taminate the fuel, clog the filters and eventually damage the fuel pump and injectors.

A portable storage tank provides the best method for storing fuel on the job. In a tank, the sediment and water can easily be drained and the fuel can be pumped into the tractor fuel tank with a minimum of handling. Consult your local Allis-Chalmers dealer for details about this type of storage tank. Since condensation will occur in the tank, it is very important that a sediment sump be provided in the bottom of the storage tank where the water and settlings can be drained daily.

Fuel should be allowed to settle at least 48 hours in the storage container before it is put in the fuel tank of the tractor. It is advisable to use a pump and draw the fuel from the tank or barrel rather than from the bottom of the container by means af a faucet or through the bung hole.

Where conditions are such that drums must be used to supply fuel, it is advisable to have enough drums to allow sufficient time for the fuel to settle. The fuel should be used only to within about three inches from the bottom. The fuel thus left in a number of drums can be collected into one drum and used after the usual time allowed for settling. In this manner, the sediment and foreign matter will be disposed of and no fuel will be wasted. Whenever drums are used for storage, they should be covered or placed under shelter to avoid the fuel becoming contaminated by water which will enter through the filler plugs when it rains, even though the plugs are tight.

The fuel tank of the tractor should be filled at the end of the day's run rather than in the morning. This will reduce the water content, as a full tank is less subject to condensation. The fuel tank is provided with a drain elbow and drain cock. Sediment will settle into this elbow and can be drained.

6. TRACTOR AND ENGINE SERIAL NUMBERS

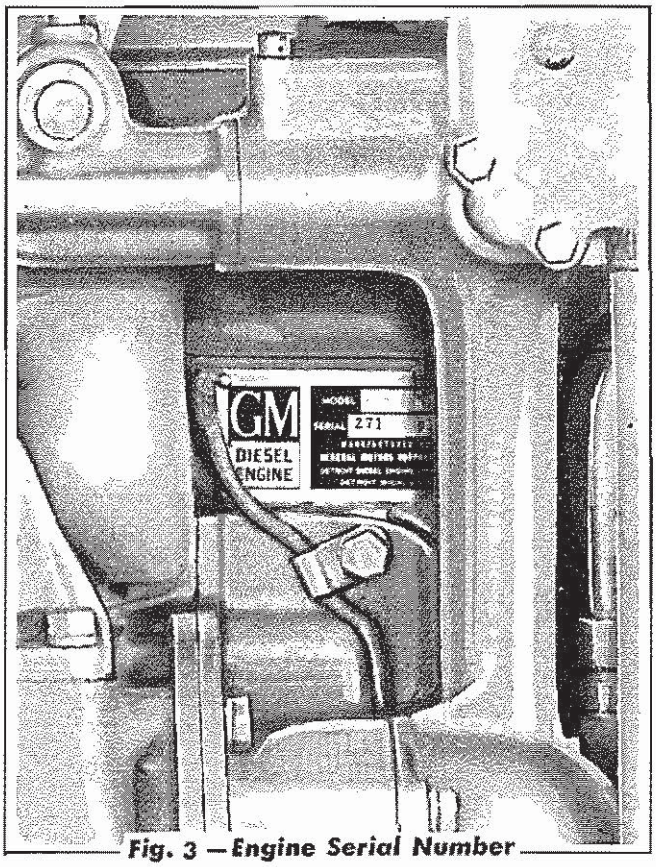


Fig. 3 —Engine Serial Number

On all parts orders and in all correspondence relative to the tractor, it is necessary that both tractor and engine serial numbers be given. This will properly identify the particular tractor and will insure obtaining the correct replacement parts for it.

Prior to engine Serial Number 2-71-11180, the engine serial number is stamped on a plate attached to the left side of the cylinder block below the governor control housing. On engines Serial Number 2-71-11180 to 2-71-15635 the number is stamped directly in the cylinder block in the same relative location. Effective on engines after 2-71-15635 the engine serial numbering system was changed. In the new system of numbering, the prefix numbers 2-71 were changed to read 2A-1, 2A-2, etc., and are stamped in the cylinder block.

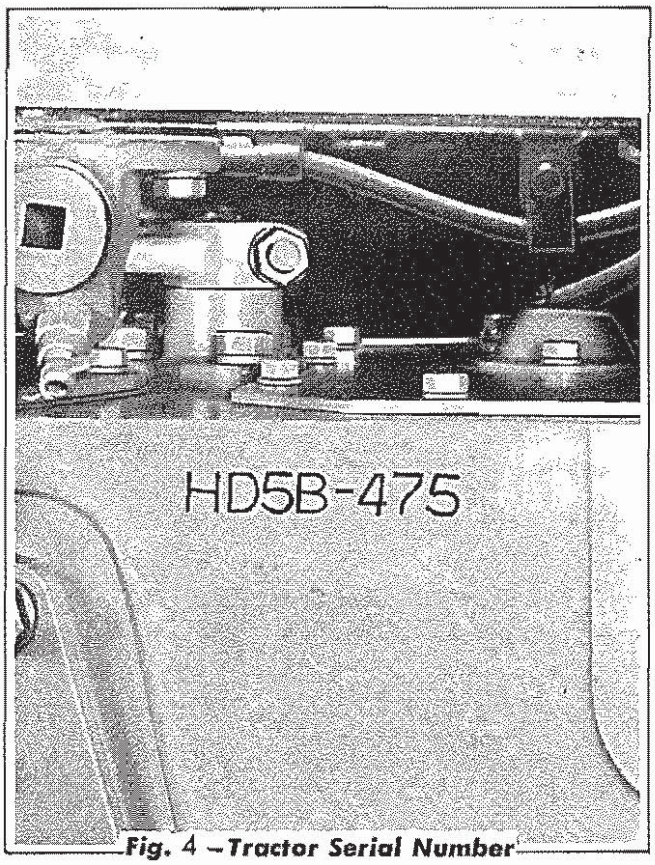
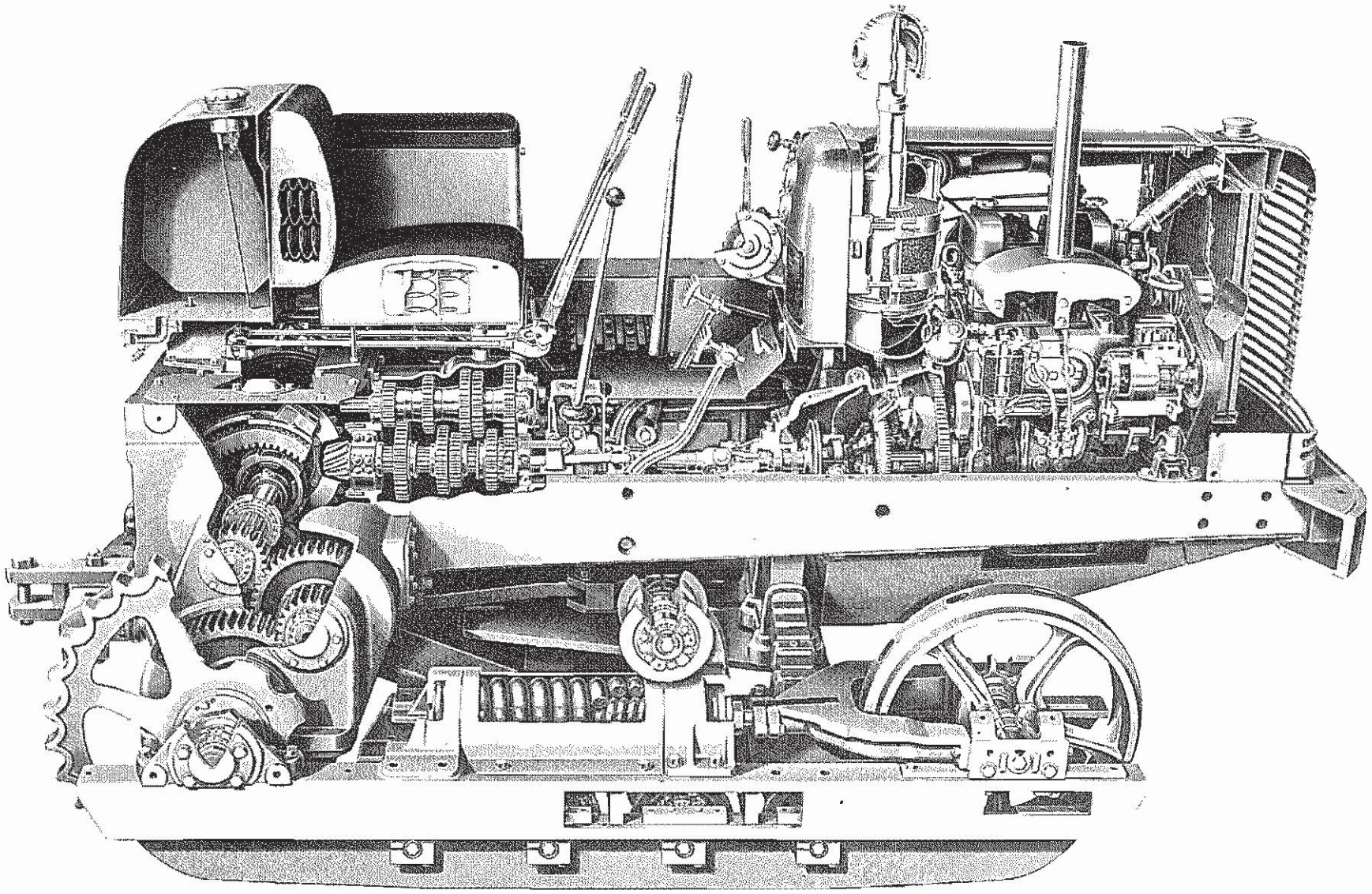


Fig. 4 –Tractor Serial Number

The tractor serial number is stamped in the rear face of the steering clutch housing near the upper right corner.



Cutaway — Model HD-5 Tractor

SECTION II — ENGINE FUEL SYSTEM

1. DESCRIPTION OF SYSTEM

The engine fuel system consists of the fuel tank, first stage fuel filter, fuel pump, second stage fuel filter, injectors and fuel lines. The fuel is drawn from the bottom of the tank and through the first stage filter by the fuel pump. The pump circulates the fuel under pressure through the second stage fuel filter and inlet fuel manifold in the cylinder head, and through the injectors. As the fuel enters each injector, it passes through a small porous metal filter in the injector body. The amount of fuel required by the engine is injected into the cylinders by the injectors. Surplus fuel not required for combustion, leaves each injector through a second porous metal filter, enters the return fuel manifold in the cylinder head and returns to the fuel tank. A pressure of 25 to 45 pounds is maintained within the system by a restricted fitting located at the cylinder head return manifold opening. The continuous circulation of the fuel through the injectors helps to cool them and eliminates the possibility of air pockets in the fuel supply system.

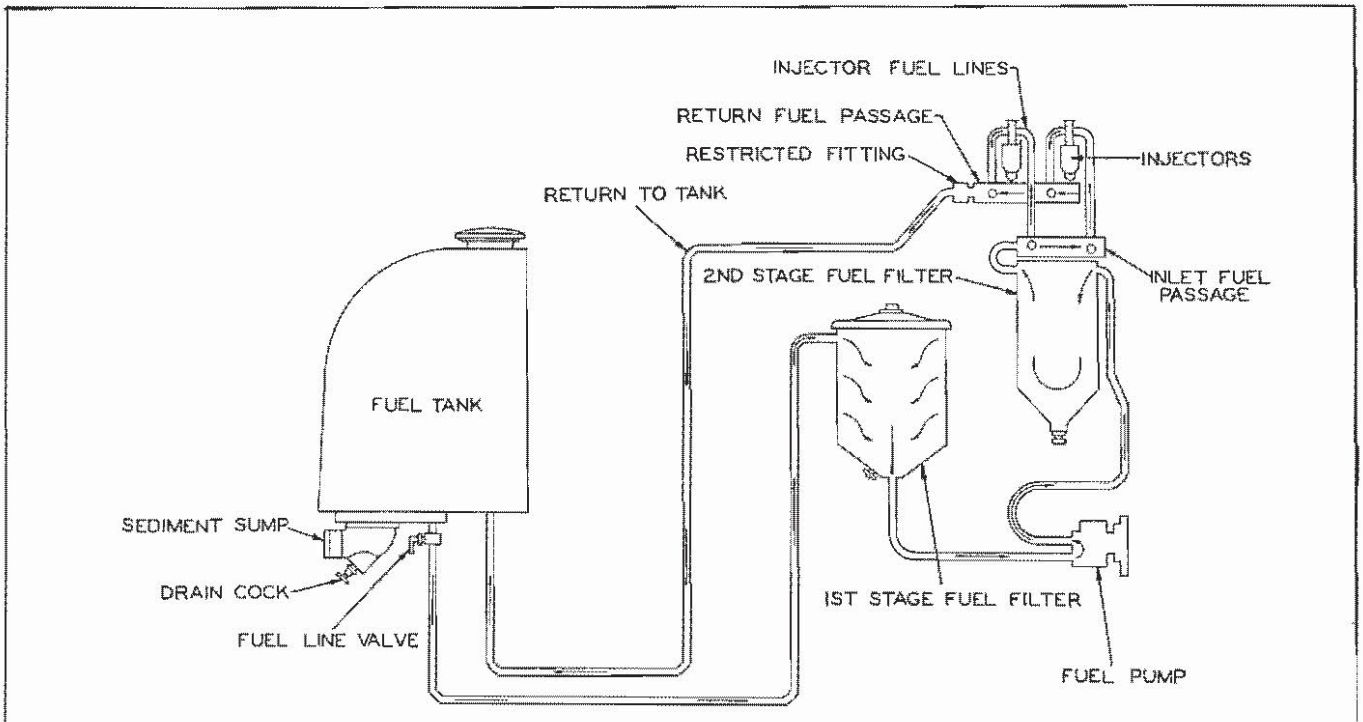


Fig. 1 — Schematic Fuel Flow Diagram

2. CHECKING FUEL SUPPLY SYSTEM

A. General.

Under normal conditions with the engine operating at full throttle, 25 to 45 pounds pressure will be indicated on the fuel pressure gauge, if the tractor is equipped with a gauge. If the tractor is not equipped with a fuel pressure gauge, and conditions occur which indicate incorrect fuel pressure, the pressure can be checked by installing a gauge in the delivery line of the fuel pump at any point between the pump and the inlet manifold opening.

Fuel pressure below normal, uneven running of the engine, excessive vibration, stalling when idling, and a loss of power are indications of insufficient fuel supply to the injectors.

To determine the cause for the above conditions check for the following:

Air being drawn into system
Clogged fuel filter elements and fuel lines
Clogged injector fuel filters
Inoperative fuel pump

To check the flow of fuel through the system, disconnect the fuel return line at any point between the fuel return manifold and the fuel tank. With the engine operating at full throttle, the system will be functioning properly when a full stream of fuel with considerable force can be observed returning to the fuel tank through the fuel return line. If only a small stream is observed returning to the tank, all the causes listed above must be checked and eliminated in turn.

B. Check for Admission of Air Into System and for Clogged Filter Elements and Fuel Lines.

To check for air being admitted into the system, remove the valve rocker arm cover and loosen or disconnect one of the injector fuel lines, then start the engine. If air is entering the fuel system, foam or bubbles will be observed in the fuel that emerges from the loosened connection. Correct this condition by tightening any loose fuel lines and filter connections between the fuel pump and the fuel tank. Test for smooth operation and full flow of fuel.

If the fuel lines or filters are clogged remove the fuel lines, clean both filter shells and install new elements. Blow out the lines while they are disconnected. This should eliminate the difficulty. Check for full flow of fuel after engine is again started.

C. Check for Clogged Injector Filters.

If the engine still runs "ragged" with suitable fuel return, the injector filters for one or both cylinders may be partially clogged. Locate the faulty injector as follows:

1. Run the engine at idling speed and cut out each injector in turn by holding the injector follower down with a screwdriver or small block of wood while the engine is running, as illustrated in Figure No. 2.

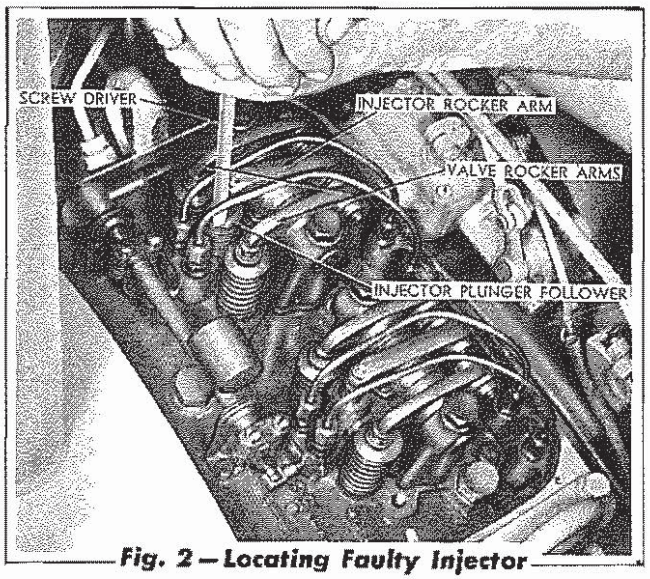


Fig. 2—Locating Faulty Injector

CAUTION: Do not allow the screwdriver to slip off the follower as damage to the valve assemblies can easily result. If the engine speed decreases when the follower is held down it will indicate that the injector for that cylinder is functioning properly. If the engine continues to run with no decrease in speed, the injector is inoperative and should be removed for further inspection.

2. Stop the engine and remove the fuel feed line that connects the injector to the return fuel manifold. Hold a finger over the injector fuel outlet and crank the engine with the starter. If the fuel gushes from the injector while the starter is cranking the engine, an ample fuel supply is indicated. Remove the injector and

check for clogged injector filters. Refer to "INJECTOR REMOVAL" in this section.

D. Check for Inoperative Pump.

Assuming that there is a sufficient supply of fuel in the fuel tank, and that the fuel is reaching the fuel pump, remove the pipe plug from the top of the second stage fuel filter. With the engine running the fuel will gush from the opening in the filter. If it does not, the fuel pump will be considered inoperative and must be removed and repaired or replaced.

E. Excessively High Pressure.

A relief valve is installed in the fuel pump to prevent high fuel pressure. When the relief valve sticks, high pressure will develop and will be indicated on the fuel pressure gauge, if the tractor is equipped with a fuel pressure gauge.

When high pressure occurs, the valve in the fuel pump should be inspected and the cause determined for its sticking. The second stage fuel filter, the restricted fitting in the fuel return line at the return manifold and all fuel lines should be inspected for clogged passages.

Continued operation with excessively high pressure (over 60 pounds) may result in damage to the fuel system.

3. FUEL TANK AND DRAIN ELBOW

A. Description.

The fuel tank, located at the rear of the tractor has a capacity of approximately 37 gallons.

The drain elbow on the bottom of the fuel tank provides a means of flushing the tank and also acts as a sediment sump. Open the drain cock on this elbow before the engine is started at the beginning of the day's operation in warm weather or shortly after the end of the day's operation in freezing weather. Close the cock when clean fuel runs out. Drain the tank, when an accumulation of rust and scale is evident, by removing the plug in the end of the drain elbow, then flush the tank thoroughly.

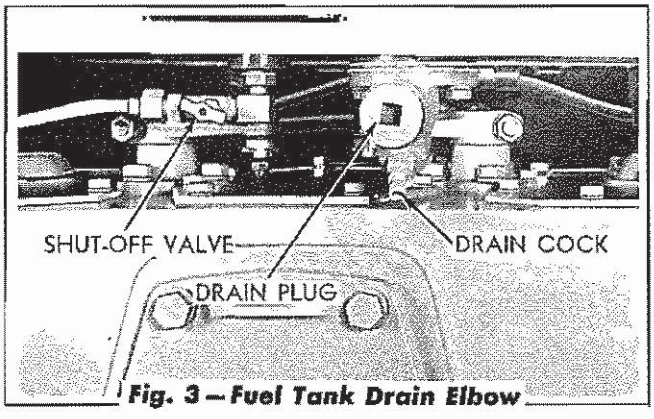


Fig. 3 — Fuel Tank Drain Elbow

B. Maintenance.

If a large accumulation of rust or scale in the tank becomes apparent, remove the drain elbow and the fuel lines from the bottom of the tank and flush the tank with clean fuel or clean the tank with live steam. This will prevent frequent clogging of the fuel filters and will eliminate possible trouble in the fuel system.

C. Removal.

When it becomes necessary to remove the fuel tank, proceed as follows:

1. Remove the arm cushions from the top of each battery box and remove the capscrews used in fastening each battery box to the fuel tank.
2. Remove the bolts attaching the tank to the rear fenders.
3. Close the fuel shut-off valve at the bottom of the tank and disconnect the fuel supply line and the fuel return line from the fuel tank.
4. Place a suitable chain or rope around the fuel tank and remove the tank from the tractor. Protect all openings of the fuel tank and disconnected lines against the entrance of foreign material.

4. FUEL FILTERS

A. Description of First Stage Fuel Filter.

This filter, mounted at the left side of the engine, contains a replaceable element. Dirt and sediment in the fuel is collected by this filter and prevented from passing on to the fuel pump. A drain cock in the bottom of the filter shell allows drainage of the sediment collected.

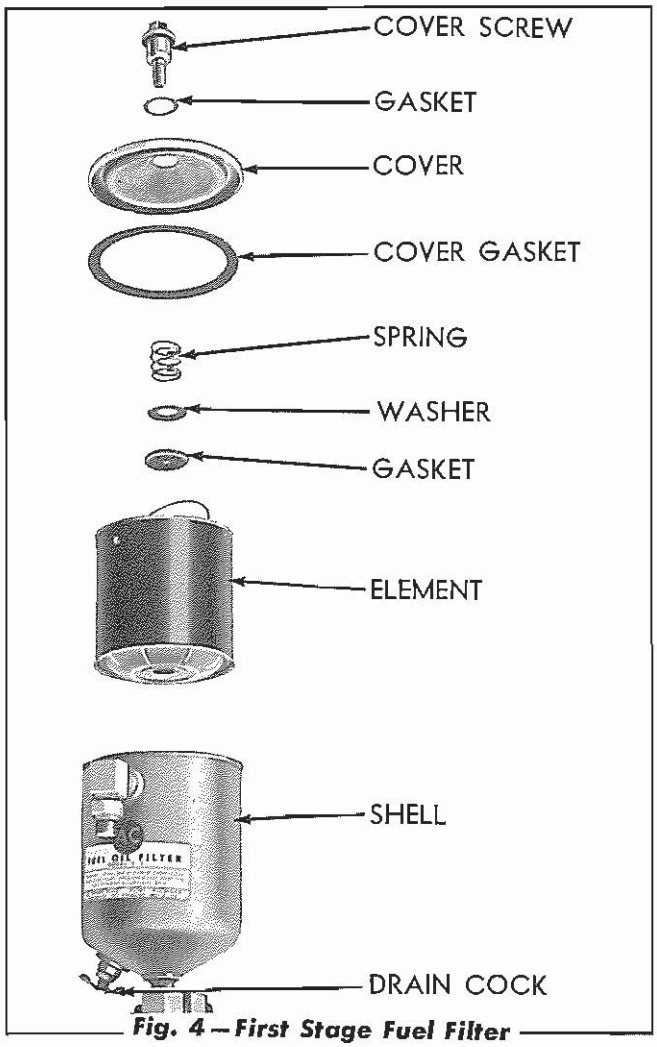


Fig. 4—First Stage Fuel Filter

B. Service of First Stage Fuel Filter.

Open the filter drain cock daily, before the engine is started at the beginning of the day's operation in warm weather or shortly after the end of the day's operation in freezing weather, and allow the water or sediment to drain. Close the drain cock when clean fuel runs out. Remove and discard the old element and install a new one after every 300 to 500 hours of operation (more often if conditions warrant) or when the filter becomes clogged. A clogged filter is usually indicated by irregular engine performance.

To change the element, remove the filter cover, drain the filter, lift out the spring and element and wash the inside of the filter shell. Place a new element and the spring in position and re-install the cover, using the new cover gasket furnished with the new element. Start the engine and check to be sure that the filter does not leak.

C. Description of Second Stage Fuel Filter.

This filter, mounted on the right side of the engine, contains a replaceable element. Any small particles of dirt, which may have passed through the first stage filter are collected by this filter and prevented from reaching the injectors. A drain cock, in the bottom of the filter shell, allows for drainage of the sediment collected.

