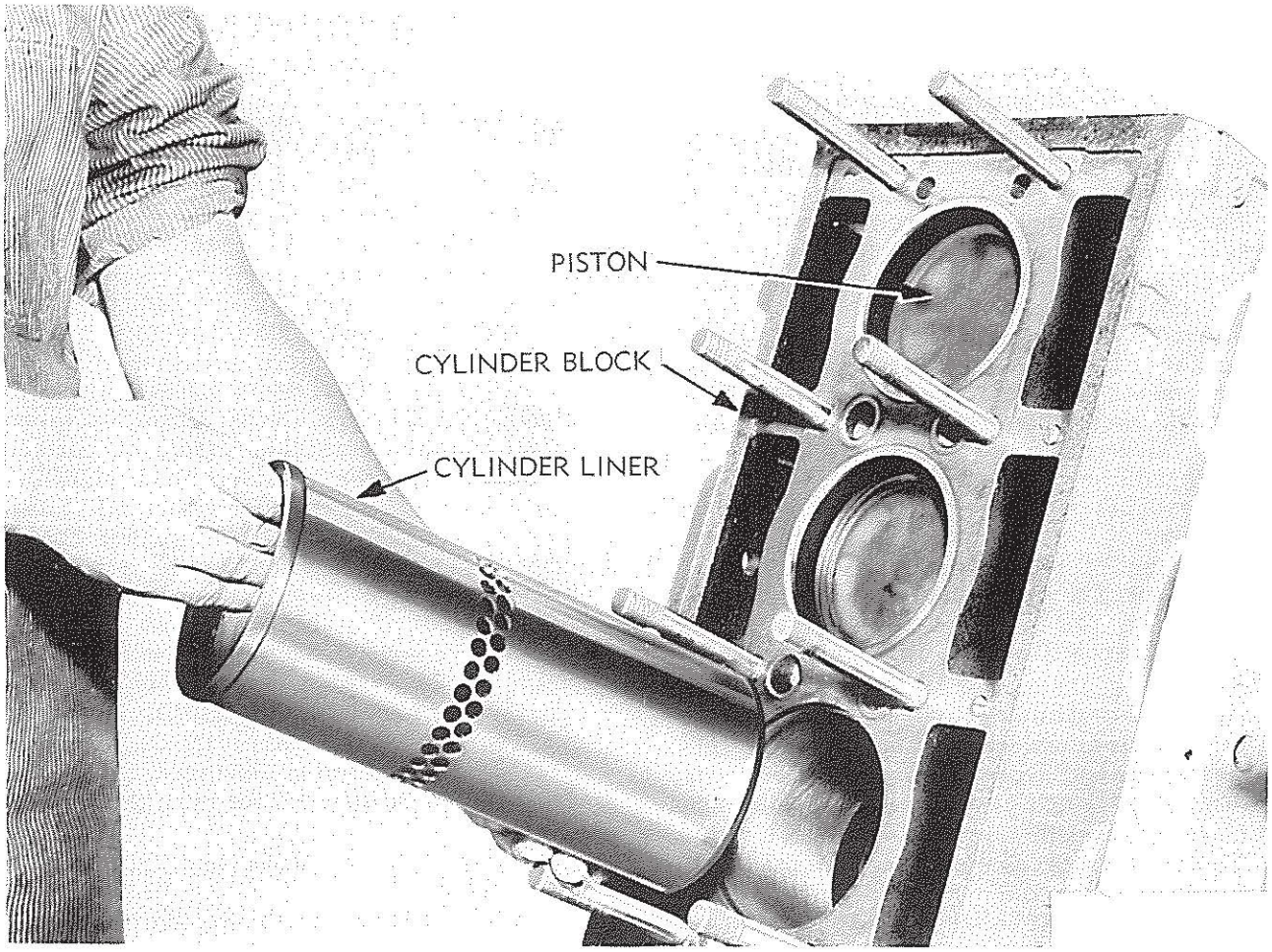


FIG. 4 A

actual running clearance of .007 the feeler thickness should be .006.

F. FITTING PISTON RINGS

When fitting piston rings, the gap between the ends of the ring should be measured with the ring inserted in the bore parallel with the top of the cylinder block, Fig. 6. This may be done by starting the ring in the bore and then locating the ring by sliding piston into bore on top of ring.

The specified gap on the compression rings is from .020" to .025" and on the oil control rings from .010" to .020". The gap may be changed by using a thin, flat, fine mill file.

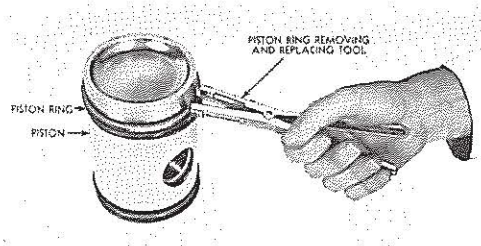


FIG. 5

After proper gap has been fixed, the rings may be installed on the piston with tool as shown in Fig. 5.

NOTE: The oil rings are the three-piece type and should be placed in the grooves as shown in Fig. 7-B. This is important to control piston lubrication properly. To obtain best results, the piston rings specified by the manufacturer should be used. Some engines have two gold seals, one plain, and one hooked oil ring on the pistons. The latest engines have four tinned groove compression rings. The use of the latter is correct when installing new rings.

Stagger the ring gaps around the piston and apply some oil to the piston wall, rings, and lower connecting rod bearing before installing in cylinder block.

1. Effective with engine serial numbers 3713834, 4714786 and 6719873, all production engines will have the two oil control piston rings installed in the double scraper position, as shown in Fig. 7B, all hooks facing down.
2. In line with the above production

change, it is recommended that field service follow the same procedure for installing piston rings in the field at time of engine reconditioning, since this new arrangement has proved to be the most satisfactory for more effective oil control.

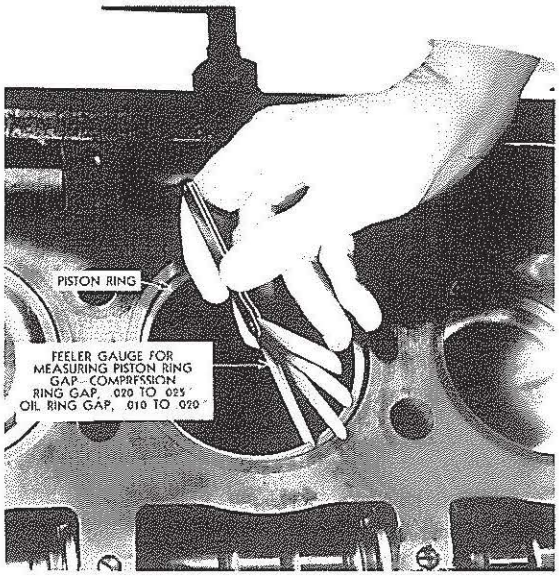


FIG. 6

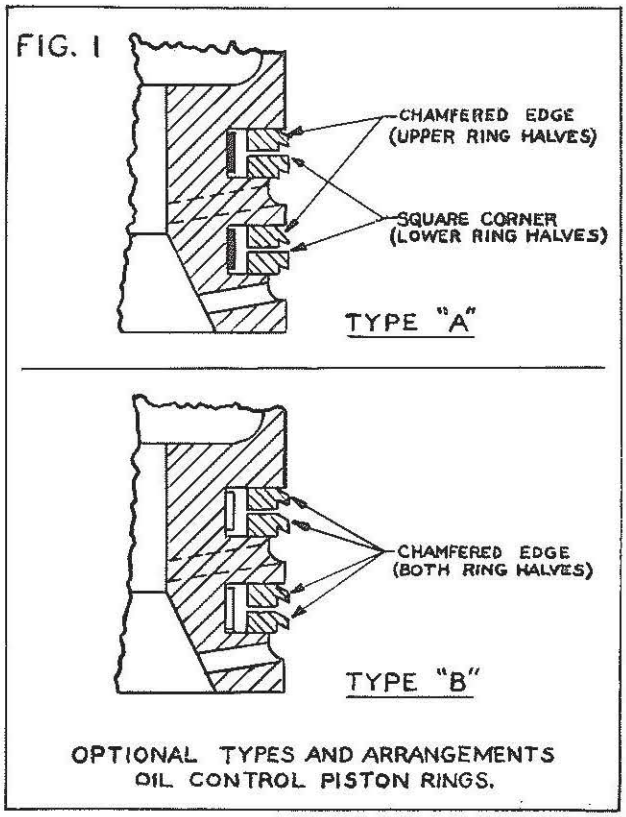


FIG. 7

G. REMOVAL OF CONNECTING ROD FROM PISTON

1. By means of a pair of small nose pliers, dislodge spring clip which retains steel cap at end of piston pin.

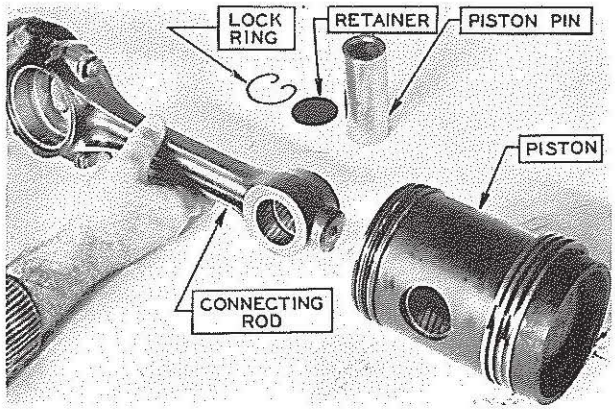


FIG. 8

2. Tap piston lightly on wood block and remove cap and pin. Should cap lodge in the groove for the spring clip, it may be readily removed with a rubber suction cup.

H. REMOVAL OF PISTON PIN BUSHINGS FROM PISTON — (SOLID BRONZE TYPE)

1. DESCRIPTION.
   The solid bronze type connecting rod bushing for service will be superseded by an improved split type steel-backed bronze bushing. A similar change will also apply to production, on both piston and connecting rod pin bushings.
   The new service replacement bushing (supplied for connecting rod only) may be identified by the protective bright cadmium plate coating. The service part numbers remain unchanged.
2. Place piston in V-block with piston pin hole in alignment with hole in block. Fig. 9.

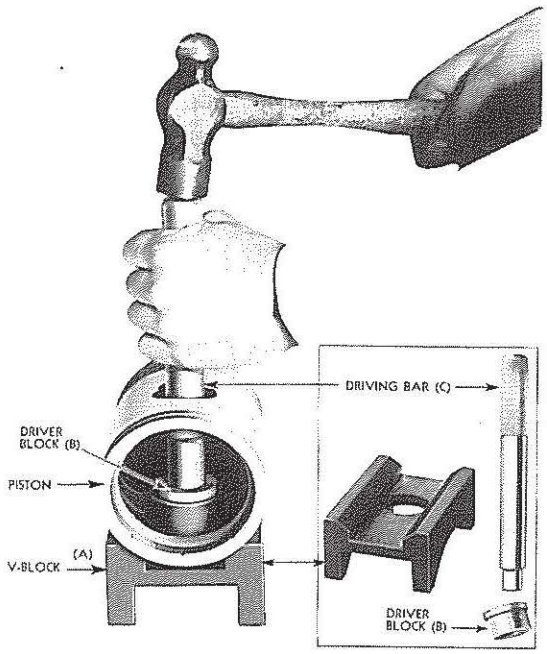


FIG. 9

3. Set small diameter of driver block (B) inside lower piston pin bushing.
4. Drive bushing from piston. Reverse piston and remove second bushing in same manner.

I. INSTALLATION OF PISTON PIN BUSHINGS IN PISTON

Bushings are installed in the piston with the same tool that was used for removal; except a stop plug is used in piston pin hole to

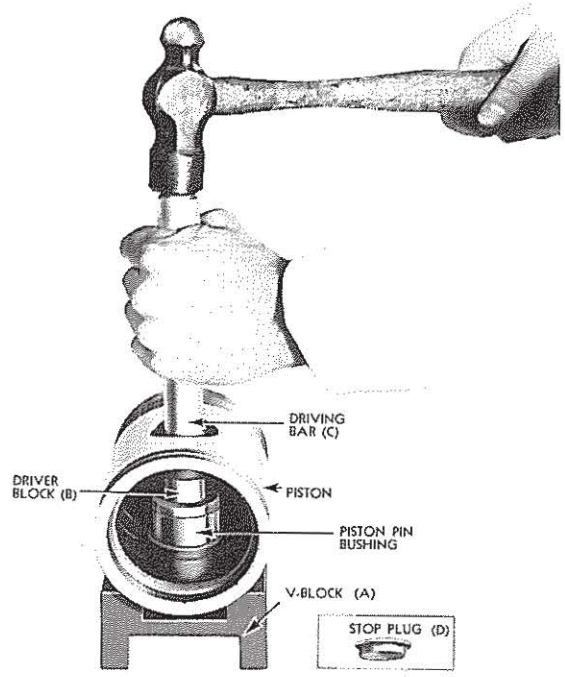


FIG. 10

locate the bushing correctly.

1. Lay stop plug (D) on V-block (A) with large diameter down and small diameter inserted in piston pin hole.
2. Start bushing in lower piston pin boss from inside piston, with small diameter of driver block (B) inside bushing and shoulder of large diameter resting on end of bushing. Fig. 10.
3. Drive bushing into boss until lower end rests on stop plug. Reverse piston and install second bushing in the same manner.

J. REAMING PISTON PIN BUSHINGS

After the bushings are pressed into the piston, they must be reamed to size. For satisfactory engine operation, the bushings must be line-reamed exactly parallel with center line of crankshaft and to the correct diameter of 1.5025" + .0005" — .0000". The tool shown in Fig. 11 properly set up, will accomplish these results.

1. Insert small long diameter of arbor (A) into long bore of fixture from inner end so that short small diameter of arbor may enter bore in piston pin boss at outer end of bushing.

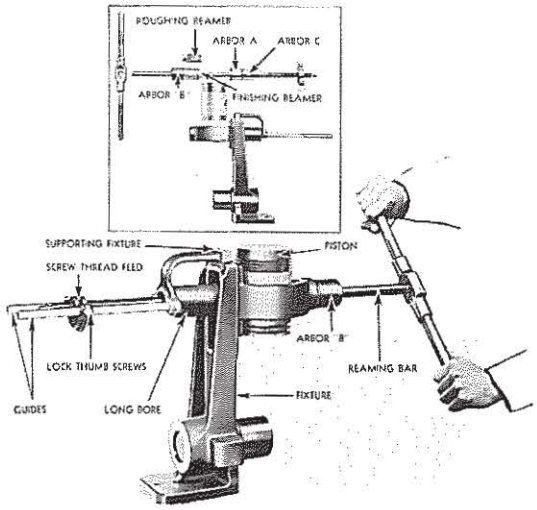


FIG. 11

2. Set piston in fixture right side up with bore in piston pin boss resting on exposed end of bore (A).
3. Slide arbor (C) into outer end of fixture and up against arbor (A).
4. Install roughing reamer onto reaming bar and slide through arbors (A and C) until outer end of reamer just contacts inner piston bushing.
5. Slide arbor (B) into inner end of fixture with small end of arbor entering bore for piston bushing.
6. Attach screw feed to threaded end of reaming bar and lock to guides of tool.
7. Turn reaming bar with handle and thread will feed reamer uniformly through bushing.
8. After rough reaming, carry out the same operations for finish reaming.
   NOTE: Always use roughing reamer for first cut and finishing reamer for last cut.
9. Lubricate a new piston pin with engine oil and try in newly reamed bushings. If work has been done properly, the pin will slip smoothly through bushings.

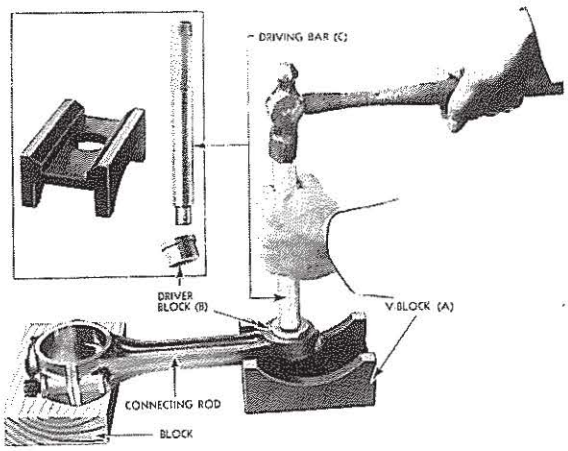


FIG. 12

K. INSTALLATION OF PISTON PIN BUSHINGS

1. Piston pin bushings are installed in the connecting rod with the same tool that was used for their removal. Fig. 10.
2. Each bushing is flush with outer edge of rod; this will leave an oil space of approximately $\frac{3}{16}$" between inner ends of bushings for passage of oil to the spray jet.

L. CONNECTING ROD BUSHINGS (SOLID BRONZE TYPE)

1. DESCRIPTION.
   The solid bronze type connecting rod bushing for service will be superseded by an improved split type steel backed bronze bushing. A similar change will also apply to production on both piston and connecting rod pin bushing.
   The new service replacement bushing (supplied for connecting rod only) may be identified by the protective bright cadmium plate coating. The service part number remains unchanged. There is .005" allowed for reaming after installed in rod. For removal of split type bushing refer to Topic 83-H.

M. ALIGN BUSHINGS FOR REAMING:

1. Remove connecting rod bearing cap and set lower end of rod over lower arbor. Install lower bearing cap sufficiently loose so rod may be moved sidewise.
2. With the aligning arbor inserted at piston pin bore, and taper tight in upper bushing at all times, slide lower end of rod tight against shoulder of fixture. Tighten bearing cap and withdraw aligning arbor.

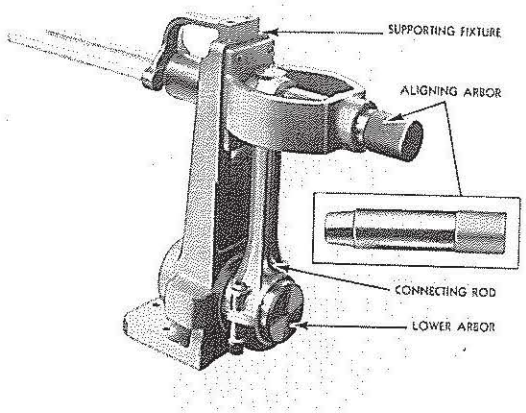


FIG. 13

N. REAMING CONNECTING ROD BUSHINGS:

To ream the connecting rod piston pin bushings, set tool up as shown in Fig. 13 and 14, refer to the following procedure as a guide

1. Slide arbor (C) into outer end of fixture.
2. Put roughing reamer over threaded end of reaming bar and push bar through arbor (C) so reamer just contacts connecting rod bushing.
3. Slide arbor (B) over inner end of reaming bar so outer diameter pilots into fixture.
4. Slide screw thread feed over guides of fixture and turn bar into threads of feed Lock screw feed onto guides with thumb screws.
5. Turn handle and reamer will feed through bushing uniformly.
6. Repeat the above operations with the finishing reamer.
   NOTE: Do not attempt to remove all the metal with the finishing reamer.

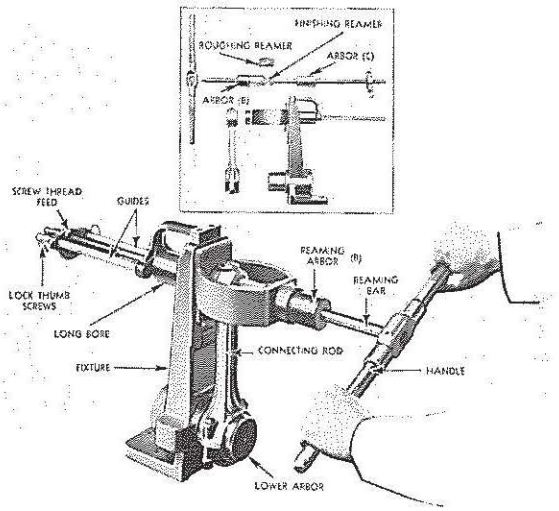


FIG. 14

7. Lubricate a new piston pin with engine non-corrosive oil and try in newly reamed bushings. If work has been done properly the pin will slip smoothly through bushings.

O. INSPECTION OF CONNECTING ROD PARTS

1. Before a connecting rod is replaced in the engine all parts should be washed clean and inspected.
2. If piston pin shows any appreciable wear install a new pin.

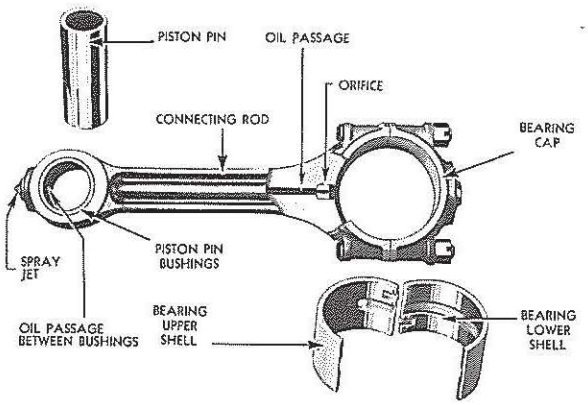


FIG. 15

3. Open orifice at lower end of rod and spray jet at upper end of connecting rod, and blow dry with compressed air through rifle drilling in rod.
4. The connecting rod bearing load is on the upper half of the shell only. Any wear will show on upper half of shell. The upper half of the shells should be examined for scoring, chipping, cracking, or signs of overheating. The backs of the bearing shells should also be in spected for any bright spots. Bright spots on the backs of the shells will indicate that the shells have been moving in their supports and are unfit for further use. If any of these conditions exist, a new upper half shell must be installed. If crankshaft journals are badly scored a new crankshaft should be installed, or ground undersize. See Topic 81-B.
5. The connecting rod bearing shells are furnished in standard sizes and .010, .020, .030 undersize.

P. ASSEMBLE CONNECTING ROD TO PISTON

NOTE: Before installing lock rings in pistons bend lock rings at ends where they contact center of pin retainer $\frac{1}{16}$" or the thickness of the lock itself, to exert firm pressure on retainer. This procedure will effect a more perfect oil seal and prevent oil from escaping into air box through liner air ports.

1. Install one piston pin retainer and lock ring into either end of piston pin hole. Make sure lock ring enters groove in piston.
2. Place upper end of connecting rod between piston bosses in line with pin holes. Lubricate piston pin with clean engine oil, non-corrosive, and slide into position. NOTE: Pin should slip readily into position without forcing, if correctly fitted.
3. Install second piston pin retainer and lock ring at exposed end of pin.

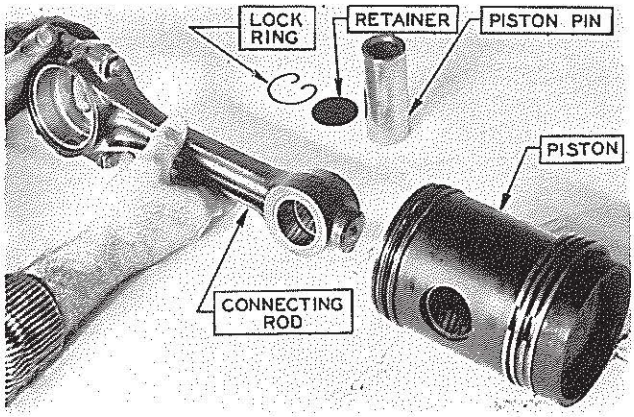


FIG. 16

Q. INSTALL PISTON AND CONNECTING ROD ASSEMBLY IN ENGINE

The lower end of each connecting rod, as well as the caps, are stamped on one side, 1, 2, 3, etc. These numbers identify the caps with the rods and show the particular cylinder with which each rod is used. These positions should always be maintained when rebuilding an engine; the marked side of the rod always faces the blower side of the cylinder block. The pistons are not marked and can be put on rod either way.

1. Stagger the piston ring gaps around the piston, apply some clean non-corrosive engine oil to piston and rings, then slide the piston ring compressor tool over the lower end of the piston skirt with flared end toward top of piston. Fig. 17. Turn the piston and rod assembly so that the identification mark on lower end of the connecting rod is toward the blower side of the cylinder block. By tapping on upper end of piston with a wood block, drive the piston in the cylinder bore.
2. Wipe clean and lubricate each connecting rod crankshaft journal. Install bearing shell with the one short groove at each parting line in the connecting rod and position rod onto crankshaft journal.
3. Heeding the marks on the bearing caps, install bearing shell with the one continuous groove from parting line to parting line into bearing cap, with lip of shell in groove of cap, and put cap and shell in place.

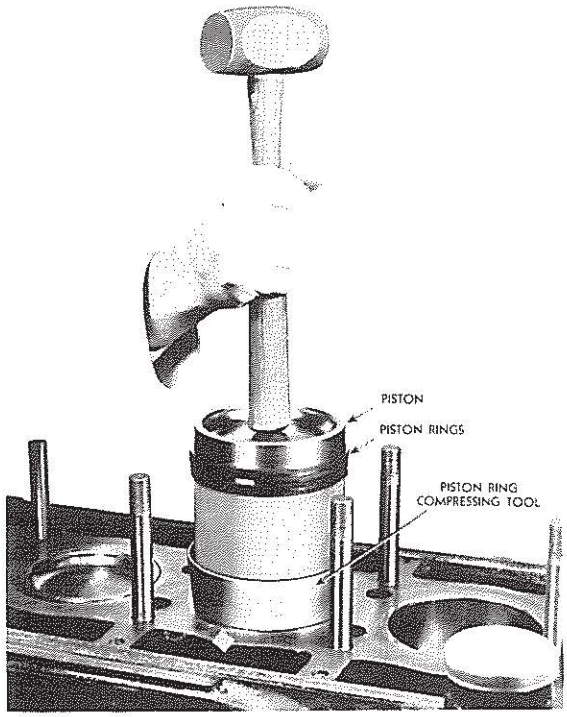


FIG. 17

4. Lock cap securely in place with bearing cap bolts and nuts and install cotter pins.
5. Install lubricating oil pump.
6. Install oil pan and fill to prescribed level. (2 on HD-14).
7. Install cylinder head.

R. REMOVAL OF PISTON PIN BUSHING (SPLIT TYPE)

1. DESCRIPTION. The solid bronze type connecting rod bushing for service will be superseded by an improved split type steel-backed bronze bushing. A similar change will also apply to production, on both piston and connecting rod pin bushing. The new service replacement bushing (supplied for connecting rod only) may be identified by the protective, bright, cadmium plate coating. The service part number remains unchanged. There is .005" allowed for reaming after installed in rod. The new bushing assures a slightly tighter fit in the connecting rod and is interchangeable with the former part, providing the following service instructions are noted carefully.
2. SERVICE NOTE: The new piston pin connecting rod bushings should be installed with split of bushings at the top of the piston pin hole in rod. Also note that the split in the piston is opposite or downward.
3. REMOVE PISTON PIN BUSHINGS FROM CONNECTING ROD (SPLIT TYPE) If the bushings at the upper end of connecting rod need changing, they may be removed from the rod by using tool, as illustrated.
   Piston pin fit in rod is approximately .0025" to .0032" when new. Due to no reversal of load, bushings do not require replacement until clearance exceeds approximately .010".
4. Support lower end of connecting rod on suitable wooden block and place upper end of rod on tool base so that bore in bushing align with hole in base.
5. Using hammer and driving bar to drive bushings from rod as shown in Fig. 12.

S. INSTALLATION OF PISTON PIN BUSHINGS (SPLIT TYPE)

1. The piston pin bushings are installed in the connecting rod with the same tool, that was used for their removal, as illustrated.
2. When installing split bushings in connecting rod, the split or joint should be at the top as shown in illustration.
3. When installing, drive each bushing in from the outside of the rod until outer end of bushing is flush with outer edge of rod; this will leave an oil space of approximately $\frac{3}{16}$" between inner ends of bushings for passage of oil to spray jet.

T. REAMING PISTON PIN BUSHINGS IN CONNECTING ROD. (SPLIT TYPE)

Since the inside diameter of replacement bushings are smaller than the final finished diameter, the bushing must be reamed after they are pressed into place.

This operation is accomplished with tool as illustrated in Figs. 13 and 14. The first illustrates how the connecting rod is placed on the fixture preparatory to reaming. The second shows the actual reaming operation.

1. Place bore at lower end of rod over arbor on fixture and draw bearing cap up tight.
2. Slide bushing into rear guide boss of fixture with hollow end facing slot in fixture for upper end of connecting rod.
3. Rotate connecting rod into position for reaming so that upper end of rod rests on boss of tool bed.
4. Install bushing on reamer. Insert reamer into front guide boss and turn clockwise with uniform motion. Do not crowd reamer too hard, as better results will be obtained by moderate pressures when turning.
5. After reaming, inspect bearing surfaces in bushings. Use a light coating of prussian blue, and slide a standard piston pin through the bushing to check for clearance. If bearings are good, and clearances are satisfactory, parts may be lubricated and the connecting rod attached to the piston as described in Topic 83-P.
   NOTE: Piston pin fit in rod is approximately .0025" to .0032" when new. Due to no reversal of load, bushings do not require replacement until clearance exceeds approximately .010" If bushings have been exceptionally overheated, due to piston failure, new bushings should be installed. Loose bushings may creep together thus blocking the supply of cooling oil to the piston.

84 -- Cylinder Liners

DESCRIPTION—Replaceable cylinder liners, made of hardened alloy cast-iron and accurately honed to a very smooth finish, are machined to form a loose fit in the cylinder block. Because of this feature, the liners are easily removed and installed.

A flange at the top of the liner fits into a recess in the cylinder block, insuring proper positioning in the block. Even temperature and minimum distortion are insured by water cooling each liner over its entire length, except at the ports, which are cooled by the scavenging air. To permit introduction of fresh air into the cylinder, sixty-four $\frac{5}{16}$" ports are drilled into the circumference of each cylinder liner. These ports are arranged in two rows—32 to each row—and are equally spaced and staggered.

FIG. 1

A. REMOVAL

Cylinder liners can be removed and installed with the motor either in or out of the tractor.

NOTE: LOOSE FIT LINERS: In engines 3711147—"HD 7"), (4712187—"HD 10"), (6712455—"HD 14") and above.

1. Remove the pre-cleaners and hood.
2. Remove the cylinder head. Refer to Topic 78-A.
3. Drain the oil from the crankcase.
4. Remove the engine support bottom cover.
5. Remove the oil pan. (On HD 14, 2 pans).
   NOTE: On the 6-cylinder motors the lower pan will have to be taken off first, then the lower oil screen cover and screen. The upper oil pan can now be removed.
6. Remove the oil pump if the cylinder liner to be installed, is over the pump.
7. Remove the connecting rod cap and push the piston out the top.
   NOTE: Before attempting to remove the piston from the cylinder liner scrape the carbon from the upper, inner circumference of the liner.