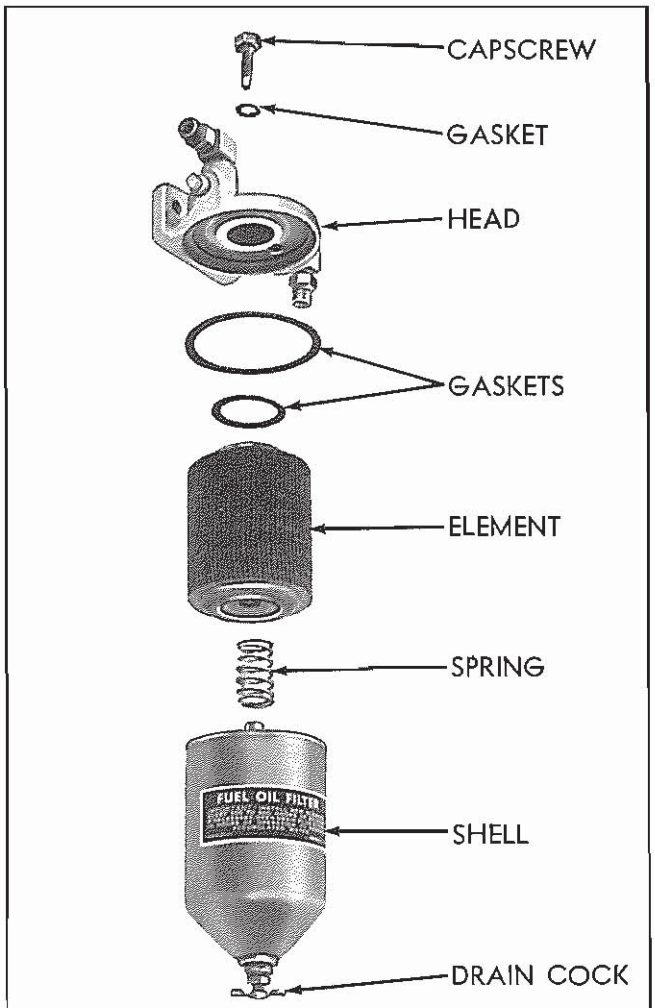


Fig. 5—Second Stage Fuel Filter

D. Service of Second Stage Fuel Filter.

Open the filter drain cock daily, before the engine is started at the beginning of the day's operation in warm weather or shortly after the end of the day's operation in freezing weather, and allow the water or sediment to drain. Close the drain cock when clean fuel runs out. Remove and discard the old element and install a new one after every 300 to 500 hours of operation (more often if conditions warrant) or when the filter becomes clogged. A clogged filter is usually indicated by irregular engine performance.

To change the element, drain the filter and remove the shell from the filter head. Remove and discard the old element. Wash the shell thoroughly. Install a new element. *NOTE: The spring is installed below the element in this filter and above the element in the first stage filter.* Reinstall the shell, using the new gasket furnished with the new element. Start the engine and check to be sure that the filter does not leak.

5. FUEL PUMP

A. Description.

The tractor may be equipped with either an "Eaton" or a "Barnes" Fuel Pump, mounted to the engine as shown in Figure No. 6.

The "Eaton" Fuel Pump is a rotor type pump having a delivery capacity of approximately 35 gallons per hour at 1000 R.P.M. The pump is bolted to an adapter, and is driven by an adapter shaft through a hollow sleeve which acts as a universal joint. The adapter shaft is driven by a helical gear on the balancer shaft of the engine.

The pump rotates in a counter-clockwise direction, viewed from the cover end. The four lobe inner rotor rotates the outer rotor eccentrically when the pump is in operation to open and close the passages in the pump housing. The four lobe inner rotor is attached to the pump shaft by a ball lock and rotates the outer rotor which is free to turn in the pump housing cover. As the rotors revolve in the housing, fuel is displaced from the inlet passage to the outlet passage.

Two pump shaft oil seals are used inside the body at the inner end. The sealing edge of one seal faces the pump cover and retains the fuel within the pump, the other faces the opposite direction and prevents engine lubricating oil from entering the pump. The seals are located approximately 1/16" apart. A drain hole, located between the two seals, vents to the atmosphere. A neoprene gasket fitted into the machined recess in the cover is compressed between the housing and the body when the attaching bolts are drawn tight. This seal prevents fuel oil from leaking out as well as preventing air leaking into the pump between the cover and the housing.

A spring loaded relief valve, located on the inlet side of the pump (right side of pump viewed from cover end) is provided to by-pass fuel back to the inlet side when the outlet pressure exceeds 37 to 47 P.S.I. This valve normally does not open since its purpose is to relieve excessive pump pressure in case of clogging in any of the fuel lines or filters.

The "Barnes" Fuel Pump is a constant flow gear type pump, having a delivery capacity of approximately 35 gallons per hour at 40 pounds pressure and 1000 R.P.M. The Barnes Pump is bolted to an adapter and is driven in the same manner as the Eaton Pump. Two steel gears revolve inside the pump housing to create a vacuum in the intake chamber, thus drawing fuel from the fuel tank. The fuel is carried around the gears in the spaces between the teeth, and is forced out of the pump under pressure.

The driving gear is mounted on a free-floating type drive shaft and is keyed to the shaft by a shear pin. The driven gear is supported in the bore of the pump housing by its supporting journals which are an integral part of the driven gear.

Two pump shaft oil seals are used inside the stator at the inner end. The sealing edge of one seal faces the pump housing and retains the fuel within the pump, the other faces the mounting flange end of the stator, and prevents engine lubricating oil from entering the pump. The seals are located approximately 1/16" apart. A drain hole, located between the two seals, vents to the atmosphere.

A spring loaded relief valve, located on the inlet

side of the pump (right side of pump viewed from cover end) is provided to by-pass fuel back to the inlet side when the outlet pressure exceeds 47 to 60 P.S.I. This valve normally does not open since its purpose is to relieve excessive pump pressure in case clogging occurs in any of the fuel lines or filters.

B. Service.

If the fuel pump is removed for reconditioning, the pump drive assembly should also be removed for inspection.

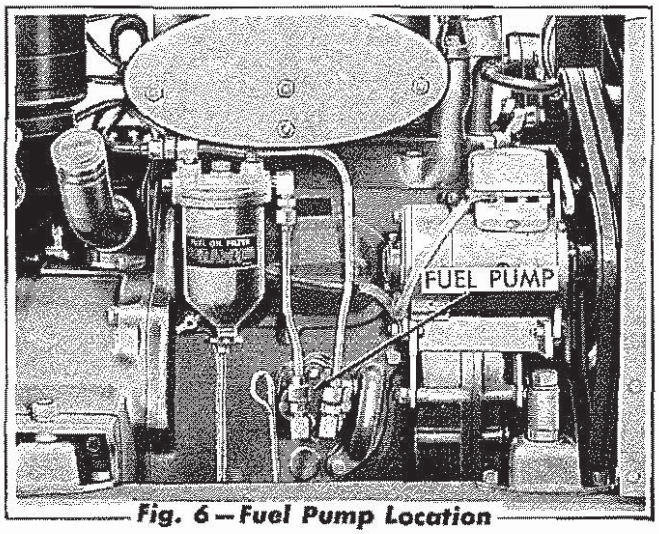


Fig. 6—Fuel Pump Location

C. Removal of Fuel Pump and Pump Drive Shaft Assembly.

1. Disconnect the fuel lines from the pump.
2. Remove the nuts attaching the fuel pump and drive adapter to the engine block.
3. Pull the pump off the attaching studs and remove the square, tubular fuel pump coupling.
4. Remove the flat head capscrew attaching the drive adapter to the engine block if capscrew is used for attaching. *NOTE:* A flat head capscrew is used to hold the adapter assembly in place on the early model engines, and a dowel is used on the later model engines.
5. Tap the drive adapter flange lightly to loosen and withdraw it from the engine block.

D. Disassembly of "Eaton" Fuel Pump.

The relief valve assembly may be removed from the pump body without disassembly of the other parts of the pump, by removing the fuel pump plug and jarring the valve parts from the body.

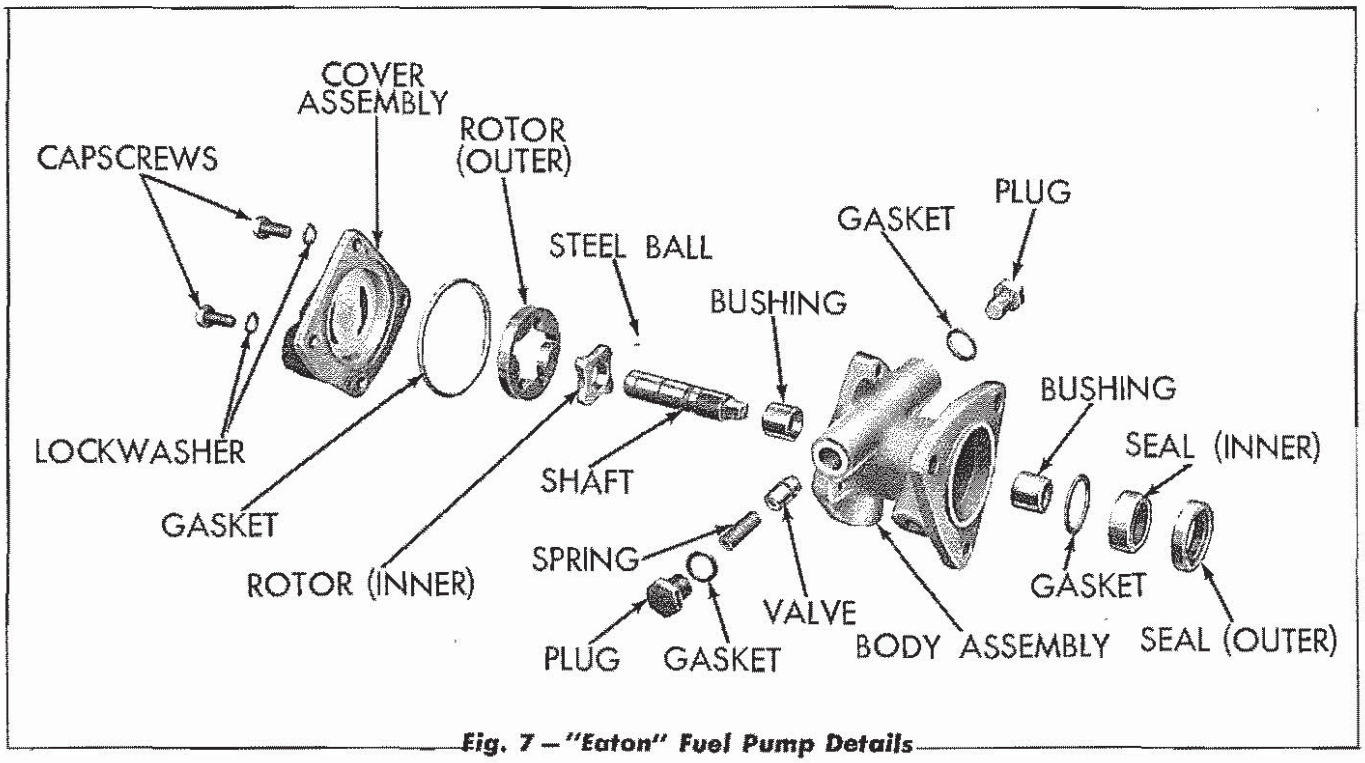


Fig. 7—"Eaton" Fuel Pump Details

When removing the relief valve assembly, note the position of each part so that the parts may be reassembled in their same relative position.

If the relief valve only is to be inspected, no further disassembly is necessary. If the entire pump is to be dismantled proceed as follows:

1. Remove the cover to body attaching bolts and install capscrews 1/4" x 20 x 3" long, so that the heads of the capscrews extend out 3/4" from the pump cover.
2. Holding the pump assembly in hand, tap on the heads of the capscrews with a soft hammer, separating the body and cover. DO NOT PRY BODY AND COVER APART.
3. Remove the outer rotor, and move the shaft out toward the cover end of the pump, slide the inner rotor forward on the shaft and remove the locking ball, then remove the inner rotor from the rotor shaft.
4. Remove the rotor shaft from the pump body carefully, so as not to damage the oil seals.
5. Drive the dowels from the pump body if necessary by means of a small punch and hammer.
6. If it is necessary to remove the seals, a tool of the proper design may be used to remove them so they will not be damaged.

E. Inspection of "Eaton" Fuel Pump Parts.

1. Wash all the parts in clean fuel oil or solvent and inspect them carefully. The oil seals, once removed from the pump, should be replaced. If the sealing edges of the seals are damaged in any way, so that they do not form a perfect seal around the shaft, either a fuel oil leak or lubricating oil leak will result.
2. Inspect the rotors and the wearing surfaces of the pump cover and body for wear and scoring. If the rotors show excessive wear or are scored they should be replaced. If the wearing surfaces in the pump cover are worn or scored, causing excessive looseness of the rotors in the cover and body, the pump should be replaced.
3. Install the inner rotor on the pump shaft with the locking ball in place. If excessive wear between these parts is found, new parts must be installed.
4. Check the fit of the pump shaft in the pump body bushings. If the shaft and bushings show excessive wear they must be replaced. The specified diameter of the shaft is .4992" and the specified inside diameter of the bushings as installed is .5015" making a clearance of .0023" between the shaft and bushings.
5. Check the pump relief valve. If the valve does not form a tight seal on its seat, lap the valve using fine valve lapping compound. A piece of wood about the size of a pencil makes a good holder for hand lapping. *CAUTION:* Use only a small amount of compound so that only the seat on the valve and in the body will be affected. The ideal seat is a ring about 1/64" to 1/32" wide in the pump body. Thoroughly wash all the lapping compound and foreign material off the valve and out of pump body.
6. Inspect the pump cover sealing gasket and the pump shaft seal gasket and replace if necessary.

F. Assembly of "Eaton" Fuel Pump.

1. Install the bushings for the pump shaft in the pump body if they were removed for replacement, then, ream the inside diameter of the bushings to .5015".
2. Install the pump shaft seal gasket in place in the pump body, then install pump shaft inner seal with the sealing edge towards the cover end of the pump. Make certain the seal is installed tight against the seal gasket.
3. Install the pump shaft outer seal with the sealing edge towards the mounting flange end of the pump.
4. Lubricate the pump shaft end seals and install the shaft in the pump body. Install the shaft from the cover end pushing it through the bushings and then through the seals being

exceptionally careful not to damage the seals. Use an oil seal pilot tool on the drive end of the shaft if tool is available. Before inserting the shaft completely into position in the pump body, install the inner rotor and locking ball on the shaft.

5. Install the outer rotor in place on the inner rotor.
6. Install the pump cover sealing gasket in the recess of the pump cover, then place the pump cover in position on the dowels and pump body. Install the cover attaching bolts and tighten securely.
7. Turn the pump shaft and test it for bind. The shaft should turn smoothly, with a slight drag, but should not bind or have tight spots.
8. Install the relief valve parts, make certain that the parts are installed properly in their respective places on the inlet side of the pump (right side when viewed from pump cover end).
9. Install the pump body plug and gasket in the side opposite the relief valve.
10. Install the fuel pump on the engine by direct reversal of the removal procedure.

G. Disassembly of "Barnes" Fuel Pump.

The relief valve assembly may be removed from the pump stator without disassembly of the other parts of the pump, by removing the pressure relief spring plug and jarring the valve parts from the body.

When removing the relief valve assembly, note the position of each part so that the parts may be reassembled in their same relative position.

If the relief valve only is to be inspected, no further disassembly is necessary. If the pump is to be dismantled praceed as follows:

1. Remove the screws attaching the pump housing to the stator and install capscrews 1/4"

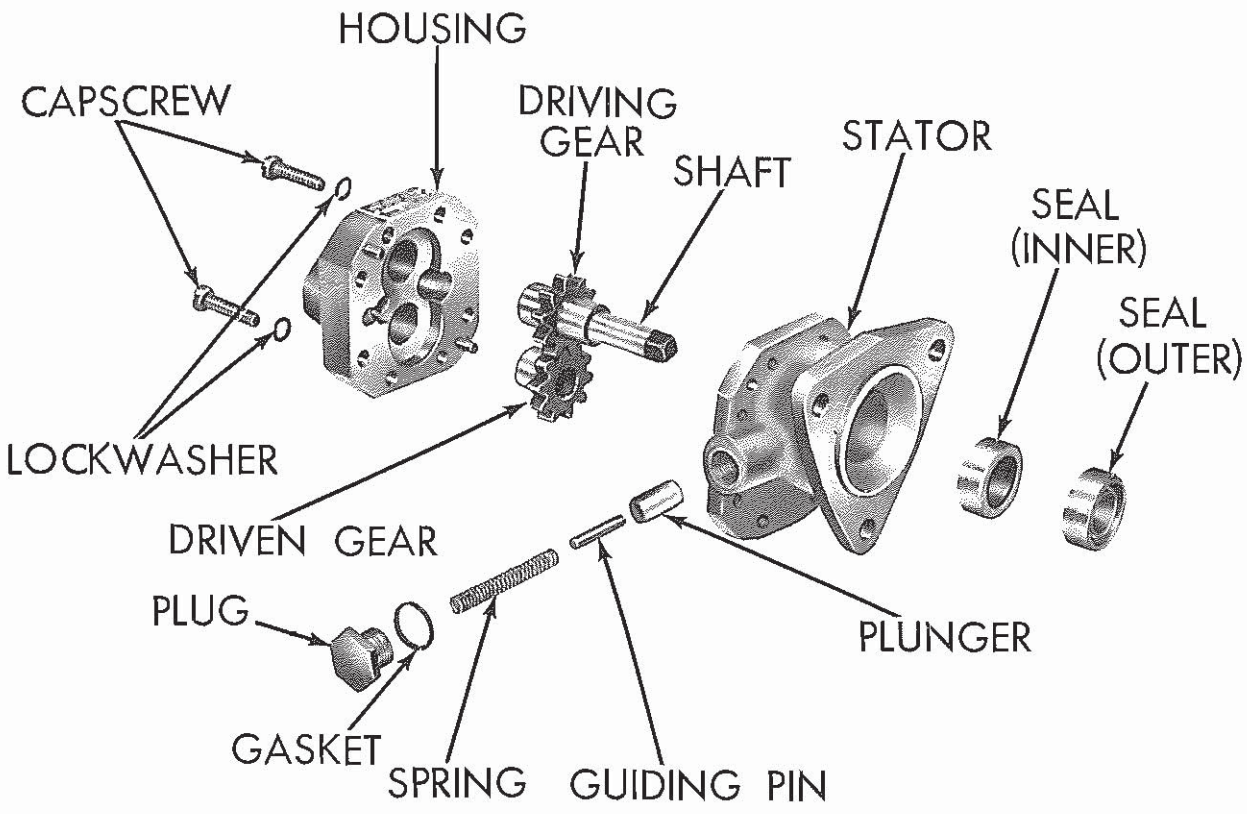


Fig. 8—"Barnes" Fuel Pump Details

x 20 x 3" long, so that the heads of the capscrews extend out about 3/4" from the pump housing.

2. Holding the pump assembly in the hand, tap the heads of the capscrews with a soft hammer, separating the stator and housing. DO NOT PRY STATOR AND HOUSING APART.
3. Remove the pump driven gear.
4. Remove the pump shaft and driving gear from the stator carefully, so as not to damage the pump shaft seals.
5. Remove the dowels if necessary.
6. If it is necessary to remove the shaft seals, a tool of the proper design may be used to remove them so they will not be damaged.

H. Inspection of "Barnes" Pump Parts.

1. Wash all the parts in clean fuel oil or solvent and inspect them carefully. The shaft seals, once removed from the pump, should be replaced. If the sealing edges of the seals are damaged in any way, so that they do not form a perfect seal around the shaft, either a fuel oil leak or lubricating oil leak will result.
2. Inspect the gears. If the gears are slightly worn on the involute surfaces, they should be replaced. If the pump is operated until an appreciable amount of wear is noticeable, the delivery capacity of the pump will be affected.
3. Inspect the driving gear on the pump shaft. The shear pin holding the gear to the shaft must be tight. Replace parts if necessary.
4. Check the fit of the gears in the bores of the stator and housing. If the stator and housing are worn or scored, causing looseness, the entire pump must be replaced.
5. Inspect the surfaces inside the stator and housing contacted by the gear faces. If the surfaces show excessive wear or are scored, the entire pump must be replaced.
6. When the pump is overhauled, it is recommended that the relief valve and spring be replaced. Replacement of these parts may prevent difficulties in pump operation in the future.

I. Assembly of "Barnes" Fuel Pump.

1. Install the pump shaft inner seal in the stator. Install the seal so that the sealing edge is toward the pump housing.
2. Install the pump shaft outer seal in the stator. Install the seal so that the sealing edge is toward the mounting flange end of pump.
3. Lubricate the pump shaft and seals and install the pump shaft (with driving gear in place) in the stator. Push the shaft through the seals being exceptionally careful not to damage the seals. Use an oil seal pilot tool on the drive end of the shaft if a tool is available.
4. Install the driven gear in place in the housing. Lubricate the gears with light engine oil.
5. Coat the machined attaching surfaces of the stator and the pump housing with a commercial non-hardening sealing compound. *CAUTION:* Do not get any sealing compound inside the pump. Place the pump housing in position on the stator, turn the pump shaft to mesh the gear teeth, and push the parts together. Install the attaching screws and tighten securely.
6. Turn the pump shaft and test it for bind. The shaft should turn smoothly, with a slight drag, but should not bind or have tight spots.
7. Install the relief valve parts, make certain that the parts are installed properly in their respective places.
8. Install the fuel pump on the engine by direct reversal of the removal procedure.

6. FUEL PUMP DRIVE

A. Description.

The fuel pump drive consists of a shaft mounted on bronze bearings which are retained inside the cast housing. A collar at one end of the shaft and a helical gear pressed on, and keyed to, the shaft at the other end positions the shaft endwise and also serves as a drive.

The non-gear end of the adapter shaft is squared to the same dimensions as the drive end of the fuel pump shaft. A coupling of suitable dimensions slips over the adjoining ends of the two shafts to provide a connection between the drive and the pump.

B. Disassembly of Fuel Pump Drive Shaft Assembly.

The fuel pump drive shaft may be removed from the adapter as follows:

1. Pull the pinion gear off the drive shaft and remove the Woodruff Key from the shaft.
2. Slide the shaft out of the adapter.

C. Inspection and Repair.

1. Inspect the pump drive pinion. If the pinion is worn excessively or damaged, it is advisable to also inspect the drive gear on the balancer shaft. If the drive gear on the balancer shaft shows excessive wear or the teeth are damaged, it will be necessary to replace both the drive pinion and the balancer shaft.
2. Check the fit of the adapter shaft in the adapter shaft bushings. If the shaft and bushings show excessive wear they must be replaced. The specified diameter of the adapter shaft is .4965" and the specified inside diameter of the bushings is .498" making a clearance of .0015" between the shaft and bushings.
3. Inspect the fuel pump coupling. If the coupling is worn and is an extremely loose fit on the adapter shaft and on the fuel pump shaft, replacement is necessary.

D. Assembly of Fuel Pump Drive Shaft.

1. Install the bushings for the pump shaft in the adapter if they were removed for replacement, then, ream the inside diameter of the bushings to .498".

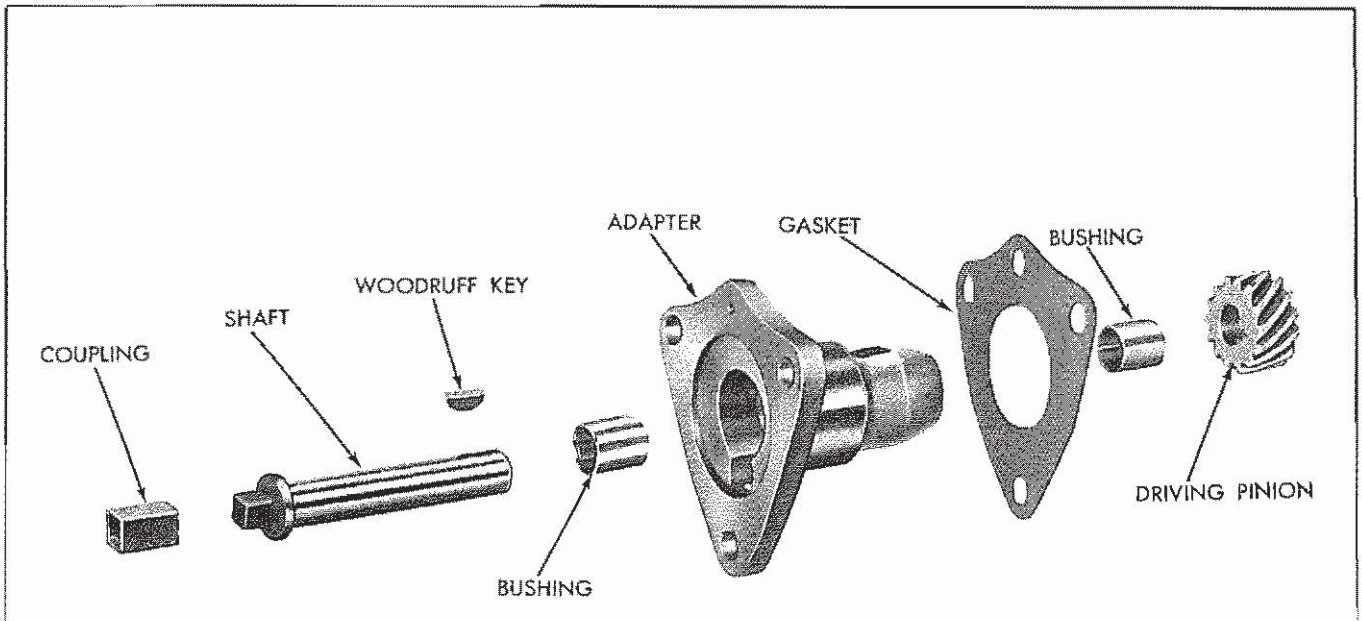


Fig. 9 — Fuel Pump Drive Shaft Details

2. Lubricate the shaft and bushings and insert the shaft in place in the adapter. Install the Woodruff Key in the shaft.

3. Press the pinion on the adapter shaft only far enough to provide .004" to .006" end play of the shaft when assembled.

4. Install the fuel pump drive on the engine by direct reversal of the removal procedure (refer to "REMOVAL OF FUEL PUMP AND PUMP DRIVE SHAFT ASSEMBLY" in this section).

7. FUEL INJECTORS

A. Description.

The unit fuel injector combines in a single unit all of the parts necessary to meter, atomize and inject the required amount of fuel into the combustion chamber of the cylinder. The fuel is injected under high pressure at the end of each compression stroke and mixes with the charge of air that has been delivered to the cylinder by the blower. Since there is an injector for each cylinder, a complete and independent injection system for each cylinder is thus provided.