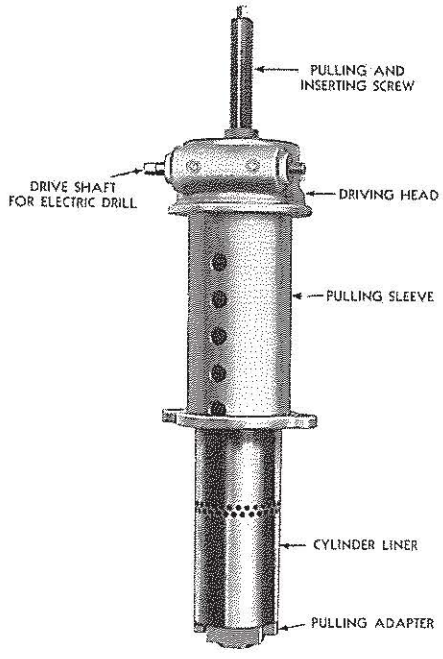


FIG. 2

8. Since the cylinder liners are a loose fit they may be removed easily from the top of the cylinder block by hand after loosening with the tool shown in Fig. 3. A study of Fig. 2 will show how to set up and use the cylinder liner puller tool.

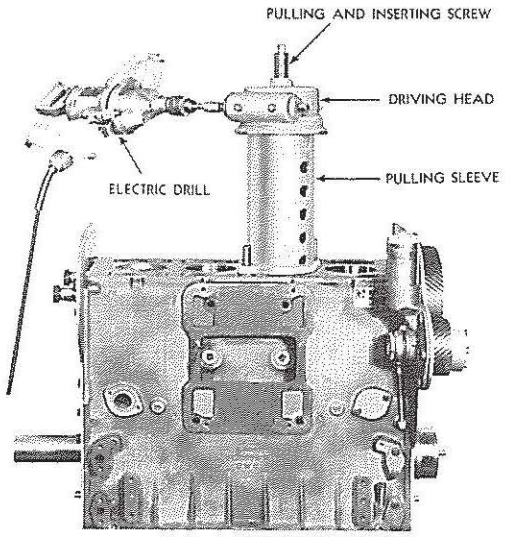


FIG. 3

The same screw and driving head of the tool is used for pulling and installing the cylinder liner. For pulling the liner the short adapter, which seats on the lower edge of the liner, is used in the lower end of the screw and the long, hollow adapter is used between the screw head and the cylinder block. As the liner is pulled from the cylinder block it follows up inside the upper hollow adapter.

NOTE: PRESS FIT LINERS:
Press fit liners have to be removed all the way from the cylinder block with the set-up as in Fig. 3.

B. INSTALLATION (LOOSE FIT)

1. To install a loose fit cylinder liner, wipe outside of liner and bore in cylinder block clean; then push the liner in by hand. When in place the top face of the liner upper flange will be from .002" to .004" above the top surface of the cylinder block.

C. INSTALLATION (PRESS FIT)

1. Reverse the removal process to install the cylinder liners except that a different adapter must be used.
   NOTE: The cylinder liners for a press fit and for a loose fit are identical; the bore in the block is different.

D. CYLINDER LINER AIR PORT CARBON REMOVAL

1. Remove Blower Assembly. Refer to Topic 79-A.
2. Remove cylinder head assembly. Refer to Topic 78-A.

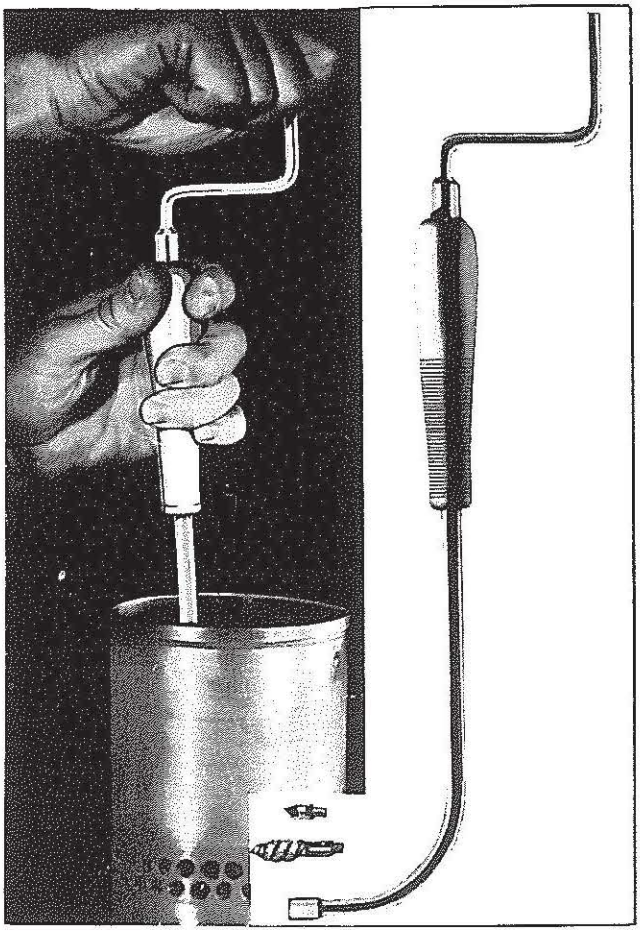
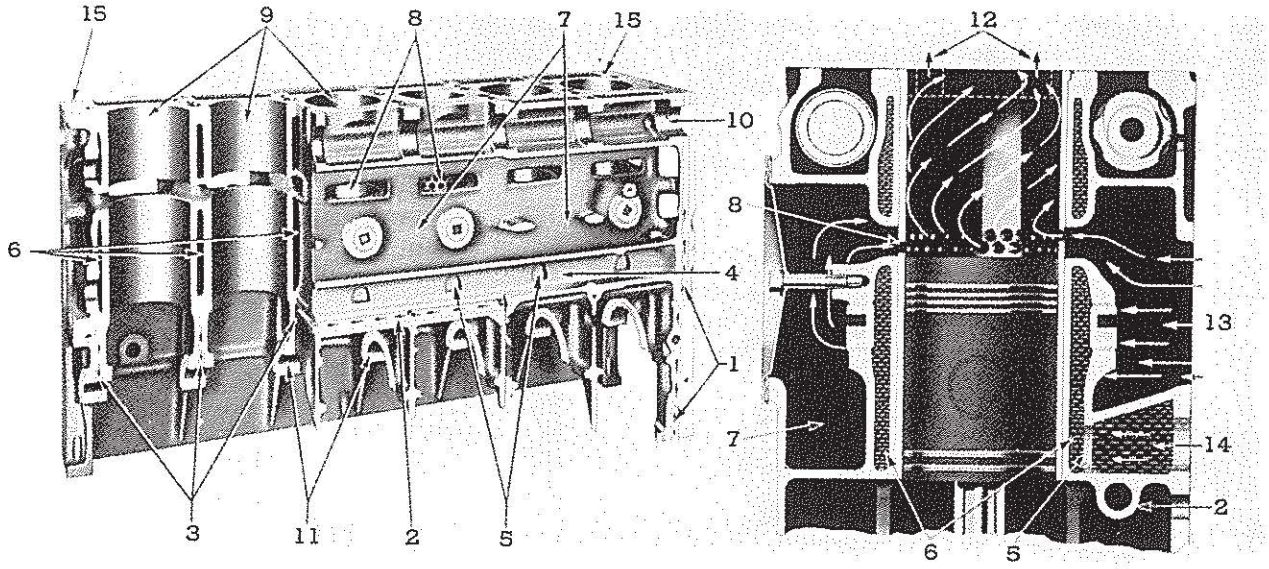


FIG. 4

3. Remove Generator.
4. Remove secondary oil filter assembly only on HD 7.
5. Remove air heater assembly.
6. Remove hand hole covers.
7. Liner air ports can now be cleaned using tool shown in Fig. 4.
8. Removing carbon from the cylinder liner port holes is normally done with cylinder liner in the block (not with liner out, as illustrated in operation view). First lower piston to its extreme position, insert tool with carbon removing reamer attached in port hole and turn operating handle which rotates the reamer and cuts its way through the carbon-plugged port hole. Continue this until all port holes have been reamed. Remove reamer, replace with cleaning brush and give each port hole a final cleaning.
   BE SURE TO BLOW ALL LOOSE CARBON AWAY FROM TOP OF PISTON AND CLEAN CARBON FROM AIR BOX BEFORE REASSEMBLING MOTOR.
   IMPORTANT: Air box drain tube must be kept open.

85 -- Cylinder Block



1. Vertical Oil Passage.
2. Oil Gallery.
3. Oil Passage to Crankshaft.
4. Cooling Liquid Manifold.
5. Cooling Liquid Inlet Opening to Liner Jacket.
6. Liner Cooling Jacket.
7. Air Box.
8. Air Passages to Cylinder.
9. Bore for Cylinder Liner.
10. Bore for Cam or Balance Shaft.
11. Upper Half of Main Bearing Seat.
12. Water to Cylinder Head.
13. Air from Blower.
14. Water from Pump.
15. Plugged Holes Each Corner.

FIG. 1

Description—The cylinder block and crankcase, which is the main structural part of the engine, is a box-like, one-piece casting made of alloy cast iron. Rugged transverse members, cast integral, provide utmost rigidity and strength, insuring perfect alignment of bores and bearings under all loads. The cylinders are bored to receive the cylinder liners, into the circumference of which a number of air inlet ports are drilled. The water jackets extend the full length of the bores and are divided into upper and lower sections, which are connected by hollow struts. Cooling water enters at the bottom of the water jacket from the water pump, and leaves the jacket at the top through holes which register with corresponding openings in the cylinder head. Surrounding the water space is an air chamber, which conducts the air from the blower to all of the inlet ports.

A camshaft and a balance weight shaft are located on opposite sides of the cylinder block and near the top. The upper halves of the main bearing seats are cast integral with the block. Drilled passages in the block carry lubricating oil to all moving parts and eliminate piping. Hand-hole plates on the side opposite to the blower permit access to the air chamber, and inspection of pistons and rings through the intake ports in the cylinder walls. Two hand-hole plates on the blower side serve the same purpose. Cylinder blocks for service are furnished with mainbearing caps, studs, and the necessary plugs. Cylinder liners, due to loose fit, are serviced separately.

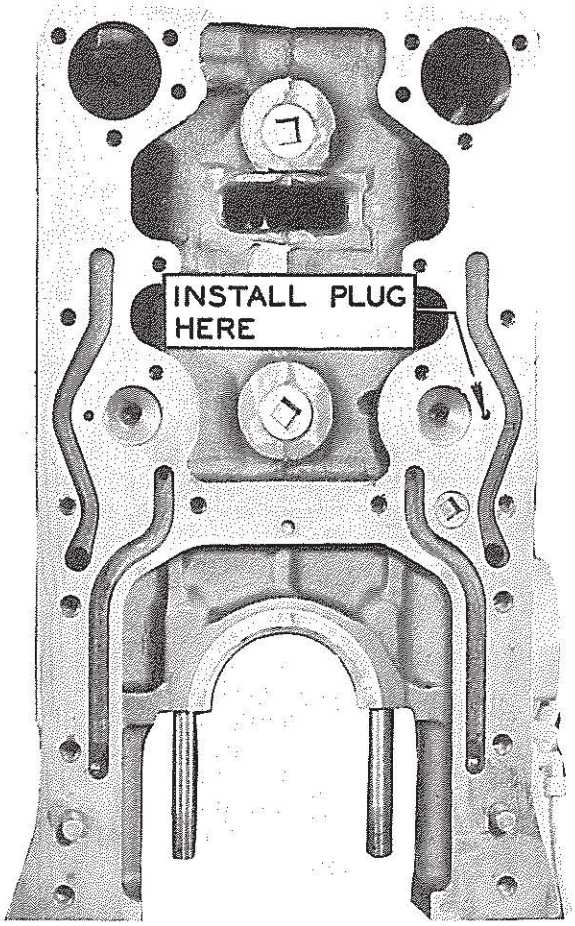


FIG. 2

A. CYLINDER BLOCK; IDLER GEAR OIL HOLES

1. To improve the oil seal at front and rear of cylinder blocks, special brass plugs ¼" dia. x 5/16", Part No. 5154319, are now installed in the oil holes of the two idler gear bosses at the front of the engine as well as in the oil hole of the idler gear boss at rear of engine, not used for the idler gear. This was effective starting with engine serial numbers 371833, 4711183 and 6177462.
2. The boss used for the idler gear, which of course is NOT plugged ,is always in the left-side of rear face for all Models.
3. The idler gear oil hole plugs may be installed in service, on engines built prior to serial numbers shown above. This can conveniently be done when engines are disassembled for inspection or overhaul.
4. To install idler gear oil hole plugs proceed as follows:
   a. Remove front and rear cylinder block end plates.
   b. Install a plug in both idler gear boss oil holes at front end of cylinder block.
   c. At rear end of cylinder block (gear train end) install a plug in the oil hole of the idler gear boss opposite that to which the idler gear hub is assembled. (Right hand side)

NOTE: Top of plugs must be below surface of cylinder block when installed. If the plugs project from the surface of the block, the end plates will be warped when attached to the block.

Cylinder block assembly replacements for service will have these plugs included in shipment as loose parts.

B. AIR BOX DRAIN TUBE

1. An improved air box drain tube became effective on Tractors HD-14, 1405, HD-10, 1711 and HD-7, 1343, to eliminate difficulty experienced in the field with air box drains clogging.
2. The improved air box drain tube may be installed on engines in the field by drilling and tapping air box as shown in Fig. 3.

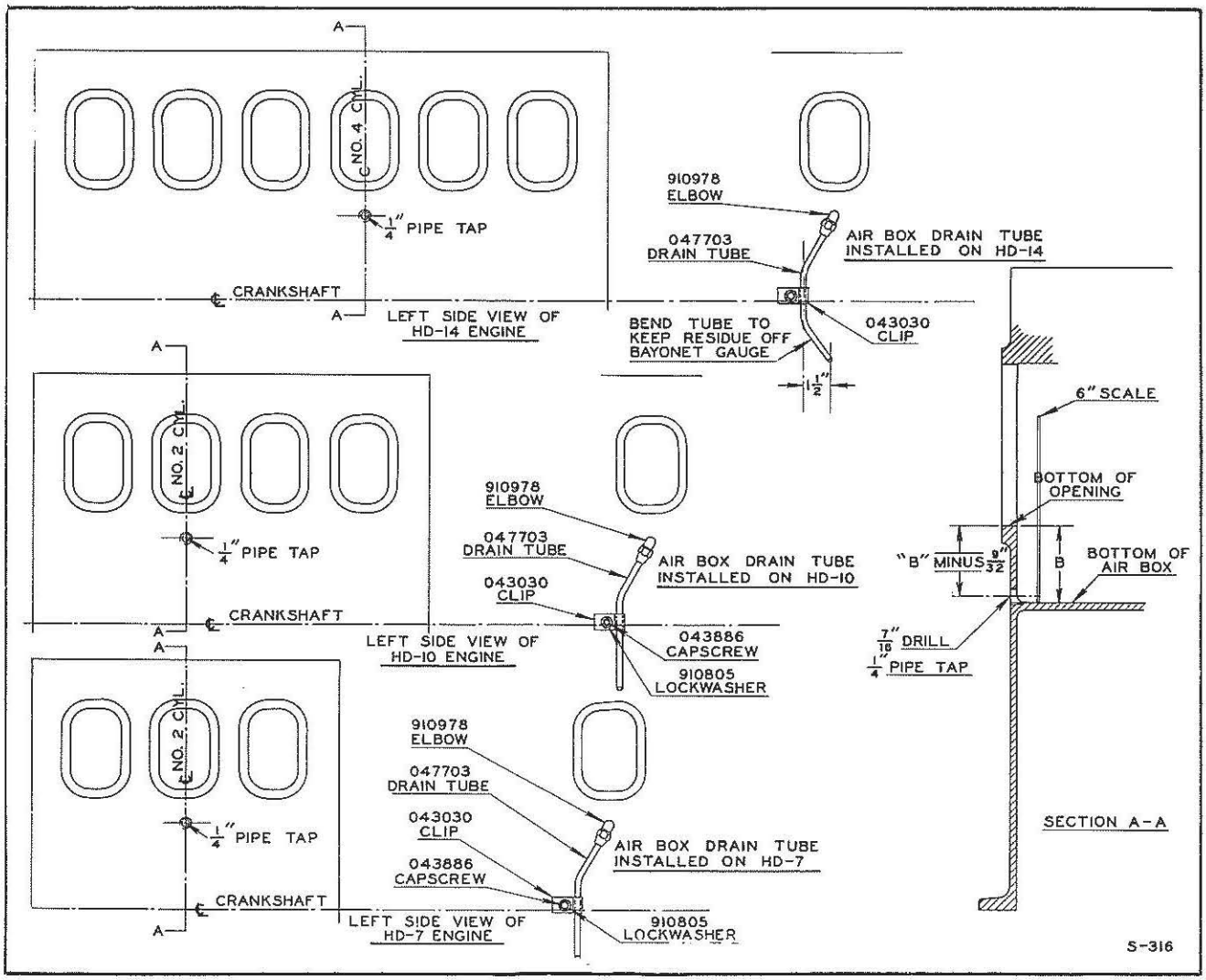


FIG. 3

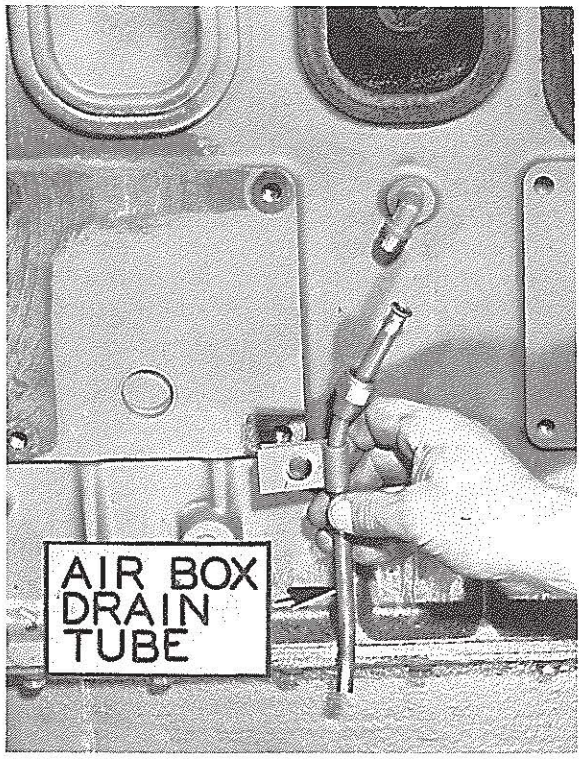


FIG. 4

3. The improved drain tube should be installed if possible.
4. It is very important that a careful measurement be made to locate the hole. Use a 6" scale as shown on sketch and measure from bottom of air box to bottom of hand hole—dimension B. Make sure scale does not rest on curvature of casting or on sludge particles which may be on bottom of air box. If dimension B is not correct, the hole will not be located to properly drain air box. To locate center of new drain hole use dimension B minus 9/32" and measure down on outside from bottom of hand hole.

   CAUTION: Care should be used when locating center of hole to be drilled as there is danger of drilling into bottom of air box. The correct measurement is, B minus 9/32". Measurement B will vary on different engine blocks so it will be necessary to measure on each engine to locate the drain hole.
5. To drill hole in air box on the HD-10 and HD-14, it will be necessary to remove the left front fender. Use a ratchet drill or weld an extension on a $\frac{7}{16}$" drill to make the drill about 14 inches long so that it will clear the motor support and allow an electric drill or a breast drill to be used. With the extension drill you will find that the drill will have to be slanted downward slightly to reach the spot marked on the block. This will cause the hole to angle downward but by exercising special care when tapping, the hole can be tapped horizontally.
6. To drill the hole in the air box on the HD-7 it will be necessary to remove the left front fender. The block is then readily accessible and no special tools will be necessary. It is suggested that a small pilot drill be used first, then a $\frac{7}{16}$" drill. Cut threads in hole with a $\frac{1}{4}$" pipe tap. Do not run tap in too far at first. Use tap and then try #910978 elbow. A desirable fit is obtained when elbow is in proper position and tight in hole with threads just extending through wall of cylinder block. If the threads are cut too deep in hole, #910978 elbow will go in too far and there will not be enough clearance between elbow and block to start nut on air box drain tube assembly. After elbow is installed, connect drain tube to elbow and clip tube to block using #043030 Clip and capscrew as shown in sketch.
7. The #047703 Drain Tube Assembly is used on all three model engines. On the "HD-14", install and clip tube as stated then bend tube as shown to prevent air box residue from blowing on bayonet gauge.
8. When improved air box drain tube is installed, original drain tubes should be removed and $\frac{1}{8}$" pipe plugs installed. Otherwise collapse old drain tubes so they will be closed.
9. For installation on tractors below the effective serial numbers, order 1—047703 Drain Tube, 1—910978 elbow, 1—043030 Clip, 1 Capscrew #043886 and 1 lockwasher 910805 for "HD-10" and "HD-7". Order same for "HD-14" but omit capscrew and lockwasher.

C. CLEAN CYLINDER BLOCK, OIL AND WATER PASSAGES

1. The motor must be completely dismantled. Refer to Topic 73-A.
2. To clean the oil passages, remove the various plugs in passages.
3. These passages can now be cleaned by high steam pressure with a solvent used in the water, to cut the sludge and foreign material that has collected.
4. After cleaning with solvent is finished, solvent must be flushed out with clean water under pressure. Make sure when replacing plugs that they are white leaded and put in their respective places.
5. To clean the water jacket of block remove the brass plugs around the water jacket. High pressure steam and water can be applied through these openings; place the block in various positions while this is being done so that the loose scale may be washed out.

6. After the cleaning is complete, replace the plugs with white lead and tighten securely.

D. CYLINDER HEAD OIL GASKET LEAKS

1. When cylinder head gaskets are replaced the cup plugs in the four corners of the cylinder block should be inspected for tightness. In case plugs are loose a recommended procedure is to drive the plug deeper in the hole and assemble a second plug, coating same with "Aviation Prematex", "Casola", or equivalent to provide a permanent seal. This will avoid any possibility of leakage at these points. Refer to Fig. 5.
2. Plugs may be purchased under the following part number: 5151122.
3. Hone cylinder block for loose liner that previously used pressed in liner.

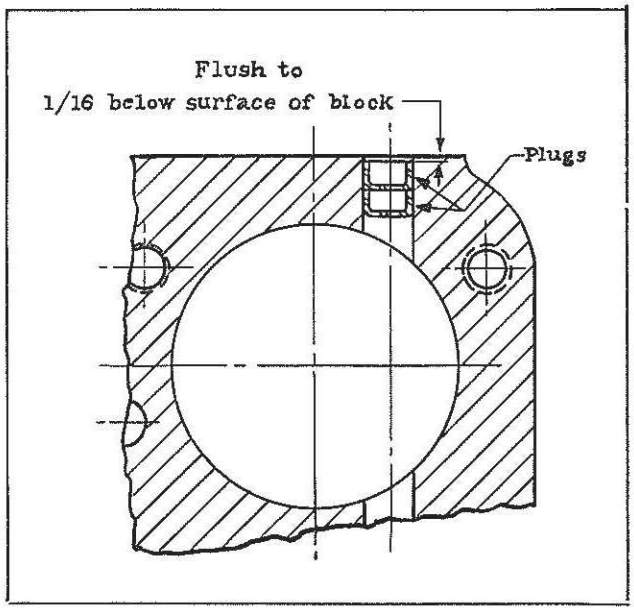
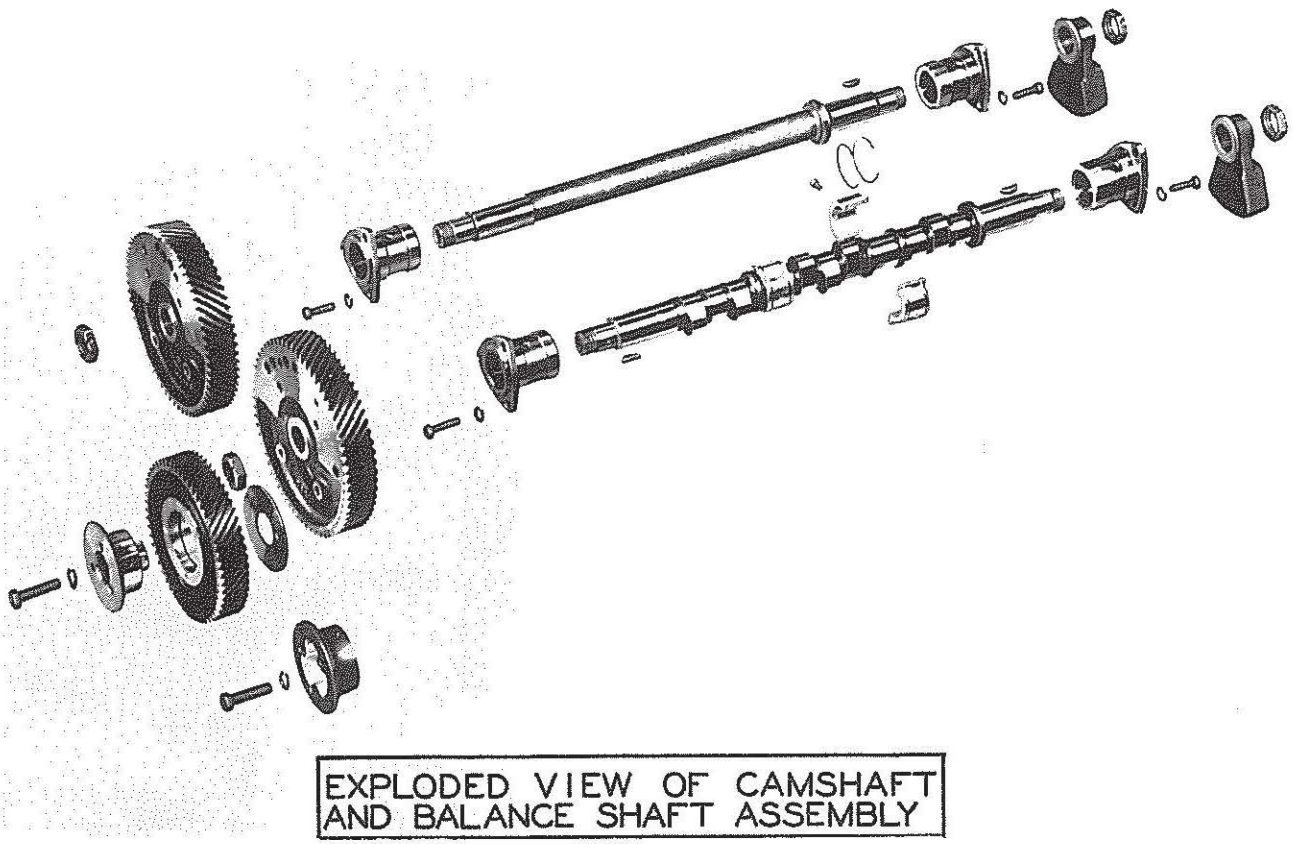


FIG. 5

86 -- Camshaft and Balance Shaft



EXPLODED VIEW OF CAMSHAFT AND BALANCE SHAFT ASSEMBLY

FIG. 1

DESCRIPTION. The camshaft is a one-piece drop-forging, case hardened at cams and journals, and is located in top of cylinder block. A one-piece bearing cage at each end, and intermediate bearings between each set of cams, provide a rigid support. The two halves of each intermediate bearing are held together by two spring retainers and the complete bearing is locked into place by a shouldered set screw in top of cylinder block. The bearing at front end of camshaft absorbs the drive thrust.

The cams are ground with parallel surfaces to promote efficient, quiet roller action, and are heat-treated to provide a hard wearing surface on working portion of cams.

The balance shaft runs parallel to the camshaft in top of cylinder block. The balance shaft, like the camshaft, is supported by a one-piece bearing cage at each end but has no intermediate bearings. In addition to the counterweighted gears at rear end, balance weights are used at the front end of both the balance shaft and camshaft. The front end balance weights are different for the three, four and six cylinder engines in that the weights are lightest for the three cylinder, somewhat heavier for the six cylinder and still heavier for the four cylinder.

The camshaft and balance shaft end bearings are lubricated from four vertical oil passages in the cylinder block which communicate with the main oil gallery. The camshaft intermediate bearings are lubricated by oil from the hollow camshaft.

A. REMOVAL

1. Remove motor from tractor, refer to Topics 74, 75 and 76 for removal instructions.
2. Remove clutch and flywheel.
3. Remove cylinder head and flywheel housing.
4. Remove front balance weight cover.
5. To prevent gears from rotating, roll a clean rag into the teeth of the timing gears. Straighten the tongues on lockwashers, and loosen retaining nuts on each end of both the balance shaft and camshaft. Remove nuts.
6. Withdraw the balance weights from balance shaft and camshaft. A slight pry will remove the weights.
7. Back out the special fillister head lock screws from top of cylinder block at each camshaft intermediate bearing.
8. Remove 3 capscrews from each rear end balance shaft and camshaft bearing cage, by means of a socket wrench inserted through a hole in the web of timing gears.
9. Withdraw both the balance shaft and camshaft timing gears and bearing assemblies from rear end of cylinder block.

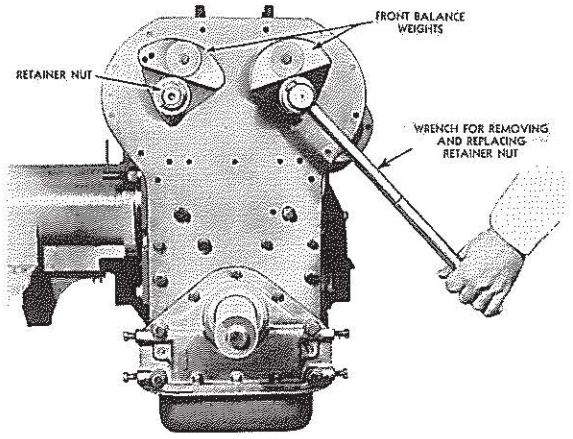


FIG. 2

10. Remove the 3 capscrews from each bearing cage at the front end of the balance shaft and camshaft; remove the cages from the engine block front end plate.

B. REMOVAL OF PARTS FROM CAMSHAFT AND BALANCE SHAFT

1. The gears may be removed from both the camshaft and balance shaft by supporting the shaft and gear assembly in an arbor press and pushing the shaft through the gear, as shown in Fig. 3.