The injectors are mounted in the cylinder head, with their spray tips projecting slightly through the cylinder head into the combustion chambers. A clamp holds each injector in place in a water-cooled copper tube which passes through the cyl-

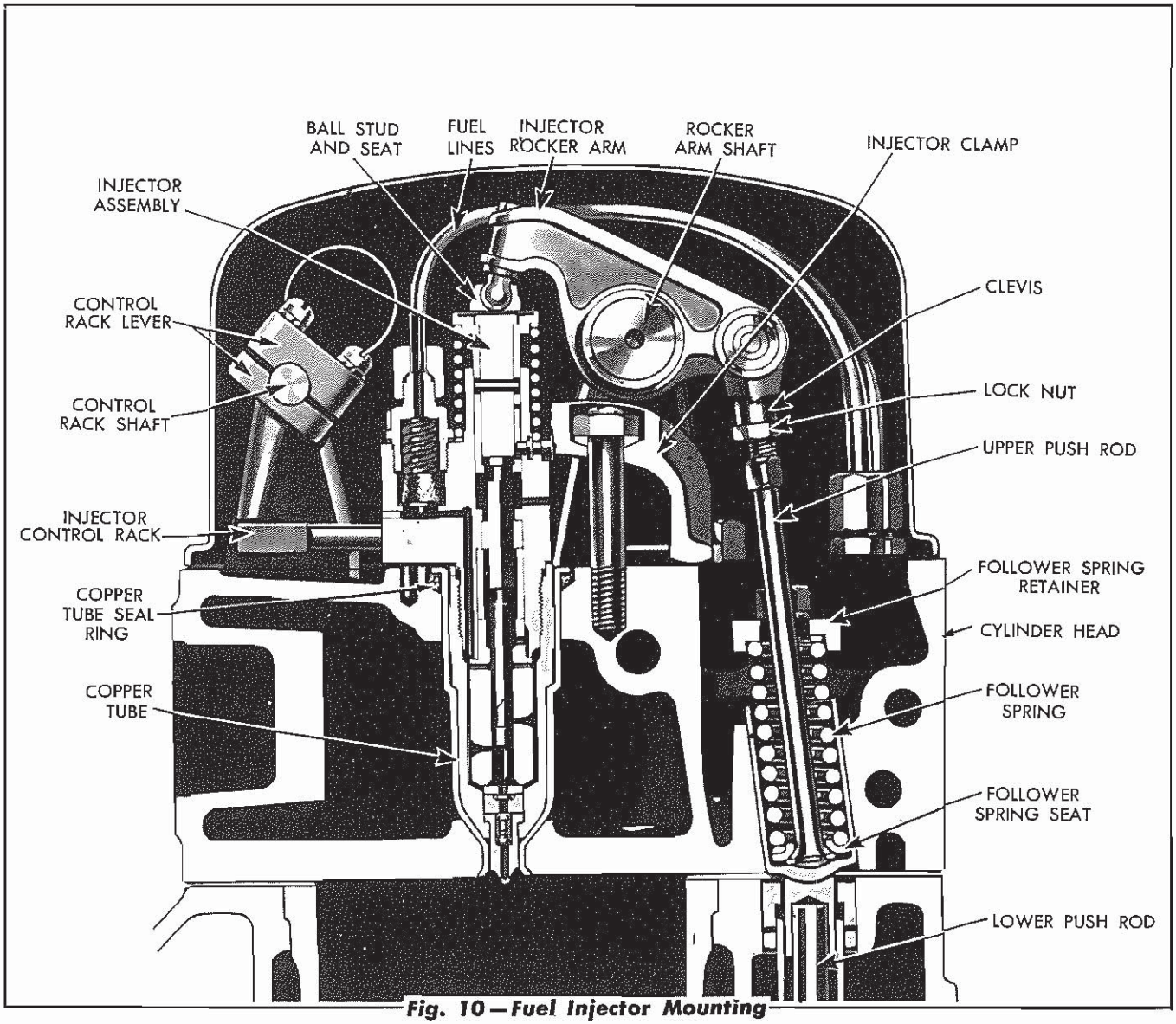


Fig. 10—Fuel Injector Mounting

inder head. The tapered lower end of the injector seats in the copper tube forming a tight seal to withstand the high pressure inside the combustion chamber.

B. Operation.

The cross section of the Model 71 Injector, illustrated in Figure No. 11, shows the various fuel injector parts. Fuel is supplied to the injector under pressure and enters the drop-forged steel body of the injector at the top through the filter cap. After passing through the porous metal filter in the inlet passage, the fuel fills the annular supply chamber between the bushing and the spill deflector. 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 in the high-pressure cylinder or bushing is first displaced through the ports back into the supply chamber until the lower edge of the plunger closes the lower port. The remaining fuel 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. The rotation of the plunger, by changing the position of

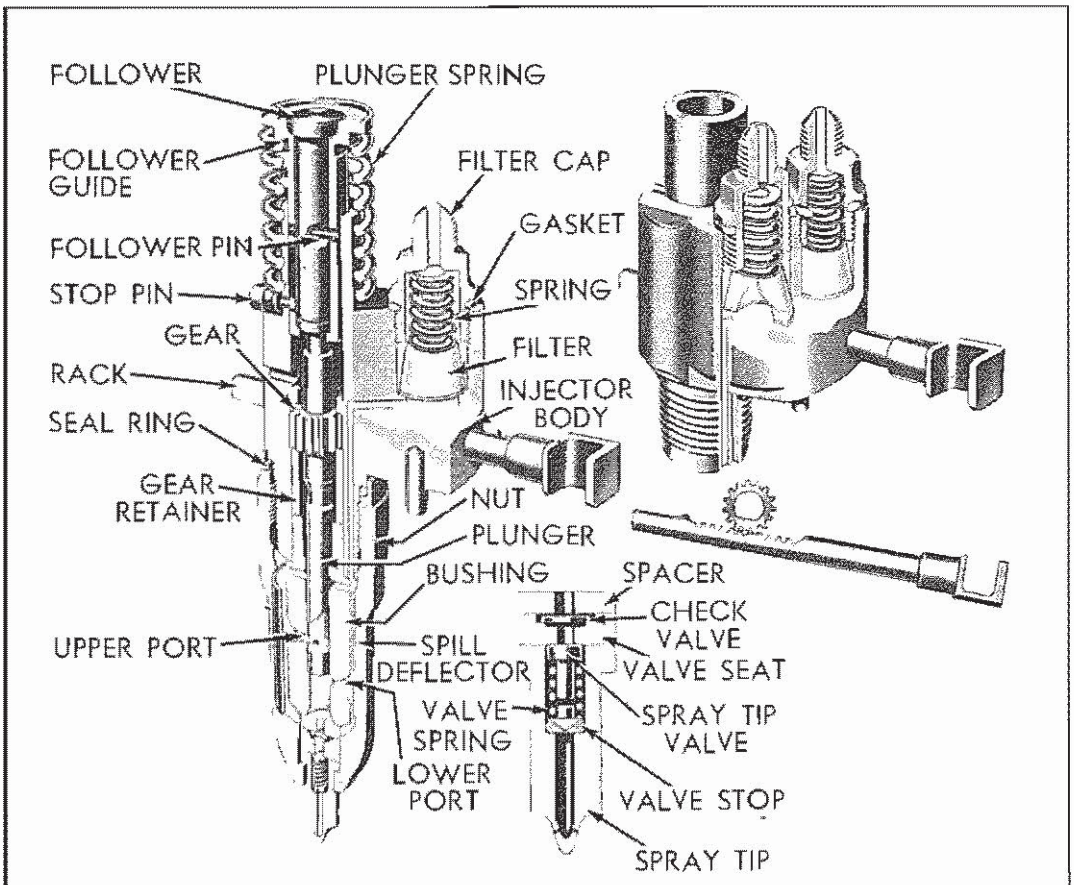


Fig. 11—Fuel Injector Details

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 helix, or cut-off, are machined into the lower end of the the helix, retards or advances the closing of the ports and the beginning and end of the injection period, at the same time increasing or decreasing the amount of fuel which remains under the plunger for injection into the cylinder.

The upper part of Figure No. 12 shows four plunger positions from NO INJECTION to FULL INJECTION. With the control rack pulled OUT (no injection), the upper port is not closed by the helix until after the lower port is uncovered. Consequently, with

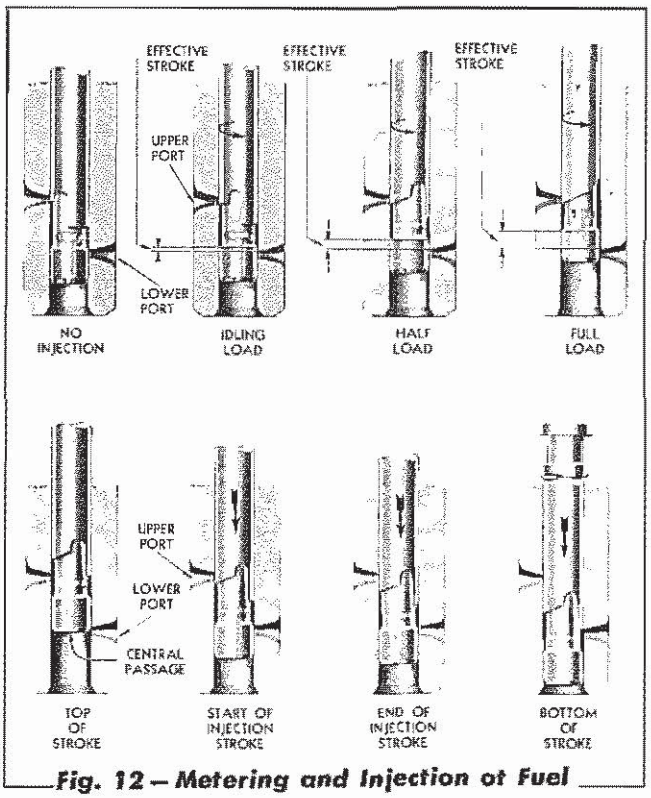


Fig. 12 – Metering and Injection of Fuel

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. With the control rack pushed IN (full injection), the upper port is closed shortly after the lower port has been covered, thus producing a full effective stroke and maximum injection.

From the NO INJECTION position to FULL INJECTION position (full rack movement) the contour of the helix advances the closing of the upper port and the beginning of injection.

The lower part of Figure No. 12 shows four positions for 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, through the check valve shown in Figure No. 11, and against the spray tip valve. When sufficient fuel pressure is built up, the valve is lifted from its seat and fuel is forced through six small orifices of .006" diameter in the spray tip and atomized in the combustion chamber.

The spray tip check valve prevents air leakage from the combustion chamber into the fuel system in case the spray tip 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 upward movement of the plunger, the high-pressure cylinder in the injector is again filled with fuel through the ports. The constant circulation of fuel through the injectors renews the fuel supply in the chamber, helps to maintain even operating temperatures of the injectors, and effectively removes all traces of air which might otherwise accumulate in the system and interfere with the accurate metering of the fuel. The fuel injector outlet opening, which returns the excess fuel supplied by the fuel pump, is adjacent to the inlet opening, and is protected against dirt or other foreign matter by a porous metal filter, exactly like the one on the inlet side.

C. Injector Service.

Because of the important part the injector plays in the operation of the engine, the necessity for proper care and cleanliness of these units cannot be over-emphasized. The instructions below must be carefully followed in connection with injector service:

1. Whenever the fuel lines are removed from an injector which is installed in the engine, protect the fuel fittings with shipping caps to prevent dirt from entering the injector and fuel system.
2. After the injectors have operated in an engine, the injector filter caps or filters should not be removed from the injector when the injector is in the engine. If the filter caps or filters are to be removed, the injector must be completely disassembled and cleaned.
3. Whenever an injector has been removed and reinstalled, or a new injector has been installed in the engine, the injectors must be timed and equalized. Refer to "INJECTOR TIMING" AND "INJECTOR EQUALIZING" in this section.
4. Any used or rebuilt injector should be tested before it is installed in an engine. Refer to "TESTING INJECTOR" in this section.

D. Injector Removal.

1. Remove the engine hood, clean off the rocker arm cover, and remove the cover from the cylinder head.

2. Disconnect and remove the two fuel lines from the injector. Install shipping caps on the fuel line fittings to prevent dirt from entering the fuel system while the injector is removed.

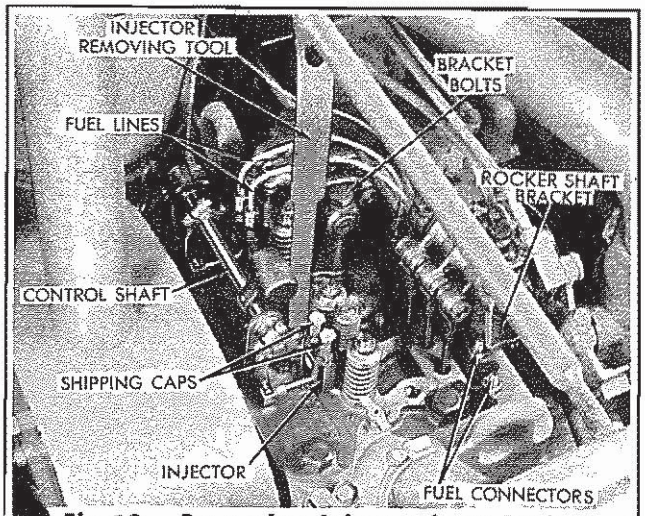


Fig. 13 — Removing Injector from Engine

3. If necessary, turn the engine with the starter until the rocker arm clevis pins (at push rod end of arms) are in line, then turn the rocker arm bracket bolts out of the cylinder head and fold the rocker arm assembly back out of the way. *CAUTION: Push rods may be bent if the rocker arms are not aligned when removing this assembly.*

4. Remove the nut from the injector hold-down stud and remove the special washer, and the injector clamp.

5. Insert the end of the injector removing tool under the shoulder at the side of the injector body and pry the injector from its seat. Disengage the control rack from the control lever as the injector is lifted up and out.

E. Injector Disassembly.

Before starting to dismantle an injector, it is necessary to have an extremely clean work bench on which to work and to store the parts. Cleanliness for the injector and its parts is emphasized because practically all injector service troubles are directly due to dirt, or other foreign material entering the injectors. Use clean paper on the work bench, and, after the injector has been disassembled, place the loose parts in a pan of clean fuel oil as protection against dirt and corrosion. Leave the parts in the clean fuel oil until needed for reassembly.

When more than one injector is dismantled, it is necessary to keep the parts of each injector separate. The plungers must always be fitted with the same bushings from which they were removed. It is advisable to keep the parts of the spray tip assembly — the spring, stop, spray tip valve and seat, as a unit, as this insures that the "pop" pressure and calibration built into the injector will remain essentially the same as when it was first tested and assembled.

NOTE: The spray tip, valves and valve seats may be removed, cleaned and replaced without disassembling the entire injector by performing steps 4 through 6 in the following disassembly procedure:

Before removing the spray tip, test the injector for free movement of the plunger by pressing down on the plunger follower with the thumb and forefinger. Also turn the injector from side to side to see if the control rack moves back and forth by its own weight. If binding of the plunger or control rack is evident by these tests, complete disassembly and inspection of parts will be required. The repair of an injector should not be attempted unless special injector tools described in the following procedure are available.

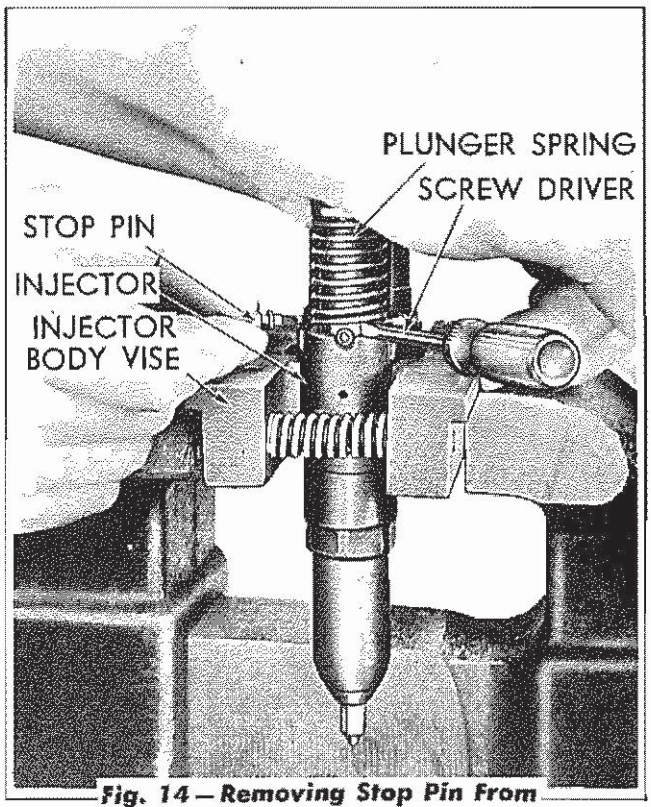


Fig. 14 — Removing Stop Pin From Injector Follower

Disassemble as follows, placing all parts in a pan of clean fuel oil as they are removed.

1. Clamp the injector in the holding fixture in a vise, right side up, and loosen (do not remove) the two filter caps. Make sure the control rack is not bound or bent when clamped in the fixture.
2. Using a screwdriver as shown in Figure No. 14, raise the follower spring, at the same time holding down on top of the follower, and withdraw the stop pin. Allow the spring to raise to its free length position after the pin is removed.
3. Remove the plunger, follower guide, follower, and the follower guide pin from the injector body by lifting up on the follower. Then take out the follower guide pin and separate these parts.
4. Clamp the injector in the holding fixture with the spray tip of the injector up, as shown in Figure No. 15 and loosen the injector nut, using the injector nut wrench. Unscrew the nut from the body, then raise the nut carefully off the spray tip so that the tip and the other small parts resting on the end of the plunger bushing will not be dislodged. If the injector has been in use for some time, the spray tip will possibly be removed with the nut.

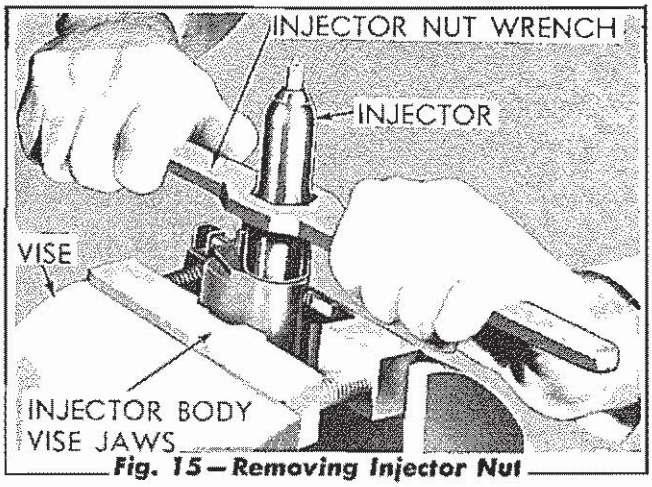


Fig. 15—Removing Injector Nut

5. Carefully lift the spray tip, check valve stop, valve spring, spray tip valve, valve seat, check valve, and spacer from the plunger bushing. If the spray tip sticks in the nut, remove it by driving on the edges of the end of the tip with a hollow steel rod. *DO NOT DRIVE DIRECTLY ON THE END OF THE TIP AS THIS WILL DAMAGE THE TIP.*
6. "Jar" the spill deflector from the nut (if it remained in the nut) or lift it from around the bushing. Remove the bushing from the injector body.
7. Remove the injector body from the fixture and "jar" the retainer and gear from the body. Slide the control rack out of the body.
8. Remove the two filter caps, filters and springs from the body.

F. Cleaning, Inspection and Reconditioning of Injector Parts.

Wash the hands thoroughly and clean all the injector parts in clean fuel oil or carbon tetrachloride. Blow the parts dry with compressed air that is free from dust or moisture. Blow through all the passages in the injector body and all the drilled holes, slots, etc., in the other parts. *Waste or rags should never be used for cleaning the injector parts,* since this would leave lint, which could collect on and clog parts of the injector when assembled. Toilet tissue is a good and inexpensive material for wiping injector parts after cleaning.

Many of the close-fitting parts in the injector are carefully lapped. When any of the internal working parts of the injector are scored or damaged, they are unfit for further use and should be replaced.

After the injector has been disassembled and all the parts carefully cleaned in carbon tetrachloride or fuel oil, they should be protected from dirt by storing them in clean fuel oil until the injector is reassembled.

1. Reaming Injector Spray Tip.

Insert the reamer, included in the injector tool kit, into the spray tip, press lightly, and turn with the fingers to remove any carbon or foreign material from the tip. After thoroughly reaming, blow out the tip with compressed air.

Clean the six spray tip orifices with the .006" wire and holder furnished with the kit. Before using, remove any sharp burrs from the wire end by honing it on the small stone included in the injector tool kit.

After the tip has been reamed and the holes

in the tip cleaned, blow out loose particles with compressed air. Then again ream the tip, clean the holes, wash the tip with carbon tetrachloride and blow out with compressed air. Discard the spray tips if the diameter of the holes exceeds .008".

2. **Valves and Seats.**

Thoroughly wash and inspect the spacer, check valve, valve seat, spray tip valve, valve stop and spray tip for smoothness (refer to Figure No. 17 for identification of parts). If these parts are chipped, pitted, or otherwise damaged, they must be replaced.

If the surfaces of the spacer, check valve, valve seat and spray tip show discoloration only, they may be lapped on a piece of plate glass or on a lapping block. Use carborundum H-40 medium lapping cream or its equivalent.

Spread the lapping cream on the block, then grasp the part to be lapped firmly with the thumb and the forefinger and lap using a figure eight motion. Always exercise care to keep the part flat on the lapping block. After several strokes, thoroughly clean the part with fuel oil, then dry and inspect the surfaces by holding it to the light to observe the differences of light reflection as an indication of the flatness. If the surface is perfectly flat, it will present a uniform appearance when held to the light and rotated.

If the upper end of the spray tip and the lower end of the bushing surfaces are discolored, they can be polished in the same manner.

The spray tip valve should *not* be flat lapped as the head of this valve is slightly crowned. Since the valve head is slightly crowned and the valve seat is flat, the two pieces contact only along the edge of the hole in the seat. This contact must be made as nearly perfect as possible. If extreme pitting or pounding of the valve face exists, the part should be replaced.

To obtain a flat mirror finish and a high popping pressure of the injector, "finish lap" the parts on the lapping block after it has been cleaned with a bristle brush, rinsed in fuel oil or kerosene and dried with compressed air.

As frequent refacing of lapping blocks will produce top quality work, it is advisable to have two grooved blocks on hand and maintain their surfaces flat and free from worn or low spots. To remove these spots, hand lap one block on another, using fine grain lapping compound. Protect the blocks when not in use against dust and damage by enclosing them in a close fitting wooden container.

3. **Plunger and Bushing.**

Clean the injector plunger bushing by immersing it in a container of carbon tetrachloride or fuel oil and working a brush through the bushing. Blow it out with compressed air and again wash it in clean carbon tetrachloride or fuel oil. For the final cleaning, wrap toilet tissue around the injector bushing cleaner tool or similar rod, and rotate this rod in and out through the bushing. The plunger should work freely in the bushing. Refer to "TESTING OF INJECTOR." Worn plungers and bushings must be replaced by new ones.

4. **Injector Nut.**

Clean the seat in the nut for the spray tip with one of the brushes provided in the injector tool kit.

5. **Injector Filters.**

If the injector filters are partially clogged, or if they show signs of disintegration, they should be discarded and new ones installed when the injector is assembled.

The injectors in the earlier model tractors are equipped with either porous bronze (copper colored), or monel metal (white colored) injector filters. The later model tractors are equipped with injectors having stainless steel wire mesh injector filters. *IMPORTANT:* Whenever injectors containing the porous bronze or the monel metal filters are reconditioned or repaired, these filters must be discarded and replaced with the stainless steel wire mesh type filters.

6. **Control Rack and Gear.**

Inspect the teeth of both the rack and the

gear carefully. Remove any burrs or rough spots from the rack or gear. Replace them with new parts if they are worn or if they bind in the injector.

G. Injector Assembly.

NOTE: When assembling an injector, the room in which the work is being done must be clean and free from flying dust. The mechanic's clothes and hands, the work bench and the tools used must all be clean. The cleaned injector parts should remain in a pan of clean fuel oil until reassembly; then each part should be taken from the pan and assembled in the injector. Care must be taken when assembling, to place the various parts in their proper relative positions. The various illustrations accompanying the assembly of the injector should be studied thoroughly.

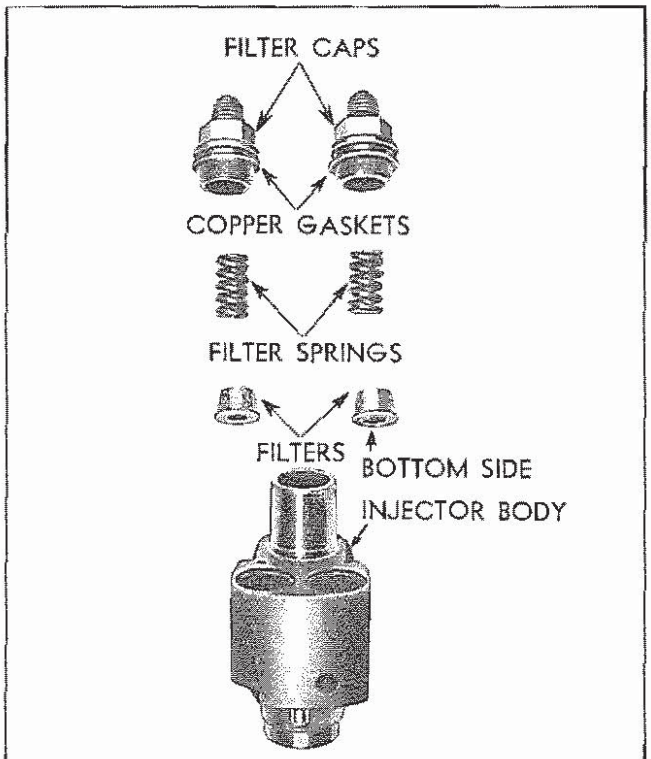


Fig. 16 — Injector Filters, Springs and Caps

1. Install Injector Filters.

a. Hold the injector body right side up and place an injector filter in each of the two fuel cavities. *NOTE:* When installing filters that have been used, it is important that each be installed in the same cavity from which it was removed. Even though they may have been washed as thoroughly as possible and dried with compressed air, particles of dirt may remain in them that would be washed into the injector and cause damage if the filter removed from the outlet side was installed in the inlet side. If they have been mixed, the outlet filter can usually be identified by its being darker in color on the inner (bottom) side while the inlet filter will be discolored most of the outer side.

b. Place the inlet filter in the fuel cavity that has the timing gauge hole located near its edge and the outlet filter in the other cavity. Place a spring above each filter, and a copper gasket up against the shoulder of each filter cap. Then lubricate the threads and tighten the filter caps in place in the injector body. Whenever a filter cap is removed, use a new copper gasket when it is installed.

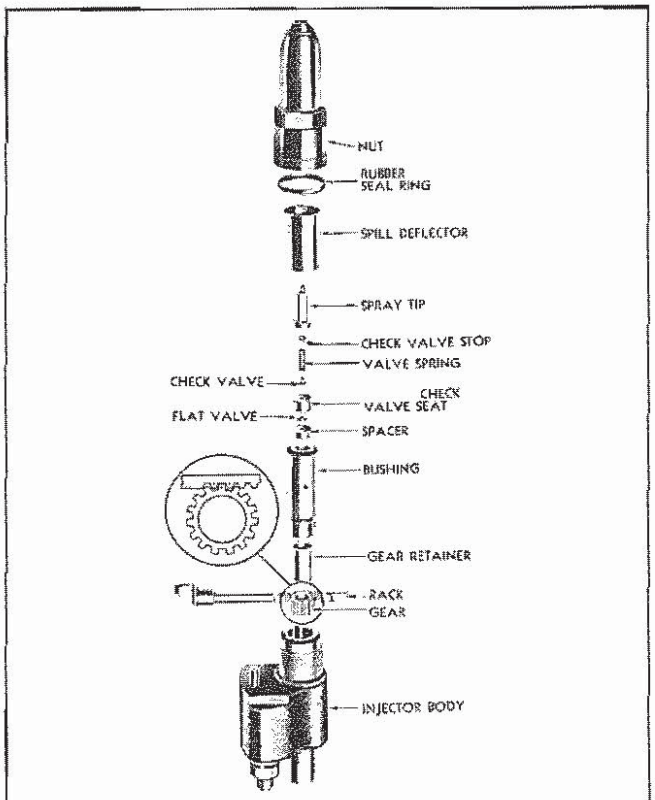


Fig. 17 — Injector Rack, Gear and Spray Tip Details

2. Install Control Rack and Gear.

Refer to Figure No. 17 and note that two of the teeth of the injector rack have a drill spot mark; also, one tooth of the 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 the rack and gear *MUST* be maintained for proper timing of the injector.

a. Hold the injector body, bottom end up, and install the rack through the hole in the body so that the two marked teeth can be seen when looking from the bottom into the bore for the gear.

b. The injector rack can be placed in the injector body in only one position and have the teeth marks show in the opening for the gear. Holding the rack in position so the teeth marks can be seen, drop the gear into the body of the injector so that the drill spot on the gear is between the two drill spots on the injector rack.

c. Slide the gear retainer down on top of the gear and the plunger bushing down on the retainer with the locating pin in the bushing guided into the slot in the injector body.

d. Clamp the injector body in the holding fixture in a vise with the bottom end of the injector up, taking care not to bind or bend the rack in the injector body. Drop the spill deflector over the bushing then slip a new rubber seal ring over the bushing and against the shoulder of the injector body.

3. Assemble Spray Tip and Valves.

Refer to Figures No. 17 and No. 18 for assembly of the following parts:

a. Place the spacer (flat down) on a clean piece of paper. Place the spray tip check valve on the spacer and set the spray tip valve seat with the recessed side down, over the check valve.

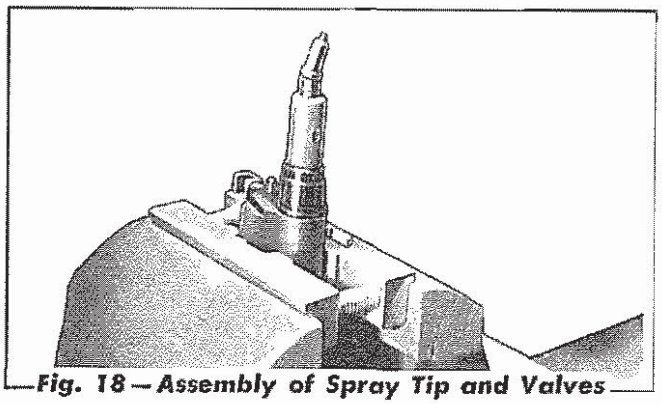


Fig. 18—Assembly of Spray Tip and Valves

b. Hold the spray tip, point down, and drop the check valve stop, large end down into the tip. Place the valve spring over the end of the stop and drop the spray tip valve in the spring with the valve end up.

c. Place the check valve assembly on the end of the plunger bushing, and the spray tip assembly on top of the valve assembly. Align all these parts with the center of the bushing.

d. Lubricate the threads in the injector nut and insert a spray tip driver rod or a length of copper tube through the nut to hold the valves and tip in position. Holding the nut and rod in one hand and holding the valves and the tip assembly in place on the bushing with the other hand, lower the nut down over the tip.

e. With the valves and tip held in position with the driver rod or tube, screw the nut on the body, being sure that the check valve assembly has not shifted. If the check valve assembly is not centrally located on the end of the bushing, the valve seat and spacer will not enter the counterbore of the injector nut. Do not force the nut, even by hand, while screwing it onto the body. It can be turned down within 1/16" of the shoulder on the body with the thumb and finger if the valve assembly is lined up properly. If the shoulder inside the nut strikes the edge of the valve and the nut does not screw on easily, shift the valve slightly by turning the spray tip. If the nut and valve can not be brought into line in this manner, the nut will have to be removed and valves again centrally located on the end of the bushing. Tighten the nut firmly with the injector nut wrench.

4. Install Plunger and Follower Assembly.

Invert the injector in the holding fixture so that the injector is right side up.

a. Refer to Figure No. 19 and slide the plunger, large end up, into the follower guide. Install the follower, large end up, in the follower guide above the plunger.

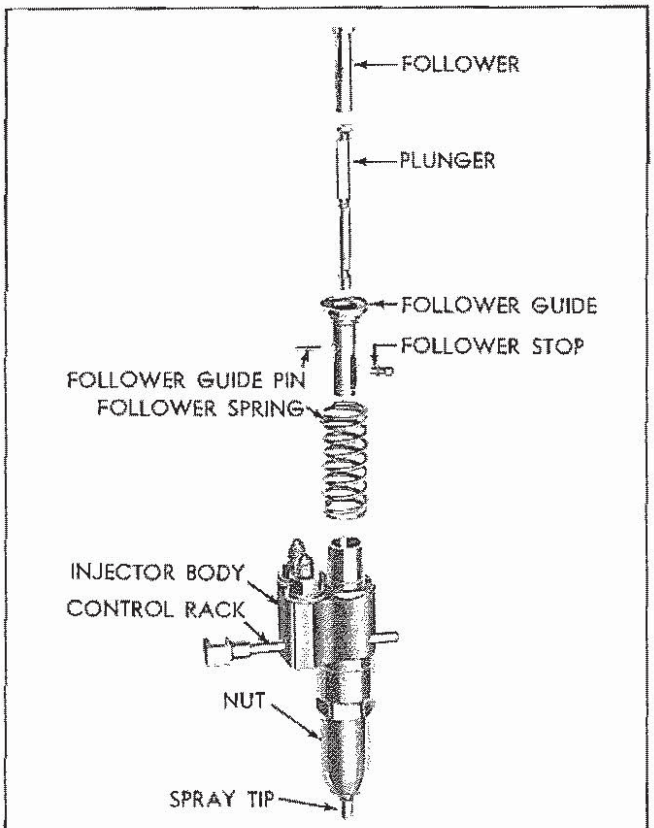


Fig. 19—Injector Plunger and Follower Details

Line up the holes through the follower and the guide and insert the follower guide pin.

b. Drop the plunger and the follower assembly through the follower spring, plunger end first. Lower the plunger and the follower assembly into the injector, first turning the plunger so that its flat side will line up with the flat side in the bore of the gear.

c. Line up the holes in the follower guide and the injector body for the follower stop pin. Then insert a screwdriver or a spring lifter tool beneath the lower end of the spring, push down on top of the follower, and, raising the spring at the same time with one hand; insert the stop pin with the other hand (refer to Figure No. 14). The stop pin will slip into place as soon as the holes in the guide and body are in alignment. When the spring is released, it will lock the pin in place.

d. Remove the injector from the holding fixture. Hold the injector horizontal and turn it from side to side. If it has been properly assembled and the parts are not binding, the control rack will slide back and forth by its own weight.

H. Testing Injector.

After an injector has been repaired or overhauled, it should be tested before it is installed in an engine or put aside for future use. Also, when in doubt about an injector functioning properly, a test will usually indicate the difficulties quickly. Two tests are recommended on the injector: (1) A "popping" test, (2) A pressure test. The "popping" test consists of operating the plunger to see that all parts are functioning properly and to open the check valve suddenly, which will usually remove any small foreign particles in the fuel or on the injector parts that might prevent proper operation. This test is made as follows:

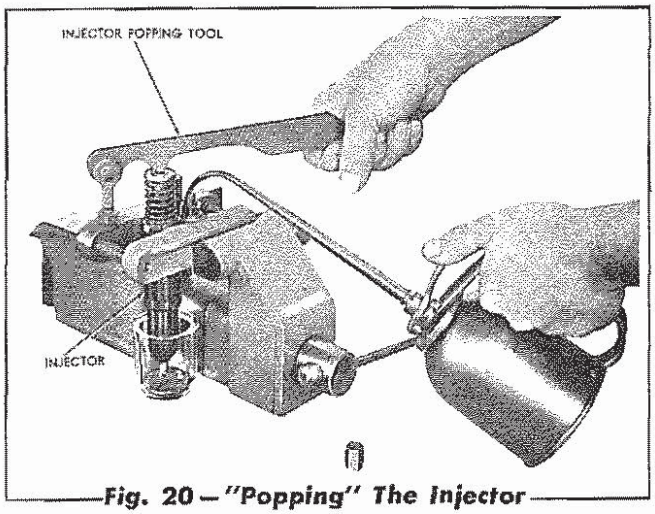


Fig. 20—"Popping" The Injector

Clamp the injector in the holding fixture and vise and screw the bolt of the popping tool into the tapped hole in the fixture. Tighten the lock nut. Introduce clean fuel oil into one of the injector openings in the filter caps by means of an oil can until the injector is completely full and fuel flows from the other opening. Set a glass beaker under and surrounding the injector spray tip so fuel injected from the tip hits the inside of the beaker. *CAUTION: Always use a beaker and keep the hands away from the spray tip when popping an injector as the finely atomized fuel from the spray tip is injected with such force that it will penetrate the skin and may cause blood poisoning.*

Push the injector rack all the way IN to full open position, and work the injector plunger up and down several times with the popping handle. Observe if the fuel is being discharged from all six

holes in the spray tip. Keeping the injector filled with fuel from the oil can, press the handle down on the plunger follower with quick motions. It may require a few minutes of operation before the injector will "come in" and a "chirp" will be heard.

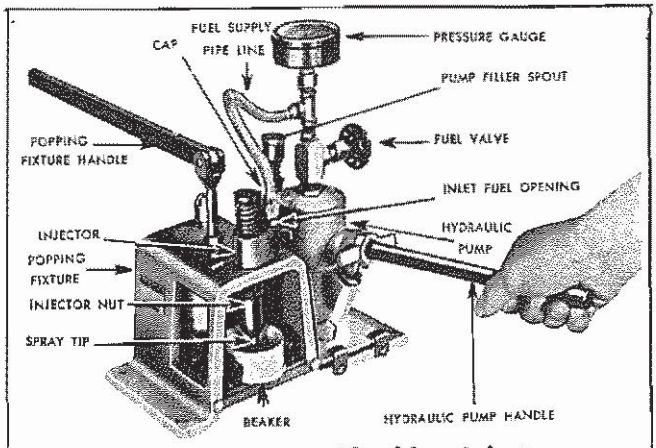


Fig. 21 — Pressure Checking Injector

The injector pressure test requires the use of a test stand similar to that shown in Figure No. 21. The injector is installed in the stand and a fuel line from the hydraulic pump is connected to the injector. A hydraulic gauge registers the pressure required to force the spray tip valve away from its seat. Check this "popping" pressure by working the pump handle up and down with smooth even strokes, at the same time watching the pressure gauge and noting at what pressure the spray tip valve opens. This pressure should be from 350 to 850 pounds.

Check for leaks around the injector body seal ring, control rack, spray tip and fuel connections by working the hydraulic pump handle until the pressure is just below the popping pressure. If a slight amount of fuel dribbles from the spray tip, pop the injector several times sharply with the popping handle. This will usually clear the injector of small foreign particles that may be preventing the spray tip valve from seating properly. If a dribble can not be stopped in this manner, remove the nut and clean the valve parts as outlined under "Valves and Seats."

Fuel leaking through the hole for the control rack is usually an indication that fuel is leaking past the plunger. In this case a new plunger and bushing must be installed in the injector.

Check the pressure drop in the injector by pumping the hydraulic handle and popping the injector sharply, then closing the valve between the pump and pressure gauge and noting the pressure drop on the gauge. A drop not to exceed 200 pounds in 50 seconds on a new injector, 200 pounds drop in 35 seconds on a used injector is permissible.

If the injector functions satisfactorily throughout the above test, it has been properly reconditioned and may be used. If it does not function properly, recheck the injector.

I. Injector Installation.

1. With the hood removed, and the rocker arm cover removed from the cylinder head, insert the injector in the copper tube in the head. The dowel on bottom of the injector body must enter the locating hole in the cylinder head. As the injector is slipped into the copper tube, engage the control rack with the rack control lever.
2. Place the injector clamp on the stud and center the side arms of the clamp as well as possible in the machined recesses of the injector body. Drop the special washer over the stud with the rounded side of the washer down. Tighten the injector clamp nut using 20 to 25 foot pounds torque.
3. Fold the rocker arms over on the valves and injector and install the bolts in the brackets. If the brackets were removed, they must be installed on the shaft with the machined sides facing the valve rocker arms. While tightening the bracket bolts, hold the rocker arms and brackets together, allowing a total of .004" to .006" clearance between these parts. Tighten the rocker shaft bracket bolts using 90 to 100 foot pounds torque.
4. The injector must now be timed and equalized. Refer to "INJECTOR TIMING," and "INJECTOR EQUALIZING." Remove the shipping caps from the fuel fittings on the injectors and in the cylinder head and connect the two injector fuel lines. Check the valve rocker arms (refer to "VALVE ADJUSTMENT" in Section IX). Start the engine and inspect the connections to be sure that there are no fuel leaks from the injector fuel lines.
5. Install the rocker arm cover and the hood.

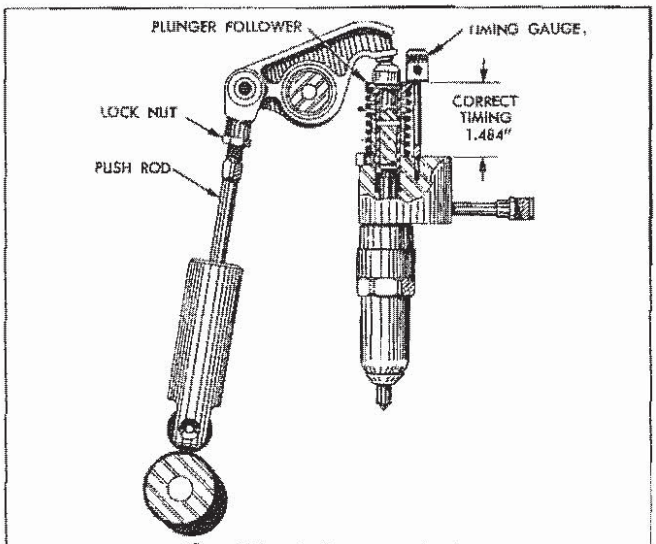


Fig. 22 – Injector Timing

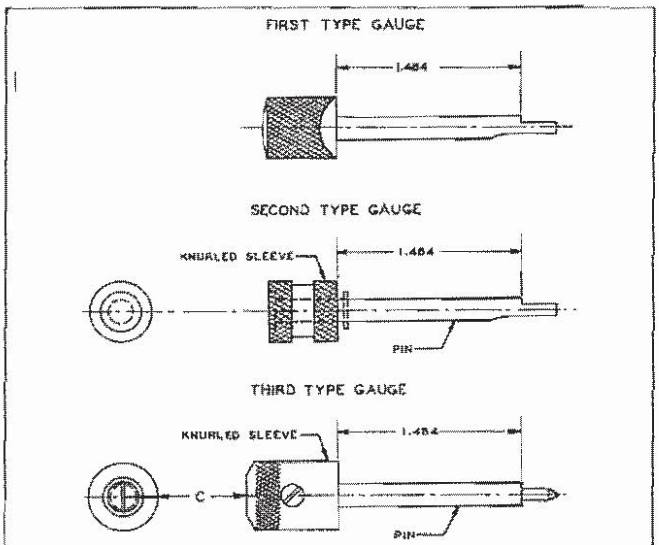


Fig. 23 – Injector Timing Gauges

J. Injector Timing.

Timing of each injector consists of properly locating the top of the plunger follower in relation to the injector body so that the fuel will be injected into the cylinder at the proper time.

1. Remove the hood and the rocker arm cover.
2. Rotate the engine with the starter until the two valve rocker arms for the same cylinder are down and the valves are fully open.
3. Remove the rear fuel lines from each injector to provide room for a screwdriver and timing gauge. Close the fuel openings on the injectors and in the cylinder head with shipping caps to prevent dirt from entering the system.
4. Place a timing gauge in the hole in the injector body; be sure that the shoulder at the bottom end of the gauge rests on the injector body and is not held up by the copper washer under the fuel connector or by dirt in the hole. Turn the sleeve of the timing gauge until it is raised as far as it will go.
5. Hold the gauge in the vertical position with a small screwdriver and turn the sleeve down until the bottom of the sleeve contacts the follower. If the injector is properly timed, the top of the sleeve will be flush with the top of the center pin and the marks on the sleeve and pin will be in line. If they are not, loosen the lock nut on the injector rocker arm push rod and turn the rod counter-clockwise to raise the follower or clockwise to lower the follower until the proper timing is obtained.
6. Tighten the lock nut and recheck the timing to be sure it was not changed by tightening the lock nut. Replace the rocker arm cover and hood. *NOTE:* The timing instructions above apply to the use of the latest (micrometer) gauge. To use the first type timing gauge, adjust the height of the follower so that the bottom of the head of the gauge will just pass over the follower. The second type gauge has a sliding sleeve. When using this gauge, adjust the height of the follower so that the tops of the sleeve and center pin are flush.

K. Injector Equalizing.

Equalizing the injectors consists of adjusting the injector rack control levers so that an equal amount of fuel is delivered to each cylinder. The greatest amount of fuel is injected into the cylinders when the injector racks are moved all the way in, no fuel is injected when the racks are moved all the way out. The engine will run unevenly or detonate (knock) if the injectors are not equalized.

1. Remove the engine hood and the rocker arm cover. Check the valve lash which should be .009" with the engine hot, also see that the injectors are properly timed (refer to "VALVE ADJUSTMENT" in Section IX and "INJECTOR TIMING").
2. Disconnect the governor to injector control shaft link at the injector control shaft lever.
3. Adjust the injector lever screws on the front

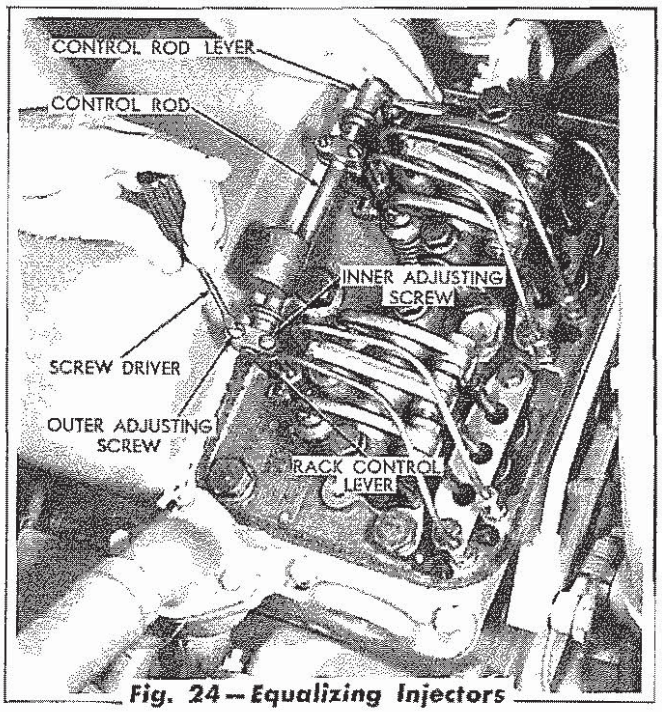


Fig. 24—Equalizing Injectors

cylinder so that the upper half of the lever is straight (not cocked) with respect to the lower half. Tighten both screws.

4. Loosen the injector rack lever screws on the rear cylinder to allow 1/8" play at the lower end of the lever. Hold the front control rack all the way in by pressing in on the lower end of the front control lever, then adjust and tighten the screws in the rear rack control lever so that the ball stud on the bottom of the lever lightly contacts the inner face of the slot in the control rack. Tightening the inner screw moves the lever in; tightening the outer screw moves it out.
5. Push the engine shut-off knob all the way in against the dash (run position) and pull the throttle lever all the way back (wide open).
6. Hold the injector racks IN by hand to the full fuel position and adjust the clevis on the injector control shaft end of the governor control link until the hole in the clevis slides freely over the pin on the rack lever. *CAUTION:* Be careful not to compress the governor spring when adjusting the governor control shift link.

NOTE: Use the procedure explained above when a rear injector is replaced. When a front injector is replaced, adjust the rack control lever by holding the rear control rack all the way in and adjust the *front* lever in the same manner.

8. INJECTOR COPPER TUBES

A. Description.

As will be seen by referring to Figure No. 10, the bore in the cylinder head for each injector is directly through the water jacket of the head. To prevent the cooling water from contacting the injector, a copper tube, shaped to receive the injector, is pressed into the injector bore in the cylinder head. This tube is sealed at the top with a neoprene packing ring and spun into a flare on the lower side of the cylinder head to form water-tight joints at the top and bottom. The coolant in the cylinder head flows around this copper tube and helps to cool the injector.

B. Copper Tube Removal.

1. Remove the cylinder head from the engine as described in "CYLINDER HEAD REMOVAL" in Section IX.
2. Remove the rocker arm shafts and brackets, and unscrew the rocker arms from the push rods. Also remove the exhaust valves. (Refer to "EXHAUST VALVES AND OPERATING MECHANISM" in Section IX.)
3. Remove the injector from the copper tube in

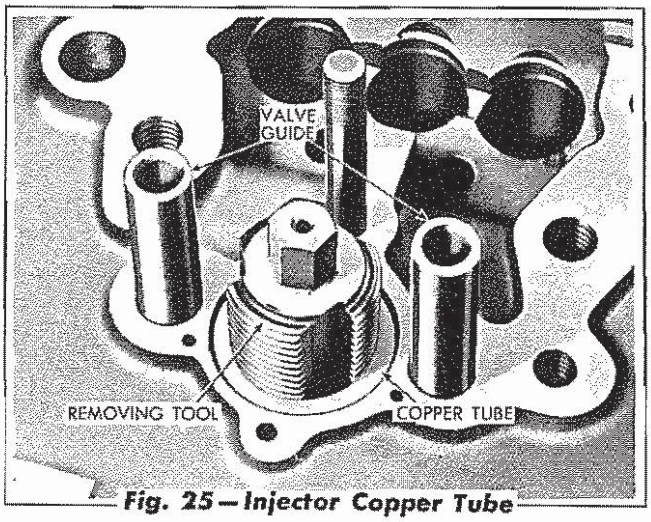


Fig. 25—Injector Copper Tube Remover Installed

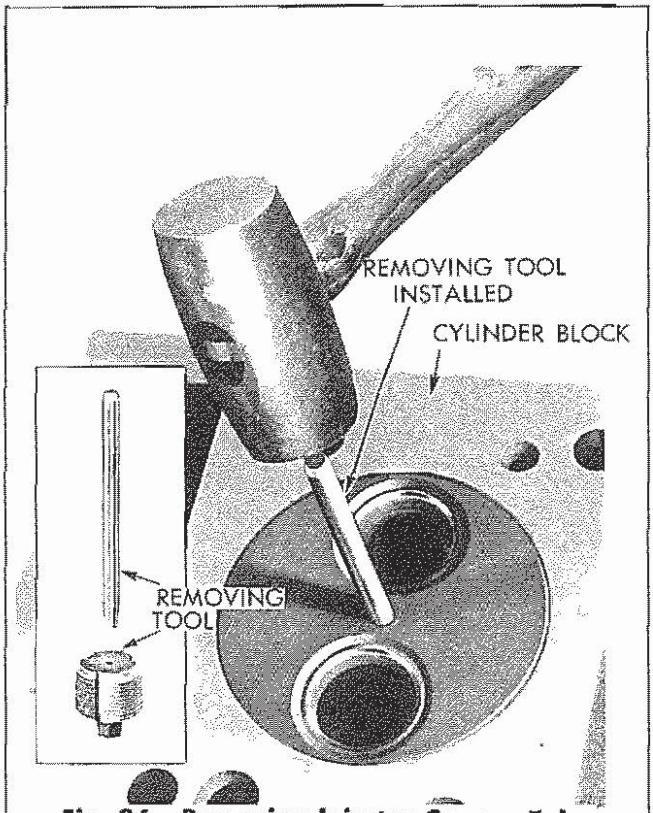


Fig. 26 — Removing Injector Copper Tube

question (refer to "INJECTOR REMOVAL" in this section).