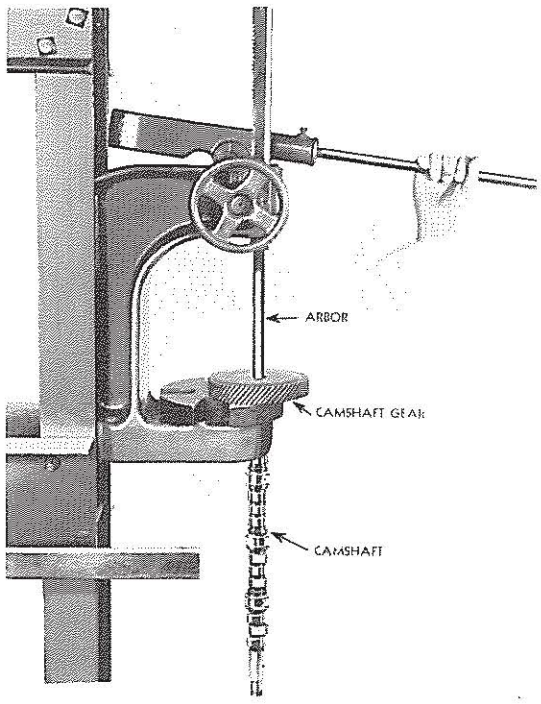


FIG. 3

2. After gears are removed, end bearings may be removed from shafts.
3. Remove spring retainers from camshaft intermediate bearings and remove the 2 halves of each bearing.

C. INSPECTION

After all parts have been cleaned and dried

with compressed air, inspect all bearings and journals for good bearing surfaces and wear before installing the parts.

Radial clearance on camshaft and balance shaft bearings is from .0015" to .003" and should not exceed .005". End clearance for these same bearings is from .002" to .005" and should not exceed .010".

Should any of the bearings show scoring or be worn so clearances exceed limits given above, install new bearings. Examine cam surfaces for wear or scoring. If cams are scored install a new shaft.

Oil is fed through the hollow camshaft to its intermediate bearings; therefore, all oil holes should be examined in the shaft and in the bearings. Sludge accumulations, might restrict the oil flow, and should be removed.

D. INSTALL PARTS ON CAMSHAFT AND BALANCE SHAFT

Parts shown below should be assembled on camshaft and balance shaft before they are installed in cylinder block.

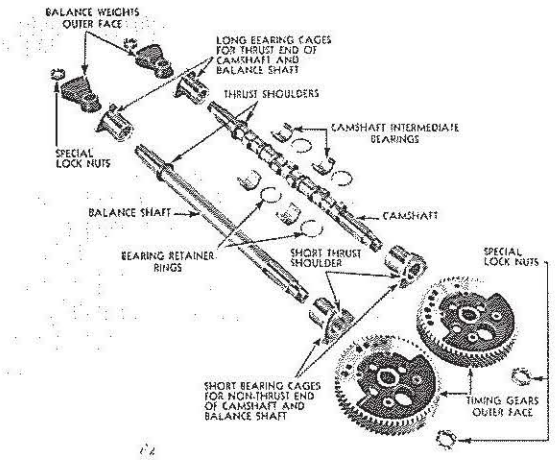


FIG. 4

Note that the teeth on one timing gear form a right-hand helix, and on the other, a left-hand helix. When viewing engine from rear, the gear with right-hand helical teeth is located on left side and vice versa for right side.

The camshaft and balance shaft gears are the same for all engines; but weights are attached to these gears on the 4 and 6 cylinder engines for balancing purposes. No weights are attached to the gears on the 3 cylinder engine. Camshaft and balance shaft gears from a 3 cylinder engine may be used on the 4 or 6 cylinder engines, if the specified weights are attached; the gears from either a 4 or 6 cylinder engine may be used on a 3 cylinder engine, if the weights are removed from the gears.

1. With end bearings located on shaft, place Woodruff keys in shafts and press the timing gears on the camshaft and balance shaft.
2. Start nuts on each shaft.
3. Install the intermediate bearings in place on camshaft and lock the 2 halves together with 2 spring retainers on each bearing.

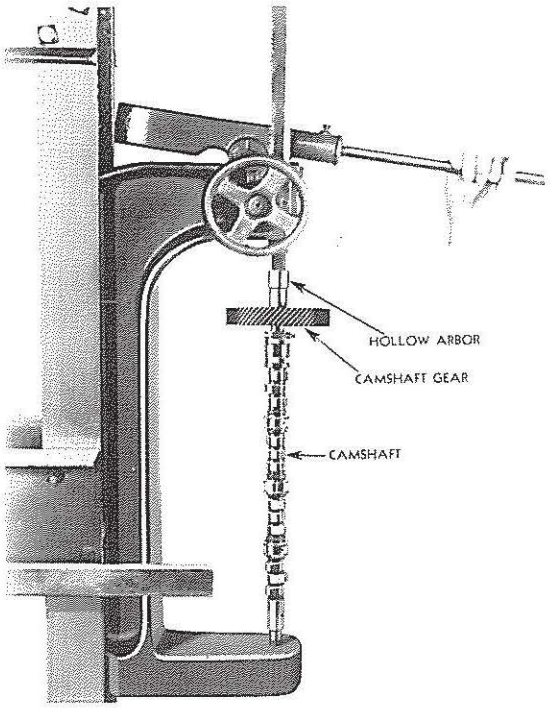


FIG. 5

THRUST BEARING ASSEMBLY "SECOND TYPE"

The first type camshaft and balance thrust bearing was a one piece assembly with plated thrust surfaces integral with the bearing cage as shown in Fig. 6. The second type became effective with engine serial numbers 3714702, 4716608 and 67116791. The intergral thrust surfaces of the first type are replaced by steel-backed bronze, washer type bearings which are separate and loose from the bearing cage. These are assembled at each end of the bearing, as shown in Fig. 7, with the bronze surfaces facing outward. Only the second type Bearing Assembly will be supplied for all service.

1. The second type camshaft and balance shaft thrust bearing is interchangeable with the first type part. However, the thrust washers are loose, and must be assembled to the cage before the bearings are installed. The thrust washers cannot be used with the first type bearing.
2. The second type cam and balance shaft bearing assembly which includes thrust washers is carried under part number 5159559. The cam and balance shaft

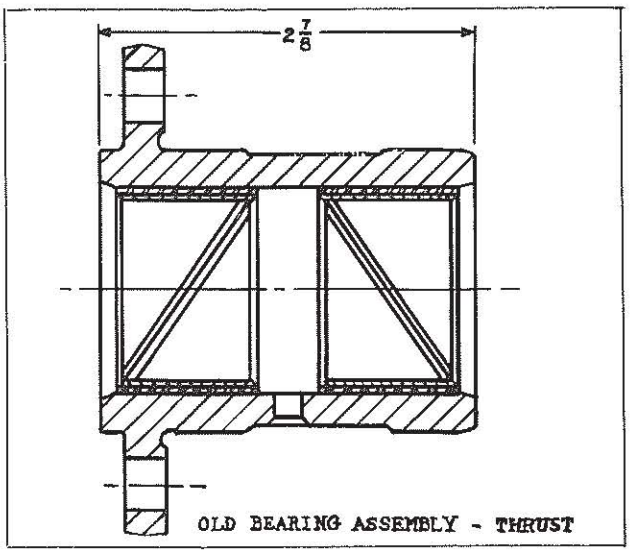


FIG. 6

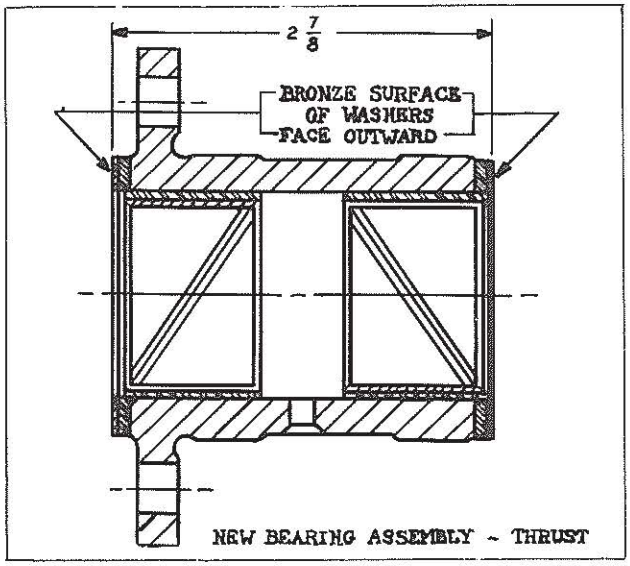


FIG. 7

thrust washer is carried under part number 5158917. The second type bearing assembly will only be serviced complete with thrust washer. Replacement thrust washers may be purchased separately.

3. When engines are disassembled for the first time it will be noted that the balance shaft thrust bearing is assembled at the front end of the engine, the same as the camshaft thrust bearing. This is followed in production to facilitate new engine assembly. It is not an absolute requirement that the balance shaft thrust bearing be installed in the front end of the engine as this bearing may be installed in the front or rear of the engine, whichever is most convenient.
NOTE:: THE CAMSHAFT THRUST BEARING MUST BE INSTALLED IN THE FRONT END OF THE ENGINE.
4. Thrust bearings are distinguished from plain bearings by the presence of oil grooves in the bushings.
5. To install new thrust bearing assemblies proceed as follows:
   a. Apply some heavy cup grease to the steel faces of the thrust washers and then place one of these washers against each end of the bearing. (Be sure the steel faces are next to the bearing ends.)
   b. Lubricate shaft journals. Install the bearing assembly on the shaft journal with bolting flange of bearing toward outer end of shaft. BE CAREFUL NOT TO DISLODGE LOOSE WASHERS ON END OF BEARING WHEN PLACING THE THRUST BEARING ON SHAFT.

E. INSTALLATION OF CAMSHAFT AND BALANCE SHAFT

The necessary parts, as shown, having been attached to camshaft and balance shaft, these assemblies may be installed in cylinder block as follows:

1. Install end bearing for front end of camshaft and balance shaft in engine block front end plate, and secure in place with lockwashers and capscrews.
2. Start camshaft, bearing and gear assembly into position at rear end of block on the side of cylinder block opposite exhaust manifold and slide into place.
   The idler gear will be on the side of engine opposite camshaft and the positioning of timing marks will take place when the balance shaft is installed in position.
3. Secure bearing cage for rear camshaft bearing to engine block rear end plate with 3 lockwashers and capscrews. These capscrews are accessible through the hole in timing gears.
4. Revolve the camshaft intermediate bearing so locking holes in bearing align with holes in top of cylinder block, and install lock screws.
5. With Woodruff key in place, slide the balance weight on front end of camshaft, with the overhanging section of the weight facing away from engine block.
6. With the exception that the balance shaft has no intermediate bearings, the procedure for installing this shaft in cylinder block is the same as that followed in installing the camshaft. The timing marks "O" on the camshaft and balance shaft gears must face each other. Topic 80, Fig. 1. Viewing engine from rear the idler gear is located on the left side of cylinder block, and the marking "R" which appears on crankshaft gear must face one of the "R" marks on the idler gear. The other "R" mark on idler

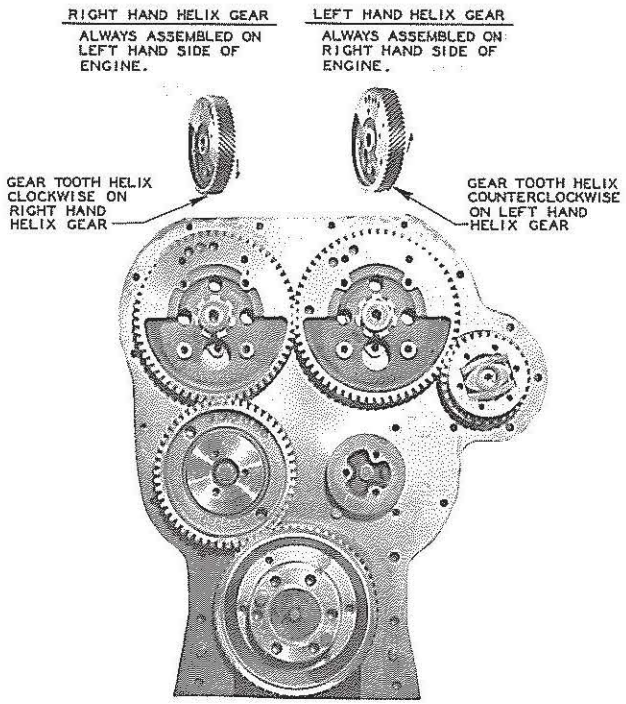


FIG. 8

gear must face the "R" mark on the balance shaft gear.

7. The camshaft and balance shaft both having been installed, wedge a clean cloth between the teeth of the timing gears and draw nuts as tight as possible with a 16" wrench and lock them in place.
8. On the 6 cylinder engine, the balance weights "A" articulate on the balance weight hubs "B". Fig. 10. After the balance weight assemblies are locked in place on the shaft a clearance of .008" should be maintained between the weights "A" and the hubs "B". If clearance does not exist as shown, the weights will not articulate on the hubs and the engine might be "rough".

NOTE: Solid balance weights are used on the 3 and 4 cylinder engines; these weights are simply keyed and locked to the shaft with special lock nuts. The front end balance weights are different for the three, four and six cylinder engines, the weights are lightest for the three cylinder, somewhat heavier for the six cylinder and still heavier for the four cylinder engine.

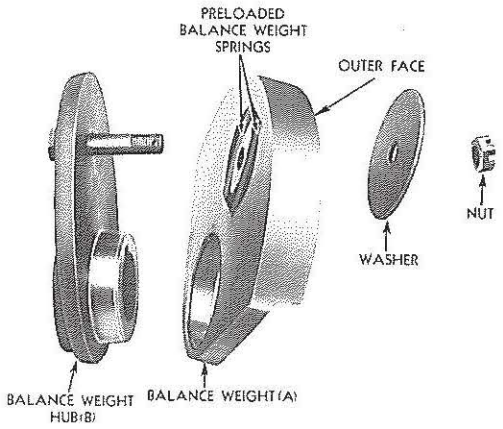


FIG. 9

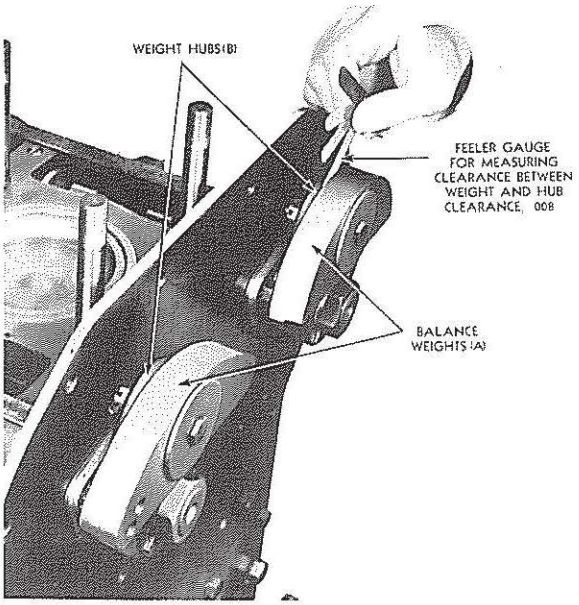


FIG. 10

F. REASSEMBLY OF MOTOR

Reverse the removal process for installing the flywheel housing, flywheel, etc.

87 -- Gear Train Cover and Flywheel Housing

A. REMOVAL OF GEAR TRAIN COVER AND FLYWHEEL HOUSING

1. Remove the motor from the tractor as directed in Topics 74, 75 and 76, "Motor Removal."
2. Remove the clutch from the flywheel and remove the flywheel.
3. Remove the capscrews and bolts holding the housing to the rear cylinder block end plate and rear lifter bracket; also remove the capscrews in the rear of the oil pan where it fastens to the

housing. Loosen all capscrews in oil pan. Now remove the housing.

NOTE: REVISED FLYWHEEL HOUSING GASKETS

The flywheel housing large and small gaskets have been reduced in thickness from the former 1/32 to 1/64.

INTERCHANGEABILITY: Is affected. Both large and small gaskets of the new thickness must be used together when replacements are necessary. Therefore, a new service gasket set is provided under part number 5150025 which includes the necessary gaskets to affect a complete changeover to new design.

B. INSPECTION

The purpose of removing the housing alone is to replace the rear oil seal and inspect housing for cracks.

C. INSTALLATION OF GEAR TRAIN COVER AND FLYWHEEL HOUSING

1. Soak the new oil seal in motor oil for at least 30 min: before installing. Drive the old oil seal out. Shellac flywheel housing before pressing new seal into place.
2. Place the oil seal assembly tool on the two dowel pins in flywheel end of crankshaft, and install flywheel housing as shown. Care must be taken when placing housing over the seal tool, that the edge of seal does not catch on edge of assembly tool. This can be very easily overlooked and will ruin seal. Install bolts in housing, and tighten capscrews in oil pan.
3. Remove special tool.
4. Install flywheel and clutch.
5. Install motor in the tractor reversing removal procedure.

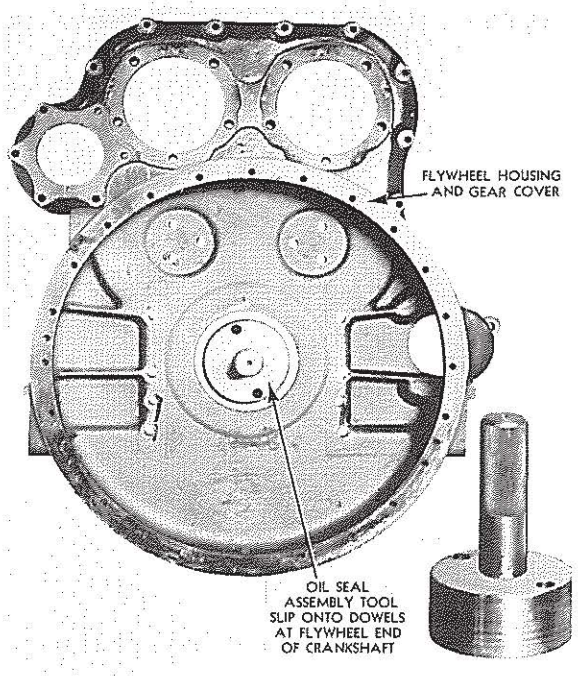


FIG. 1

88 -- Flywheel

A. REMOVAL OF FLYWHEEL

1. Remove motor from tractor as directed in Topics 74, 75 and 76.
2. Remove clutch from flywheel.
3. Remove the 6 capscrews holding the flywheel to the crankshaft.
4. There are two 7/16" N. C. threaded holes in the flywheel to facilitate removal. Screw two 7/16" N. C. capscrews into these holes, pushing the flywheel off the crankshaft hub.

B. INSPECTION OF PARTS

1. If a new starter ring gear is to be installed on the flywheel, remove the old ring by grinding a notch through, at the root of a tooth.
2. To install the ring gear; heat the gear uniformly to 450° F. (red heat, visible only in the dark) and place it in position on the flywheel which is at room temperature.

NOTE: The ring gear should not be over-

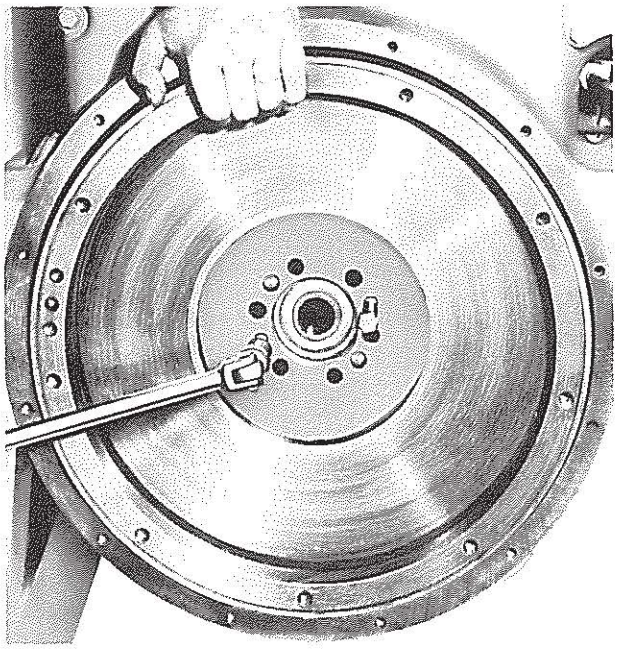


FIG. 1

heated as the original heat treatment will be destroyed.

C. INSTALLATION OF FLYWHEEL

1. Install the flywheel on the crankshaft hub.
   NOTE: The capscrew holes in the crankshaft are irregularly spaced so the flywheel cannot be installed incorrectly. After capscrews are installed, lock with wire.
2. Install the clutch and install the motor in the tractor. See Topics 74, 75 and 76, "Motor Installation."

89 -- Lubricating Oil Pump

A. REMOVAL OF OIL PUMP

3 AND 4 CYLINDER ENGINES

1. Remove engine support bottom cover.
2. Drain oil from crankcase.
3. Remove the oil pan.
4. Remove the oil pump outlet pipe, oil pump inlet bracket, and the 2 nuts holding pump to the main bearing cap. The pump can now be removed by sliding it back so the oil pump drive gear shaft disengages the oil pump drive sleeve. Watch for shims between pump assembly and main bearing caps, they are used to obtain proper tension on drive chain, some engines do not require shims.
5. Remove the oil pump by-pass valve assembly.

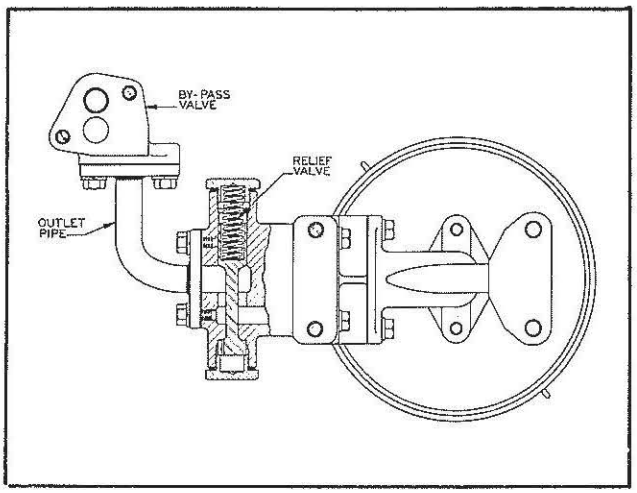


FIG. 1

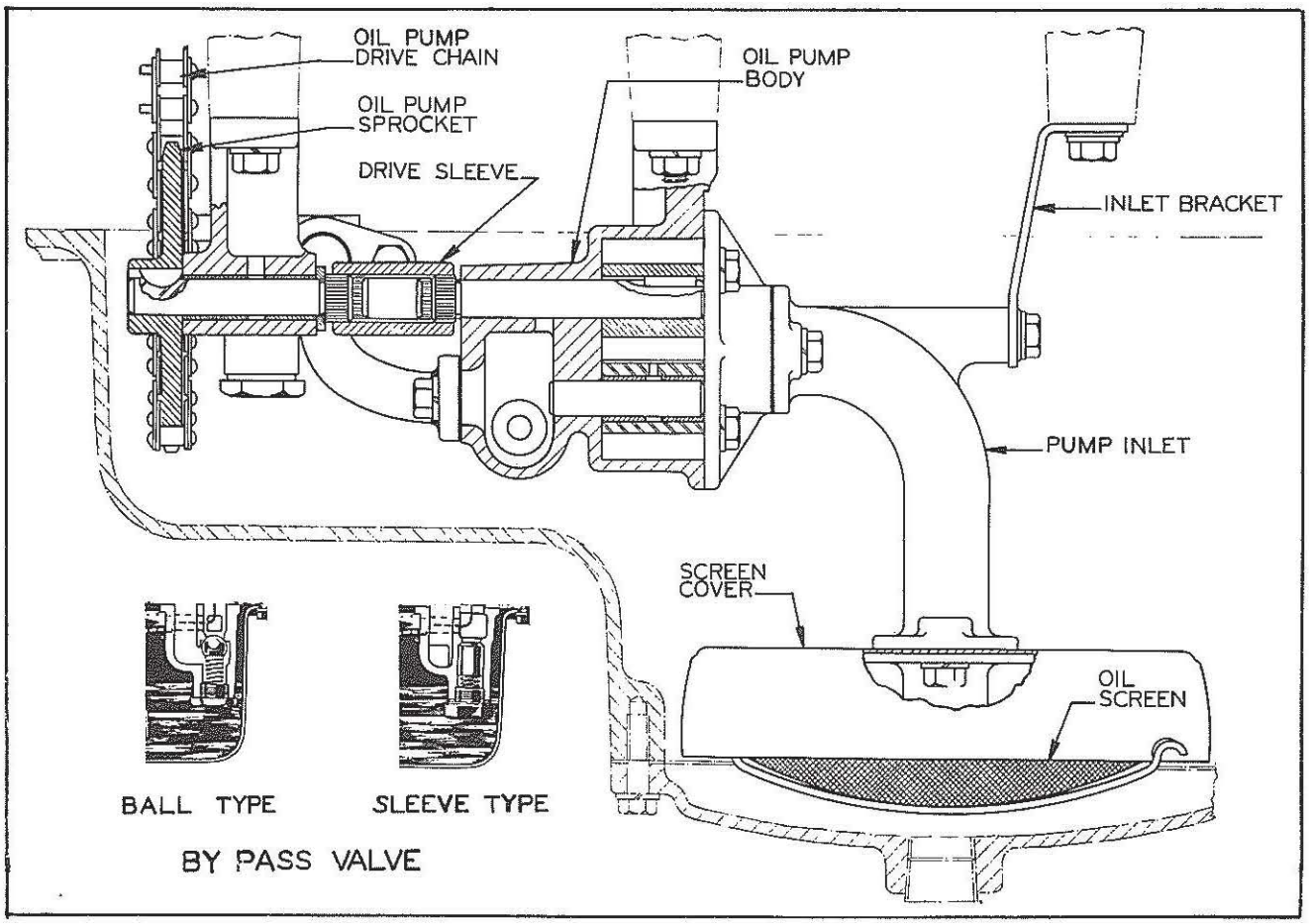


FIG. 2

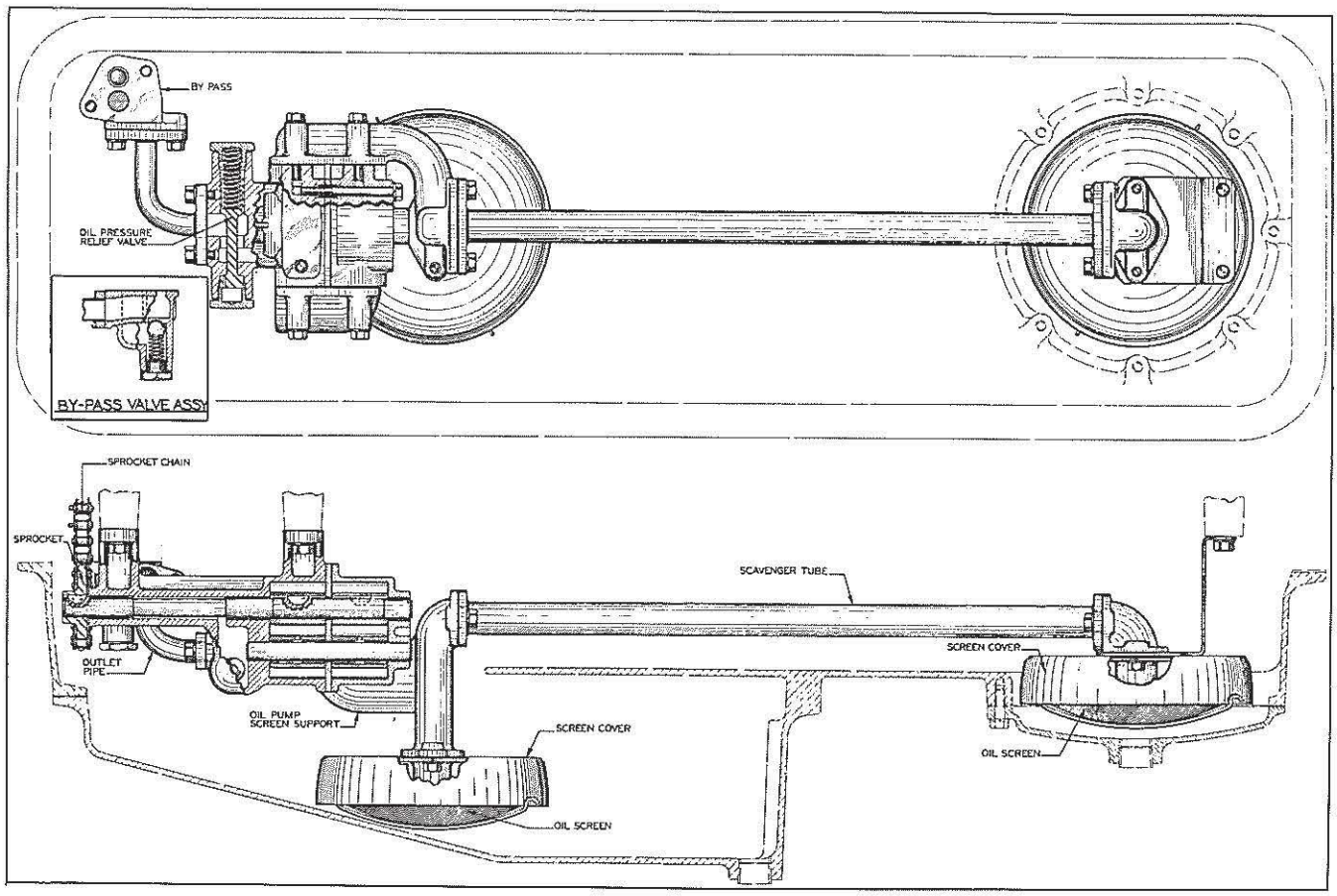


FIG. 3

6. Remove oil pump sprocket shaft assembly from front main bearing. By manipulating sprocket assembly, sprocket can be disengaged from sprocket chain.

6-CYLINDER ENGINES

On the 6-cylinder engines remove the capscrews holding the pump assembly to the main bearing caps and slip the pump shaft sprocket from beneath the drive chain.

NOTE: If motor is out of tractor and bottom side up, support chain to prevent it from dropping down inside crankshaft front cover.

B. DISASSEMBLE OIL PUMP

6-CYLINDER ENGINES

NOTE: Care should be taken when disassembling pump to notice relative position of parts thus saving valuable time in assembling. Refer to Figs. 3 and 4 while disassembling pump.

1. Remove the 2 retaining nuts and copper gaskets from each side of pump body and jar the relief valve assembly from body of pump.
2. Remove the pump cover from the body.
3. Remove the pump idler gear from stub shaft.
4. Fasten pump body in vise, place puller on sprocket and pull sprocket from shaft as shown in Fig. 5.

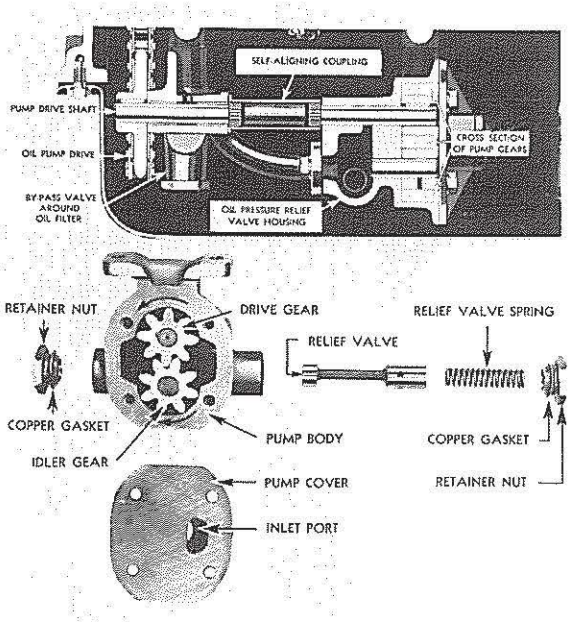


FIG. 4

5. Remove Woodruff Key from shaft and withdraw shaft from pump body.
6. If drive gear is to be removed from shaft, place gear on press and push shaft through gear.

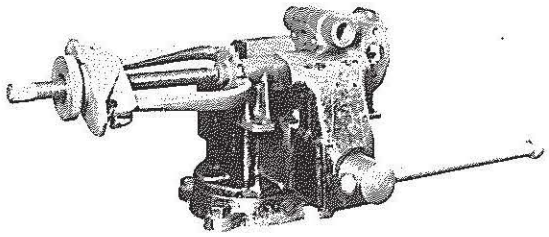


FIG. 5

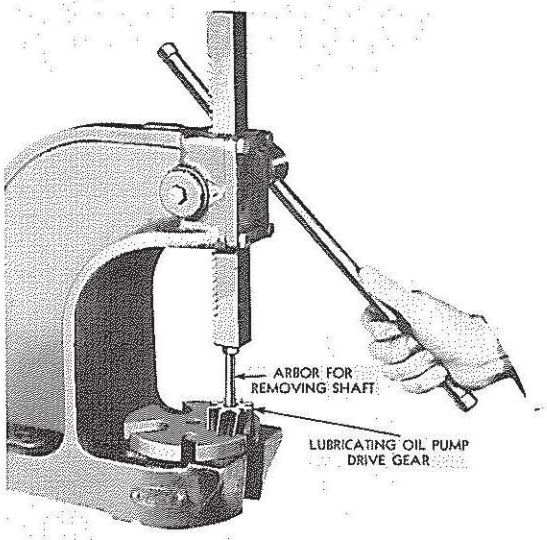


FIG. 6

3 AND 4-CYLINDER ENGINES

1. Steps 1 to 3 are the same as for the 6-cylinder engines.
4. Place pump body and drive-gear assembly on bed of arbor press, "cover side" up, and by means of arbor on gear end of pump shaft, press shaft through gear, removing gear and feather key from the shaft.

NOTE: Be careful not to cover keyway with arbor when removing gear, thereby preventing key from being removed with gear.

C. INSPECTION OF OIL PUMP PARTS

1. Wash all oil pump parts thoroughly before inspection.
2. The principle wearing parts are the gears of the oil pump. If the oil has been kept clean the wear on these parts will be very slow. If, however, dirt and sludge have been allowed to accumulate due to negligent oil filter servicing, wear on these gears will be rapid. This practice abuses not only the oil pump, but other parts of motor as well.
3. Inspect gears for wear and scored teeth; if worn or scored install new gears.
4. In an efficient pump, the gears will run freely with no perceptible looseness.
5. Inspect seat and ball of by-pass valve (first type); install new parts where necessary.
6. The second type by-pass valve is a sleeve type; inspect assembly, install new parts where necessary.

D. ASSEMBLE OIL PUMP

1. The oil pump operates in clockwise direction when viewed from sprocket end, and the intake will be located on left side. Relief valve will be on the same side of pump (toward blower side of engine).
2. The gear and pump drive shaft has a Keyway about 1-5/8" from end of shaft. If gear was removed, install Woodruff key and press gear on shaft with arbor, press until inner end of gear is $6\frac{15}{32}$" from sprocket end of shaft.
3. Lubricate the shaft and insert it into the pump body.
4. Install Woodruff key at the sprocket location and align the keyway with the key. Start sprocket on the shaft with flat face of sprocket facing pump body.
5. Support gear end of pump shaft on bed of arbor press and press sprocket on shaft to within .010" from pump body.
6. Lubricate stub shaft and install idler gear.
7. See that finished face of pump body is perfectly flat so that it will make a tight joint between cover and body as there is no gasket used at this joint.

NOTE: Observe Fig. 4 as to the position of the oil pump covers for the 3 and 4-cylinder engines. After pump is assembled, revolve shaft by hand to see if there is any bind. Pump shaft will turn freely when the pump is correctly assembled.

E. INSTALLATION OF OIL PUMP

With main bearing caps in place and the pump drive chain in position on the crankshaft sprocket, the lubricating oil pump may be installed as follows:

1. On the 6-cylinder, work sprocket on pump shaft under drive chain and secure pump assembly to main bearing caps with 4 lockwashers and capscrews.
   On the 3 and 4-cylinder, secure pump assembly to number two bearing cap, but dont tighten. If shims were remov-

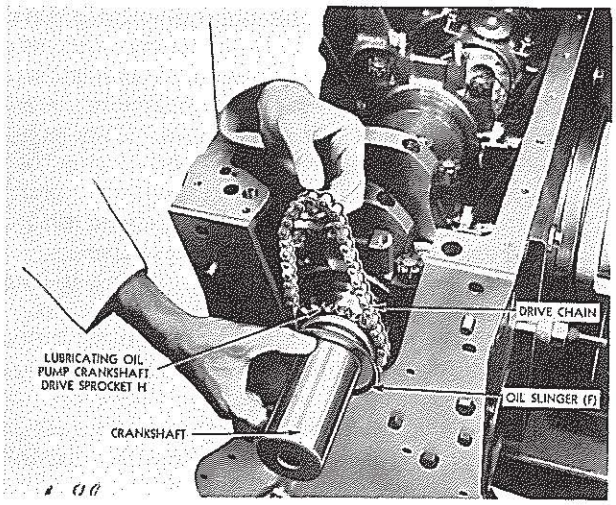


FIG. 7

ed, they must be replaced for correct chain tension. Pump may need shifting later to align drive coupling.

If driven sprocket and bearing assembly was removed, slip drive coupling on end of pump shaft and work sprocket under drive chain, slip drive coupling back on sprocket shaft and secure assembly to front main bearing cap with 2 lockwashers and capscrews, finger tight only. Observe whether coupling slips freely on both shafts with pump and sprocket bearing assembly in place. Coupling must be free on both shafts when assemblies are tightened in place.

NOTE: Inspect backlash of the oil pump drive chain, this must be from ¼" to ¾". Add or remove shims to obtain correct backlash.

2. Using new gasket, attach by-pass valve housing to cylinder block with 2 lockwashers and capscrews.
3. Using new gasket at each end, attach oil outlet pipe to by-pass housing valve and oil pump body, with 2 lockwashers and capscrews at each end.
   CAUTION: The 2 capscrews attaching oil outlet pipe to pump body must not exceed ⅞" in length.
   When tightening capscrews on oil outlet pipe, shift drive coupling endwise at the same time. If coupling binds on shaft, loosen and shift sprocket bearing assembly and perhaps outlet pipe, then retighten so coupling is free.
4. Position screen supports on the 2 correct main bearing caps and, with lockwashers on capscrews, start capscrew in place. Do not tighten.
5. Using new gasket at pump end, secure oil outlet pipe to pump body on 6-cylinder or to pump cover on 3 and 4-cylinder engines.
6. Install screen cover, screen and screen retainer on the 3 and 4-cylinder motors.
   NOTE: On the 6-cylinder motor install the scavenger tube and rear screen assembly.
7. Inspect for tightness of bolts and install oil pan.
   NOTE: Install upper oil pan on 6-cylinder motor. Then attach front screen assembly and install lower oil pan.
8. Refill with oil of proper specifications.

90 -- Oil Cooler

A. REMOVAL OF OIL FILTER AND COOLER ADAPTER

1. Drain the cooling system.
2. Remove the oil filter shell and oil filter element.
3. Disconnect the water by-pass tube from the cooler housing.
4. Remove the governor breather pipe.
5. Disconnect the cooler housing from the water pump and from the lower water connection.
6. Remove the 8 capscrews holding the cooler housing to the oil filter and cooler adapter.
7. Remove the oil cooler element.
   NOTE: Do not lay this element where it will be damaged; the fins on the cooler element can be damaged easily and will cause the oil to leak into the water.
8. Remove the 7 capscrews holding the oil

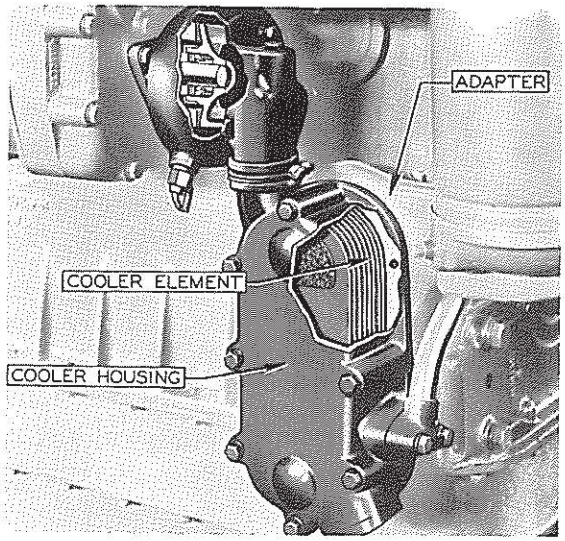


FIG. 1

filter and cooler adapter to the cylinder block.

B. INSPECTION

Inspect the oil cooler element for possible leaks, or for clogging.

C. INSTALLATION OF OIL FILTER AND COOLER ADAPTER

Be sure to use new gaskets throughout the installation of this assembly. SHELLAC THE GASKETS ON BOTH SIDES. Reverse the removal procedure to install the cooler adapter, cooler element, etc.

The above operations can be performed with the motor either in or out of the tractor.

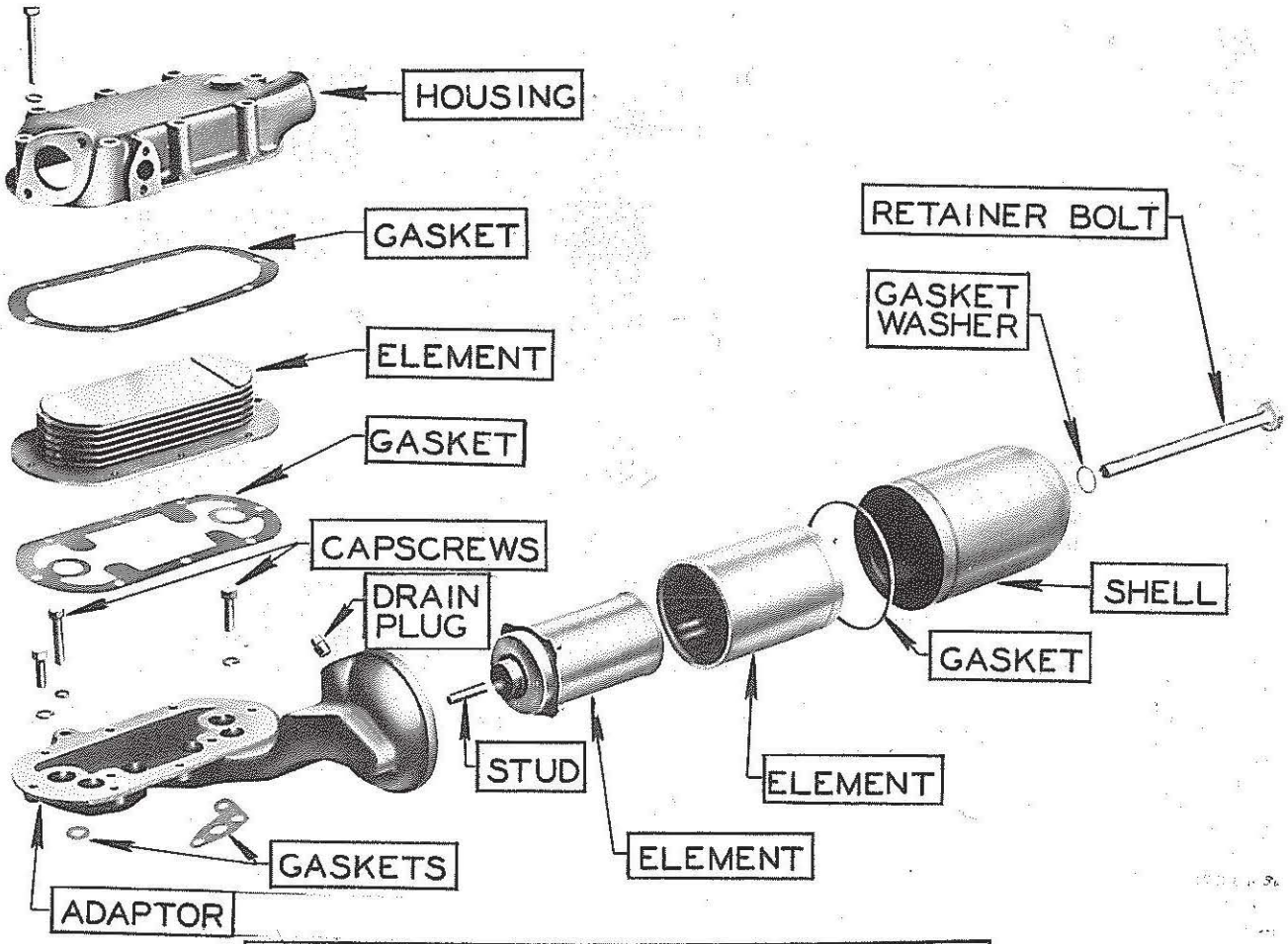


FIG. 2

91 -- Fuel Pump

Description—The fuel oil pump is the positive displacement vane type. The pump is bolted to the rear end of the blower cover, and driven from the lower blower rotor shaft through a U-shaped steel stamping which acts as a universal joint. An integral steel rotor and shaft supported in the pump flange and cover, revolves in a housing, the bore of which is eccentric to the shaft.

Two spring-loaded vanes, carried in the rotor, revolve inside the eccentric housing, thus displacing the liquid from the inlet to the outlet port. Two oil seals are used inside the flange at the drive end of the rotor shaft. One seal retains the fuel oil under pressure, the other prevents the lubricating oil in the blower timing gear compartment from creeping along the pump shaft.

The seals are located approximately $\frac{1}{16}$" apart and the feather edge of the leather on the inner seal faces the blower and that on the outer seal faces the pump body. A drain hole located between the two seals vents to atmosphere.

A spring-loaded, horizontal relief valve is provided in the cover of the pump, connecting the inlet and the outlet ports, which opens at a pressure of approximately 55 pounds per

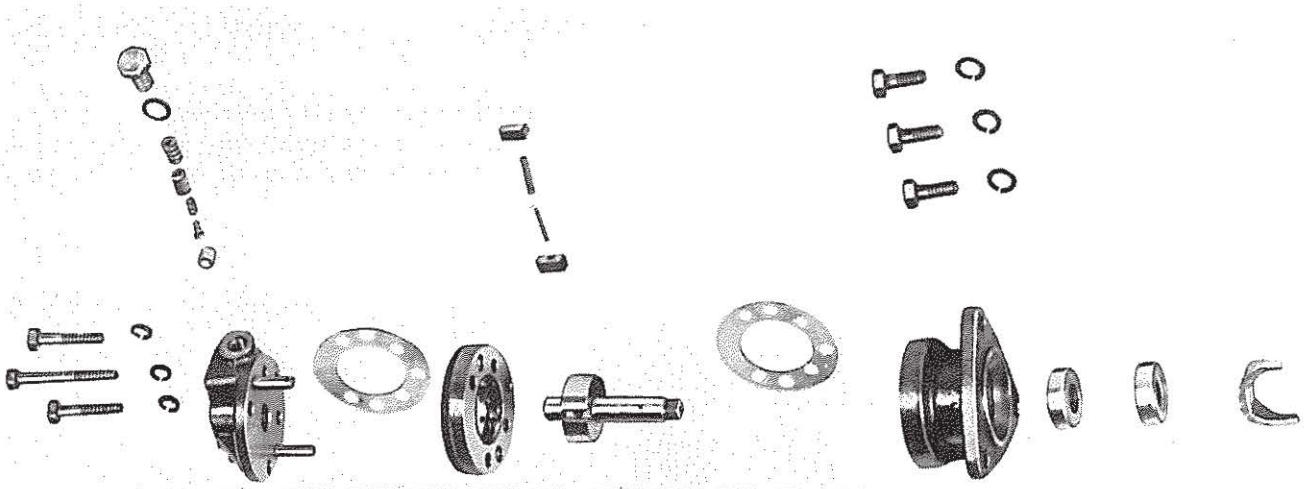


FIG. 1

square inch. This valve normally does not open since its purpose is to relieve excessive pump pressure in case any of the fuel lines or filters become plugged and build up an extremely high pressure in the pump. When the valve opens, fuel passes from the discharge side (pressure side) to the suction side of the pump.

When the fuel pump is installed on the blower, the inlet opening is always next to the cylinder block.

A. REMOVAL OF FUEL PUMP

1. Remove the right front fender.
2. Disconnect both the intake and discharge fuel lines from the pump.
3. Remove 3 capscrews that attach fuel pump to rear end of blower end cover.
4. Remove the pump and coupling fork as an assembly.

B. DISMANTLING FUEL PUMP

1. Remove the 3 capscrews that hold pump cover, body and flange together.
2. Drive the 2 dowels back into the pump flange and remove the cover and the gasket.

   CAUTION: Be careful not to destroy gaskets at each side of pump body as the same thickness gasket must be used again when assembling pump.
3. Tap pump body off dowels with soft faced hammer. Rotor assembly can be withdrawn from position after removing cover. As rotor assembly is removed, hold vane with fingers.
4. Use new seals when ever pump is dismantled. Oil seals must be removed and replaced with special tools. Figs. 3 and 6.

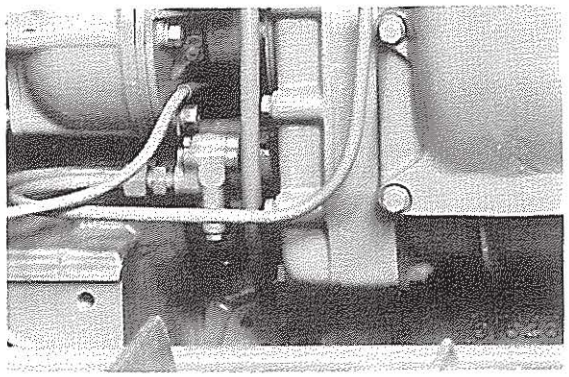


FIG. 2

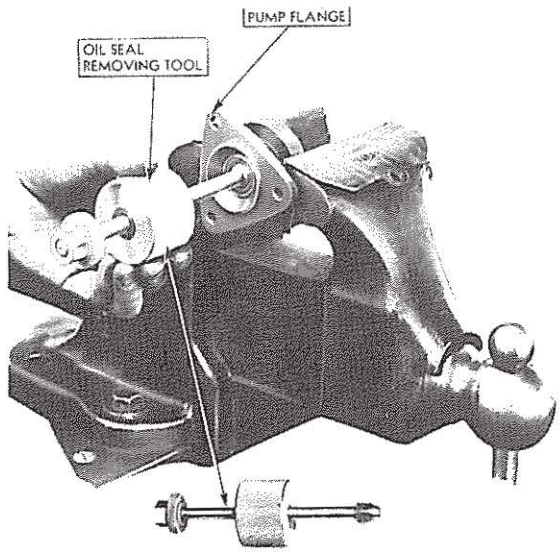


FIG. 3

C. INSPECTION OF FUEL PUMP PARTS

1. Inspect all parts for wear and breakage.
2. The paper gasket used on this pump body is the proper thickness. Do not use anything heavier.
3. If the relief valve does not form a tight seal with its seat, no attempt should be made to lap the valve or seat; new parts should be installed.

D. ASSEMBLE FUEL PUMP

1. Install the relief valve in the cover

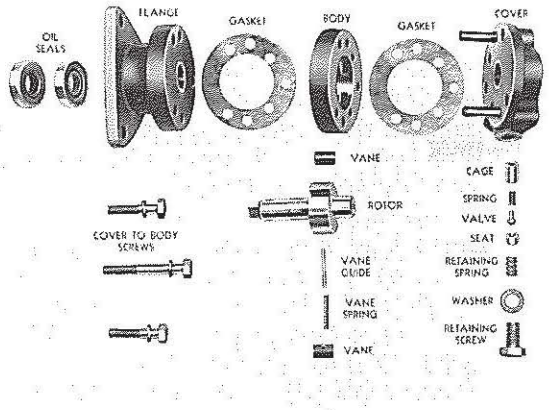


FIG. 4

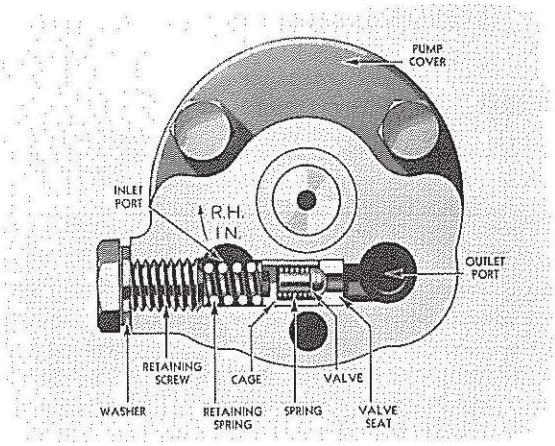


FIG. 5

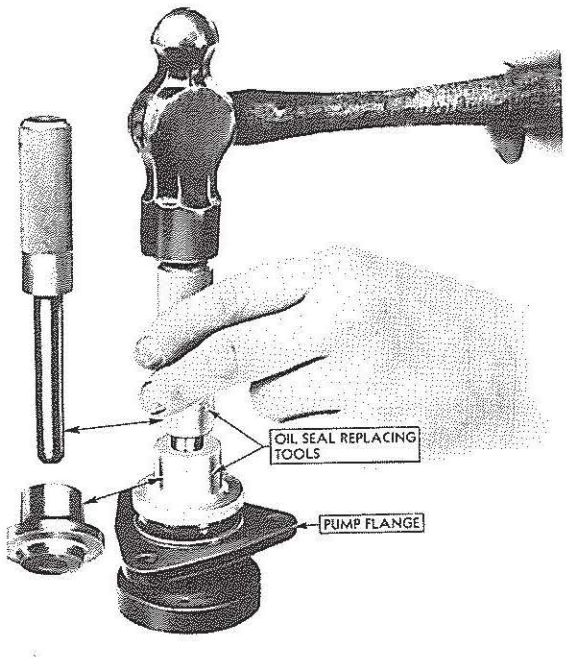


FIG. 6

using care to see that the relief valve seat is toward the fuel discharge opening. Fig. 5.

2. Install new seals in pump flange; locate seals as shown in Fig. 7; that is, with leather or inner seal pointing toward squared end of rotor shaft. Drive outer seal down tight against bottom of seal cavity and inner seal down to within approximately 1/16" from outer seal using special tool.
3. Withdraw the 2 dowels from the pump flange and start dowels through the 2 holes in the pump cover.
4. Install the gasket between pump cover and pump body and install body on cover with recessed portion of body at pump inlet and outlet toward bottom of pump. Drive dowel through body with faces of body and cover tight against gasket.

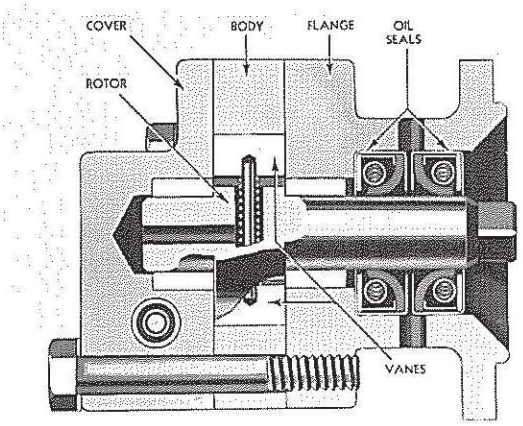


FIG. 7

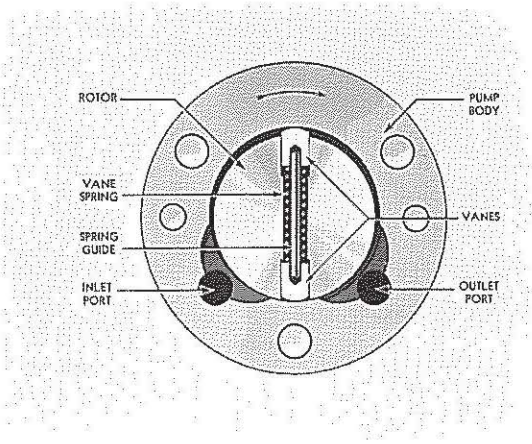


FIG. 8

5. Assemble spring guide, spring, and vane in rotor, compress vanes flush with outside diameter of rotor and place rotor on vane assembly in pump body. Fig. 8.
6. Use the assembling tool shown in Fig.

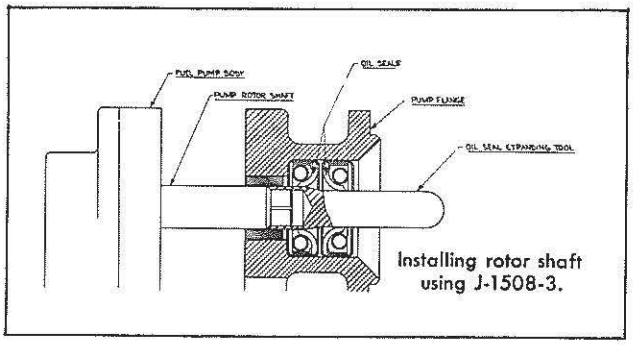


FIG. 9

9. Slide the flange on the rotor shaft and fasten pump securely together with the 3 lockwashers and capscrews.
7. See that the shaft turns freely before installing fuel oil connectors in pump cover. Make sure that the 3 capscrews bolting the pump cover to body are tight. Tightening the fuel connections with these capscrews loose may result in damage to rotor and shaft.

E. INSTALLATION OF FUEL PUMP

1. Install the drive coupling fork (arms out) on the squared outer end of the pump shaft and a new gasket on the pump supporting flange.
2. Set the pump assembly up against the blower end cover, being sure that the drive fork engages the slots in the driving plates. The lugs will engage the plate when the pump body rests tight against the end of the blower end cover.
3. Be sure that the end of the valve seat housing casting marked "IN" faces the cylinder block, then slide pump assembly into place and secure with 3 capscrews and lockwashers. Connect the fuel intake and discharge line to the pump.

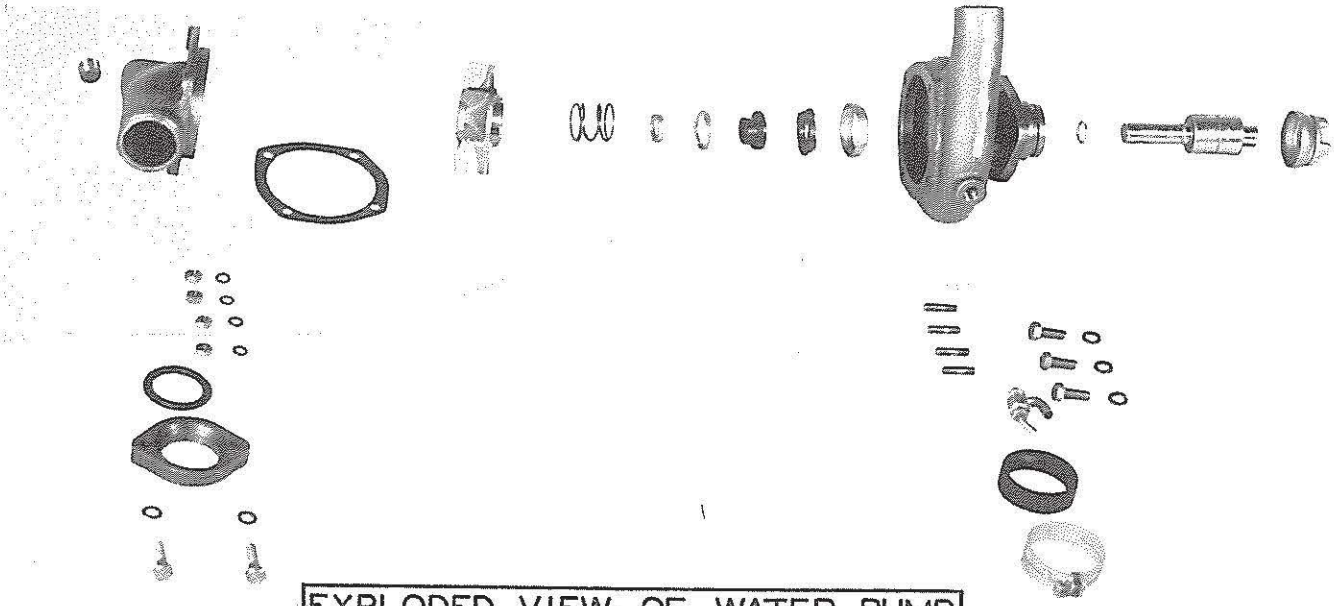
92 -- Water Pump

Description—A centrifugal-type water pump is used for circulating the cooling liquid through the cylinder block, cylinder head, and the radiator. A bronze impeller with straight blades is pressed onto one end of the case-hardened steel shaft, and a pump drive coupling with an oil slinger is pressed onto the opposite end. The oil slinger shrouds the inner end of the pump body flange to prevent oil from creeping along the shaft and through the shaft bearing. The shaft is supported at the drive end on a sealed double-row combination radial and thrust ball bearing, and prevented from moving endwise by peening the pump housing at the inner end of the bearing.

Water is prevented from creeping along the shaft at the impeller end by means of a spring loaded Neoprene seal, retained in the impeller by a brass stamping. A wire slinger is fitted on the shaft between the pump housing and ball bearing to prevent moisture from creeping along the shaft to the bearing. The pump shaft and bearing constitute one assembly, and are serviced as such inasmuch as the shaft serves as the inner race of the ball bearing.

A. REMOVAL OF WATER PUMP

1. Drain the cooling system.
2. Loosen hose connection between water



EXPLODED VIEW OF WATER PUMP

FIG. 1

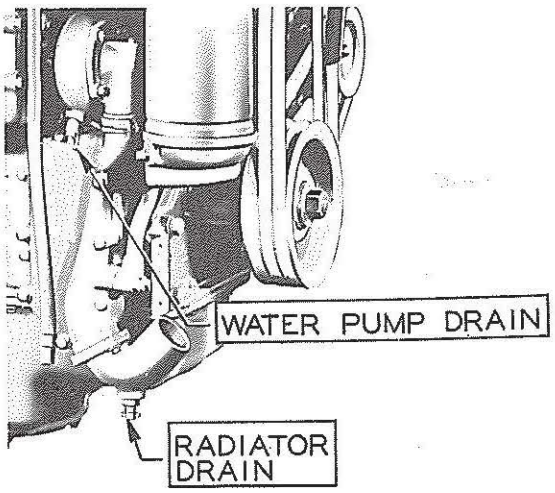


FIG. 2

pump and oil cooler.