4. Support the cylinder head, top side up, on blocks and screw the threaded injector tube remover tool into the upper end of the copper tube as shown in Figure No. 25.

5. Invert the cylinder head, supporting it on suitable blocks, and insert the driving rod of the tube remover through the spray tip opening of the tube until it rests on the threaded tool. Then drive the tube out of the head (Figure No. 26).

C. Copper Tube Installation.

1. Clean the hole in the lower side of the cylinder head and scrape any remnants of old neoprene packing ring from the counterbore in the top of the head.

2. With the cylinder head supported on blocks, right side up, install the neoprene packing ring in the counterbore of the head.

3. Force the injector tube through the packing ring and into the bore in the cylinder head. Insert the driving tool into the tube and drive the tube firmly into position in the cylinder head. When the tube is properly located, the

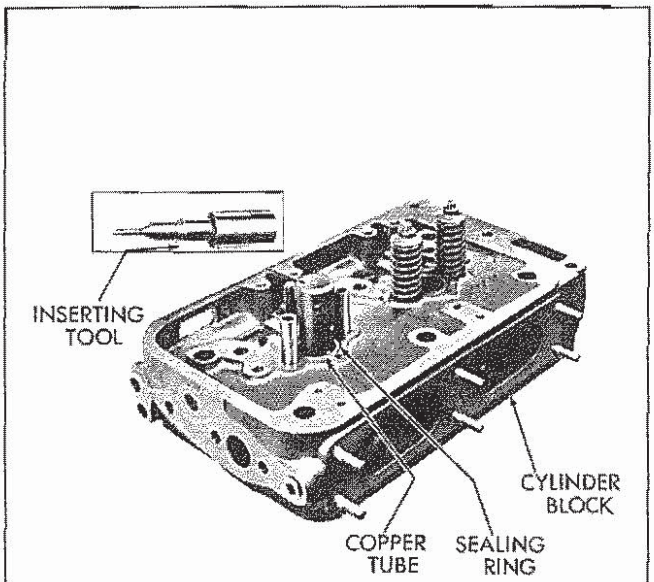


Fig. 27 — Installing Injector Copper Tube

flange at the upper end will seat on the packing ring and into the counterbore in the cylinder head.

4. After the tube is driven into place, the lower end of the tube must be flared out to lock it in place, this is done as follows:

   a. Support the edge of the cylinder head on a work bench and install the tube driving tool in the copper tube.

   b. Using the two hold-down bolts provided in the feet of the clamp fixture, shown in Figure No. 28, attach the clamp to the top of the cylinder head, using two of the cylinder head-to-block stud holes.

   c. Loosen the lock nuts on the screw and turn the screw down against the top of the driving tool so that the copper tube is firmly seated in the cylinder head and against the sealing ring. Hold the screw in this position with the lock nuts.

   d. Install the flaring tool over the lower end of the driving tool and upset the copper tube into the counterbore at the lower side of the cylinder head. *NOTE: The flaring tool will work more satisfactorily if the tapered end is ground down flat (90° to axis) to .470" O.D.*

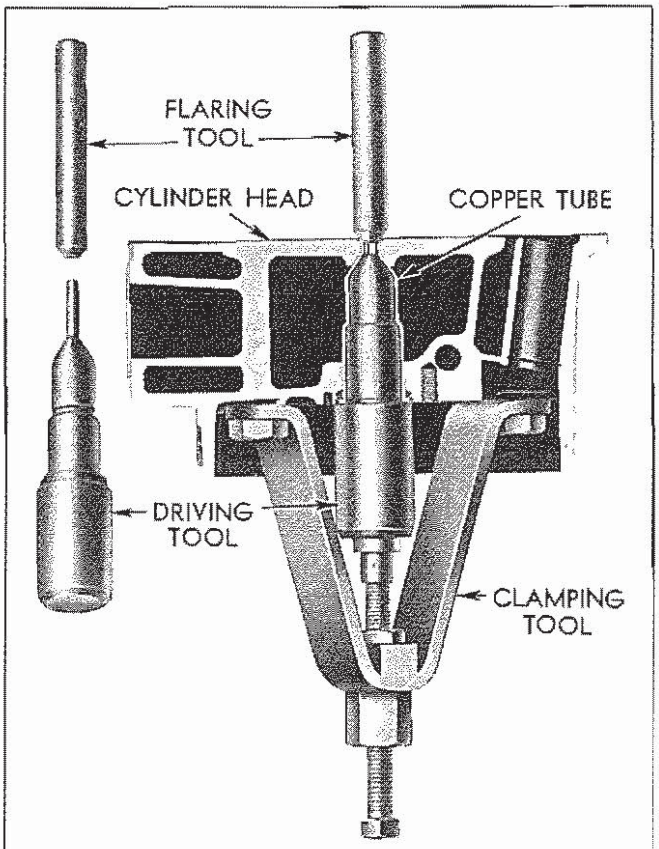


Fig. 28 — Flaring End of Copper Tube

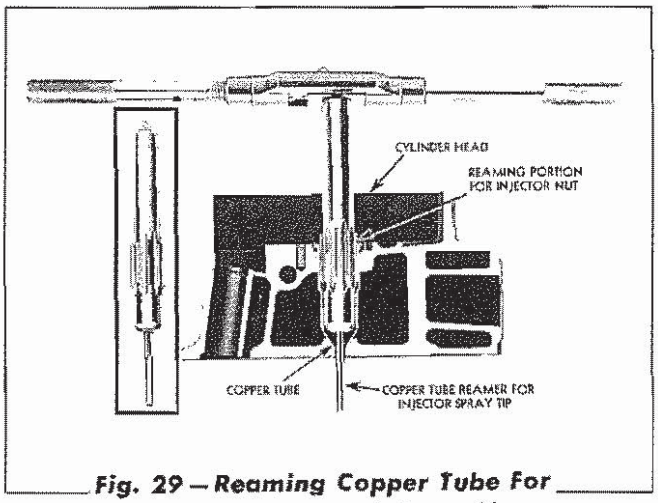


Fig. 29 — Reaming Copper Tube For Injector Body and Spray Tip

5. The tube must now be reamed; first, to receive the injector body nut and the spray tip; and second, for good seating of the bevel on the lower end of the injector nut. Reaming the upper end of the tube to its proper size for the body nut and spray tip is accomplished by use of the reamer illustrated in Figure No. 29. Reaming the bevel seat in the tube is accomplished as follows by use of the bevel seat reamer shown in Figure No. 30.

   a. Insert the injector tube bevel seat reamer into the tube and place the reamer feed clamp plate and block on the cylinder head as illustrated in Figure No. 30. Put the feed screw of the tool directly over the center of the reamer.

   b. Bolt the plate and block securely to the head and turn the feed screw down *finger tight only*.

   c. Using a cutting compound consisting of equal parts of cutting oil and kerosene, ream the bevel seat for the injector nut so that the shoulder of the spray tip will be just flush with the under surface of the cylinder head (Figure No. 31). Check the depth of the cut during the reaming operation by installing an injector in the tube and taking measurements.

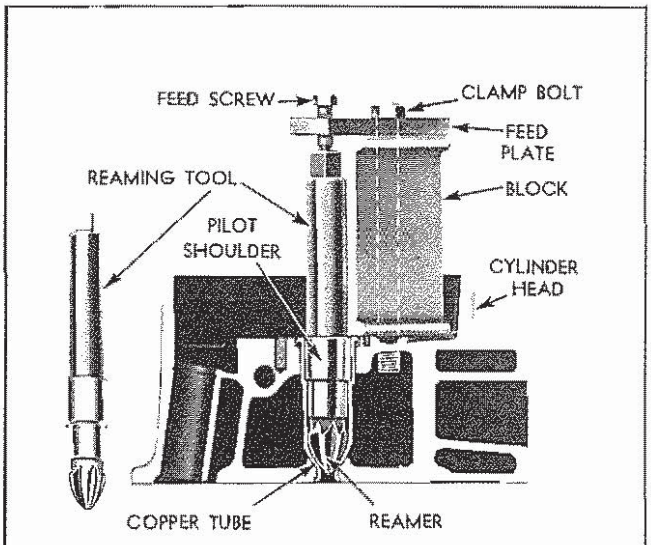


Fig. 30 — Reaming Bevel Seat In Copper Tube

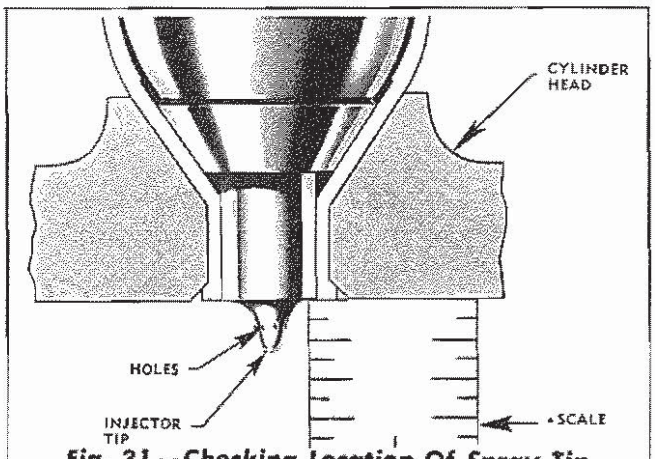


Fig. 31 — Checking Location Of Spray Tip

9. FUEL MANIFOLDS

A. Description.

Fuel is supplied to the injectors by the fuel pump through the lower of the two fuel passages located in the left side of the cylinder head and connected to the injectors by the short steel injector fuel lines. The upper (return) passage in the cylinder head returns the excess fuel oil from the injectors through the tubing to the fuel tank. Pressure is maintained in the injectors by a restricted fitting at the cylinder head return manifold opening.

B. Service.

Since the fuel manifolds are drilled in the cylinder head, the only service necessary is to keep the drilled passages clean.

SECTION III — ENGINE AIR INTAKE SYSTEM

1. DESCRIPTION OF SYSTEM

The engine air intake system includes the air pre-cleaner, air cleaner, air valve, air box, and blower. The blower supplies the fresh air needed for combustion of fuel in the cylinders and for the scavenging or removal of burned gases from the cylinders. The air, drawn from the atmosphere by the blower, passes through the air pre-cleaner and air cleaner before it enters the blower. Dust, always present in the air, is thus filtered from the air before it is delivered to the engine. If the air were delivered to the engine uncleaned, the dust particles would cause rapid wear on pistons, cylinder liners, and other parts.

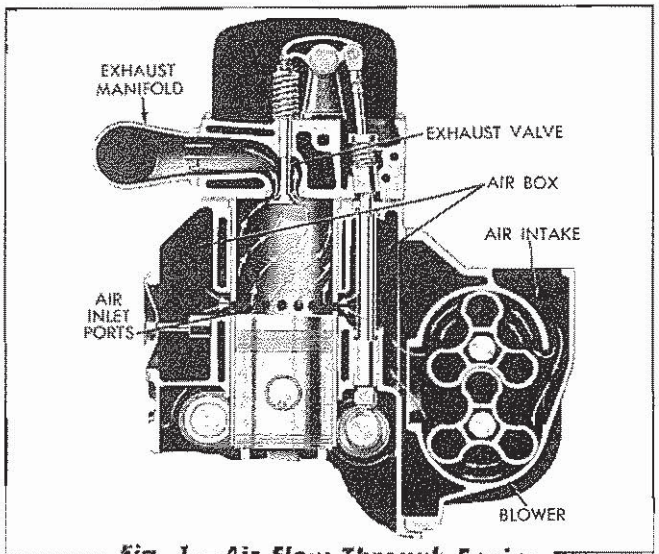


Fig. 1 — Air Flow Through Engine

The air is discharged from the blower into a hollow section of the cylinder block surrounding the cylinders, called the air box. The air passes into the cylinder from the air box through holes (air ports) in the cylinder liners that are uncovered by the pistons as they near the bottom of their stroke. These holes remain uncovered long enough for the fresh air to rush through the cylinders to scavenge the exhaust gases and leave the cylinders filled with clean fresh air which permits highly efficient combustion. This circulation of the air through the cylinders also helps cool the internal engine parts, particularly the exhaust valves.

The fuel injected into the cylinders is ignited by the heat of the air compressed within the combustion chambers on the upstroke of the pistons. In cold weather, the "drag" caused by cold oil between the pistons and cylinder walls and in the bearings reduces the cranking speed of the engine. A large part of the heat generated by compression of the air is absorbed by the pistons and cylinder walls. This loss of heat and the reduced cranking speed may result in the temperature of the air in the cylinders being too low to ignite the fuel. A starting aid must then be used when starting the engine. Tractors prior to Serial Number 4208 are equipped with an Air Heater. The air heater is used to pre-heat the air delivered by the engine blower to the engine as it passes through the engine air box into the cylinders. A sufficiently high temperature for ignition is thus attained. Tractors Serial Number 4208 and above are equipped with a Starting Fluid Primer. The primer is used to inject starting fluid (ethyl ether) into the air intake tube and the starting fluid is then picked up by the engine blower and is blown into the cylinders. Since the starting fluid is highly combustible, it is easily ignited by compression in the cylinders.

Two air box drain tubes, one located on each side of the engine, are provided for draining fuel that might leak into the air box and would otherwise be drawn into the cylinders with the air.

2. AIR PRE-CLEANER

A. Description and Purpose.

The tractor may be equipped with either a United or a Donaldson Air Pre-Cleaner and Air Cleaner.

The purpose of the air pre-cleaner and the air cleaner is to remove dust and other foreign matter from the air used by the engine. The life of the engine depends largely on proper maintenance of the Air Cleaner System. Fast wear on cylinder liners, pistons and rings will result if the air pre-cleaner and air cleaner are not kept in good condition and properly serviced.

Air for the engine enters through the pre-cleaner mounted on the top of the air cleaner extension tube. The pre-cleaner is of a centrifugal type, consisting of a body and shell (dirt bowl). Fins in the body are set at an angle that gives the incoming air a swirling motion and causes the dirt in the air to be thrown to the outside and deposited in the shell. All large particles of dirt as well as other foreign material are thus removed from the air before it enters the air cleaner. The level of the dirt collected in the pre-cleaner shell is visible through the pre-cleaner inspection glass.

B. Air Pre-Cleaner Service—United.

Empty the pre-cleaner whenever the dirt level reaches half way up on the inspection glass.

1. Unscrew the wing nut to remove the cap from the shell.
2. Lift the shell from the pre-cleaner body. Clean the dirt out of the shell and wipe the inside of the shell with a dry cloth. Be sure the fins in the cleaner body are not bent, damaged, or clogged.
3. Wipe the dust off the cap gasket and reassemble the pre-cleaner. Install a new gasket if the old one is not in good condition. Install the wing nut finger tight. *DO NOT USE A WRENCH.*

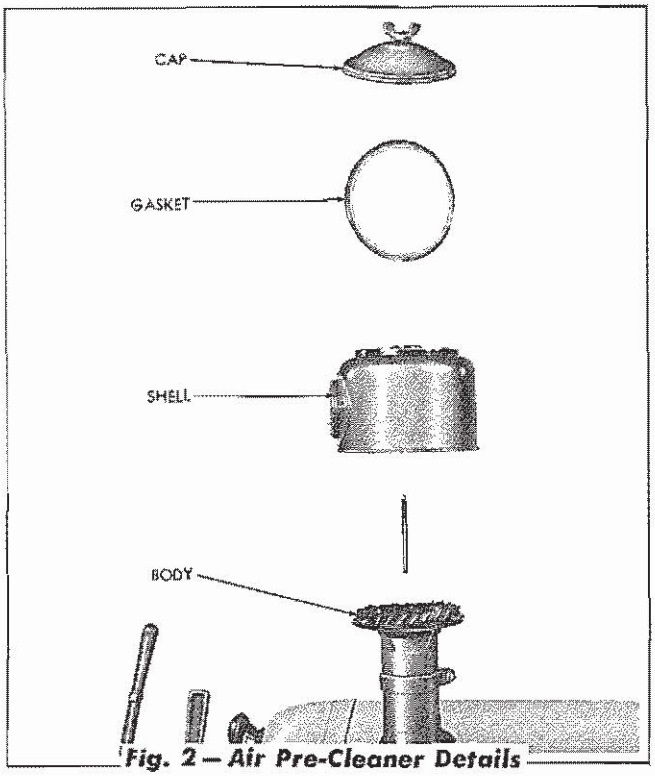


Fig. 2—Air Pre-Cleaner Details

C. Air Pre-Cleaner Service—Donaldson.

The pre-cleaner shell must be emptied whenever the dirt level reaches the top of the transparent ring below the hood of the unit.

1. Remove the wing nut at the top of the hood and remove the hood from the pre-cleaner.
2. Lift the transparent ring from the body of the pre-cleaner and clean the dirt from the cleaner. Be sure all openings for entrance of air are open and not restricted in any way.
3. Place the ring back on the body, then install the hood above the ring. Be sure these parts are not "cocked" when installed. Install the wing nut and draw the hood and ring down tight against the pre-cleaner body. Install the wing nut finger tight. *DO NOT USE A WRENCH.*

3. AIR CLEANER

A. Description.

The air cleaner consists of a cylindrical body packed to a prescribed density with a rust-proof metallic matting and has an oil cup suspended from the bottom of the body by a hinged bail. This cup is filled to a specified level with engine lubricating oil. A tube extends down through the

center of the cleaner body into the oil. The air pre-cleaner is mounted on the upper end of the tube. After passing through the pre-cleaner, the air enters the air cleaner through the air cleaner head and inlet tube that extends through the center of the air cleaner body. As the air is drawn through the cleaner, a portion of the oil in the cup is whipped up into the matting and the air passes on through the matting to the blower. The oil with which the matting is saturated collects the dust from the air, and, in dripping back into the cup, carries the dirt with it and deposits it in the cup. Thus, only clean air enters the blower for delivery to the cylinders.

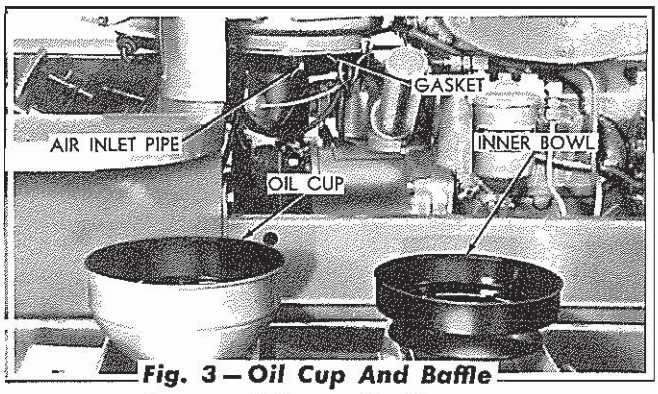


Fig. 3—Oil Cup And Baffle Removed From Air Cleaner

B. Air Cleaner Service.

At periodic intervals, depending upon operating conditions, the oil cup must be removed, cleaned, refilled with new oil, and the inlet air tube swabbed out. Dirt mixed with the oil will collect inside the air cleaner tube and, if not removed, will in time restrict the flow of air, resulting in an insufficient supply of air to the engine. A broken hose, loose hose clamp, damaged blower gasket, or leak of any kind that allows air to enter the cylinders without first passing through the air cleaner will defeat the purpose of the air cleaner, and must be corrected at once.

Remove the oil cup daily (more often if operating in extremely dusty conditions) to check the oil level in the cup and to determine the condition of the oil. Empty and wash the cup whenever the oil becomes discolored, indicating a quantity of dirt has collected, then refill with clean oil.

Keep the oil cup filled to the top of the cone, in the center of the baffle plate in the cup, when servicing the United Cleaner and to the top of the oil tray when servicing the Donaldson Cleaner. Use SAE 30 engine oil when the temperature is above 32° F., SAE 10 when temperature is 32° F. or below. *NOTE: SOME DIESEL LUBRICATING OIL MAY FOAM WHEN USED IN THE AIR CLEANER. DO NOT USE AN OIL THAT FOAMS AS IT REDUCES THE AIR CLEANER EFFICIENCY AND IN SOME CASES ALLOWS THE OIL TO BE PULLED OVER INTO THE ENGINE, CAUSING SERIOUS DAMAGE.*

C. To Service Cleaner.

1. Remove the oil cup from the bottom of the cleaner body. Remove the oil tray and empty the oil from the cup. On the United Air Cleaner the baffle plate must be removed to empty the cup.
2. Wash the oil tray and cup with clean oil or solvent. Swab out the air cleaner inlet tube, in the center of the cleaner.
3. When servicing the United Air Cleaner install the oil baffle in the cup and fill to the top of the center cone with clean oil. Replace the cup on the bottom of the cleaner body. See that the gasket above the cup makes a tight seal.
4. When servicing the Donaldson Air Cleaner proceed as above and fill the cup to the top of the oil tray with clean oil.
5. Once or twice a year remove the cleaner body from the mounting bracket. Remove the oil cup and immerse the body in a tub of clean fuel oil or cleaning solvent and rinse the dirt from the filter mat in the body.
6. The air cleaner should be inspected for cracked air outlet flanges, opened seams and loose oil cups. The hoses should be inspected for loose hose clamps, holes and damage on the inside of the hoses.

   A suggested method of inspecting the air cleaner for leaks is to remove the air cleaner, cork air outlet hole and fill the cleaner with a non-combustible cleaning solvent or fuel oil. The penetrating qualities of the fluid will indicate small cracks hardly discernible to the naked eye. Allow the air cleaner to dry thoroughly before installing.

   The oil cup may be considered as being too loose if it can be twisted on the air cleaner

by hand with the cup retaining bail in position.

If any of the above conditions are present, they must be corrected.

REMEMBER, THAT ALL CONNECTIONS BETWEEN THE PRE-CLEANER AND THE BLOWER MUST BE KEPT TIGHT AND THE AIR CLEANER MUST BE KEPT IN LEAK-PROOF CONDITION IF GOOD ENGINE LIFE IS TO BE EXPECTED.

D. Air Cleaner Removal and Installation.

To remove the air cleaner assembly, remove the pre-cleaner from the air cleaner, remove the engine hood, loosen the hose clamp that connects the hose to the air cleaner pipe, then loosen or remove the mounting straps and lift the air cleaner assembly from the tractor.

To install the cleaner assembly, reverse the procedure for its removal. Coat the inside of the air cleaner pipe hose with gasket cement before it is connected to the cleaner. Before tightening the mounting straps around the air cleaner, adjust the cleaner, so that the outlet tube of the cleaner is at the right height and angle for a proper connection of the hose between the air cleaner outlet tube and the air cleaner pipe.

4. AIR INTAKE TUBE AND AIR SHUT-OFF VALVE

A. Description.

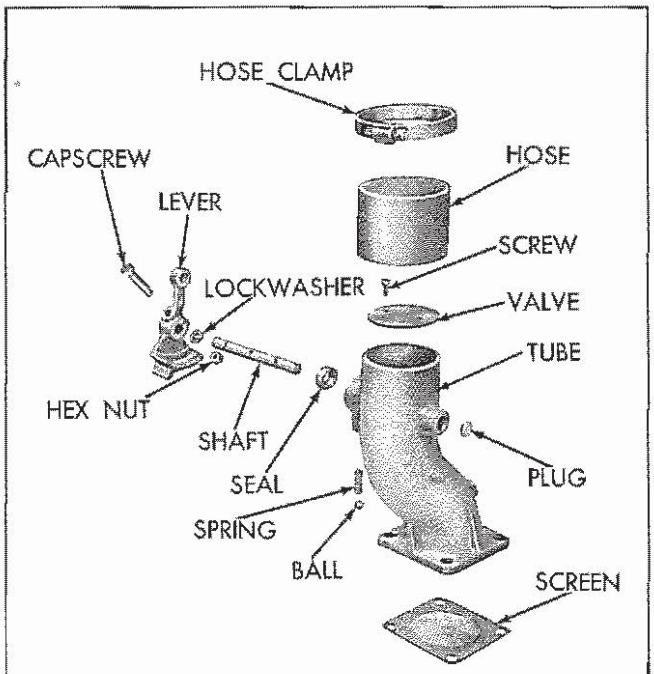


Fig. 4—Air Intake Tube And Air Shut-Off Valve Details

The air intake tube, located above the blower air inlet housing (Figure No. 4) contains the engine air shut-off valve assembly. This is a butterfly type valve that is manually controlled by the engine shut-off rod. When the engine shut-off rod is pushed in, the valve is opened and air can pass through the intake tube to the blower. When the rod is pulled out, the valve closes against the seating surfaces in the intake tube and the air supply to the engine is shut-off. This valve also acts as an emergency engine shut-off device. If for some reason fuel collects in the air box, speeding up of the engine will cause this fuel to be drawn from the air box into the cylinders, and the engine speed will be increased beyond its maximum governed speed because of this added supply of fuel. The governor has no control over an engine in such instances, however, the engine can be stopped by the closing of the air valve as this shuts off the supply of oir necessary for combustion of the fuel.