3. Remove 2 capscrews and disconnect pump discharge flange from cylinder block.
4. Remove 3 capscrews and disconnect water pump from front end of blower. The inner capscrews (next to cylinder block) must be removed with special wrench, the same as is used on the fuel pump.
5. Withdraw pump assembly from end of blower.

DISASSEMBLY OF WATER PUMP

1. Remove pump cover.
2. Support the water pump in an arbor

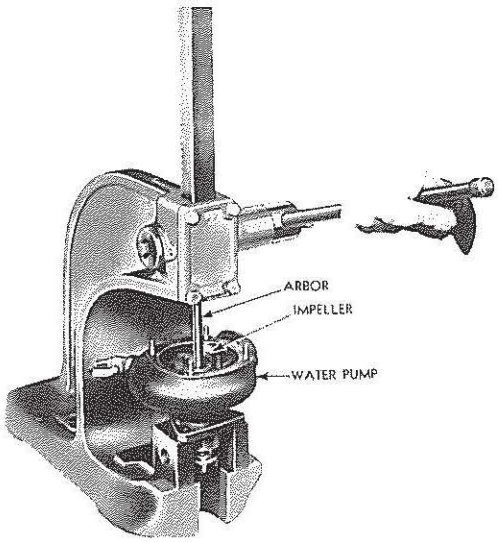


FIG. 3

press (flange down) and press the shaft through the impeller. Shaft and bearing assembly can also be removed from the housing during this operation.

C. ASSEMBLY OF WATER PUMP

1. The water pump may be assembled by

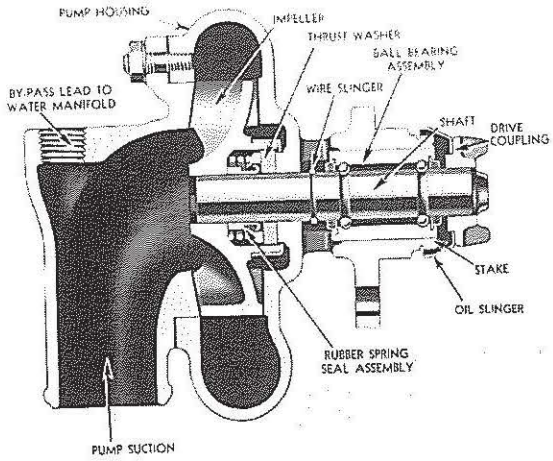


FIG. 4

reversing the sequence of operations for disassembly. After the impeller or the drive coupling has been removed from the shaft, these parts cannot always be used successfully the second time. These parts are held on the shaft solely by press fits and after they have been pressed on the shaft, the metal stretches slightly and may turn on shaft.

If a new shaft and bearing assembly is installed, the drive coupling may be pressed on the outer end of the shaft before the bearing assembly is installed into the pump housing. The outer face of the coupling hub should be flush with outer end of shaft when in place. Before starting the pump assembly study Fig. 4, which shows the relative location of all parts in the pump.

2. Press the shaft and bearing assembly into the pump housing with the inner face of bearing flush with the inner face of flange on pump body. Then STAKE bearing from endwise motion by upsetting pump flange with chisel or punch at 3 or 4 points.
3. Press impeller and new water seal assembly on outer end of pump shaft and a new drive coupling on inner end of shaft with face of coupling flush with end of shaft. Be sure a running clearance exists between the inner face of impeller blades and pump body. When the pump impeller is properly pressed on shaft, a running clearance will exist between the outer face of impeller blades and pump cover.
4. Bolt pump cover in place; then rotate shaft to see that impeller does not interfere with pump cover.

NOTE: As the water pump ball bearing is of the "shielded" type and filled with lubricant when assembled, no further lubrication is necessary.

D. INSTALLATION OF WATER PUMP

Reverse the above procedure to install the water pump on the motor.

NOTE: The water pump can be removed easily whether the motor is in or out of the tractor.

93 -- Governor

Description—Since the horsepower requirements on a tractor continually vary, due to fluctuating loads, some means must be provided to control the amount of fuel required and hold the tractor speed reasonably constant during such load fluctuations. This end is ac complished by means of a mechanical governor.

Since the governor operating mechanism is connected to the engine throttle, or to the injector control racks, the term "Throttling" governor is applied to this device. The functioning of the governor is brought about by a force, created by rotating weights, which is transmitted mechanically to the governor actuating mechanism.

The limiting speed governor is the mechanical type. The motion produced by the travel of the governor weights, between their inner and outer positions, is transmitted to the injector racks by a system of cams and levers to which can be attached a manual control.

The governor, which is mounted at the front of the blower, is divided into three main assemblies embodied in separate housings. These assemblies are:

1. Governor Weights and Housing.
2. Control Housing and Mechanism.
3. Cover.

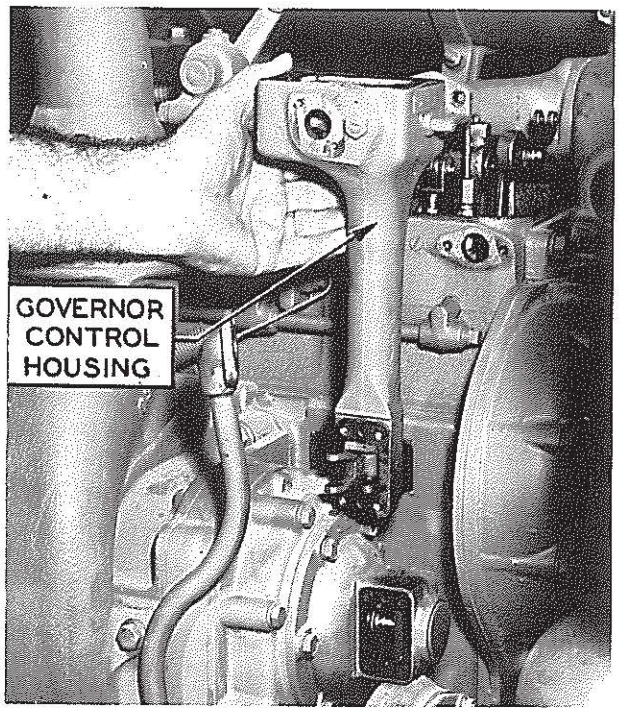


FIG. 1

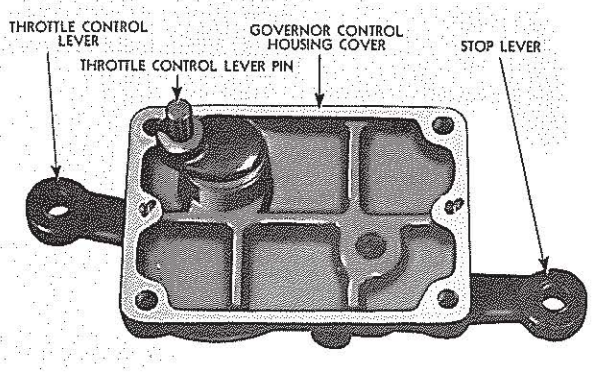


FIG. 2

A. REMOVAL OF GOVERNOR

1. Remove valve covers
2. Remove pin from control tube lever and governor control link.
3. Remove 4 fillister head capscrews and lockwashers from control housing cover assembly.
4. Remove clip and washer from differential lever and pin assembly; now remove governor control link.
5. Remove the 2 fillister head capscrews that hold breather pipe to governor housing assembly. Now breather pipe can be pulled up out of the clip, fastened at bottom on the oil cooler body.
6. Remove 4 capscrews and lockwashers holding governor body assembly to governor weight housing.
7. Remove 2 capscrews and lockwashers holding governor housing assembly to cylinder head.
8. Remove 6 capscrews and washers holding governor weight housing to front end of blower assembly. Now place on bench for further disassembly.

B. DISASSEMBLY OF VARIABLE SPEED SPRING HOUSING

1. Remove clip and washer from differential lever and pin assembly.
2. Remove 2 capscrews and washers holding variable speed spring housing to governor control housing.
3. Remove variable speed spring, and variable speed spring retainer. Watch for the washers in spring retainer.
4. Remove 1/8" pipe plug from top. Through this hole remove Allen set screw. The variable speed spring lever

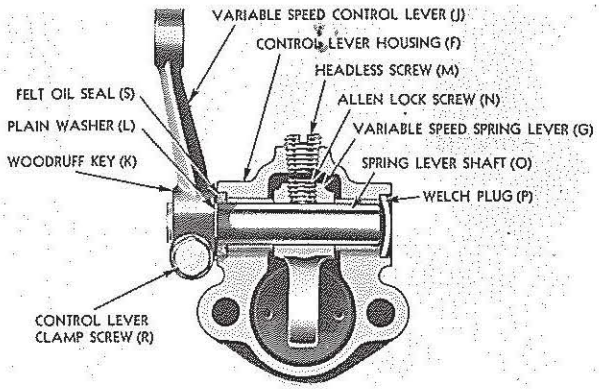


FIG. 3

and shaft, felt, and steel washer can be removed.

C. DISASSEMBLY OF CONTROL HOUSING

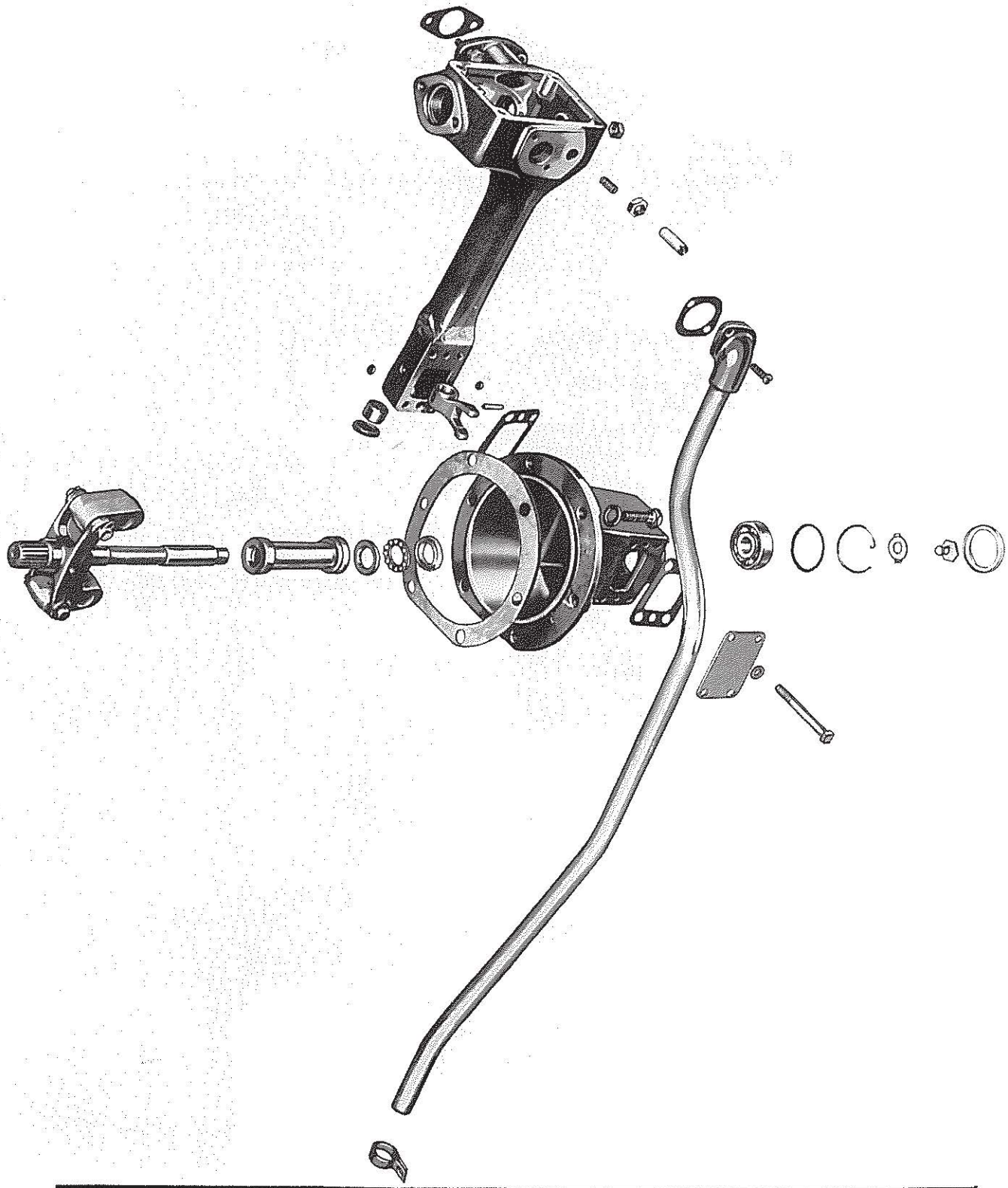
1. Remove variable speed plunger.
2. Remove 2⅜" expansion plugs from lower part of housing, by using curved punch.
3. Punch out tapered pin that holds yoke to operating shaft.
4. Remove round head machine screw holding bearing and shaft in upper part of housing.
5. Remove tapered pin from yoke and shaft in lower part of housing; now lift out the shaft assembly from the top.

D. DISASSEMBLY OF OPERATING SHAFT

1. To remove bearing from shaft, drive taper pin from differential lever and pin assembly.
2. If variable speed spring plunger guide is worn and loose, drive it out and install a new one.
3. To remove the parts from the governor housing cover assembly, remove cap-

EXPLODED VIEW OF GOVERNOR CONTROL ASSEMBLY

FIG. 4



EXPLODED VIEW OF GOVERNOR WEIGHT ASSEMBLY

FIG. 5

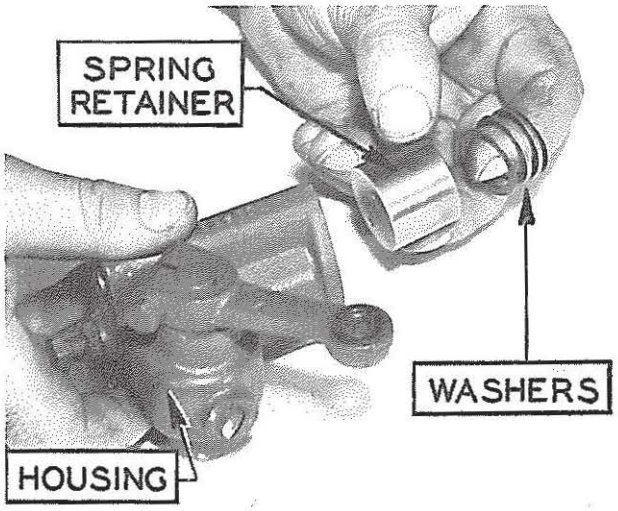


FIG. 6

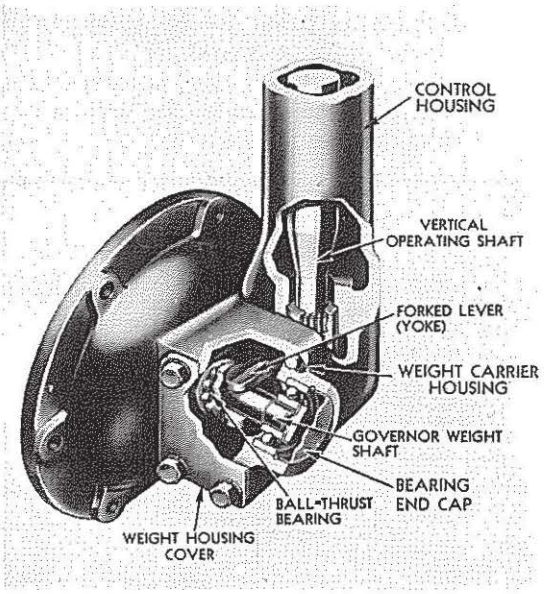


FIG. 8

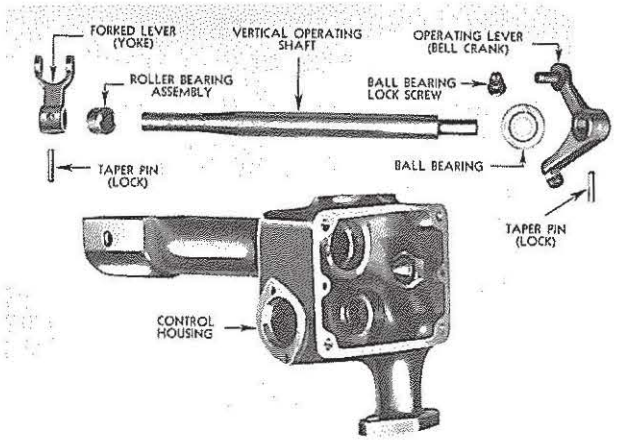


FIG. 7

FIG. 9

screw from shutoff lever, drive out taper pin and remove the shaft.

4. To remove governor lever shut off stop, remove clip and washer.

E INSPECTION OF GOVERNOR PARTS ASSEMBLY

Remove housing end cap, straighten lockwasher on retainer screw, and remove retainer screw. Governor weight shaft assembly can now be removed and disassembled. The bearing can be taken out by removing the snap ring in outer end of housing.

1. Before assembling the governor, parts must be thoroughly cleaned, inspected for wear, and new parts installed where needed.

   When bearings and moving parts in the governor become worn, new parts must be installed to insure proper functioning of the governor.

F. ASSEMBLY OF GOVERNOR

1. To assemble the governor, reverse the disassembling procedure.

CAUTION: When assembling the variable speed spring, be sure to install the same total thickness of variable speed spring washers in the variable speed spring retainer as was removed at the time of disassembly, see Figure 6. These washers are installed to get the correct high idle speed. When replacing the control housing be sure the ball thrust bearing, Fig. 8, is toward the blower, between the forked lever and the governor weight housing.

All gaskets must be in good condition or new gaskets installed.

2. Before installing the control housing cover assembly, make the following test of the governor. Fig. 10.

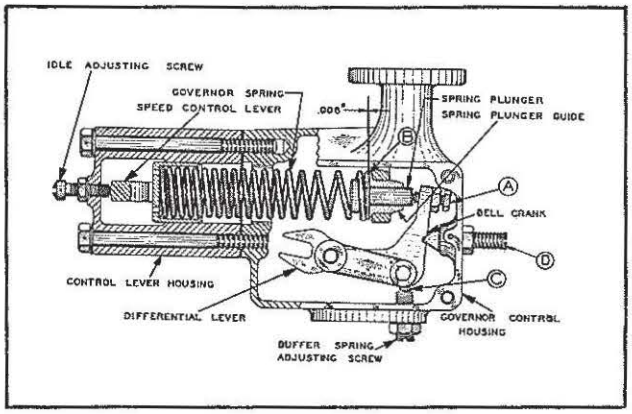


FIG. 10

a. Pull the throttle control lever all the way back.
b. Loosen locknut on adjusting screw (A) and turn adjusting screw in or out until a .006" feeler gauge can be inserted between the spring plunger and spring plunger guide at (B).
c. Tighten locknut.
d. Loosen locknut on buffer spring adjusting screw.
e. With the hand, push the governor injector control link toward the buffer spring so as to close the injectors completely.
f. Turn the buffer spring adjusting screw in or out until a .020" feeler gauge can be inserted between the differential lever and the buffer spring screw at (C).
g. Tighten locknut.
h. Install the governor control housing cover. Be sure dowels are in holes and pin is in slot in differential lever.

NOTE: When the motor was originally assembled, the adjusting screw (D) was backed out as far as possible and the locknut securely tightened. This screw plays no part in the adjustment or operation of this governor. It will never be necessary to change the original setting of the screw, Later governors do not have this adjusting screw, as shown.

G. ADJUSTMENT FOR R.P.M.

After the governor is reassembled and placed on the tractor the R.P.M. should be checked. This can be done as shown in Fig. 11. Be sure the generator belt is tight and not worn. Determine the R.P.M. of the crankshaft. Generator turns 1.7 times crankshaft speed.)

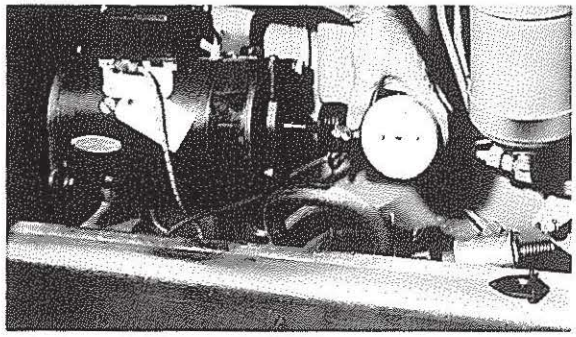


FIG. 11

The high idle speed of the "HD 14" and "HD 7" is approximately 1650 R.P.M. and the high idle speed of the "HD 10" is 1750 R.P.M.

NOTE: If the high idle speed is not correct, proceed as follows:

1. Make certain that all motor adjustments are correct, all controls running from dash to motor have the correct adjustment and the motor is in good operating condition BEFORE THE R.P.M. IS INCREASED.
2. After all adjustments and controls have been examined and corrected, if necessary,, proceed again to determine the R.P.M. as shown in Fig. 11.
3. If the R.P.M. is too low, variable speed spring washers can be added. Washers are available in two thickness, .078" and .015". Only the .015" washers are used to increase R.P.M. unless the governor has been taken apart and washers have been lost; then possibly the .078" washer will be required.
   One .015" washer will increase the speed approximately 40 R.P.M. If the R.P.M. is too high, washers should be removed. See Fig. 6.

94 -- Electrical Equipment Warranty and Adjustment Policy

Manufacturers of electrical equipment used on Allis-Chalmers tractors are responsible for the equipment they furnish. Any claim for defective or faulty equipment of this nature must be presented to the manufacturer of the equipment, not to Allis-Chalmers Mfg. Co. All suppliers of such equipment are represented by distributors in nearly all cities and are glad to make reasonable adjustments or replacements for their respective companies.

95 -- Starter Motor

Starter Motor and Dyer Drive—The Dyer Drive, which transmits the power of the starter motor to the engine flywheel, consists of the splined portion of the armature shaft, the shift sleeve, the pinion guide, the pinion, the pinion stop, washers, and springs. The thrust washers furnish a thrust bearing for the shift sleeve when it is in the returned position; the springs aid in the lock operation and in the engagement action. The entire drive is contained in the starter motor drive housing. The movement of the pinion is controlled by means of a shift lever which is connected directly to the shift sleeve. The Dyer Drive provides for positive engagement of the starter motor pinion with the engine flywheel before t he starter motor switch contacts are closed or the armature is rotated. The pinion is thrown out of mesh with the flywheel by the reversal of torque as the engine starts.

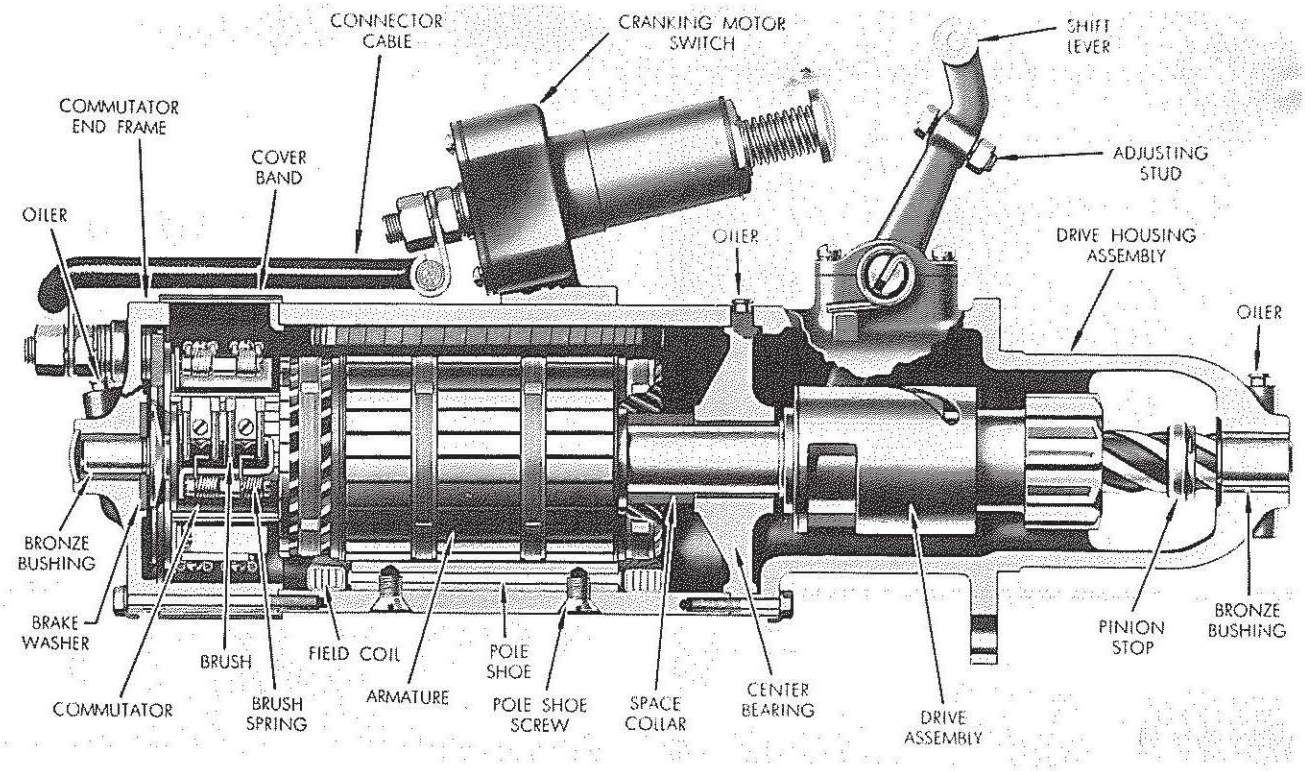


FIG. 1

A. STARTER SWITCH MAY BE FAULTY

After extended use, the contact surfaces of the starter switch may become burned or corroded so that either no current at all, or insufficient current for starting is transmitted to the motor. A faulty switch might be indicated by the engine cranking hard or difficulty in keeping the battery charged. The switch can easily be disassembled so that the burned or corroded surfaces may be reconditioned.

1. Disconnect battery cable at starting motor; tape the exposed end of the cable.
2. Remove bottom plate of switch by removing 4 capscrews.
3. Remove contact disc from plunger by removing castellated nut.
4. Clean and smooth contacting surfaces with a file or sandpaper. Be sure that

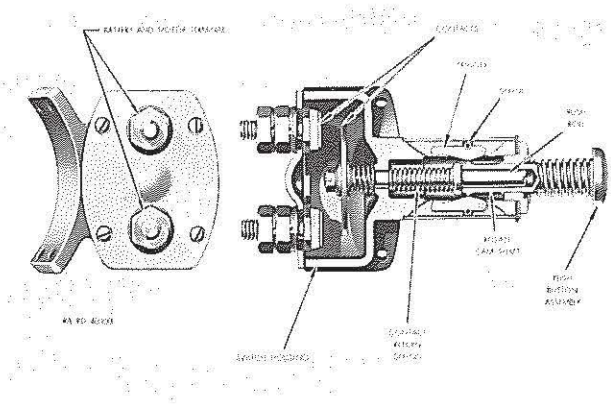


FIG. 2

surfaces contact over the entire area when reassembled.

B. DYER DRIVE MAY BE INOPERATIVE

If grease and dirt are allowed to accumulate on the armature shaft or in the mechanism, the Dyer Drive may seize or lock. If this occurs while the pinion is engaged, considerable damage may result to the starter motor.

To disassemble and service this drive assembly:

1. Disconnect battery cable from starter motor; tape the exposed end of the cable. Remove starting motor assembly from engine.
2. Remove Dyer Driver housing from starter motor.
3. Remove pinion stop on the armature shaft by removing cotter key.
4. Completely disassemble, clean all parts, and oil with light oil. Reassemble in reverse sequence.

C. STARTER MOTOR MAY BE INOPERATIVE

CAUTION: Do not operate starter for more than 30 sec. at one time.

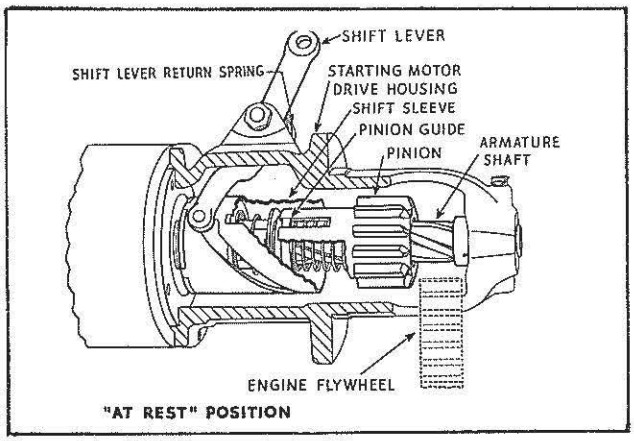


FIG. 3

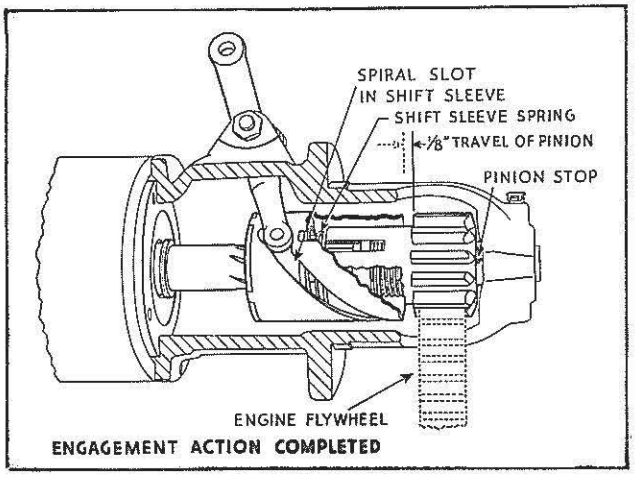


FIG. 4

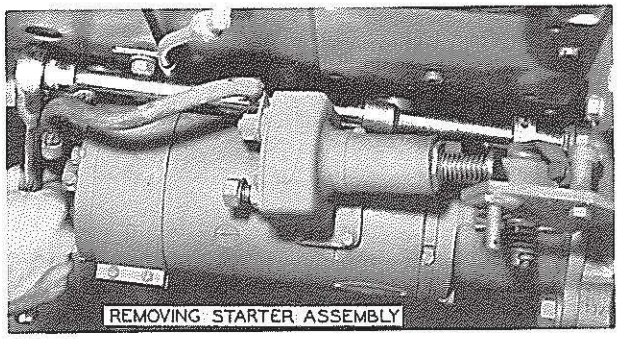


FIG. 5

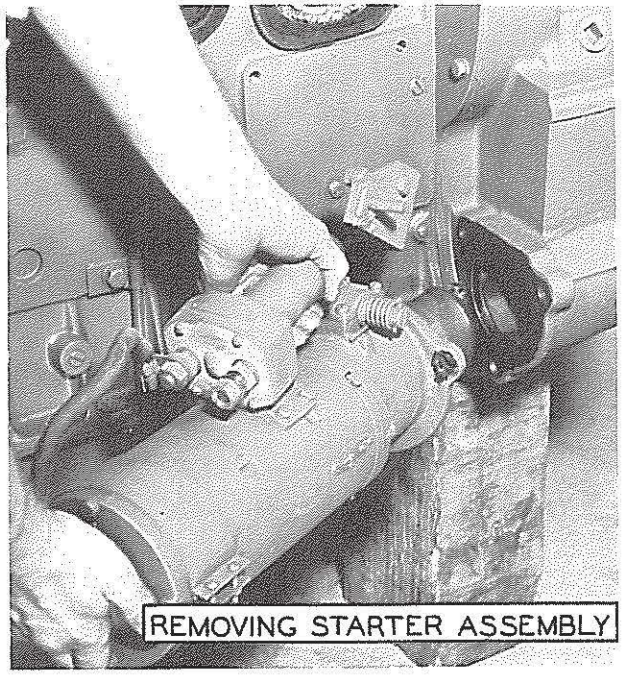


FIG. 6

1. Brushes may not be making good contact.
   a. If brushes are not seating properly, they should be fitted to conform to the contour of the commutator. To do this, place a strip of #00 sandpaper between the brush and the armature. roughened side toward the brush.