The valve is held in its open and closed positions by a spring and ball in the housing which contacts notches in the lever on the valve shaft.

B. Removal, Disassembly, and Inspection.

1. Remove the engine hood and disconnect the hose from the upper end of the air intake tube.
2. Disconnect the end of the engine shut-off control rod from the air shut-off valve lever.
3. Disconnect the starting fluid primer tube from the air intake tube if tractor is equipped with a primer.
4. Remove the capscrews attaching the air intake tube to the blower housing and lift the tube from the housing.
5. Remove the clamp bolt from the air shut-off valve shaft lever and remove the lever from the shaft. *CAUTION:* Do not loose the air valve locking spring and ball as they will fall

out when the lever is removed.

6. Remove the locking wire from the screws used to hold the shut-off valve in place in the slotted shaft, then remove the screws and shut-off valve.
7. Remove the air shut-off valve shaft from the intake tube. Remove the shaft dust seal from the intake tube.
8. Clean and inspect the parts for wear. The shaft must be straight and not excessively worn or the valve will not seat properly in the elbow. The expansion plug in the outer side of the intake tube must fit tight in its bore to prevent air being drawn past it. Always install a new seal in the counterbore in the inner side of the intake tube when the tube and valve are assembled. Make sure that the shaft rotates freely.

C. Assembly and Installation.

Lubricate the ends of the air shut-off valve shaft and install the shaft in the intake tube with the notched end to the inner side. Place the shut-off valve in the slot of the shaft and attach it in place with the screws, then lock the screws with lockwire. Install a new shaft dust seal in the counterbore in the inner side of the intake tube. Hold the air valve locking spring and ball in position in the boss of the intake tube, then install the valve shaft lever on the end of the shaft. Install the expansion plug in the outer side of the elbow making sure that the plug fits tightly in the counterbore. Refer to Figure 4.

Attach the intake tube to the blower housing, using a new air inlet screen and gasket. Coat the inside of the air cleaner pipe hose with cement or sealing compound and connect the air intake tube to the air cleaner pipe. Tighten the hose clamps securely to insure an air-tight joint. Connect the engine shut-off control rod to the air shut-off valve shaft lever. Adjust the controls as explained in "Engine Shut-Off Control Adjustment," Section VI.

5. BLOWER

A. Description.

The blower supplies the fresh air needed for combustion and sweeping the cylinders clear of exhaust gases. 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 in a twisted or helical form.

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 in Figure No. 1. 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 when the engine is operating at its maximum speed. As the piston uncovers the intake ports of the cylinder (which begins at 48 degrees of crankshaft rotation before bottom dead center), the air sweeps through the ports into the cylinder. The angle of the ports in the cylinder liners imparts a rotary motion to the intake air as it enters the cylinder. This rotation

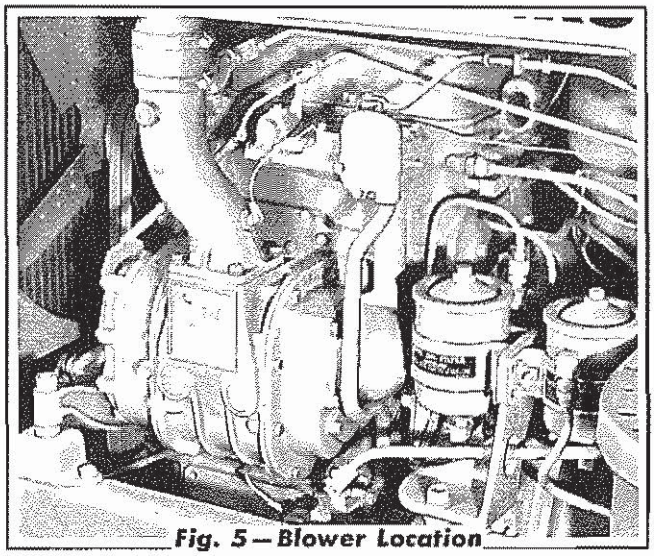


Fig. 5—Blower Location

of air persists throughout the compression stroke and improves combustion.

Two timing gears on the drive ends of the rotor shafts space the rotor lobes with a slight clearance. Thus, because 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 rotor lobes and also seal the oil, used for

lubricating the timing gears and rotor shaft bearings, from the rotor compartment. The lower rotor is driven at twice engine speed by the camshaft gear. The upper rotor is driven from the lower rotor through the blower timing gears.

Each rotor is supported on the doweled end plates of the blower housing by a single-row radial ball bearing at the rear end, and a two-row, preloaded, radial and thrust ball bearing at the front or gear end.

The blower gears and front bearings are lubricated by oil splash from the oil pan into which space the gears are exposed. The blower rear bearings, governor weights, and carrier assembly, are lubricated by the oil which drains from the valve operating mechanism into a vertical drilled passage in the cylinder block, then through a transverse hole to the blower housing. Cored and drilled openings in the blower housing provide an oil passage to the top of the blower rear end plate, from which the oil flows over the blower shaft rear bearings and is splashed on the governor weight and carrier shaft bearings. The oil then drains into the crankcase through openings in the blower rear end plate and cylinder block.

B. Service and Inspection.

The blower is not a delicate device. Nevertheless, great care is taken when the unit is assembled at the factory. The same care must be taken when the blower is serviced in the field.

As pointed out in the foregoing description, the blower rotors revolve with a slight clearance between the two lobes and also between the lobes and the blower housing. Bearings are used at each end of the rotor shafts and suitable oil seals are used back of each bearing to seal the engine oil from the rotor compartment. Double-row ball bearings provide proper end clearance between the rotors and the end plates. The blower rotors are "timed" by the two gears at the front end of the rotor shafts. This timing or spacing must be correct; otherwise the required clearance between the rotor lobes will not be maintained.

Normal gear wear causes an increase of rotor-to-rotor clearance between the leading flanks of the upper rotor lobes and the trailing flanks of the lower rotor lobes. Clearance between the opposite sides of the rotor lobes is decreased correspondingly. While rotor lobe clearance, due to gear wear, may be corrected by adjustment, the gear back-lash cannot be corrected. Therefore, when the gears have worn to the point where the back-lash exceeds .004", the gears must be replaced. The procedure for timing the blower rotors for proper clearance is outlined under "Blower Timing."

Because of the important part that the blower plays in the efficient operation of the engine, an inspection of the unit should be made every 1,000-engine hours, especially if the tractor has been operating under extremely dusty conditions. If this practice is followed, minor irregularities can usually be detected and corrected before more serious difficulties develop. A blower may fail to function properly because of any one or a combination of the following reasons:

1. Dirt or foreign matter having been drawn through the blower, thereby scoring the rotor lobes and housing.
2. Worn oil seals, permitting lubricating oil to be drawn into the rotor compartment.
3. Loose rotor shafts, worn gear teeth, or worn bearings, causing contact between the rotor lobes, rotors and end plates, or between the rotors and housing.
4. Out of time — that is, due to timing gear wear, the mating rotor lobes may not have sufficient clearance at one side and too much clearance on the opposite side.

The blower should be removed from the engine to inspect for any of these conditions.

C. Blower Removal.

To remove the blower from the engine as an assembly:

1. Remove the governor assembly from the engine and blower. (Refer to "Governor Removal," Section VI.)
2. Disconnect the end of the engine shut-off control rod from the air shut-off valve lever.
3. Loosen the lower hose clamp connecting the air intake tube to the air cleaner pipe.
4. Disconnect the starting fluid primer tube from the air intake tube if the tractor is equipped with a primer.

5. Remove the capscrews attaching the air intake tube to the blower housing and lift the tube from the housing.

6. Remove the air heater if the tractor is equipped with an air heater. Refer to "Air Heater Removal."

7. Remove the bolts and lockwashers which attach the engine front gear housing cover to the blower.

8. Remove the air box drain tube clip, and tube.

9. Remove the bolts and lockwashers which attach the blower assembly to the cylinder block, also the special 7/16" by 7½" bolt at the center of the blower front end plate.

10. Move the blower assembly slightly towards the rear of the engine to free the gasket between the gear cover and the blower end plate; then move the blower away from the cylinder block.

    CAUTION: Be careful when loosening the blower from the block so as not to destroy the gasket between the gear cover and blower front end plate. If the gasket is destroyed, the gear cover must be removed to install a new gasket.

D. Inspection of Blower Assembly.

After the blower assembly has been removed from the engine, cleaned with carbon tetrachloride and dried with compressed air, this assembly may be inspected for scored rotors, worn bearings, etc., applying the hints given below as a guide.

CAUTION: Do not clean the blower assembly in hot solvents, as such practice will destroy the oil seals.

1. **Dirt or chips** drawn through the blower will cause deep scratches in the rotors and housing and raise up burrs around such abrasions. If burrs cause interference between rotors and housing, the parts should be dressed down to eliminate interference, or rotors replaced if too badly scored.

2. **Leaky oil seals** are usually indicated by the presence of excessive oil on the blower rotors or inside the housing.

3. **If loose rotor shafts or worn bearings** are causing blower difficulties, such a condition will be indicated by rubbing and scoring between crowns of rotor lobes and mating rotor roots, between rotors and end plates, or between rotors and housing.

4. **Excessive gear back-lash** due to abnormal gear tooth wear will throw blower rotors out of time and result in lobes rubbing throughout their entire length. Refer to "Blower Rotor Timing."

E. Disassembly of Blower.

When blower overhaul is necessary, the unit may be disassembled, parts inspected, and rebuilt by referring to the following instructions:

1. Wedge two pieces of clean cloth between blower lobes to prevent rotation of rotors when the blower rotor nuts are loosened; then straighten tangs on locking washers and remove the blower rotor nuts from the rotor shafts.

2. Removing Timing Gears: *IMPORTANT: THE TWO TIMING GEARS MUST BE PULLED FROM THE ROTOR SHAFTS AT THE SAME TIME.* This may be done with two gear pullers in the conventional manner. Before pulling, note that the upper gear has teeth with right-hand helix, and lower gear teeth are left-hand helix. When reassembling, the gears must be replaced with these identifications in mind.

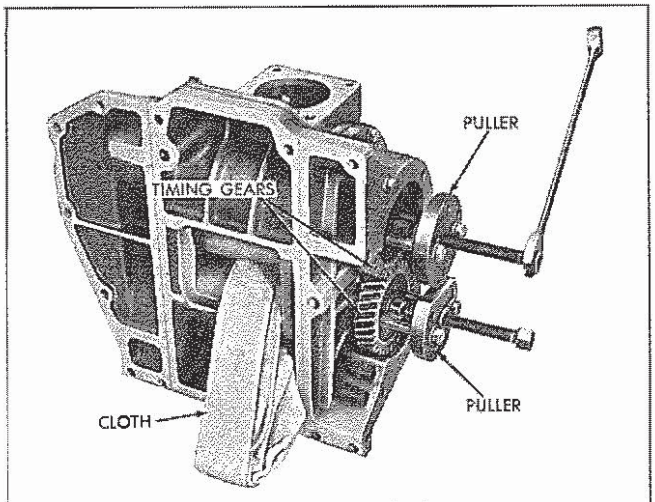


Fig. 6—Pulling Rotor Timing Gears

3. Note the number and thickness of rotor mesh adjusting shims on each rotor shaft if shims were used. Identify each group with the shaft to which it was assembled, and when reassembling, install shims on same shafts from which they were removed.

4. Remove the capscrews attaching the blower front end plate to the blower housing. Then tap on the end plate flanges with a rawhide hammer until the plate can be pulled off the dowels. *DO NOT PRY BETWEEN THE HOUSING AND END PLATE.* Such practice will damage the sealing surfaces and result in air leaks between the plate and housing.

5. Pull the front end plate off the rotor shafts. To free the rotor shafts from bearings, it may be necessary to tap the end of the shafts with a rawhide hammer at the same time the plate is being pulled.

6. Remove Rotors from Housing: Tap the rear ends of the shafts lightly with a soft hammer to slide the rotor shafts out of the rear bearings. Rotors may then be withdrawn through the front end of the housing.

7. Remove the capscrews attaching the blower rear end plate to the blower housing and pull the end plate off the dowels as described in item (4) above.

At this stage of the blower disassembly, an inspection should be made to determine if further disassembly is necessary.

Inspect the end plates around the oil seals for oil leakage past the seals. Leakage would be evidenced by streaks of grease radiating from the inner diameter of the seal. If no leakage is present, and the seal lips are smooth and pliable, removal is unnecessary. Wash the bearings and end plates with carbon tetrachloride, dry with compressed air and apply a thin film of light oil. If the bearings roll freely and without shake in the races, removal is not necessary. If any of the above parts are found defective, replacements should be made and further disassembly may be carried out as follows:

8. Remove the blower rotor shaft bearings and oil seals from the end plates as follows:

   a. Remove the slotted head screws which attach each bearing retainer to the front end plate.

   b. Remove the front double-row bearings by crowding from position with the fingers or tapping uniformly from position with a soft bar on the bearing outer races.

   c. Remove the oil seals by tapping on the inner face of the seal and driving uniformly from position into the bearing cavity.

   d. Remove the single-row bearing retainer rings from the rear end plate, using a pair of pliers or similar tool.

   e. Remove the bearings and oil seals, as in Items b and c, above.

9. Remove the two plugs from the outside of

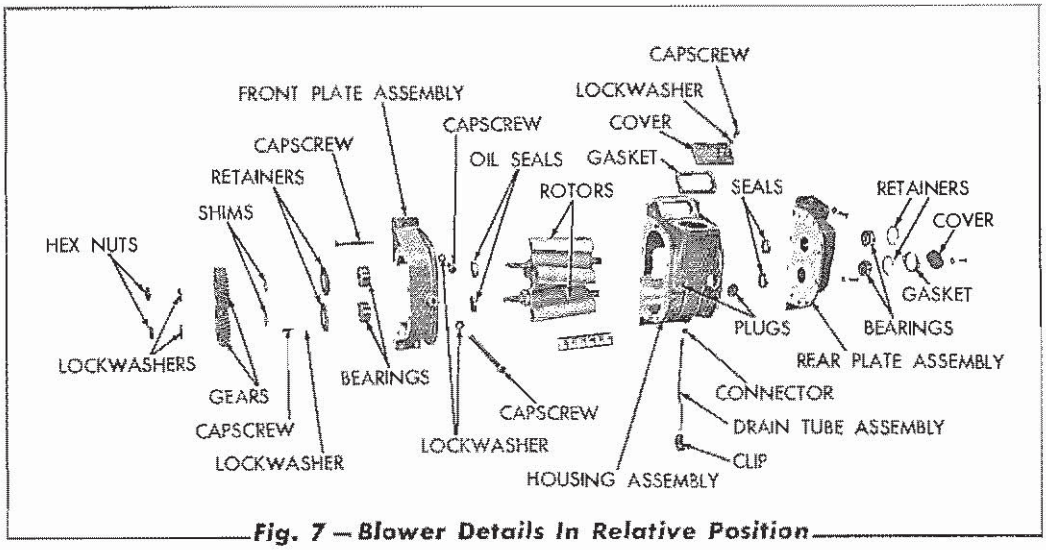


Fig. 7 — Blower Details In Relative Position

the blower housing. This is necessary in order to check rotor timing after reassembly.

After the blower has been disassembled, all parts should be washed in clean carbon tetrachloride, blown off with dry compressed air, and inspected before reassembly.

10. Inspect the ball bearings as follows: Wash the ball bearings by rotating the bearings by hand in clean carbon tetrachloride until free from grease and oil. Clean the balls and races by directing air through the bearings, at the same time rotating the bearing by hand. *DO NOT SPIN THE BEARING BY AIR PRESSURE.* If necessary, repeat cleaning operation to be sure all foreign substance is removed. 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 preloaded and have no end play; in fact a new double-row ball bearing will seem to have considerable resistance when revolved by hand.

11. Check the oil seals in the end plates, and if necessary, replace. Oil seals that have been used should be lubricated with clean engine oil at the time of assembling blower; new oil seals should be soaked for at least 60 minutes in thin, clean engine oil before assembling.

12. Inspect the blower rotor lobes for smoothness, and shaft serrations and bearing surfaces for wear or burrs.

13. See that the end plate finished faces are smooth and flat.

14. See that the finished ends of the blower housing, which receives the end plates, are flat and free from burrs. The end plates must set flat against the blower housing.

15. Check the blower gears for wear.

16. As will be seen from Figure No. 9 the rotors must revolve inside the blower housing with a specified clearance between the housing and rotor lobes. Inspect the inside of the housing to see that the surfaces are smooth.

F. Blower Assembly.

All blower parts having been inspected, assemble the blower by reversing sequence of operation for disassembly as follows: Refer to Figure No. 7 showing blower details in relative position.

1. **Install Oil Seals in Blower End Plates.**

   The seals must be installed so the sealing edge of the leather is pointing toward the rotor bearings. Start the seals squarely into place by hand, and then drive into position with a block of wood and hammer. Drive the seals in so that the flat faces of the seals are .003" below the inner finished face of the plates.

2. **Install Blower Rear End Plate.**

   The blower rear end plate may be identified by the wide cylinder block-to-end plate bolting flange.

   With this identification in mind, and being sure that adjoining faces of the blower housing and end plate are perfectly smooth and flat, assemble the rear end plate on the dowel pins and draw tight with capscrews and lockwashers.

   Before further assembly of the blower, certain checking operations are necessary to insure the proper relationship of parts. The lobes of one of the blower rotors and the teeth on one of the drive gears form a right-hand helix and on the mating parts a left-hand helix. The rotor with the right-hand helix must be used with the gear having the right-hand helical teeth, and vice versa. Rotor and gear with right-hand helixes are the upper units in the blower; and the parts with the left-hand helixes, the lower units. Furthermore, for convenience in blower timing, one serration is omitted on the drive end of each blower shaft with corresponding omissions on the gear hubs. Also, an "O" is indented in two of the blower drive gear teeth. Gears must be placed on the shafts with the omitted serrations on proper registration; so that the two "O's" on the gear teeth will be together.

   The latest type drive gears do not have the two "O" marks in the teeth for properly mating the teeth, but this can be accomplished by setting both rotors so that the omitted serrations point directly downward.

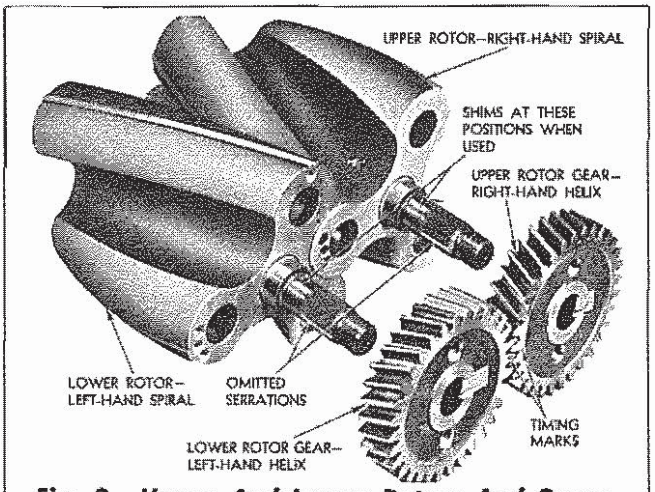


Fig. 8—Upper And Lower Rotors And Gears

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 Figure No. 8.

3. Assemble Rotors Into Housing.

With the above checks in mind, guide the rear (short) ends of the rotor shafts through oil seals in rear cover plate. Care must be exercised not to damage or to turn the lips of the oil seals back when guiding the shafts through the seals. A thin piece of shim stock wrapped around the shaft at the oil seal wiping surface will prevent damage to the seal.

4. Install Blower Front End Plate.

Assemble blower front end plate in manner described for rear end plate. Six 5/16" x 1" and one 5/16" x 3¼" capscrews and the necessary lockwashers are used to make this assembly.

5. Install Rotor Shaft Rear Bearings.

Single-row ball bearings are used at the rear end of the blower rotar shafts and double-row ball bearings at the front end. The bearing number is stamped at one end of the ball race only. When assembled, the markings face the end plate. With these identifications in mind:

a. Start the single-row bearings onto the rear end of the rotor shafts (short end of shaft).

b. Using a suitable tool, drive the bearing into the cavity of the rear end plate and over the rotor shaft. Repeat this operation on the other rotor shaft.

c. Install the bearing retainer rings to lock the bearings in place.

6. Install Rotor Shaft Front Bearings.

a. Install the front rotor shaft bearings exactly the same way the rear bearings were installed.

b. With flange at inner diameter of the bearing retainers pointing away from the bearings, attach retainers to the end plate, using three slotted head screws and lockwashers in each retainer.

7. Press Timing Gears Onto Rotor Shafts.

If blower once used is being reassembled, mesh adjusting shims were no doubt used back of one, or perhaps both the timing gears. They should be installed in their original positions before pressing the gears on the shafts. If new gears and shafts are used, install without shims, and add shims later, if necessary, when timing the gears.

Hold the gears in their proper position, the two "O" marks in the teeth together and the gear with the right-hand helix on the top, check to see if the omitted serrations on the rotor shafts will register with the blind serrations in the gears. If the blind serrations in the gears are to the top, turn the rotors in the blower housing so that the omitted serrations will register with the blind serrations in the gears, rotor omitted serrations up.

The latest type drive gears do not have the two "O" marks in the teeth for properly mating the teeth, but this can be accomplished by setting both rotors so that the omitted serrations point directly downward.

Apply some engine oil at the shaft serrations and proceed to press the gears uniformly onto the shafts. This may be done by supporting the blower assembly on the bed of an arbor press with the rear (nan-gear) ends of the rotor shafts resting on supports and pressing the gears into position *simultaneously*. Lock the gears tight in place with the rotor nuts and washers.

8. **Blower Rotor Timing.**

At this stage of the blower assembly, the blower rotors must be "timed."

The blower rotors, when properly positioned in the housing, run with a slight clearance between lobes. This clearance may be varied by moving one of the helical gears in or out on the shaft relative to the other gear. This positioning of the gear to obtain the proper clearance between the rotor lobes is known as *Blower Timing*.

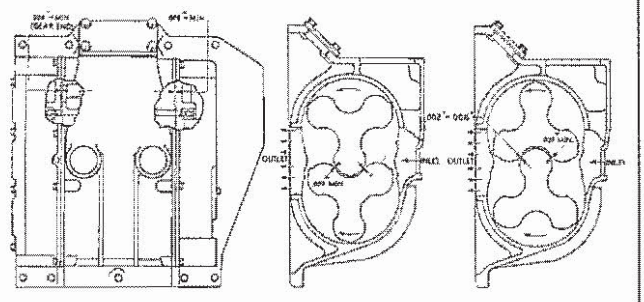
If the *upper* gear is moved out, the *upper* rotor will turn *counter-clockwise* when viewed from the gear end. If the *lower* gear is moved out, the *lower* rotor will turn *clockwise* when viewed from the gear end.

Moving the gears OUT or IN on the rotors is accomplished by adding or removing mesh adjusting shims between the gear hubs and the bearings.

Refer to Figure No. 9 and note that when the blower assembly is viewed from the gear end, the clearance between the trailing side of the upper rotor and the leading side of the lower rotor is .009" minimum, and between the leading side of the upper rotor and the trailing side of the lower rotor the clearance is set to hold a .006" feeler and pass a .002" feeler.

9. **Check Rotor Lobe Clearance.**

The clearance between rotor lobes may be checked with various thickness feeler ribbons 1/2" wide. When measuring clearances of more than .005", laminated feelers made up of .002", .003", or .005" are more practical than one single thick feeler.



NOTE: TIME ROTORS TO DIMENSION ON CHART FOR CLEARANCE BETWEEN LEADING SIDE OF UPPER ROTOR AND TRAILING SIDE LOWER ROTOR (.002 to .006) FROM BOTH OUTLET AND INLET SIDES OF BLOWER

Fig. 9 — Rotor Lobe Clearance

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 check must be made between each pair of mating lobes at each end and at all points indicated in Figure No. 9.

A .003" mesh adjusting shim in back of the blower gear will revolve the rotor .001". Having determined the amount one rotor must be revolved to produce the proper clearance, add mesh adjusting shims in back of either the upper or lower gears, as shown in Figure 8 to produce the desired result.

When additional mesh adjusting shims are required to time the rotors, both gears must be pulled from the rotors, as directed in Item No. 2 under "Disassembly of Blower." Install the required thickness of mesh adjusting shims back of the proper gear and next to the bearing inner race, and again press the gears in place and pull up tight with the rotor nuts. Recheck the clearance between the rotor lobes.

Wedge a clean cloth between the blower rotors, install the special locking washers next to the gears, tighten the nuts on the rotor shafts, and lock the nuts with the ears on the locking washers.