Work the sandpaper back and forth around the commutator so that the brush is "WORN IN" to shape. After this is done, the commutator should be polished and cleaned as described under paragraph on "commutator." (Paragraph 2 below)

b. Brush arms may be sticking so that the brushes do not come in actual contact with the commutator.

c. The brush arm springs may have lost their tension so that there is poor contact between the brush and the commutator. This spring tension may be tested with a small spring scale. Attach the scale to the brush directly under the heads of the screws that hold the brush to the arm. If a pull of less than 36 oz. will move the brushes off the commutator, the springs have lost their tension and new springs should be installed. If this tension is over 40 oz. excessive wear will occur on the brushes.

2. Commutator may be dirty or worn. This can easily be detected by an inspection with the cover band removed. If the commutator is dirty or slightly grooved, it can be cleaned by means of a piece of #00 sandpaper. Place the sandpaper between the brush and the commutator with the rough side toward the commutator. Then rotate the armature. After this polishing, the dust from the sandpaper should be removed from the armature and brushes. If the commutator is worn badly, the armature should be removed as a unit and trued in a lathe.
3. Starting motor may be burned out. This will occur if the motor is abused or if it is operated longer than 30 sec. at one time. If this occurs, it is advisable to either install a new motor or have it rebuilt by an authorized service station.

96 -- Generator

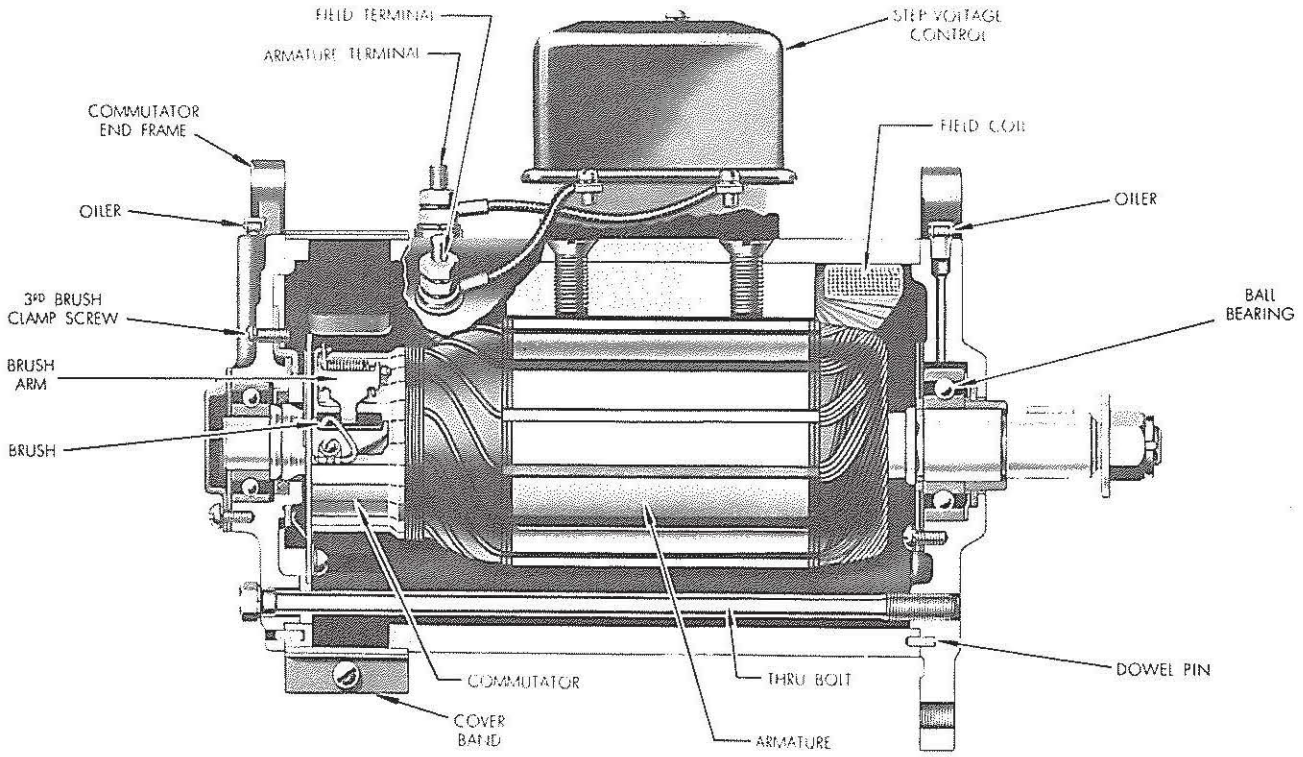


FIG. 1

A. TESTING AND ADJUSTING GENERATOR CIRCUIT

No attempt should be made to test or adjust any part of the generator circuit without dependable instruments. If such instruments are not available, the tests may be made by any United Motors Service Station, who are authorized to carry out any service operation in connection with the electrical starting system.

NOTE: All tests should be made with the voltage regulator cover in place.

B. INSTRUMENTS REQUIRED FOR GENERATOR-VOLTAGE CONTROL TESTS

To test the generator, the following instruments are needed: an accurate 0-10 or 0-20 ampere ammeter, an accurate 0-20 volt voltmeter, and a 2-ohm variable resistance of sufficient capacity to carry 10 amperes continuously. If these instruments are not available, take the units to your nearest United Motors Service Station. The voltage control cannot be adjusted on the tractor. This should be done by an authorized United Motors Service Station.

C. GENERATOR VOLTAGE CONTROL TESTS

1. A low charging rate with a fully charged battery indicates proper operation.
2. Excessive gassing of the battery indicates overcharge. The voltage control is designed to reduce the generator charging rate to approximately 2 amperes at 2000 generator r.p.m. (approximately 1200 engine r.p.m.) when the battery has approached a fully charged condition. Test the voltage control action by stopping the engine and connecting ammeter into the charging circuit. Disconnect load from Battery terminal of voltage control and connect negative ammeter lead to this terminal. Connect positive ammeter lead to disconnected lead. With the ammeter connected and the engine running, there should be 6 to 8 amperes charge for a short time (up to 30 minutes with a charged battery). As the energy used in starting is replaced in the battery, the battery voltage will rise until the voltage control operates. This should reduce the charging rate to about 2 amperes. Failure of the units to operate in this manner will necessitate their being taken off the engine for further test and adjustment.
3. A low battery, and a low or no charging rate, indicate either the third brush of the generator or the voltage control is out of adjustment. Loose connections in the charging circuit, particularly at the battery terminals, may also cause a low charging rate with a low battery. Connect ammeter in the charging circuit as described above. With the generator operating at about 2000 r.p.m. (approximately 1200 engine r.p.m.) and a low battery, the output should be 6 to 8 amperes. If less than 5 amperes is obtained, connect a jumper lead from the terminal of the voltage control to ground, (base of voltage control is satisfactory). If the output increases to 6 to 8 amperes, the trouble is in the voltage control. If the output does not increase to 6 to 8 amperes with the jumper lead connected from the terminal of the voltage control to ground, then the generator is at fault and must be tested as follows:

D. TESTING GENERATOR OUTPUT

1. Disconnect lead from "BAT" terminal of voltage control and connect to one terminal of the variable resistance. Connect positive ammeter lead to "BAT." voltage control terminal. Connect negative ammeter lead to other terminal of the variable resistance. Connect negative voltmeter lead to "BAT." voltage control terminal and positive lead to ground (base of voltage control or generator frame.)
2. Connect a jumper lead between the terminal of the voltage control and the ground to eliminate the voltage control resistance.
3. Set engine speed for maximum generator output (approviate 2000 generator r.p.m. or 1200 engine r.p.m.)
4. Adjust variable resistance until voltmeter reads 14.1 to 14.5 volts. The output should be approximately 6 to 8 amperes with the generator at operating temperature. Adjust the generator output by shifting the third brush in the direction of rotation to increase the output, and in the opposite direction to decrease the output. Adjust the variable resistance after shifting third brush to maintain 14.1 to 14.5 volts before taking ampere reading.
   CAUTION: Never, under any circumstances, set the generator output above 8 amperes at 14.1 to 14.5 volts.
5. If unable to obtain 6 to 8 amperes by shifting the third brush, remove the generator and voltage control and take them to a competent service station for a thorough test.

97 -- Fan

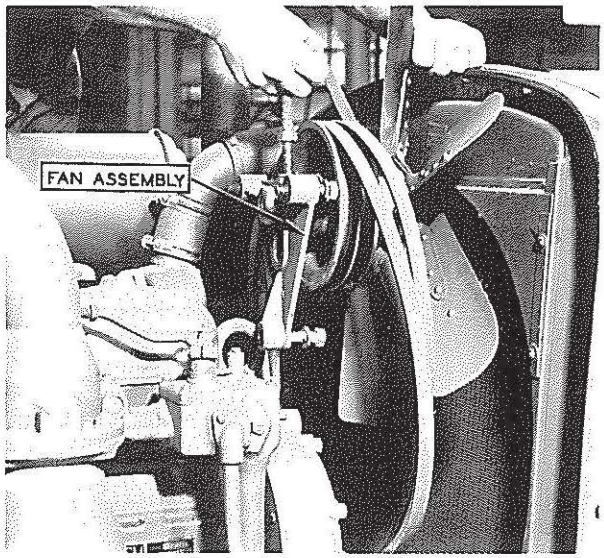


FIG. 1

A. REMOVAL OF FAN

1. Loosen the large nut at the rear end of the fan shaft, and loosen the lock nut and adjusting screw.
2. Remove the 3 capscrews holding the fan assembly to the balance weight cover and remove the assembly.

B. DISASSEMBLE FAN

1. Remove the large nut at rear end of shaft also the adjusting screw, then remove the fan bracket.
2. Remove fan blades and nut on front end of fan shaft, unscrew cork retainer at rear end of shaft.
3. The shaft can now be pressed from the pulley.
4. Install new bearings if worn and also a new cork washer.

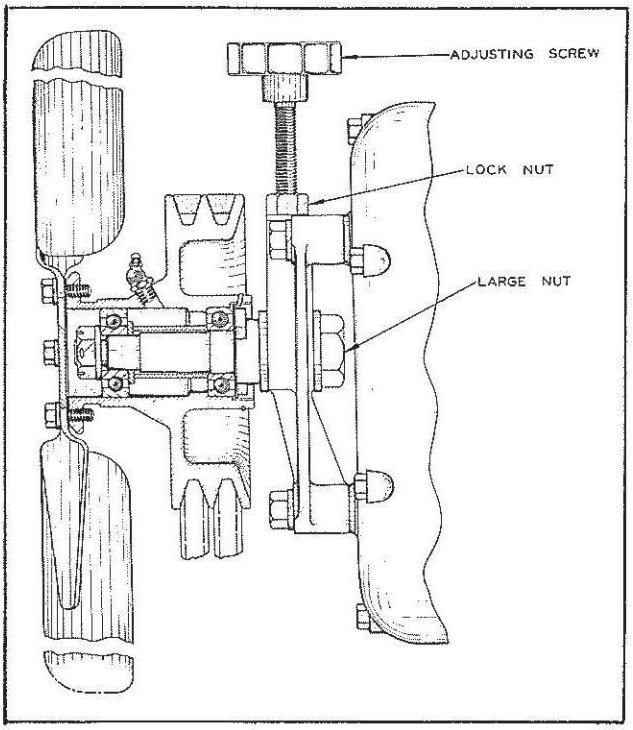
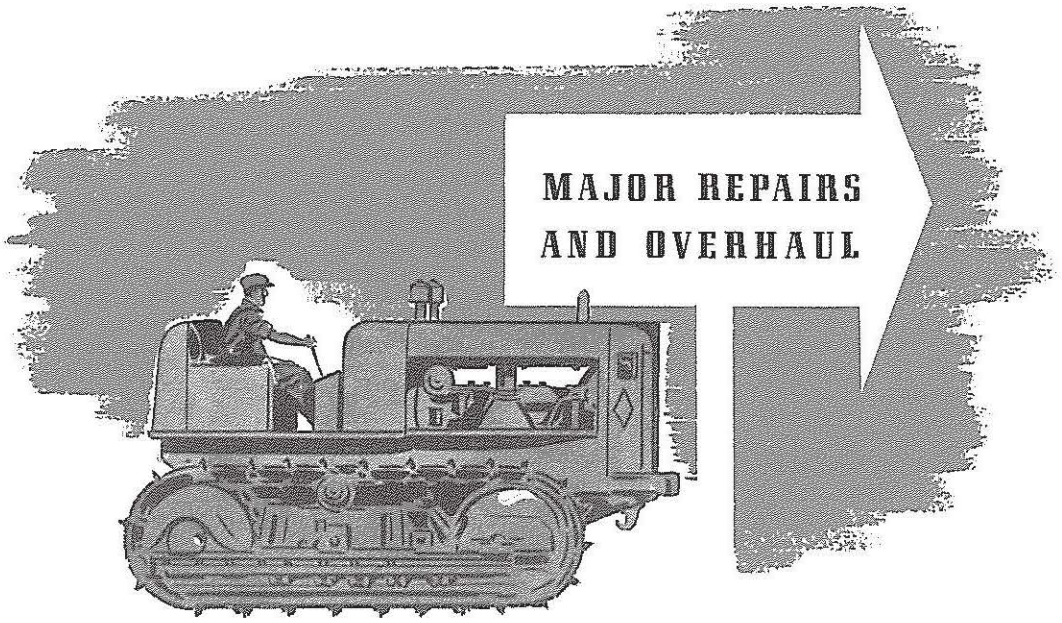


FIG. 2

C. REASSEMBLE AND INSTALLATION OF FAN

Reverse the above procedure for reassembly and installation.



SAFETY:

Particular care must be exercised when using hoisting equipment, cribbing under heavy loads, or working around cable under extreme tension.

MAJOR REPAIRS AND OVERHAUL

73 -- Motor Disassembly and Assembly

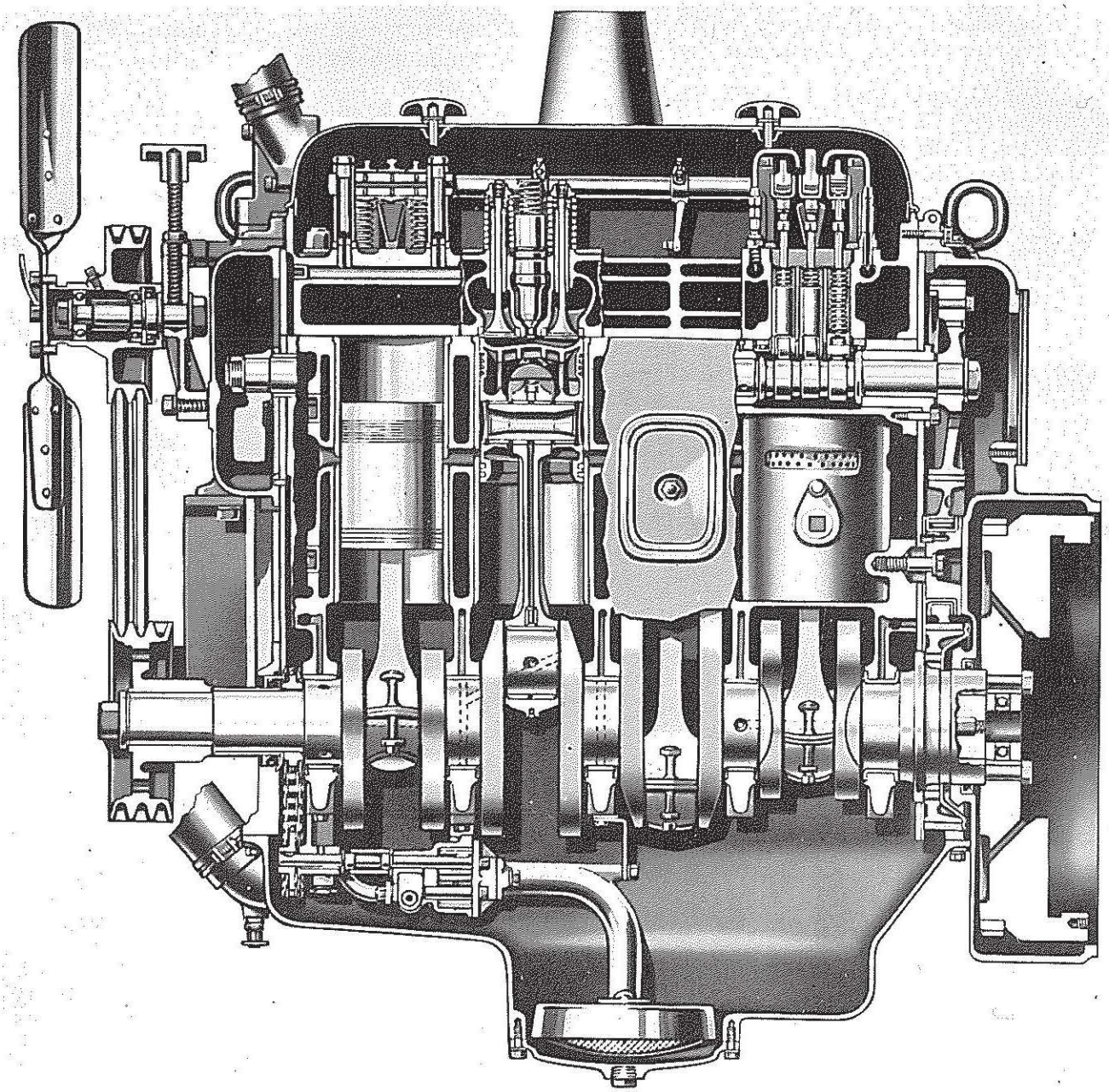


FIG. 1

When a complete overhaul is required, it is advisable to disassemble the motor completely and clean the motor block thoroughly. There is no prescribed method for disassembling or assembling this motor, but as follows is an outline that will be helpful. There is no detailed description here as to how the different parts are removed from the engine because this is covered in minute detail under headings that deal with each part. If in doubt as to how to remove and disassemble a fuel pump, lubricating pump, etc. refer to these assemblies under their separate headings.

A. DISASSEMBLE MOTOR

1. Drain the oil.
2. Suspend the motor with a hoist until the oil pan just rests on the floor.
3. Remove the capscrews that hold the oil pan to the motor block.
4. Hoist the motor up and remove the oil pan or pans, the HD-14 has two oil pans. Part of the oil pump has to be dismantled before the upper oil pan can be removed.
5. Remove the oil pump, oil screen and

by-pass assembly.
6. Remove the fan drive pulley and crankcase front cover assembly.
7. Remove the oil seal spacer and oil pump drive sprocket.
8. Block up under the cylinder block so the crankshaft can be rotated without hitting the blocks. Disconnect the chain hoist.
9. Remove the clutch assembly from the flywheel.
10. Remove the flywheel.
11. Remove the combination gear train and flywheel housing.
12. Remove the water by-pass.
13. Remove the fan assembly.
14. Remove the balance weight cover.
15. Remove the cylinder head.
16. Remove the blower and attached parts such as fuel pump, water pump, etc.
17. Remove the oil filter and cooler adapter.
18. Remove the blower drive gear assembly.
19. Remove the camshaft and balance shaft.
20. Remove the idler gear and the spacer and dowel assembly.
21. Remove the pistons and connecting rods.
22. Remove the main bearing caps and lift the crankshaft out.
23. Remove the 2 end plates.
24. Pull the cylinder liners.

B. INSPECTION OF MOTOR PARTS

Inspect all parts while the motor is dismantled and install new parts as required. Clean the block thoroughly, especially the airbox and oil passages.

C. REASSEMBLE MOTOR

1. Installing liners, be sure liners are washed clean, and no lubricant used when pressing them in block. Place liner in hole of block, care being taken that liner is centered in hole. Next set up puller and push liner in. Repeat this operation until all liners are installed.

   NOTE: On the engine block having the larger bore, liners can be installed by pushing them in with your hand.

2. Install the upper half of main bearings in cylinder block.

   NOTE: The upper halt is marked "upper" and has a continuous groove from parting-line to parting-line. The lower half is marked "lower" and has no groove.
   The rear main bearing takes all of the thrust from crankshaft and must be installed in proper place next to flywheel.

   NOTE: When looking from the rear of the motor, the blower is ALWAYS on the RIGHT side of the block.
   The flywheel and timing gears go to the rear of the motor. Install the crankshaft in the block with the flywheel flange toward the rear. Place number one cap on number one bearing, etc., until all main bearing caps have been installed

   NOTE: All caps are numbered and all numbers must go to blower side of motor.
   Tighten all main bearing nuts, and rotate the crankshaft to see that it turns free, then install keys. Main bearings need no further adjusting as there are no shims. Never file a main bearing cap to make it fit. If bearings are loose, install new bearing shells.
3. Install piston to connecting rod.

   NOTE: Connecting rods have spray nozzle in upper end. Make sure these orifices are open.
   Install piston rings on piston. Install number one connecting rod and piston in number one liner. (Use piston ring compressor.) Repeat this operation until all connecting rods and pistons are installed, care being taken that the numbered connecting rods are placed in their respective cylinders. Install the upper half of bearing shell in upper half of connecting rod and lower half of bearing shell in lower half of connecting rod. These shells are marked "upper" and "lower." The upper half has two holes with a short groove at each parting line. The lower half has no holes, but a groove from parting-line to parting-line. The connecting rods are also numbered; all numbers go toward blower side of motor. Tighten connecting rod nuts and rotate crankshaft to see that it turns free, lock with cotter keys.

   NOTE: In tightening connecting rod nuts, do not use a wrench over eight inches (8") in length as bolts are small. There are no shims used with these bearings. Never file a cap to fit; if bearings are loose, install new bearing shells.
4. Install the clyinder block end plate, front and rear, using new end plate gasket.

   NOTE: Install all capscrews in end plates, but do not tighten them as end plates may have to be shifted when installing camshaft and balance shaft.
5. Install camshaft and camshaft intermediate bearing lock bolts.

   NOTE: Camshaft goes to blower side of motor, or right side.
   Next install the balance shaft and gear. Camshaft gear and balance shaft gear must be timed. This is done by getting the mark on camshaft gear to correspond with mark on balance shaft gear as shown. Install the balance and camshaft

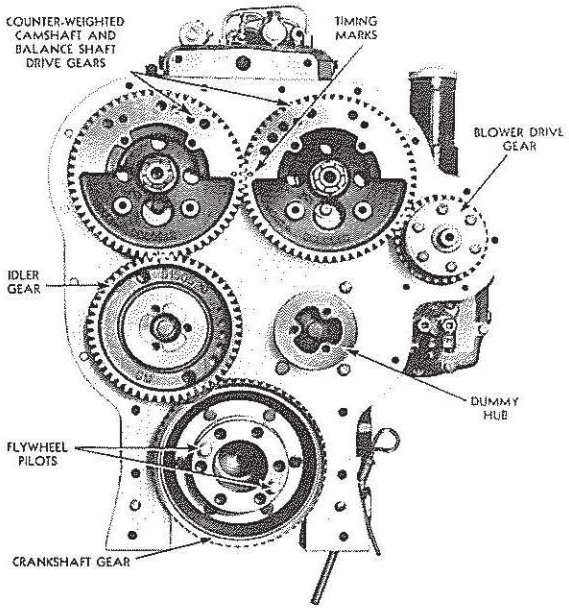


FIG. 2

front end bearings. Install the balance weights and tighten all capscrews which hold cylinder block end plates.

6. Install the crankshaft gear and oil slinger to crankshaft. Turn the crankshaft until mark on gear is pointing up. Next, install the idler gear so that the mark on the idler gear corresponds with mark on the balance shaft gear and the other mark on the idler gear corresponds with mark on the crankshaft gear as shown. Next install the idler gear hub and washer; inspect to see if all the above mentioned marks correspond. If they do, the motor is in time. Next install the blower drive gear.
   NOTE: There is no timing of this gear. Install the spacer and dowel assembly and tighten capscrews.
7. Install all parts which drive from the blower before installing blower on motor. These parts are as follows: blower drive, cover, fuel oil transfer pump, governor weight housing, and water pump. Always use new gaskets when reassembling a motor. To install these parts, determine the front and drive end of the blower. This is very easy as blower will only go on motor one way. The end facing the flywheel is the drive end of blower. The blower drive cover belongs at top and the fuel oil transfer pump at bottom of blower on the drive end. The governor weight housing attaches at top and water pump at bottom of blower, on front end.
8. Install blower on cylinder block, using new blower gasket and water pump outlet gasket.
9. Install blower drive coupling hub. Next, install blower drive shaft, then blower drive coupling retainer.
10. Install the oil cooler and primary filter. Be sure to use all new gaskets; also see that Neoprene water pump inlet seal between pump and cooler is in good condition.
11. Install oil pump drive sprocket, also oil pump, using new gaskets at all connections.
12. Install flywheel housing assembly using all new gaskets and a new oil seal.
13. Install flywheel.
14. Install balance weight cover using new gasket.
15. Install crankshaft front cover assembly, using new gasket and seal.
16. Install oil pan using new gasket.
17. Install hand hole cover plates, using new gaskets.
18. Install cylinder head, cylinder head gasket and oil gaskets. (Side and end pieces, cement on both sides).
19. Install governor control housing assembly on cylinder head.
20. Install governor control link.
21. Install water manifold assembly.
22. Install blower drive bearing oil pipe assembly.
23. Install breather pipe to governor.
24. Time injectors, equalize injectors and set valve lash. Refer to Topics 42, 43 and 44.

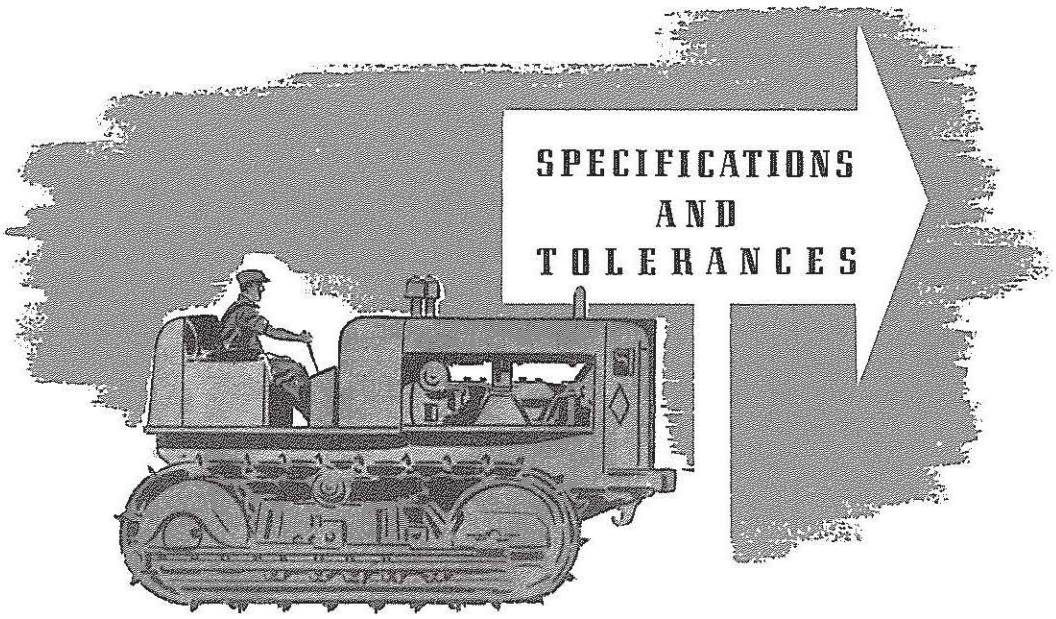
74 --"HD 7" Motor Removal and Installation

It will be necessary to have the following equipment, or its equivalent, on hand in order to remove the motor from the tractor.

1. A one ton hoist.
2. A ten foot length of ½" cable or ⅜" chain.
3. One motor stand or sufficient wooden blocks to support motor.
4. Ample supply of cleaning fluid available in clean container.
5. At least 6 clean containers for holding nuts, bolts, capscrews, etc.

A. REMOVAL OF ENGINE FROM TRACTOR

1. Disconnect battery by removing terminal connection from battery post.
2. Loosen clamp bolts and remove precleaners. Fig. 1.
   NOTE: On late production models the



SAFETY:
When working with another man be sure you both understand the plans. Remember, congenial team work promotes safety.

67 -- Specifications and Tolerances

ENGINE	DATA			Install New Parts When Clearance Exceeds
	HD-7	HD-10	HD-14	
Weight of motor, completely equipped	1585	1865	2093	
Engine—Make	General Motors Diesel-Model "71"			
Type	2-Cycle in Line			
No. of Cylinders	3	4	6	
Bore	4 1/4	4 1/4	4 1/4	
Stroke	5"	5"	5"	
Total Displacement Cu. In.	213	284	425	
Direction of Rotation from front	Clockwise	Clockwise	Clockwise	
Speed Range—R.P.M. (Governed)	450 to 1500	450 to 1600	450 to 1500	
H.P. at Drawbar } Note: Std. Conditions	60.10	86.63	132.19	
H.P. at Belt } Note: Std. Conditions	71.08	101.62	150.48	
Maximum Torque R.P.M.	800 to 1200 R.P.M.			
N.A.C.C. Rating	21.70	28.90	43.40	
Compression Ratio	16 to 1	16 to 1	16 to 1	
Compression Pressure (approx.) lbs. per sq. inch at 1000 R.P.M.	500	500	500	
Compression Pressure (approx.) at Governed Speed, lbs. per sq. inch	600	600	600	
Firing Order	1-3-2	1-3-4-2	1-5-3-6-2-4	
Injector Pump	Unit injector combined with plunger and spray nozzle for each cylinder.			
Governed R.P.M. (Full Load)	1500	1600	1500	
High Idle R.P.M.	1650	1750	1650	
Low Idle R.P.M.	450	450	450	
Lubrication	Force Feed			
A. CYLINDER LINERS				
1. Diameter inside	4.2492" to 4.2507"			
2. Dia. Piston Skirt	4.2432" to 4.2437"			
3. Clearance—Piston with Liner	.006" to .007"			.010"
4. Allowable Taper	.001"	.001"	.001"	
5. Allowable out of round	.001"	.001"	.001"	
6. Clearance, liner with block 1st type	Press Fit	Press Fit	Press Fit	
7. Clearance liner with block 2nd type	Slip Fit	Slip Fit	Slip Fit	
B. PISTONS				
1. Material	Pearlitic Malleable Iron Tin Plated or Parco Lubrited			
2. Piston Length	6.00"	6.00"	6.00"	
3. Piston Pin Length	3.725"	3.725"	3.725"	
4. Dia.—Skirt	4.2432" to 4.2437"			
5. Dia.—Inside Liner	4.2492" to 4.2507"			
6. Clearance Piston with Liner	.006" to .007"			.010"
7. Dia., Inside—Pin Bush.	1.503" to 1.5025"			
8. Dia., Outside—Pin	1.500" to 1.4998"			
9. Clearance—Pin in Bushing	.0025" to .0032"			.010"
C. PISTON RINGS—COMPRESSION				
1. No. and width	4—1/8"	4—1/8"	4—1/8"	
2. Gap between ends fitted	.020" to .025"			.060"
3. Clearance in Groove Upper Ring	.010" to .012"			.030"
4. Clearance in Groove 2nd from top	.008" to .010"			.020"
5. Clearance in Groove 3rd & 4th from top	.006" to .008"			.015"
D. PISTON RINGS—OIL CONTROL				
1. No. and Width	Two 3/16" Three-Piece Ring			
2. Gap between ends fitted	.010" to .020"			.040"
3. Clearance in Groove	.004" to .008"			.012"

ENGINE	DATA			Install New Parts When Clearance Exceeds
	HD-7	HD-10	HD-14	
E. CRANKSHAFT				
1. Material	High Carbon, Manganese Steel, Tocco Hardened Journals			
2. Dia.—Crank Pin Journals	2.750" +.000-.001			
3. Width between cheeks	2.125" +.001-.001			
4. Dia.—Main bearing Journals	3.500" +.000-.001			
5. Length Shaft Journal Thrust	1.500" +.001-.001			
6. Crankshaft Journals may be ground under-size	.010", .020", .030"			
7. Under-size bearings available	.010", .020", .030"			
8. End Play	.0025" to .0075"			.012"
F. MAIN BEARINGS				
1. Material	Copper-Lead, Steel Backed, Precision Type			
2. No. per Engine	4	5	7	
3. Dia.—Inside Shell	3.502" +.001-.000			
4. Dia.—Journal	3.500" +.000-.001			
5. Clearance—Shell on Journal	.002" to .004"			.008"
6. Length—Shell only	1.125"	1.125"	1.125"	
7. Length—Over thrust Bearing	1.4965" +.000-.003			
8. Length—Shaft Journal Thrust	1.500" +.001-.001			
9. Clearance—Thrust—Rear main Bearing	.0025" to .0075"			.012"
10. Bearing Projected Area—Total, Square Inches	15.75	19.68	27.56	
11. Material—Thrust Flange	Babbitt flange on rear main bearing			
12. Under-size bearings available	-.010", -.020" & -.030"			
G. CONNECTING ROD BEARINGS				
1. Material	Copper-Lead, Steel Backed Precision Type			
2. Length	1.780"	1.780"	1.780"	
3. Diameter, Inside	2.752" +.001-.000			
4. Projected Area—Total, Square Inches	14.68	19.58	29.37	
5. Undersize Bearings available	.010", .020" & .030"			
6. Clearance, Lower Shell with Journal	.002" to .004"			.008"
H. CONNECTING RODS				
1. Material	Chrome—Molybdenum			
2. Length	10.125"	10.125"	10.125"	
3. Weight, Complete—Lbs.	6.8	6.8	6.8	
4. Dia.—Inside Lower Shell	2.752" +.001-.000			
5. Clearance—Lower Shell with Journal	.002" to .004"			.008"
6. Width—Lower End	2.117" to 2.115"			
7. End Play—Lower End	.006" to .012"			
8. Dia.—Piston Pin	1.500" to 1.4998"			
9. Dia, Inside—Bushing—Upper End	1.503" to 1.5025"			
10. Clearance—Pin with Bushing	.0025" to .0032"			.010"
I. GEAR TRAIN				
1. Backlash, Crankshaft—to Idler—to Camshaft—to Blower Drive Gear—the various mating Gears.	.004" to .006"			.010"
2. Type of Gears	Helical			
3. Location	Rear end of Motor			
4. Width of Gears	1½"	1½"	1½"	
5. Crankshaft Gear Rotation	Counter Clockwise—viewed from rear			

ENGINE	DATA			Install New Parts When Clearance Exceeds
	HD-7	HD-10	HD-14	
J. IDLER GEAR				
1. Dia., Inside—Gear Bushing	2.7485" +.0005,-.0000			
2. Dia., Outside—Hub	2.7465" +.0000,-.0005			.006"
3. Clearance—Gear Bushings w/Hub	.002" to .003"			
4. Length—Between Hub Shoulder and Thrust Washer	1.185 +.001, -.001			
	1.189" +.001, -.001			
6. End Clearance between Gear & Hub	.003" to .006"			.008"
7. Rotation	Clockwise—Viewed from rear			
8. No. of teeth—1st Type	54	54	54	
9. No. of teeth—2nd Type	68	68	68	
10. Driven from	Crankshaft Gear			
11. Type of Gear	Left Hand Helical			
K. EXHAUST VALVE				
1. Type	Poppet			
2. Valve Arrangement	Two overhead per Cylinder			
3. Valve Material	Silchrome			
4. Valve Lift	.375"	.375"	.375"	
5. Angle of Valve Seat	45°	45°	45°	
6. Valve Face Width	$\frac{3}{16}$"			
7. Valve Lash	.012" at Running Temperature			
8. Dia.—Head of Valve	$1\frac{9}{16}$"	$1\frac{9}{16}$"	$1\frac{9}{16}$"	
9. Dia.—Stem of Valve	.3425" +.0000, -.0010			
10. Dia.—Inside Guide	.3445" +.0010, -.0000			
11. Stem with Guide Clearance	.001" to .003"			.005"
12. No. of Valves Ea. Motor	6	8	12	
L. VALVE INSERT				
1. Type	Replaceable, Press Fit			
2. Seat Angle	45°			
3. Seat Width	.078" or 5/64"			
4. Material	Heat-Treated, Chrome Molybdenum Casting			
M. VALVE GUIDE				
1. Type	Replaceable			
2. Diameter, External	.566"			
3. Diameter, Internal	.3435" +.001, -.000			
4. Location—Depth from Bottom of Head to Guide	$1\frac{7}{8}$"			
5. Clearance between Valve Stem & Guide	.001" to .003"			.005"
N. ROCKER ARMS				
1. Dia., Outside—Rocker Shaft	.8740" +.0000, -.005			
2. Dia., Inside—Rocker Arm Bushing	.8750" +.0010, -.0000			
3. Clearance, Shaft with Rocker Arm	.001" to .0025"			.005"
4. No. of Injector Rocker Arms	3	4	6	
5. No. of Exhaust Valve Rocker Arms	6	8	12	
6. Bushing, Material & Type	Replaceable Bronze			
7. End Clearance Rocker Arm Assy.	.004" to .006"			
O. CAM FOLLOWERS				
1. Dia.—Outside Follower	1.060" +.001, -.000			
2. Dia.—Follower Bore in Cyl. Head	1.062" +.001, -.000			
3. Clearance Follower w/Cyl. Head	.001" to .003"			.005"
4. Looseness—Radial Follower w/Pin	.0005" to .0016"			.005"

ENGINE	DATA			Install New Parts When Clearance Exceeds
	HD-7	HD-10	HD-14	
P. BALANCE SHAFT				
1. Material	One piece drop forging—case hardened at journals			
2. Driven from	Idler Gear			
3. Bearing Dia—Inside of Plain & Thrust Bearings	1.500" +.001, -.000			
4. Dia.—Outside Shaft	1.4980" +.0005, -.0000			
5. Clearance—Bearings with Shaft	.0015" to .003"			
6. Length—Thrust Journal between Shoulder of Shaft & Gear	2.875" +.001, -.001			
7. Length—Thrust Bearing	2.865" +.001, -.001			
8. Clearance, End—between thrust shoulder & bearing	.008" to .012"			.016"
9. Type of gear	Right Hand Helical			
10. Rotation (Drive End)	Counter Clockwise			
11. Gear, No. of teeth—1st Type	62	62	62	
12. Gear, No. of teeth—2nd Type	78	78	78	
13. Ratio of drive to crankshaft	1 to 1	1 to 1	1 to 1	
Q. CAMSHAFT				
1. Material	One piece drop forging—case hardened at journals and cams			
2. Driven from	Balance-Shaft Gear			
3. Bearing Dia., Inside—end bearings plain and thrust	1.500" +.001, -.000			
4. Bearing Dia. inside, intermediate bearings	1.501" +.001, -.000			
5. Dia., Outside—Shaft Journals	1.4980" +.005, -.0000			
6. Clearance, end bearings with shaft	.0015" to .003"			.005"
7. Clearance, intermediate bearings with shaft	.0025" to .004"			.006"
8. End clearance, between thrust shoulder and bearing	.008" to .012"			.016"
9. Length, thrust bearing	2.865 +.001, -.001			
10. Length, thrust journal, between shoulder of shaft and gear	2.875 +.001, -.001			
11. Type of gear	Left hand Helical			
12. Rotation (Drive End)	Clockwise			
13. Gear, No. of teeth—1st Type	62	62	62	
14. Gear, No. of teeth—2nd Type	78	78	78	
15. Ratio of drive to crankshaft	1 to 1	1 to 1	1 to 1	
R. BLOWER				
1. Blower, Type	Roots type, three lobed, helical rotors			
2. Blower R.P.M.	1.95 times engine speed			
3. Blower drive gear driven from	Camshaft gear			
4. Clearance—rotors to rear end plate	.007" to .009"			
5. Clearance—rotors to front end plate	.014" to .016"			
6. Clearance—leading side upper rotor with trailing side of lower rotor	.012."-018"	.014"-.020"	.016"-.022"	
7. Clearance—trailing side of upper rotor with leading side of lower rotor	.002" to .006"			
8. Upper rotor and gear helix angle	Right hand			
9. Lower rotor and gear helix angle	Left hand			
10. Length of housing—approx.	7½"	9 31/32"	15"	
11. No. of teeth, blower gears	27	27	27	
12. Backlash in gears—1st type	.001" to .0015"			.002"
13. Backlash in gears—2nd type	.001" to .0015"			.004"
14. Rotation, upper rotor (Drive end)	Counter clockwise			
15. Type—driven end bearings	2 single-row ball bearings			
16. Type—drive end bearings	2 double-row ball bearings			
17. Oil seals no. & type	4 spring-loaded rawhide			

ENGINE	DATA			Install New Parts When Clearance Exceeds
	HD-7	HD-10	HD-14	
S. BLOWER DRIVE GEAR				
1. Dia., inside, support bushings	1.6260" +.0005, -.0000			
2. Dia., outside, hub	1.6250" +.0000, -.0005			
3. Clearance annular—bushings with hub	.001" to .002"			.005"
4. Length—support over bushings	2.997" +.000, -.001			
5. Length, hub between shoulders	3.000" +.002, -.000			
6. Clearance, end-bushings w/Hub	.003" to .006"			.010"
7. Rotation of gear, drive end	Counter clockwise			
8. Type of gear	Left hand Helical			
9. No. of teeth—1st type	32	32	32	
10. No. of teeth—2nd type	40	40	40	
T. LUBRICATING OIL PUMP				
1. Lubricating oil pump	Spiral gear type			
2. Lubricating oil—crankcase capacity	11 qts.	13 qts.	14 qts.	
3. Backlash—Drive Chain	1/4" to 3/4"			
4. Dia.,—outside gear	1.683" +.000, -.002			
6. Width—gear	1.7480" +.0000, -.0005			
7. Width—body	1.7500" +.002, -.000			
8. Backlash in gears	.018" to .020"			
9. Radial clearance—Gears with pump body	.002" to .0045"			.0045"
10. End play, gears with pump body	.002" to .0045"			.0045"
11. Rotation (Drive end)	Clockwise	Clockwise	Clockwise	
12. Ration of drive to crankshaft	.791 to 1	1.39 to 1	1.668 to 1	
13. No. teeth on crankshaft (drive sprocket)	19	25	25	
14. No. teeth on oil pump (driven sprocket)	24	18	15	
15. Driven by	Chain and sprockets from crankshaft			
16. Force feed to	Main and connecting rod bearings, piston pins, rocker arms, camshaft, balance shaft, blower drive gear and idler gear bearings and dome of piston for cooling.			
17. Gravity feed to	Cam follower assemblies, blower gears and bearings, upper part of injectors and exhaust valve stems.			
18. Splash to	Cylinder walls, governor, gear train, and oil pump chain.			
U. LUBRICATING OIL COOLER				
1. Description	Oil-to-water type, built into engine oil and water system,			
2. Location	Lower right front of cylinder block.			
V. LUBRICATING OIL FILTER "PRIMARY"				
1. Description	Full flow 2 piece removable metal element			
2. Location	Lower right front of cylinder block			
3. Size openings in filtering elements	.005"	.005"	.005"	
4. Service	At each oil change—30 to 60 hrs.			

ENGINE	DATA			Install New Parts When Clearance Exceeds
	HD-7	HD-10	HD-14	
W. LUBRICATING OIL FILTER "SECONDARY"				
1. Description	By-pass filter, replacement element type			
2. Location	Left side of motor			
3. Service	Replace element every 4th oil change or after each 240 hrs. of operation			
X. OIL PRESSURE				
1. At low idle speed	Not less than 5 lbs.			
2. At high idle speed	25 to 35 lbs.			
3. Pressure adjustments	None			
Y. INTAKE AND EXHAUST TIMING				
1. Exhaust valves close	52° A. B. D. C.			
2. Exhaust valves open	84° B. B. D. C.			
3. Cylinder inlet ports open	48° B. B. D. C.			
4. Cylinder inlet ports close	48° A. B. D. C.			
5. No. of ports in each cylinder	64 (Two rows—32 in ea. row)			
6. Diameter of ports	$\frac{5}{16}$"			
7. Angle of ports	16° from the radial in the transverse plane			
Z. STARTER				
1. Rotation "Drive End"	Clockwise	Clockwise	Clockwise	
2. Ratio of drive to crankshaft	9.27 to 1	9.27 to 1	10.7 to 1	
3. No. of teeth (drive)	11	11	11	
4. No. of teeth (driven)	102	102	118	
AA. GENERATOR				
1. Rotation (drive end)	Clockwise	Clockwise	Clockwise	
2. Ratio of drive to crankshaft	1.7 to 1	1.7 to 1	1.7 to 1	
3. Pitch dia (drive sheave)		7.803"		
4. Pitch dia. (driven sheave)	4.59"	4.59"	4.59"	
BB. WATER PUMP				
1. Rotation (drive end)	Clockwise	Clockwise	Clockwise	
2. Ratio of drive to crankshaft	1.95 to 1	1.95 to 1	1.95 to 1	
CC. INJECTORS				
1. Make	General Motors			
2. Type	Unit injector			
3. Timing by & gauge height	Timing Pin—1.484"			
4. Spray tip hole size	.006"	.006"	.006"	.008"
5. No. of holes in each tip	6	6	6	
6. Angle of spray tip holes—below horizontal	30°	30°	30°	
7. No. of filters in each injector	2	2	2	
8. Type of filters	Replaceable, Cone-shaped, Porous Bronze			
9. Start of injection	Variable, at various loads			
10. Injection starts at full load	14° B. T. D. C.			
11. Injection ends	2° B. T. D. C.			
DD. FUEL TRANSFER PUMP				
1. Type	Rotating Vane			
2. Cap in gals, per hr. at 1500 engine R.P.M. at 50 lbs. per sq. in. pressure	30	30	30	
3. Rotation (Drive end)	Counter clockwise			
4. Ratio of drive to crankshaft	1.95	1.95	1.95	

ENGINE	DATA			Install New Parts When Clearance Exceeds
	HD-7	HD-10	HD-14	
EE. GOVERNOR				
1. Type	Mechanical flyball			
2. Make	Handy			
3. Type of thrust bearing	3 piece ball bearing			
4. Means of speed regulation	By hand throttle			
FF. ELECTRICAL SYSTEM				
1. Generator	12 volt, 195 Watts			
2. Starting motor	12 volt, Dyer drive engagement			
3. Batteries, No. & type	Two 6-volt in Series	Two 6-volt in Series	Two 12-volt in Parallel	
GG. AIR CLEANER				
1. Make	United			
2. Type	Oil bath			
3. Total oil capacity ea. oil cup	Fill cup so the center of baffle extends up out of the oil only $\frac{3}{16}$"			
4. No. of air cleaners ea. tractor	1	2	2	
HH. PRE-CLEANER				
1. Make	United			
2. Type	Dry Centrifugal			
3. No. of Pre-Cleaners	1	2	2	
II. COOLING SYSTEM				
1. Radiator type	Tubular core			
2. Water pump type	Centrifugal			
3. Pump driven from	Blower, Front end, Lower Rotor Shaft			
4. No. of drain cocks	Two: One at pump, one at bottom of oil cooler connection			
5. Capacity each system, Gal.	5¾	9¾	12	
6. Cooling fan	Belt driven from crankshaft			

JJ-GEAR TRAIN

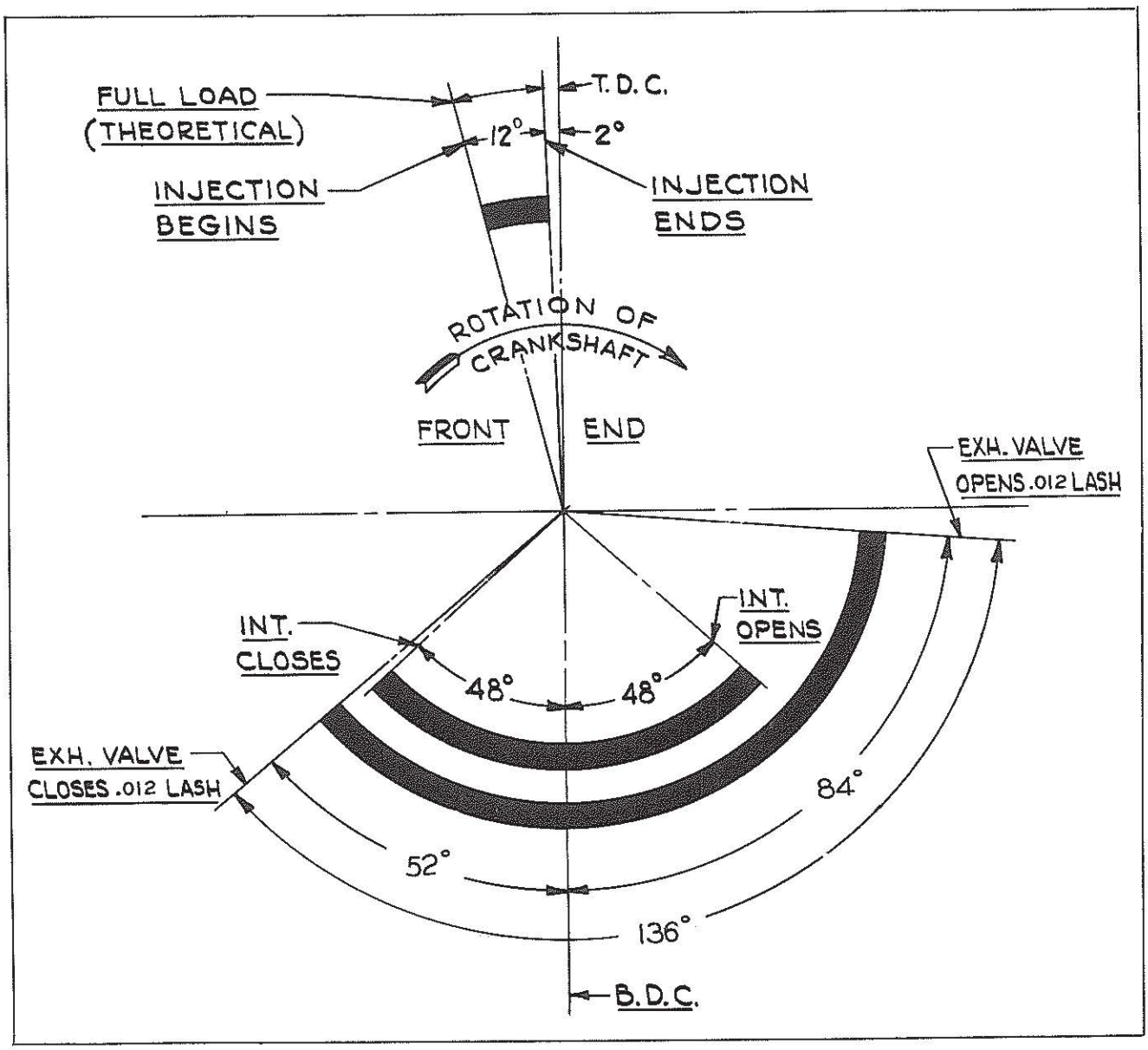
Name of Gear	Number of Teeth		Helical Angle	
	1st Type	2nd Type	1st Type	2nd Type
Crankshaft Gear	62	78	41°	19°
Idler Gear	54	68	41°	19°
Balance Shaft Gear	62	78	41°	19°
Camshaft Gear	62	78	41°	19°
Blower Drive Gear	32	40	41°	19°

68 -- Torque - - Wrench Specifications

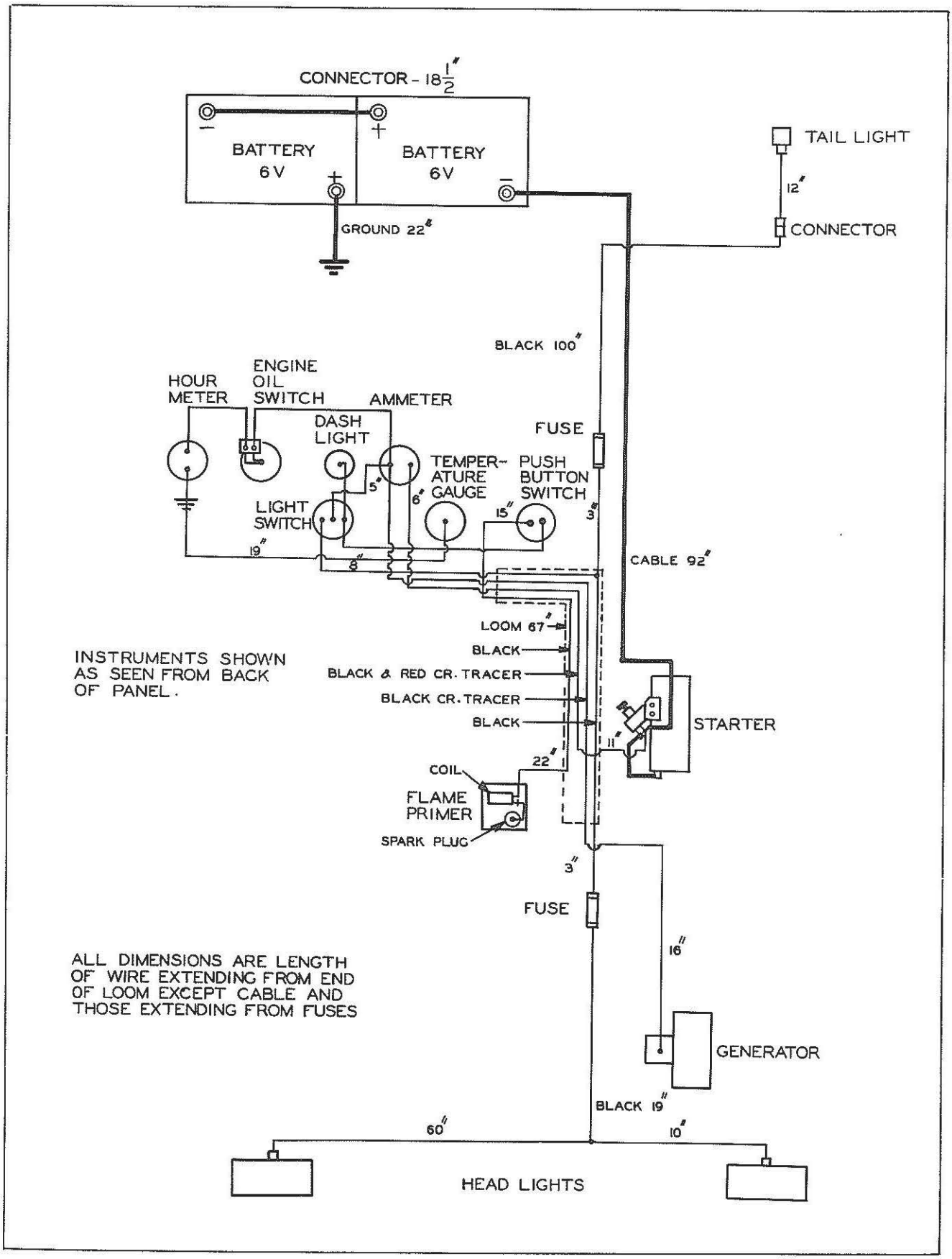
When a torque wrench is available, the following values may be used.

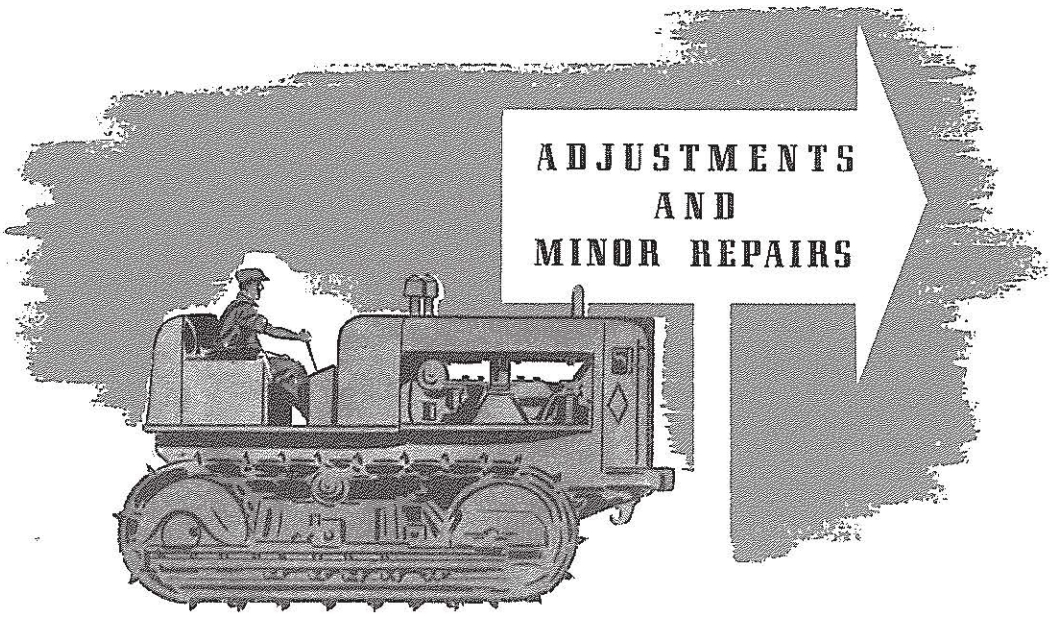
APPLICATION	torque — lb. ft.
A. Injector clamp nuts	20-25
B. Cylinder head stud nuts	165-175 Cold
C. Connecting rod cap nuts	65-75
D. Main bearing cap nuts	155-185
E. Flywheel housing cylinder block bolts, ½" size	90-100
F. Camshaft and balance shaft end nuts	300-325
G. Blower rotor gear retainer bolts	
½" dia.—2nd type	40-45
⅜" dia.—1st type	25-30

69 -- TIMING DIAGRAM "ENGINE"



70 -- WIRING DIAGRAM "HD 7"





SAFETY:

Broken or worn out tools cause mashed fingers, bruised knuckles and many other serious injuries. See that the tools you use are in good condition.

ADJUSTMENTS AND MINOR REPAIRS

42 -- Injector Timing

The timing of an injector consists of properly locating the top of the plunger follower in relation to the injector body. This must be done separately for each injector after it has been installed in the engine.

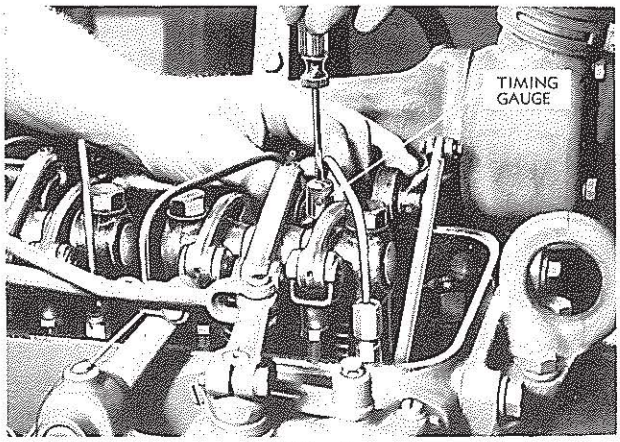


FIG. 1

1. Remove cylinder head cover.
2. Rotate engine until both valves of the same cylinder are down (fully opened).
3. Place timing gauge in hole of injector body. Adjust push rod so it is just possible to turn shoulder of gauge over the top of follower without lifting gauge. Tighten locknut on push rod and inspect adjustment to be sure it remained unchanged. This operation must be repeated for each injector.

   NOTE: When inspecting timing, hold the gauge vertical. Be sure there is no dirt or obstruction in the hole in the injector body. When gauge with the sliding sleeve (2nd type) is used, adjust the push rod so the sleeve comes flush with the top of the center pin.