10. **Attach Blower Assembly to Cylinder Block.**

a. Before attaching the blower assembly to the engine, examine the inside of the blower for any foreign material and revolve the rotors by hand to test for smooth operation. Rough particles in the blower may score the rotors and impair blower efficiency. Cement a new gasket to the cylinder block at the blower pad.

b. Place the blower on the cylinder block locating flange and install the 7/16" x 7½" "through" bolt in front end plate. Do not tighten bolt.

c. Install the bolts which hold the blower assembly to the cylinder block.

d. Tighten the attaching bolts uniformly. After the back-lash between the lower rotor gear and the camshaft gear has been checked, the remainder of the blower-to-engine assembly may be completed.

e. Install the engine front cover bolts in the blower front end plate.

f. Install the air heater if tractor is equipped with an air heater. Refer to "Air Heater Installation."

g. Install the air intake tube and connect the engine shut-off control rod to the air shut-off valve lever. Coat the inside of the air cleaner pipe hose with gasket cement or sealing compound before it is connected to the air intake tube. Tighten the hose clamps securely to insure an air-tight joint.

h. Connect the starting fluid primer tube to the air intake tube if tractor is equipped with a primer.

i. Install the governor. Refer to "Governor Installation," Section VI.

6. AIR BOX AND CYLINDER LINER AIR PORTS

A. Air Box and Drain Tube.

The upper part of the cylinder block is hollow and is called the air box. The cylinder liners extend through this hollow part and down into the lower part of the block. Air ports in the cylinder liners register with openings into the air box. Air supplied by the blower passes through the air box and into the cylinders through the air ports in the liners as the ports are uncovered by the pistons.

In normal operation, water vapor from the air, as well as a slight amount of fuel and lubricating oil fumes, condense and settle in the bottom of the air box. A small vent hole is drilled and tapped in the under side of the blower housing and another of the same size in the right-hand side of the cylinder block into the air box and a drain tube is installed in each hole to allow drainage. *It is important that these drain tubes be kept open at all times.*

A stream of air can be felt emerging from the end of the tubes when the engine is running. If the tubes become clogged, run a wire through the tubes or remove and clean the openings. Refer to Figures No. 7 and 10.

B. Cylinder Liner Air Ports.

The engine may be equipped with liners having either a single row of 5/8" holes (15 holes to each row) or a double row of 5/16" holes (32 holes to each row) drilled in the circumference of each cylinder liner. These holes or ports must be kept open to allow free passage of air into the cylinders for combustion of fuel. Inspection for the condition of the air ports should be made at frequent intervals (at least every 500 hours), as hard carbon or sludge will build up in the ports and restrict the passage of air. Remove the inspection cover from the right side of the cylinder block to inspect the ports.

If the inspection shows the port openings reduced

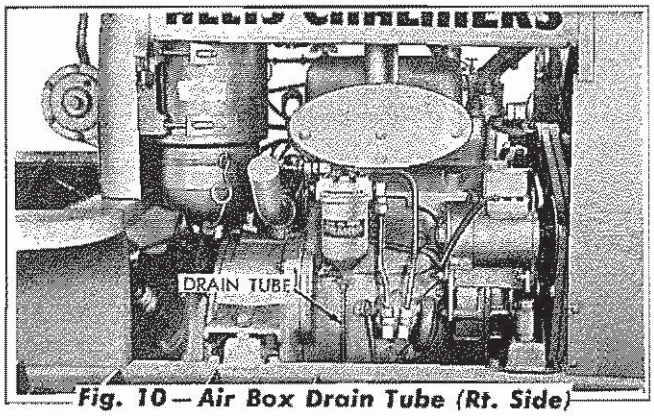


Fig. 10—Air Box Drain Tube (Rt. Side)

by 30% or more due to clogging, cleaning of the ports is necessary. The cylinder head must be removed to clean the ports properly and to remove the material scraped from the ports during the cleaning operation. Proceed as follows to clean the ports.

1. Remove the cylinder head assembly. Refer to "Cylinder Head Removal," Section IX.

2. Rotate the engine by hand until the piston in the cylinder liner to be cleaned is at the bottom of its stroke.

3. Using a bolt or a square stick of wood sharpened to a tapered point, clean all ports from the inside of the liner.

4. After all the holes in one cylinder liner have been cleaned, use compressed air to blow all carbon particles off the head of the piston and out of the cylinder. Touch up the area around the ports with fine emery paper to be sure no burrs or nicks are left on the inside of the liner. Again clean the cylinder with compressed air, before turning the engine to work on the other cylinder.

5. After the air ports in both cylinder liners have been cleaned, clean all the carbon from the air box. Remove the air box inspection cover and the air box drain tubes and fittings, while cleaning the air box.

6. Be sure that the air box drain tubes and the fittings are open before replacing the tubes.

NOTE: With the liners removed from the engine, the ports may be cleaned by soaking the liners in a hot caustic solution of soda or lye long enough to loosen carbon deposits. Final cleaning may then be accomplished by brushing away the loosened deposits.

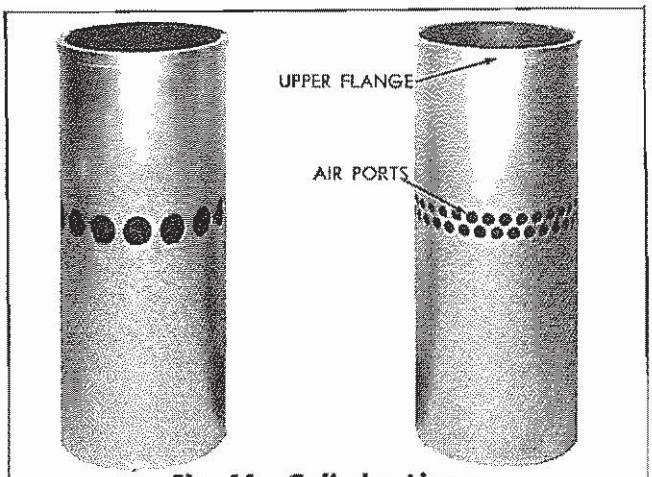


Fig. 11 — Cylinder Liners

7. AIR HEATER AND AIR HEATER PUMP

A. Description.

In warm weather, sufficient heat is generated through the compression of the air in the cylinders, to ignite the fuel and start the engine within a very short cranking period. However, in cold weather the "drag" caused by cold oil between the pistons and the cylinder walls and in the bearings reduces the cranking speed of the engine. A large part of the heat generated by the compression of the air is absorbed by the pistons and cylinder walls. This loss of heat and the reduced cranking speed may result in the temperature of the air in the cylinders being too low to ignite the fuel. A starting aid must then be used when starting the engine.

Tractors prior to Serial Number 4208 are equipped with an Engine Air Heater. The air heater is used to pre-heat the air delivered by the engine blower to the engine as it passes through the engine air box into the cylinders. A sufficiently high temperature for ignitian is thus attained. Tractors Serial Number 4208 and above are equipped with a starting fluid primer used as an aid in starting. Refer to "Starting Fluid Primer."

The air heater is essentially a small oil burner with electric ignition, mounted on the top of the blower housing. The air heater is supplied with fuel by a combination suction and pressure pump mounted on the left side of the cowl. A push button switch located on the cowl, is provided to close the electric circuit to furnish current to the electrodes of the burner unit. Fuel is drawn from the fuel tank

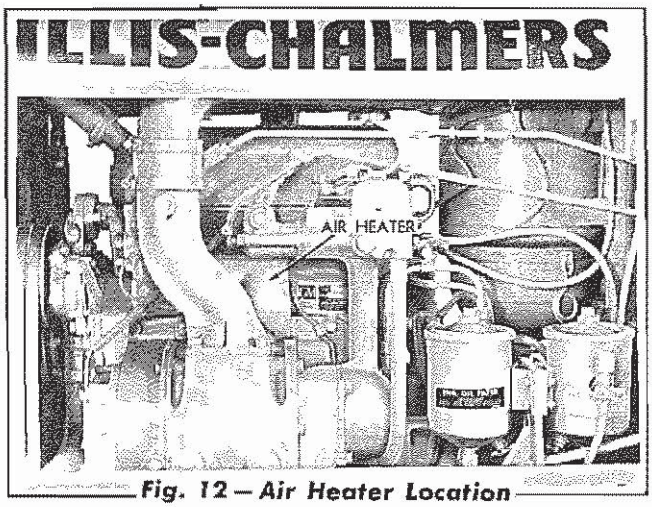


Fig. 12 — Air Heater Location

and is pumped to the burner unit and out through the spray nozzle. A high tension current, built up by the coil in the burner unit, provides a continuous hot spark between the electrodes of the burner, and this spark ignites the fuel as it comes out

through the spray nozzle. A large flame is thus produced in the air box to heat the air.

CAUTION: The air heater can be used only to heat the in-going air while cranking the engine. *IT HAS NO OTHER FUNCTION.* Confusion has been created in the past by referring to the air heater as a "flame primer" and some operators have considered it a means of "priming" the engine with fuel.

Refer to "Starting Engine" in Operator's Manual for use of the air heater.

B. Inspection and Reconditioning of Air Heater.

If the engine is cranked with the throttle wide open and does not start after two or three strokes of the air heater pump, it is advisable to stop cranking the engine and inspect the air heater to determine the reason for starting failure.

If an adequate cranking speed of 80 R.P.M. or over is obtained, and fuel is getting to the cylinders (usually indicated by light blue smoke from the exhaust), the trouble is probably due to improper functioning of the air heater. Check the air heater as follows:

1. Air Heater Ignition System.

The ignition system to the electrodes may be considered in working order if a buzzing sound is heard when the switch is closed. However, the same buzzing sound will be produced by a spark shorting across the insulator assembly instead of arcing at the electrodes as it should. Remove the cylinder block handhole cover from the right side of the engine. Crank the engine so that one of the pistons is at the bottom of its stroke. If a fine mist of fuel is observed through the port holes in the cylinder liner when the air heater pump is operated and no flame is observed when the air heater switch is pressed in, it is probable that carbon or sludge has accumulated on the electrodes causing a short circuit. Occasionally, holding the push button switch in and allowing the unit to "buzz" will burn away this accumulation and the spark will occur at the electrodes. However, this should be done for a brief period only. For further inspection, the burner unit must be removed from the blower. Refer to "Air Heater Removal."

With the air heater removed from its position on the blower housing and reconnected outside of the engine in such a position that the heater operation can be readily observed, press in on the air heater switch. The coil points should vibrate rapidly and continuous hot sparks should occur between the ignition electrodes. If the points do not operate properly, inspect the unit to determine if the switches, wiring and all connections are tight. Inspect the points beneath the cover on top

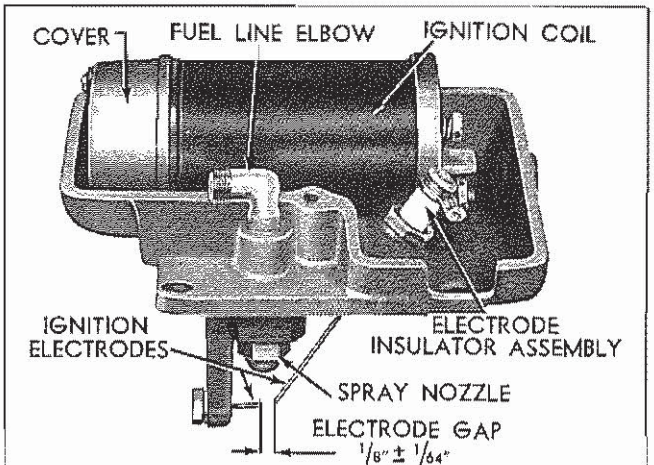


Fig. 13 — Air Heater

of the coil for dirt or carbon. The points may be cleaned with fine sandpaper or a point file. Reset the points after cleaning to allow .018" gap with the vibrator arm held against coil body. If the spark jumps across the porcelain of the electrodes, check the gap between the electrodes. Adjust for 1/8" gap if necessary by bending the wire electrode. Do not attempt to bend the electrode on the electrode insulator. If the gap is correct, remove the electrode insulator by removing the threaded gland nut and withdrawing the assembly. Do not lose the small insulator gasket under the insulator. Scrape off any accumulated carbon and wash the electrode insulator with cleaning fluid. Reassemble the electrode insulator as shown in Figure No. 13 and test it for proper operation.

2. Spray Nozzle.

A clogged spray nozzle will usually be indicated by excessive resistance on the air heater pump. A partially clogged nozzle

will not properly "fog" the fuel. To clean the nozzle, first remove the wire electrode and electrode insulator and unscrew the nozzle assembly from the heater body, using a 5/8" thin-walled socket wrench. Remove the spray nozzle, filter, and filter spring from the body, and unscrew the swirl pin from the center of the nozzle. Wash and clean these parts thoroughly and dry them. *CAUTION:* Do not use steel wire or a drill to clean the nozzle orifices as the size and shape of the orifices and grooves are very important and any damage to them will render the nozzle useless.

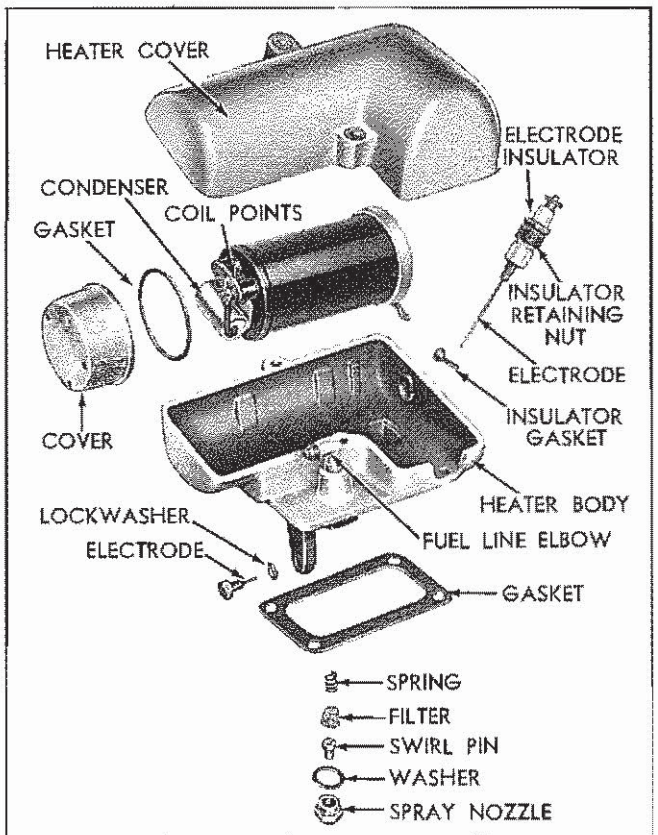


Fig. 14 — Air Heater Details

After cleaning re-assemble the nozzle assembly by first placing the filter spring and filter in the heater body, with washer end of filter out. Then screw the swirl pin into the spray nozzle, using care not to damage the slotted passages in the end of the pin by over-tightening. Place the washer on the nozzle and screw the nozzle into the body against the filter. Re-install the wire electrode and electrode insulator, spacing the electrodes for a 1/8" gap, BEND ELECTRODE ON SCREW ONLY. Operate the pump and check for proper fuel spray through the nozzle.

3. Air Heater Pump.

Failure of the pump to function properly may be caused by worn or damaged piston "leathers," clogged fuel lines, or "frozen" or clogged check valves (see Figure No. 15). The piston "leathers" on the plunger are molded of a special oil resistant composition and must be replaced by duplicate parts if they are broken or worn. To replace these "leathers," unscrew the nut (under the pump knob) from the pump body and pull the plunger out of the body. Remove the retaining screw from the end of the plunger

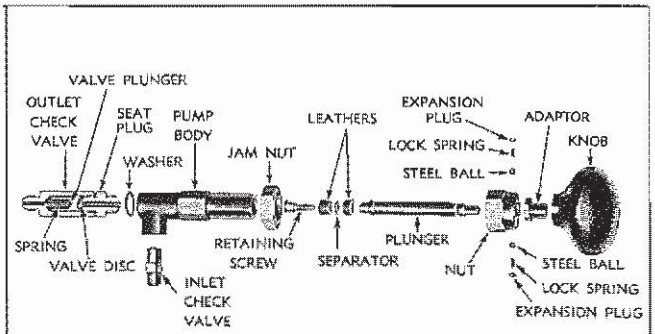


Fig. 15 — Air Heater Pump Details

then remove the "leathers" and separator from the plunger. Install new "leathers" on the plunger with the separator between them and install the retaining screw. Coat the "leathers" with light oil to facilitate their entrance into the cylinder of the pump body. Insert the plunger assembly in the body, taking care that the edge of the first "leather" is not turned back during installation.

4. Pump Outlet Check Valve.

This valve is provided to prevent the passage of fuel through the air heater into the engine air box when the heater is not being used. It is a one way valve consisting of a spring, valve plunger and valve disc enclosed in a body and installed on the end of the pump body. In the event of clogging or fuel seeping into the air bax, disconnect the outlet fuel line from the valve and unscrew the valve from the pump body. Unscrew the seat plug from the body of the valve and remove the valve disc, valve plunger, and spring. Clean these parts thoroughly. If valve disc is corroded or scored, install a new disc. Re-assemble the valve and test it to be sure it

will not allow fuel to pass through it in a direction opposite to the arrow stamped on the body of the valve. Attach the valve to the pump body with the arrow pointing away from the pump. After installing the valve and connecting the fuel lines, test the operation of the pump.

C. Air Heater Removal.

1. Disconnect the end of the engine shut-off control rod from the air shut-off valve shaft lever.
2. Loosen the lower hose clamp connecting the blower intake tube to the air cleaner pipe.
3. Remove the bolts holding the blower air intake tube to the blower housing and remove the intake tube. (Cover the opening in the blower.)
4. Disconnect the throttle control rod retracting spring from the rod.
5. Disconnect the fuel inlet line to the air heater at the elbow.
6. Remove the two bolts attaching the air heater cover to the body, and lift the cover from the body.
7. Disconnect the high tension lead wire from the electrode by unscrewing the thumb nut and removing the wire.
8. Disconnect the battery lead wire from the high tension coil.
9. Tilt the end of the coil (end opposite contacts) out of the air heater body. Remove the bolt that holds the coil ground lead and air heater body to the blower housing. Lift the coil out of the air heater body.
10. Remove the three remaining bolts which attach the air heater body to the blower housing, and carefully lift the assembly from position. Remove the air heater to blower housing gasket.

D. Air Heater Installation.

The air heater assembly may be re-installed on the blower housing by reversing the sequence of removal operations.

1. Using a new gasket between body and housing, carefully place the air heater body in position on blower housing, with the opening for battery lead wire pointing toward flywheel end of the engine.
2. Attach body to the blower housing with three bolts, leaving the bolt hole nearest the battery lead wire hole open.
3. Holding the high tension coil over the air heater body, with the contact end of the coil pointing toward opening for battery lead wire, and the opposite end tilted up, and with the terminal of coil ground lead wire in register with the open bolt hole, insert the bolt through ground terminal, body, and into the blower housing. Tighten bolt.
4. Place the high tension coil in position on the air heater body.
5. Attach the battery lead wire to the terminal in the coil.
6. Connect the high tension lead wire to the electrode and fasten in place with the thumb nut.
7. Fasten the air heater cover to the body with two bolts.
8. Connect the fuel inlet tube to the air heater.
9. Connect the throttle control rod retracting spring to the rod.
10. Install the blower air intake tube and tighten the blower hose clamp.
11. Connect the end of the engine shut-off control rod to the air shut-off valve shaft lever.

8. STARTING FLUID PRIMER

(Engine Cold Weather Starting Aid)

A. Description.

Tractors prior to Serial Number 4208 were equipped with an Engine Air Heater which was used to pre-heat the air delivered by the engine

blower to the engine as it passed through the engine air box into the cylinders. A sufficiently high temperature for ignition was thus attained for starting in cold weather. Refer to "Air Heater" for instructions.

The starting fluid primer system, used on tractors Serial Number 4208 and above, consists of a dispenser assembly which holds and punctures a capsule containing ethyl ether starting fluid, a primer pump to force the fluid through a small nozzle into the blower intake tube, an elbow primer assembly, and the necessary lines to complete the system.

The elbow primer, screwed into the blower air intake tube, atomizes the starting fluid before it is introduced into the engine blower. The fluid for the elbow primer is drawn from a dispenser, used to hold and to puncture a capsule containing the fluid, by a combination suction and pressure pump. The dispenser and pump are mounted on the cowl. The vaporized starting fluid (ethyl ether) forced through the elbow primer into the air intake tube, is picked up by the engine blower and is blown into the cylinders. Since the starting fluid is highly combustible, it is easily ignited by compression in the cylinders. The engine will start quickly at low ambient temperatures with the aid of the primer, if the starter will crank the engine even at a very low cranking speed. The starting fluid capsules, available in 7 c.c. and 17 c.c. sizes, can be obtained at the nearest Allis-Chalmers Dealer.

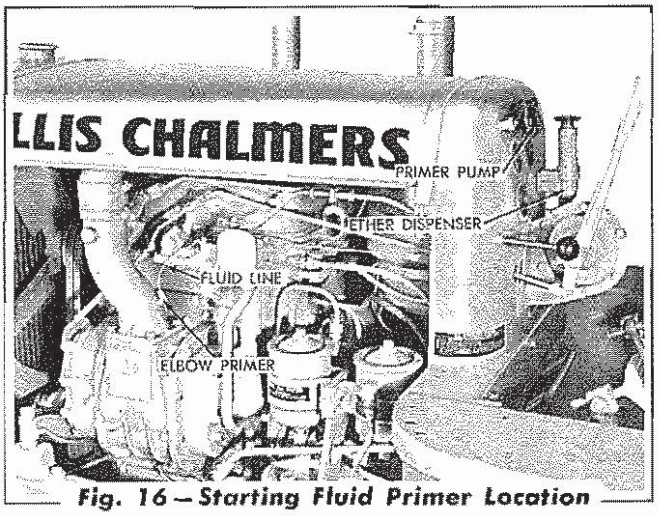


Fig. 16 — Starting Fluid Primer Location

B. Operation.

1. Unscrew the upper chamber of the fluid dispenser.
2. Place a capsule of fluid, small or large size depending upon air temperature and requirements established by trial, in the lower chamber or body of the dispenser. In extremely low temperatures, one large and one small capsule may be necessary.
3. Pull the plunger to the top of the upper chamber and screw the chamber tightly into the dispenser body.
4. Push the plunger to bottom, thus puncturing capsule and releasing fluid so it can be picked up by the primer pump.
5. Push the engine shut-off knob all the way in (against stop).
6. Pull the throttle lever all the way back (wide open).
7. Press forward on the starter pedal to crank the engine and at the same time use the primer pump to pump the starting fluid into the air intake system until the engine starts and runs normally on regular fuel. Use a capsule only of the size required to start the engine and pump until all fluid has been injected into the engine.
8. While the engine is warming up, again unscrew the upper chamber of the dispenser and remove the empty capsule. Screw the upper chamber back into the dispenser body.

CAUTION: The starting fluid contained in the capsule is essentially ethyl ether, highly inflammable and should be treated with the same caution as high octane gasoline. Gelatine capsules dissolve in water and soften at high temperatures. Therefore, the following precautions must be taken:

AVOID.

1. Breathing large quantities of the fumes from the fluid.
2. Cutting of hand on barbs of puncturing plunger.
3. Proximity of fluid and capsules to open flames, sparks, or hot surfaces.
4. Contact of capsules with water.
5. Subjection of capsules to high temperatures (above approximately 120° F.).

C. Inspection and Service.

If the engine is cranked with the engine shut-off knob in run position (pushed all the way in) and with the throttle wide open and does not start after two or three strokes of the primer pump, it is advisable to stop cranking and inspect the primer system to determine the reason for starting failure. Check the primer system as follows:

1. Elbow Primer Assembly Clogged.

This condition will usually be indicated by excessive resistance on the primer pump. A partially clogged primer assembly will prevent the delivery of sufficient starting fluid to the air inlet system. To clean the elbow primer assembly, remove the elbow assembly from the blower air intake tube and remove the small nozzle from the elbow primer assembly. Remove and clean the nozzle swirl pin and open the hole in the end of the nozzle, if clogged. *CAUTION:* Do not enlarge the hole in the end of the nozzle.

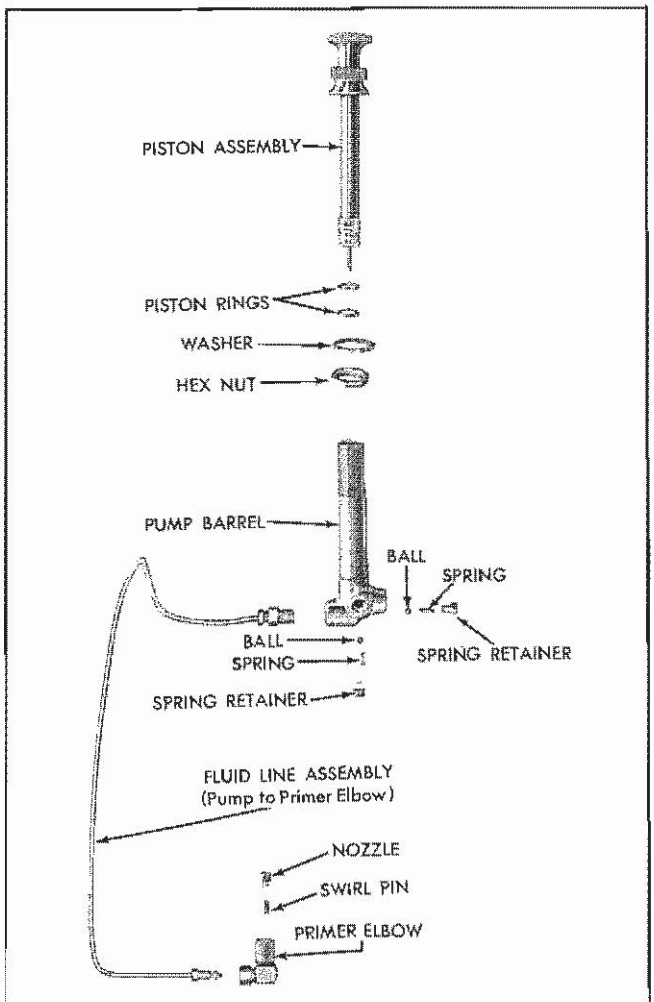


Fig. 17 — Primer Pump and Elbow Primer Details

After cleaning, re-assemble the elbow primer assembly and install the assembly in blower air intake tube.