   When the top surface of the threaded sleeve (3rd type) is flush with the top of the pin injector it is properly timed. This is determined when the marks "C" on the sleeve and pin line up.
4. Injector timing must be inspected whenever an injector is removed and replaced.

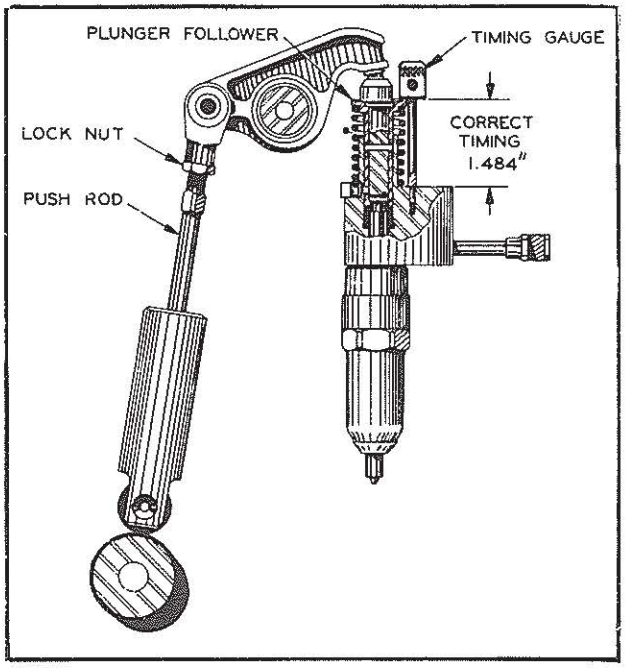


FIG. 2

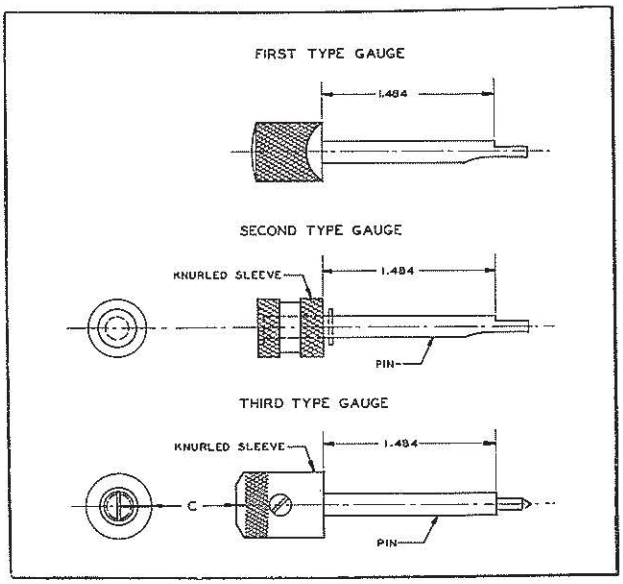


FIG. 3

43 -- Equalizing Injectors

Following are directions for equalizing the injectors:

1. Remove link pin from governor control lever.
2. Be sure all control rack levers are engaged with the injector control racks.
3. Loosen adjusting screws on all control rack levers and be sure the levers are free on the shaft and the shaft free in the bearings.
4. Injectors must be timed before being

equalized.

5. Set engine "shut-off" in running position.
6. Pull throttle all the way back.
7. Push control tube lever toward water manifold as far as possible and hold firmly in this position.
8. Adjust inside screw on number 1 rack control lever so it pulls control tube lever hole 1/64" past hole in governor control link. Lock control lever in this position by tightening outside screw on lever.

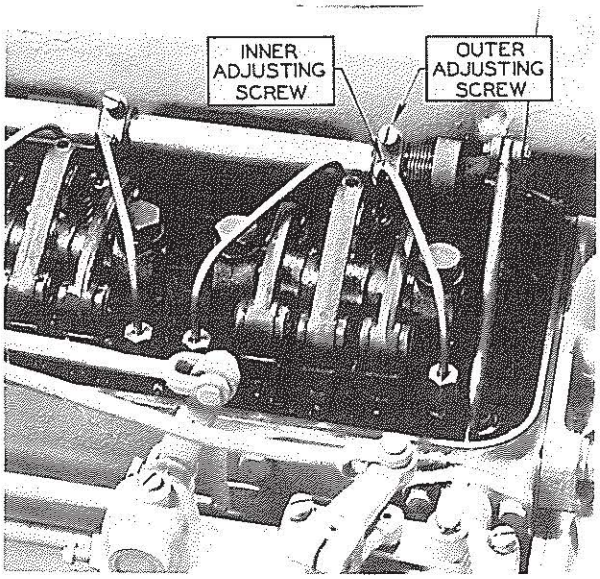


FIG. 1

9. Using a medium sized screwdriver, turn inner screw on number 2 rack control lever in until a pressure is felt on control tube lever. Now back screw out until this pressure is relieved (this is done to be sure that there is no binding between rack control lever and control tube). With screwdriver held lightly in finger tips turn screw in again until a slight pressure is felt on screwdriver. Turn in and out a few times in order to set screw at the exact position where pressure starts. Now lock by tightening outer screw.
10. Adjust remaining rack control levers as described.
11. Still holding control tube lever in position as described in paragraph #7, inspect control racks. These racks, when rack control levers are adjusted properly will all be tight. If any should be found loose at this point readjust by loosening outer screw and tightening inner screw. (Do not change adjustment of #1 rack control lever.)
12. Replace pin in governor control link and control tube lever. Secure same with cotter pin.
13. Do not attempt to obtain a smooth running motor, by changing control rack adjustment individually without regard to this method of equalizing.

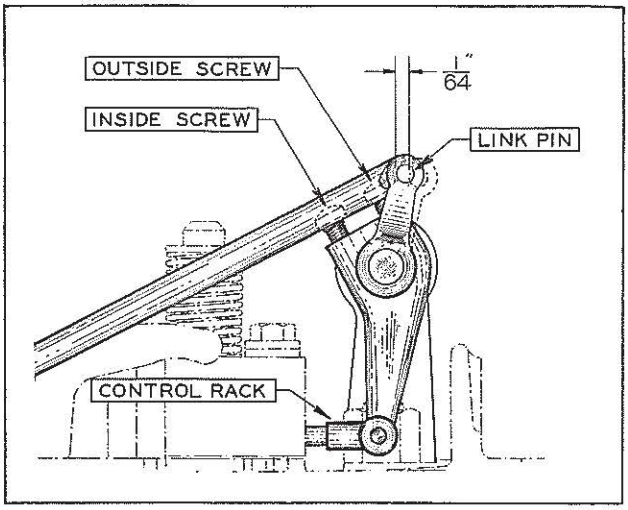


FIG. 2

44 -- Valve Lash

Owing to the high compression in this engine, it is very important that the correct valve lash be maintained. Too little clearance will cause a loss of compression, missing cylinders, and eventual burning of valves and seats. Too much clearance will result in noisy operation especially at idling speeds.

The valves should be adjusted to give .009" clearance between the valve stem and the rocker arm. This must be done with the engine at recommended operating temperature.

1. To adjust valves, rotate engine with starter until the injector is at the bottom of its stroke.
2. Use a .009" thickness gauge and adjust each push rod until gauge will just pass

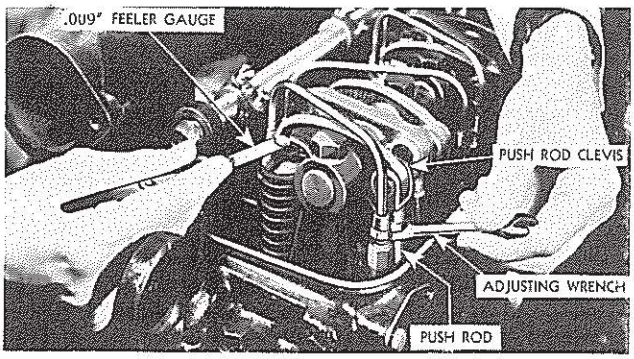


FIG. 1

between valve stem and rocker arm with a slight drag.

3. Repeat this operation for each cylinder.
   CAUTION: If for any reason a push rod has been disconnected from a rocker arm, care must be taken to have the push rod screwed entirely through the clevis before any attempt is made to rotate engine. If the valve is held down owing to the push rod being adjusted too long, it will be damaged by the piston and necessitate replacement.

45 -- Governor

Governor faults are usually manifest in speed variations of the engine, but it does not necessarily mean that all such speed variations indicate governor faults. Therefore, when improper speed variations appear, the following procedure should be carried out.

A. CAUSES FOR SPEED VARIATIONS

1. Be sure that the speed changes observed are not the result of load fluctuations.
2. If the load is uniform, carefully inspect the engine and be sure that all cylinders are firing properly.
3. See that no bind exists in the governor mechanism or operating linkage between governor and engine; also that no bind is manifest in the injector control rack shaft or its mounting brackets.
4. Inspect ball thrust bearing for wear or improper assembly.

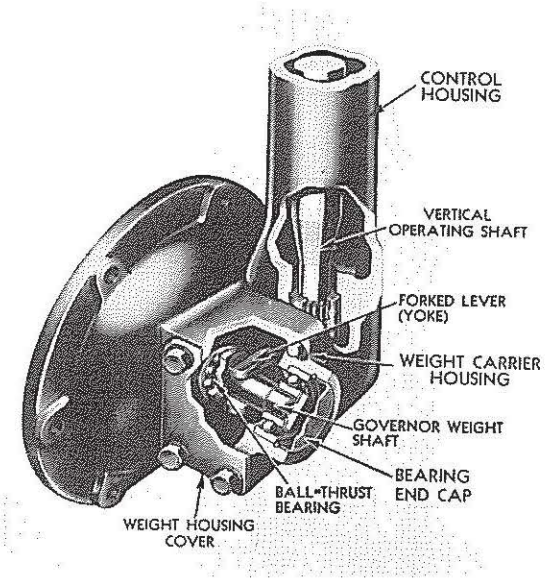


FIG. 1

5. If the engine races (beyond governor control) remove the hand hole covers on the left hand side of the cylinder block and inspect for an accumulation of oil in the airbox. If this condition exists clean the drain tubes. Refer to Topic 85B.
   The injectors will all have to be removed and tested as the tips may be burned off. Refer to Topic 77.

B. LOCATING CAUSE OF GOVERNOR NOT OPERATING PROPERLY

1. Injector racks may stick or move too hard. This may be due to the injector hold-down clamp being too tight or not positioned properly and can often be eliminated by tapping the foot of the clamp lightly with a small hammer and a long punch. An injector which has been in service a long time may get sticky due to an accumulation of gum and sludge. This can be corrected by washing in a pail of clean fuel oil.
2. Injector rack may stick due to being cramped by the rack control lever. Loosen the screws in the rack control lever. If this relieves the binding move the lever endwise on the control shaft until the rack control lever no longer cramps the injector rack. Cocking of the rack control lever may also be due to damage to the ends of the adjusting screws or the surfaces which they contact, and may be corrected by filing. After the trouble has been remedied, the injector must again be equalized.
3. Control shaft may stick or turn hard in its small ball bearings. These bearings must be free from chips, dirt, or sludge, and must be lubricated. Binding due to poor alignment of the bearing supports can be corrected by loosening the bearing support capscrews and re-aligning the bearing supports. When the injector rack control shaft is free of bind and while operating the injector racks, the shaft should return freely to the "no fuel" position by the shaft return spring only. Any time the control shaft bearing suports have been loosened, the injectors must be equalized.
   CAUTION! Never stretch or tamper with rack control spring to change the tension. If spring is not standard, install a new one.
4. Control shaft may have too much friction due to control shaft spring being bent. Install a standard spring.
5. Pin in link connecting governor to control shaft may be binding in the control shaft lever. Free pin.
6. Having made the above inspection, if the governor still fails to control the engine properly, a complete governor overhaul is

necessary. See Topic 93.

7. The full load speed adjustment is made at the factory and must not be changed in the field. However, if the engine is not

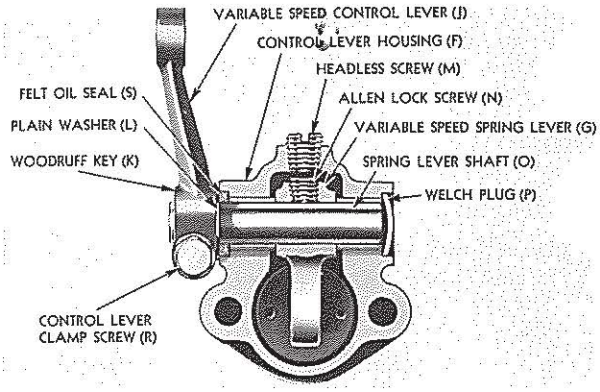


FIG. 2

running at rated speed, (at high idle), inspect variable speed control lever as it may be turning on shaft. Remove headless screw "M" in top of housing and tighten Allen lock screw "N", holding lever on shaft. Shaft, lever and lock-screw may be worn to the extent that new parts should be installed. If this variable speed control lever is all right, see that throttle control rod is pulling the variable speed control

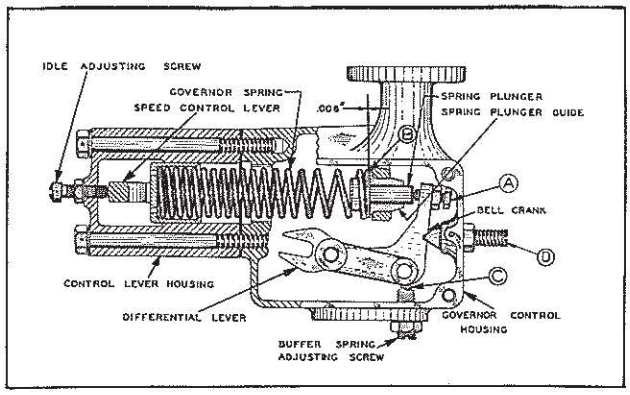


FIG. 3

lever back to the wide open position. If not, adjust by means of adjustable yoke. If it becomes necessary to change the idling speed, start the engine and operate until it has reached the normal operating temperature. Loosen the lock nut on the adjusting screw and turn the screw "IN" (clockwise) for higher speeds, or "OUT" (counter clockwise) for slower speeds until the desired speed is obtained; the correct idling speed is 450 r.p.m. Inspect the fuel lines and fuel filters, and make sure that all motor adjustments are properly set.

46 -- Fuel Shut-Off and Air Valve Control

Provided fuel oil pressure is normal, a loss of power in the engine is an indication that the fuel shut-off and air valve control linkage is incorrectly adjusted.

Inspect and adjust as shown below:

A. FIRST TYPE CONTROL

1. INSPECTION.
   a. With shut-off control knob pushed in and locked in running position, pin on bottom of governor fuel shut-off lever should contact rear end of slot in governor shut-off lever stop.
   b. Pull shut-off control knob to OFF position and see that pin is now contacting forward end of slot in governor shut-off lever stop. If pin stops at some intermediate position in slot, inspect fuel shut-off lever and linkage for binding and fuel shut-off lever for slippage on shaft.
   c. Start engine and allow to run at full speed. Disconnect rod from fuel shut-off lever and hold shut-off lever in running position. Now pull shut-off control knob to OFF position thus closing the air valve. Engine should immediately stop. If engine continues to run it is an indication that air valve is not being held completely closed with knob in OFF position and linkage should be adjusted.

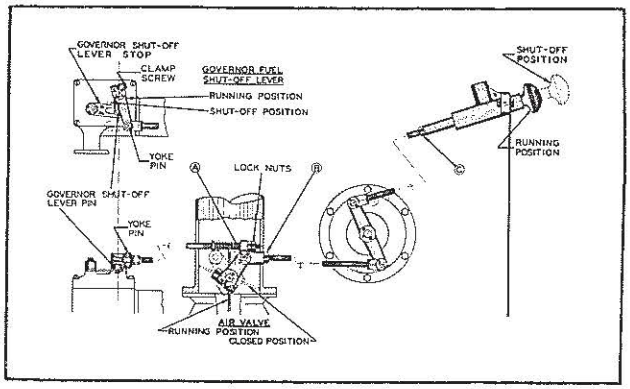


FIG. 1

If air valve is found to be out of adjustment adjust it as follows:

2. ADJUSTMENT.
   a. Disconnect rod from air valve arm at "A" and move arm forward until it comes to a definite stop. Air valve is now closed.
   b. Pull shut-off control knob out until it locks in OFF position. Adjust linkage at "B" or "C" until rod can be reconnected at "A" with air valve in closed

position (arm forward). Make sure that air valve is held completely closed with shut-off control knob in OFF position and that all lock nuts on linkage are tightened securely.

c. Back off fuel "shut-off" adjustment nuts to end of rod and tighten. Push control knob in as far as it will go where it will lock in RUNNING position.

d. Loosen the clamp screw on the governor fuel shut-off lever. Position lever pin until it contacts the rear end of the slot in the governor shut-off lever stop. Tighten the clamp screw. After all adjustments have been completed, inspect the set-up again as outlined in the first three steps.

B. SECOND TYPE CONTROL

1. With the shut-off knob pushed into running position, see if the shut-off lever stop assembly is in position as shown. The ball in the stop assembly should be centered in the hole in the shut-off lever as shown. If not, the shut-off knob is probably contacting the dash. To adjust, remove pin "A" and move shut-off lever until the ball is centered in the front hole in the shut-off lever. Now adjust linkage at "B" until

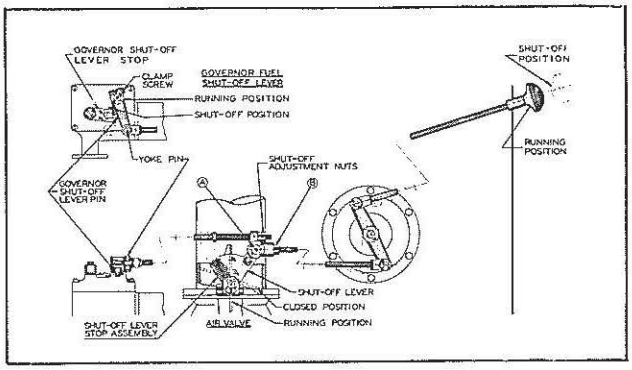


FIG. 2

the rod can be reconnected at "A". Now inspect the shut-off lever in running and closed position to make certain that the ball in the stop assembly is centered in both positions.

2. With the linkage set in running position, see that the governor shut-off lever pin contacts the rear of the slot in the shut-off lever stop. If not, back off fuel "shut-off" adjustment nuts to end of rod and tighten lock nut. Loosen clamp screw on the governor fuel shut-off lever and position the lever pin until it contacts the rear end of the slot; tighten the clamp screw.

47 -- Engine Pre-Heater

A. REPAIRING ENGINE PRE-HEATER

1. Blower fan not working.
   a. Make sure the insulated wire to the fan motor is properly connected to the source of electricity.
   b. Make sure sufficient and solid ground connections have been established.
2. Fuel not being delivered from spray nozzle.
   a. No fuel in fuel chamber. Fill ½ to 2/3 full of fuel oil.
   b. No pressure in fuel chamber. Pump up to 120 pounds pressure. Inspect for leaks.
   c. Spray Nozzle may be clogged.
      (1) Unscrew nozzle assembly and remove.
      (2) Remove the vortex plug in center of nozzle. Wash parts in clean fuel oil and dry with compressed air. Do not clean nozzle with drill bit or steel wire as this will damage the nozzle and render it useless.

      With spray nozzle removed, determine if the fuel filter element is clogged. Pump up to the 120 pound pressure and open the fuel needle valve. If a good flow of fuel is evident, the filter is free of obstruction.
   d. Fuel Filter Element clogged.
      (1) Remove the filter plug and the filter element.
      (2) If filter element cannot be cleaned satisfactorily, install a new filter element being careful to seat it properly at both ends. Replace filter plug.
   e. Before installing the spray nozzle, pump up the pressure and open the needle valve to wash out any foreign material in the passage to the nozzle. Close the valve and install the cleaned spray nozzle.

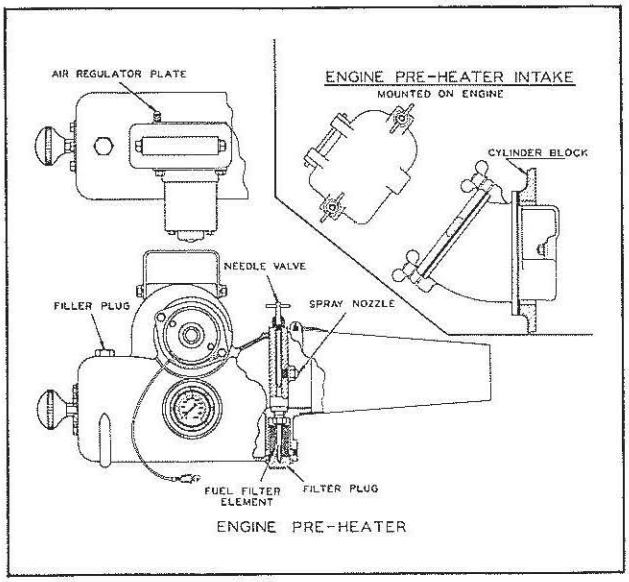


FIG. 1

48 -- Air Heater

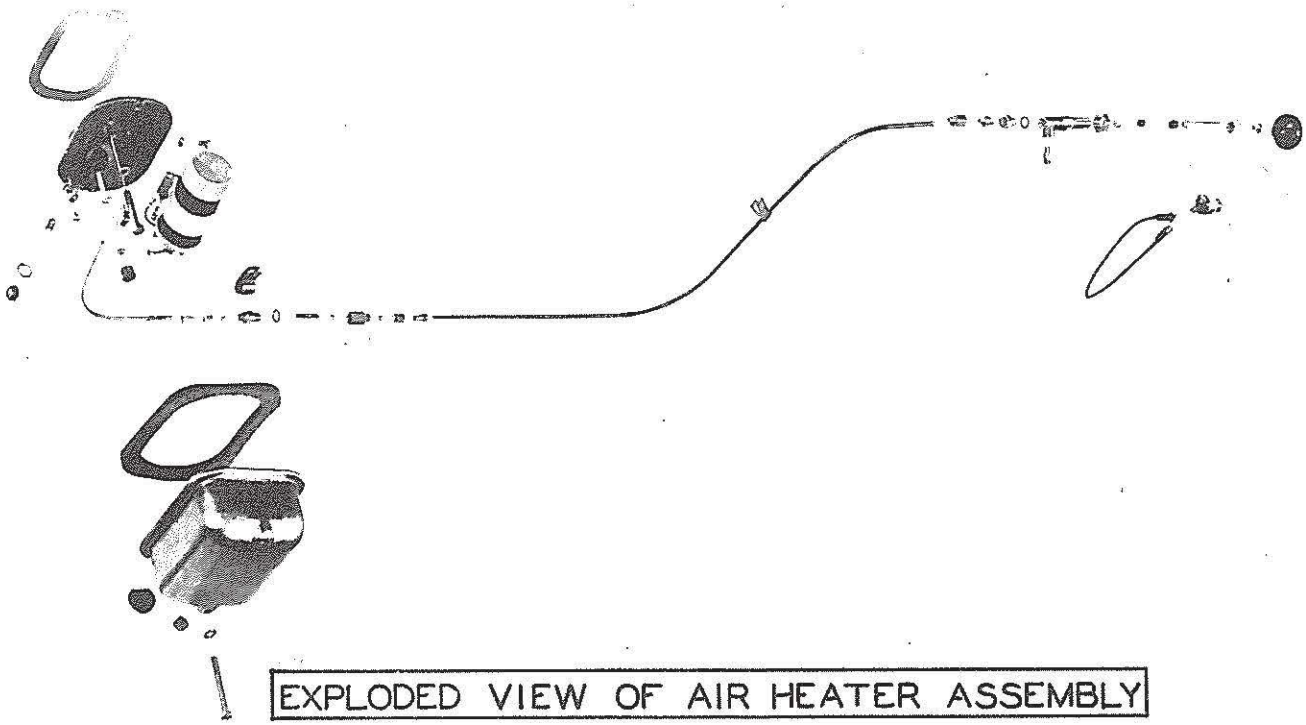


FIG. 1

A. VIBRATOR NOT WORKING

Key or dashlight switch must be "On" before air-heater can be used. The vibrator should buzz audibly when heater switch button is pressed. If no buzz can be heard look for these causes:

1. Lack of current being supplied to coil.
2. Vibrator points struck. The points (on top of coil under the cover) will probably free up if top of coil is rapped gently with the butt of a screw driver.
3. Vibrator points burned or fused. Examine by removing top of coil and inspect points. If they are burned, recondition with ignition file or install a new coil assembly.

B. SYSTEM MAY BE SHORTED AT IGNITION POINTS

1. Inspect porcelain for cracks or breaks.
2. Spark gap may be improperly set. This should be set to ⅛" plus or minus 1/64". In adjusting this gap, bend the grounded electrode to give proper gap. Do not attempt to move or bend the insulated electrode, for to do so would result in breakage of the porcelain.
3. Sludged or oily ignition points.

C. FUEL OIL NOT BEING DELIVERED TO IGNITION CHAMBER OF HEATER

1. The spray nozzle of the heater may be clogged. This would be indicated by excessive pressure on the pressure pump, or by failure of the nozzle to atomize the fuel. To clean, proceed as follows:

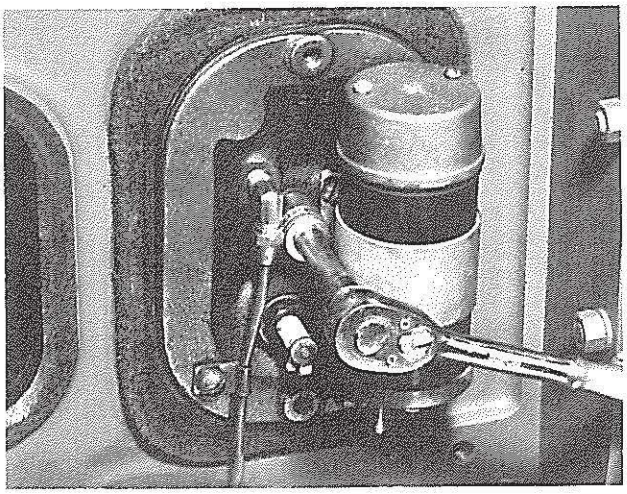


FIG. 2

   a. Remove both electrodes and unscrew nozzle assembly using a 5/8" thin-walled socket.
   b. Remove nozzle filter spring and vortex plug in center of nozzle. Wash parts in clean fuel oil and dry with compressed air. Do not clean nozzle with drill bit or steel wire as this will damage the nozzle and render it useless.
   c. Reassemble, taking care that no dirt enters assembly. Be sure nozzle gasket does not leak.
2. Pump piston leather may be dry. This condition is liable to occur if the tractor

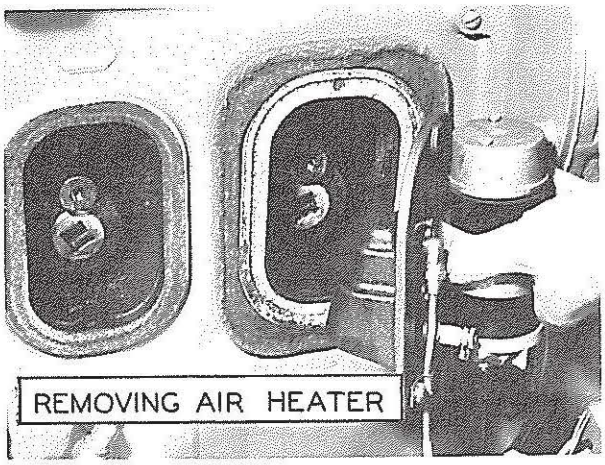


FIG. 3

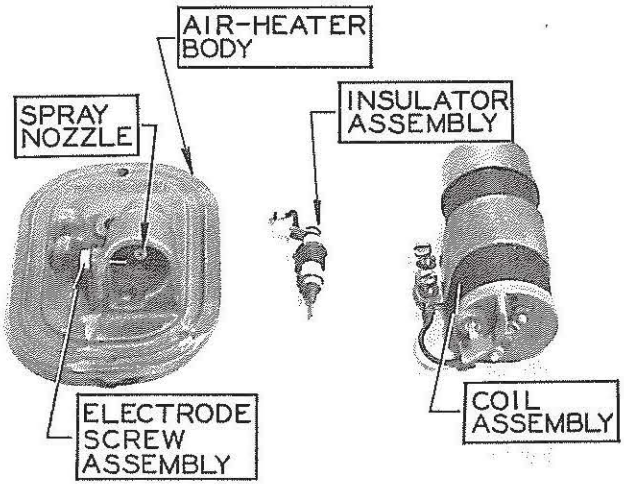


FIG. 4

has remained inoperative for a considerable period of time. It would be detected by a lack of pressure on the plunger when it is stroked. In this case, the leather must be replaced.

3. Pump leather worn or damaged. This also would be indicated by lack of pressure when the plunger is stroked and would require replacement of the leather. To install leathers, proceed as follows:
   a. Remove nut on outside of panel and withdraw plunger assembly.
   b. Remove retaining screw on end of plunger and remove leathers.
   c. Install new leathers and run retaining screw up tight. Use a few drops of oil to facilitate entering the assembly back into cylinder. Be careful that the edges of the entering leather are not torn or cracked in entering.
4. The inlet line to the heater pump may be loose or broken.

49 -- Dampener for Fuel Pressure Gauge

The dampener, installed on back of fuel pressure gauge, is designed to eliminate vibration of the recording hand of gauge.

HD Series Tractors manufactured prior to March 12, 1941 were not equipped with a fuel gauge dampener. Installation of this dampener can be easily made on tractors not so equipped.

For the HD-14 model, order #043952 dampener only.

For the HD-7 and HD-10, order the #043952 dampener and one each #907059 street ell and #040740 female coupling.

50 -- Generator Belt

To adjust the generator belt, loosen the capscrews in the generator adjusting link. Move the generator in or out as necessary to correct the adjustment and tighten capscrew. The adjustment is correct when the belt has about 1 inch slack measured halfway between the pulleys. Too tight a belt will cause bearing failure and undue wear on belt.

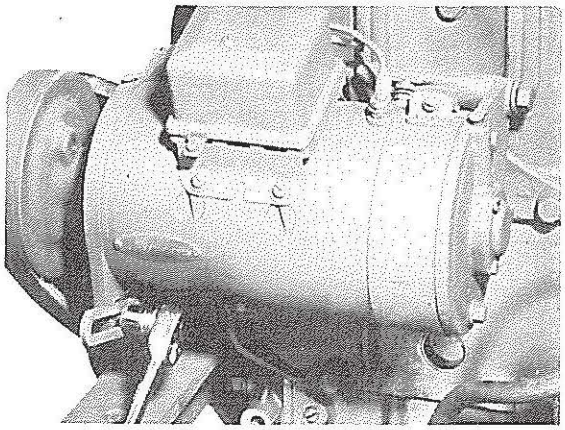


FIG. 1