2. Inoperative Primer Pump.

The primer system may be equipped with a "General Motors Pump Assembly" (same as used in the Engine Air Heater System), or a "Kohler Pump Assembly." If the primer system is equipped with a General Motors Pump, refer to "Air Heater Pump" for repairing instructions. Instructions for repairing the Kohler Pump are as follows:

Failure of the primer pump to function properly may be due to worn or damaged packing rings, a clogged dispenser filter screen, clogged fluid lines or "frozen" or worn check valve balls. The packing rings on the plunger are made of a special rubber composition and must be replaced by duplicate parts if worn or damaged.

To replace the packing rings, remove the knurled nut (under knob) from the pump barrel and withdraw the piston assembly from the barrel. Remove the packing rings from the grooves of the piston assembly and install new rings. Lubricate the packing rings and piston with light engine oil and install the piston assembly in the barrel.

The two spring loaded ball check valves, located on the inlet and outlet openings of the pump, are provided to close the pump openings at the proper time. When the pump piston is pulled out (suction stroke, drawing fluid from dispenser) the ball check valve at inlet port opens, allowing the fluid to be drawn from the dispenser. When the pump piston is pushed in (delivery stroke, supplying fluid to the elbow primer assembly), the ball check valve at the outlet port opens allowing the pump to force the fluid to the elbow primer assembly. Worn or "frozen" ball check valves or broken springs will prevent the pump from operating properly. When this occurs, remove the spring retainers, springs, and balls from the inlet and outlet ports of the pump. Inspect the balls, ball seats, and springs for wear or damage. Clean the pump body and all its components

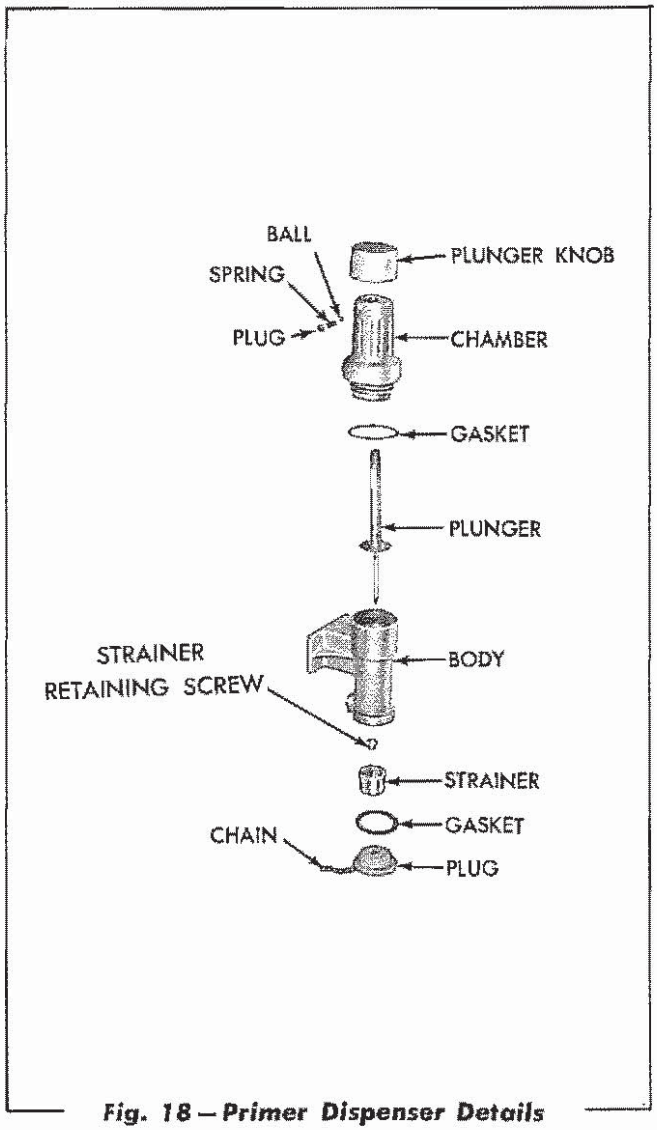


Fig. 18 — Primer Dispenser Details

thoroughly and re-assemble using new parts where necessary.

3. **Clogged Dispenser Strainer Screen.**

This screen is soldered to the inner end of the connector assembly located in the bottom of the starting fluid dispenser. If the gelatine capsules are not removed soon after puncturing, the gelatine will melt and plug the strainer screen in the dispenser body. To clean the dispenser body and the strainer screen, remove the connector assembly from the dispenser body and wash in hot water. Remove the plunger knob from the plunger assembly and the upper capsule chamber from the dispenser body, the body may then be cleaned with hot water. Re-assemble the dispenser assembly and connector assembly by direct reversal of the disassembly procedure.

SECTION IV — ENGINE COOLING SYSTEM

1. DESCRIPTION OF SYSTEM

Engine cooling is accomplished by means of liquid circulated through the cylinder block and cylinder head by a centrifugal pump, mounted at the front of the engine on the oil cooler cover, and driven by dual "V" belts. This liquid circulating pump works in conjunction with a radiator through which the liquid passes in the process of cooling.

A cooling fan is provided to force air through the radiator core, thus lowering the temperature of the cooling liquid while passing from the top to the bottom of the core.

In this system of cooling, the pump draws the cooling liquid from the bottom of the radiator and forces it through the oil cooler and into the lower water jacket in the cylinder block.

Two large cored passages between the cylinders permit the water to flow upward into the top jacket. Eight cored openings in the top deck of the block connect with corresponding openings in the cylinder head, where water circulates around the valves and fuel injectors.

From the cylinder head, the heated liquid enters the water manifold, which contains a thermostat, then passes to the radiator upper tank, and the process is repeated.

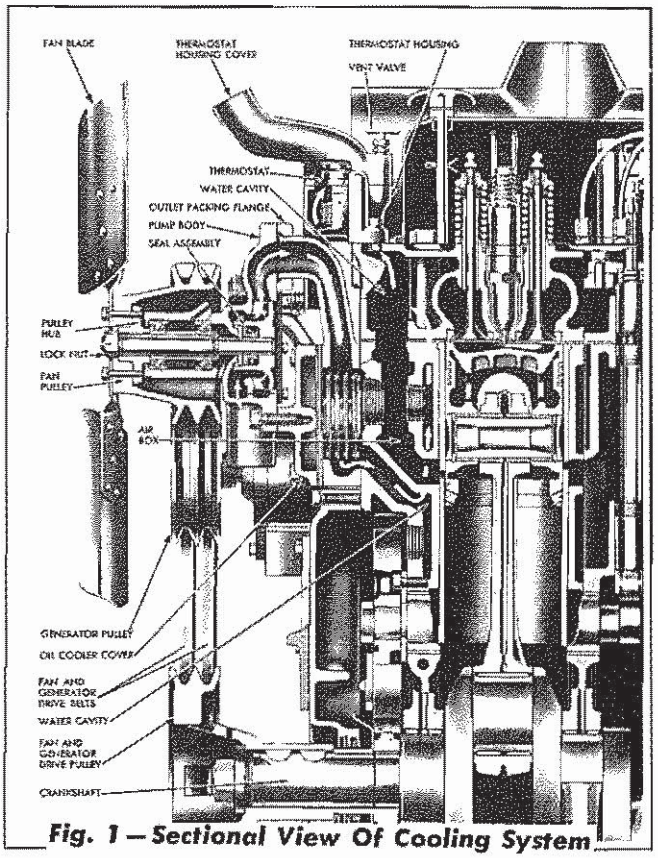


Fig. 1 — Sectional View Of Cooling System

2. GENERAL MAINTENANCE

Keep the cooling system filled with clean water that is free from lime or alkali. The use of water containing lime will result in lime deposits in the cylinder head and block, causing hot spots in the engine and eventually restricting the water passages. Alkali in the water will cause a corrosive action detrimental to the engine.

In freezing weather use an ethylene glycol anti-freeze solution in the system to protect it against damage from freezing. This type of anti-freeze has

a much higher boiling point than water. After any addition of water or anti-freeze compound, test the solution after the added quantity has become thoroughly mixed to be sure that it will withstand prevailing or anticipated temperatures. A mixture of 60% ethylene glycol solution and 40% water will provide maximum protection; the use of more than 60% ethylene glycol solution in the cooling system will raise the freezing point and provide less protection against freezing.

Keep the radiator air passages clean and free of debris which will restrict the flow of air through the radiator. All leaks in the cooling system must be corrected as soon as they are evident and the fan belts must be kept in proper adjustment. The most efficient engine operation is obtained with the temperature held within a range of 160° F. to 185° F. Operating the engine with the temperature below this range will result in incomplete combustion of fuel, higher fuel consumption and less power, and will cause harmful gummy deposits to form within the engine.

Maintaining the correct engine temperature (160° F. to 185° F.) depends mostly on the proper functioning of the thermostat. If the engine temperature remains consistently below normal, the thermostat should be removed and inspected. If the thermostat is corroded and stuck or if the bellows of the unit leaks, install a new unit.

3. FILLING AND DRAINING OF SYSTEM

A. Filling Cooling System.

Close the drain cocks, one in the right side of the cylinder block and the other at the bottom of the radiator, then fill the cooling system through the radiator filler cap. *IMPORTANT: The vent valve in the thermostat housing must be opened when filling the system to allow the air trapped in the engine to escape.* Close the vent valve after the system is filled. If the valve is left open, it will prevent proper engine warm-up and regulation of the engine temperature by the thermostat. Since the valve opens and closes inside the thermostat housing, the only way to determine if the valve is open or closed is to turn the handle. The valve is opened by turning it out and closed by turning it in.

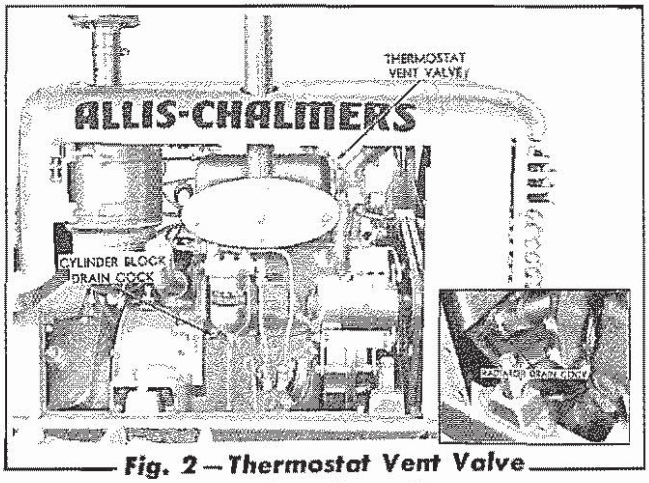


Fig. 2—Thermostat Vent Valve and Drain Cocks

B. Draining Cooling System.

Drain the cooling system by opening the cylinder block and radiator drain cocks. Also open the thermostat vent valve to allow drainage of the water trapped above the thermostat. Remove the radiator cap to insure complete draining of the system.

4. CLEANING OF COOLING SYSTEM

It is recommended that the cooling system be cleaned at least twice a year, usually at the beginning of cold weather before an anti-freeze solution is put in the system and again after the anti-freeze solution is removed. Cleaning at these intervals will reduce clogging and resultant overheating to a minimum, and will largely eliminate the necessity for removal of the radiator and cleaning by a radiator repair shop. If hard water has been used, the necessity for cleaning is greater, since lime deposits, or scale will form in the radiator, engine block and head. This lime deposit is detrimental to the engine and the radiator core. Flushing the radiator will remove obstructions in the radiator tubes and other water passages, that, if not removed, would eventually clog these pas-

sages. It is also important that the air passages through the radiator be kept free of obstructions and that the exterior of the engine be kept free from thick deposits of dust and oil.

A. Cleaning Materials.

Sal Soda is a very effective and safe solvent for removal of lime scale and other foreign deposits in the cooling system. It should be used in the proportions indicated and according to the directions printed on the container, in which it is purchased. Many other good cleaning solvents for this purpose are on the market; these should also be used according to directions. *CAUTION: Never mix anti-freeze compounds or solutions or inhibitors with any cleaning, neutralizing or flushing compound.*

After the solvent has been in the cooling system the prescribed length of time, the system should be completely drained, and after the engine has cooled sufficiently, thoroughly flushed with clean water. In some cases, the use of certain solvents requires the use of a neutralizer solution. The neutralizer compounds are usually packed and sold with the cleaning compound and should be used as directed.

B. Flushing.

If the tubes in the radiator become clogged, the obstructions may sometimes be removed by pressure flushing of the radiator. When clogging occurs, the debris is usually deposited at the tops of the radiator tubes. Disconnect the lower radiator hose and connect a pressure water hose to the lower radiator connection with a suitable adapter. Then plug the upper radiator hose connection, remove the radiator cap, and force water upward through the radiator. The debris will then be loosened from the top of the tubes and will flow out through the top of the radiator with the water. *CAUTION: Do not use over 5 pounds pressure in this flushing operation as excessive pressure may cause the radiator tubes or tanks to rupture.*

C. Inspect for Leaks After Cleaning or Flushing.

After the cooling system has been cleaned or flushed as outlined in the above paragraphs, a complete inspection should be made of the entire system to detect any leaks that might have been uncovered by performing the above operations. Before the new coolant is poured into the system, correct all leaks. When servicing the cooling system for summer operation it is recommended that a reliable rust inhibitor be added to the water to keep the system free from rust. Use the inhibitor as directed on the container.

D. Cleaning Exterior of Radiator.

Cleaning the fins of the radiator can best be accomplished by means of an air blast carrying a grease solvent, such as oleum spirits or carbon tetrachloride directed at the front side of the core and passing through to the back, or the fan side. *Never use gasoline, fuel oil or kerosene for cleaning the radiator.* The radiator grille should be opened and the engine should be covered before performing this operation. *NOTE: Provide adequate ventilation of the working area, during this operation to avoid possible toxic effects of the cleaning spray.*

5. RADIATOR

A. Description.

The radiator is of the fin and tube type, supported in a heavy shell, and protected from damage by limbs and brush by a heavy bar-type grille. In order that the fan may pull all the air used for cooling through the radiator core, a shroud is provided back of the core and surrounds the cooling fan. An overflow tube is connected to the upper tank of the core and leads to the bottom of the radiator.

B. Cleaning and Flushing.

Cleaning and flushing of the radiator is described in topic 4 of this section.

C. Radiator Removal.

1. Drain the cooling system. Open the thermostat air vent valve and remove the radiator

cap when draining system.

2. Remove the engine pre-cleaner from the air cleaner tube, then remove the engine hood.
3. Loosen the hose clamps attaching the radiator inlet and the outlet hose to the radiator.
4. Disconnect the head light cable from the main wiring harness and remove the fuse.
5. Remove the bolts attaching the front fenders to the radiator shell, then remove the capscrews attaching the radiator to the main frame. Remove the front nut on the radiator bracing rod.
6. Lift the radiator and shell assembly from the frame.
7. Remove the capscrews attaching the radiator to the shell and remove the radiator.

D. Inspection and Repair.

Clean the air passages in the core and test the core for clogging or leaks. Clean the core if clogging is evident and repair any leaks by soldering. Straighten or repair the fan shroud if it is bent or cracked. Be sure that the overflow pipe is open.

E. Installation.

1. Install the radiator and shell by a direct reversal of the removal procedure. Coat the inside of the radiator hoses at each end with gasket cement or sealing compound before connecting them.
2. Close the cooling system drain cocks and fill the system. Close the thermostat vent valve after filling. Check the cooling system for water leaks.
3. Install the engine hood and engine pre-cleaner.

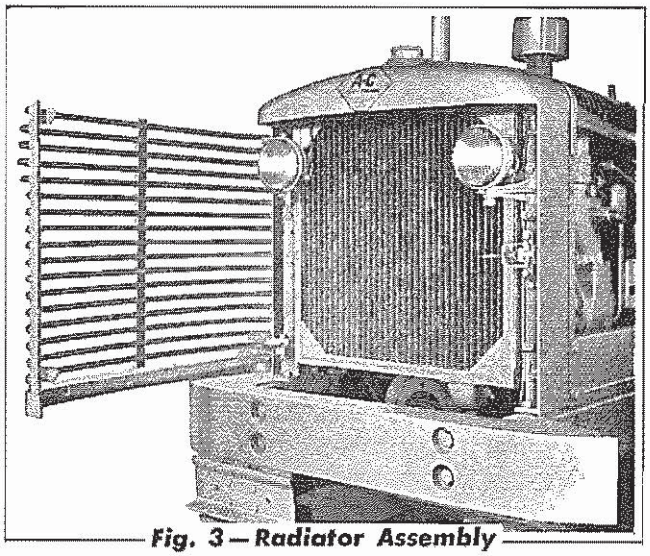


Fig. 3 — Radiator Assembly

6. WATER PUMP

A. Description.

A centrifugal type circulating water pump with cast iron body and bronze impeller is attached to bosses on the oil cooler cover. Water is drawn through the lower inlet opening from the radiator and forced by the pump impeller out of the upper opening into the oil cooler housing, as shown in Figure No. 1. A rubber packing at the pump outlet, retained by a flange bolted to the body, insures a tight seal between the pump body and the oil cooler housing.

The pump itself is composed of a shaft supported on two semi-shielded ball bearings, a pulley hub keyed and locked to the outer end of the shaft, a bronze impeller pressed on the small end of the shaft, a seal assembly, body and cover.

The seal assembly carried within the impeller consists of a synthetic rubber seal fitted tight to the pump shaft and also held against a carbon washer by a coil spring. The carbon washer in turn bears

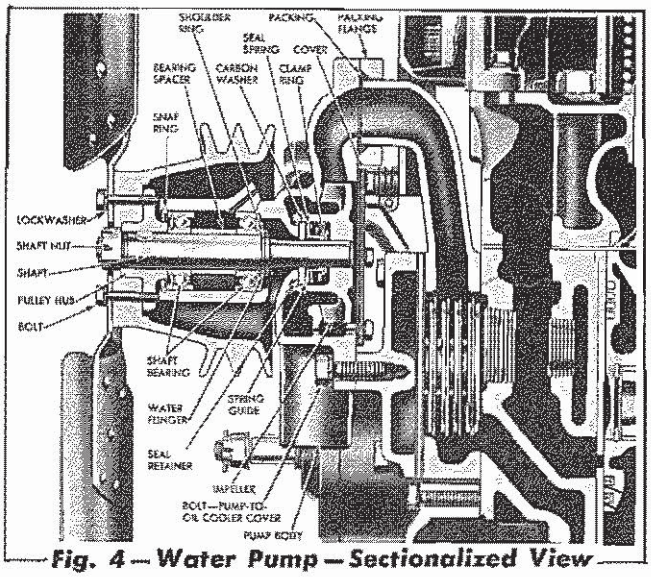


Fig. 4 — Water Pump — Sectionalized View

against the polished boss of the housing.

B. Water Pump Lubrication.

The ball bearings of the pump are lubricated through a pressure grease fitting located on the upper, blower side of the pump body. The grease cavity must be filled with a good grade water pump lubricant before the engine is put into operation. The bearings should be lubricated periodically.

C. Service.

The construction of the water pump is conducive to long life with minimum attention, providing that only clean water is poured into the cooling system and care is taken to keep grit or abrasive material from being circulated through the system. Water containing alkali is especially harmful to the water pump because it causes corrosion of the seating surface for the water pump seal.

D. Water Pump Removal.

1. Drain the cooling system. Open the thermostat air vent valve when draining system.
2. Remove the radiator assembly. Refer to "Radiator Removal."
3. Remove the water by-pass tube.
4. Loosen the generator mounting bolts and move the generator toward the engine, thus freeing the drive belts. Remove the fan and generator drive belts.
5. Remove the bolts, nuts, and lockwashers holding the outlet packing flange to the pump body and slip the packing (synthetic rubber seal) away from the pump body.
6. Remove the bolts attaching the pump body to the oil cooler housing cover.
7. Tap the pump body lightly with a soft hammer to loosen it from the oil cooler cover and withdraw the pump from the engine.

E. Water Pump Disassembly.

With the water pump removed from the engine, it can be disassembled in the following manner.

1. Remove the bolts and lock washers holding the fan blade assembly and fan pulley to the pulley hub.
2. Rest the pump in a bench vise and remove the shaft nut, then remove the pulley hub from the pump shaft, using a puller.

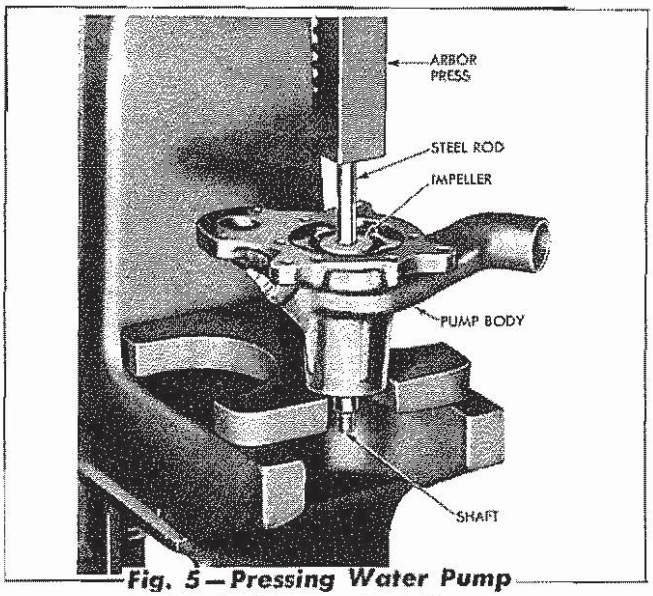


Fig. 5—Pressing Water Pump Shaft From Impeller

3. Remove the Woodruff Key from the shaft, also the snap ring retaining bearings in the pump body.
4. Remove the bolts and lock washers holding the pump cover to the body.
5. Support the pump in an arbor press with bearing side down and press the shaft through the impeller, using a piece of steel rod as shown in Figure No. 5. The bearings will also be removed from the body during this operation.
6. Thoroughly wash and dry the bearings and seal and inspect.

   If the carbon washer of the seal is damaged or worn to the extent that a tight seal cannot be maintained between the washer and its contacting surface on the pump body, the seal must be replaced.

   The ball bearings should roll freely without high spots. However, if high spots are evident or the races and balls are pitted, the bearings must be replaced.

   When necessary, the pump seal or bearings are removed as follows:

7. Remove the seal retaining ring, carbon seal washer, seal, spring guide, spring, and seal clamp from the impeller.

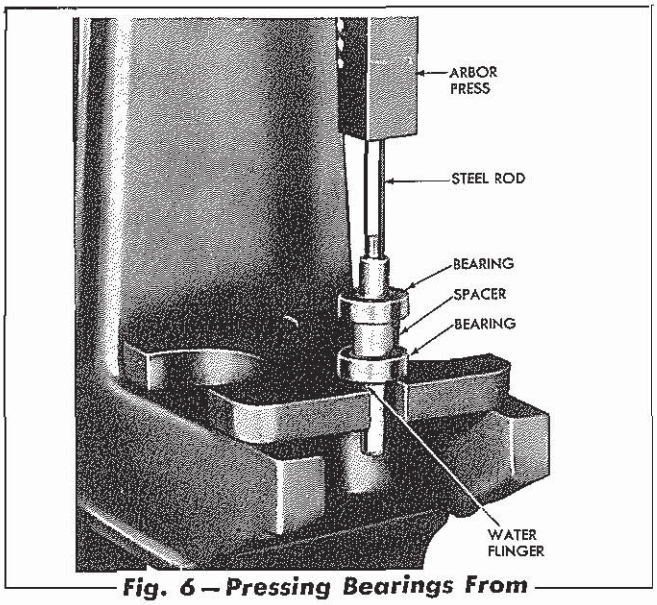


Fig. 6 — Pressing Bearings From Water Pump Shaft

8. Support the water flinger at inner race of inner ball bearing on a hollow sleeve resting on the bed of the arbor press, and, with a rod on the upper end of the shaft, press the shaft through the two ball bearings as shown in Figure No. 6. The bearing spacer will be removed at the same time.

9. Remove the water flinger and shoulder ring from the shaft.

F. Inspection and Repair.

Repair to the water pump will consist of replacement of any parts that are excessively worn. If the seat surface in the water pump body (contacted by the carbon sealing washer), is scored or rough, it may be smoothed to form a tight seal by the use of a pump seat refinishing tool.

G. Water Pump Assembly.

The pump may be assembled by referring to Figure No. 7 for relative location of parts and reversing sequence of disassembly operations, as follows:

1. Place the split shoulder ring in undercut of the pump shaft and slide the *NEW* water flinger over the large end of the shaft and into position to retain the split shoulder ring as shown in Figure No. 4.

2. Support the small diameter (inner) end of the shaft on the bed of the arbor press.

   NOTE: The ball bearings have a shield on one side only and are assembled on the shaft with non-shielded sides facing each other, thus forming a grease cavity between the bearings.

   With this in mind, assemble one bearing onto the shaft, shielded side down (toward water flinger), and press tight against the water flinger.

   A steel sleeve resting against the inner race of the bearing should be used in this operation.

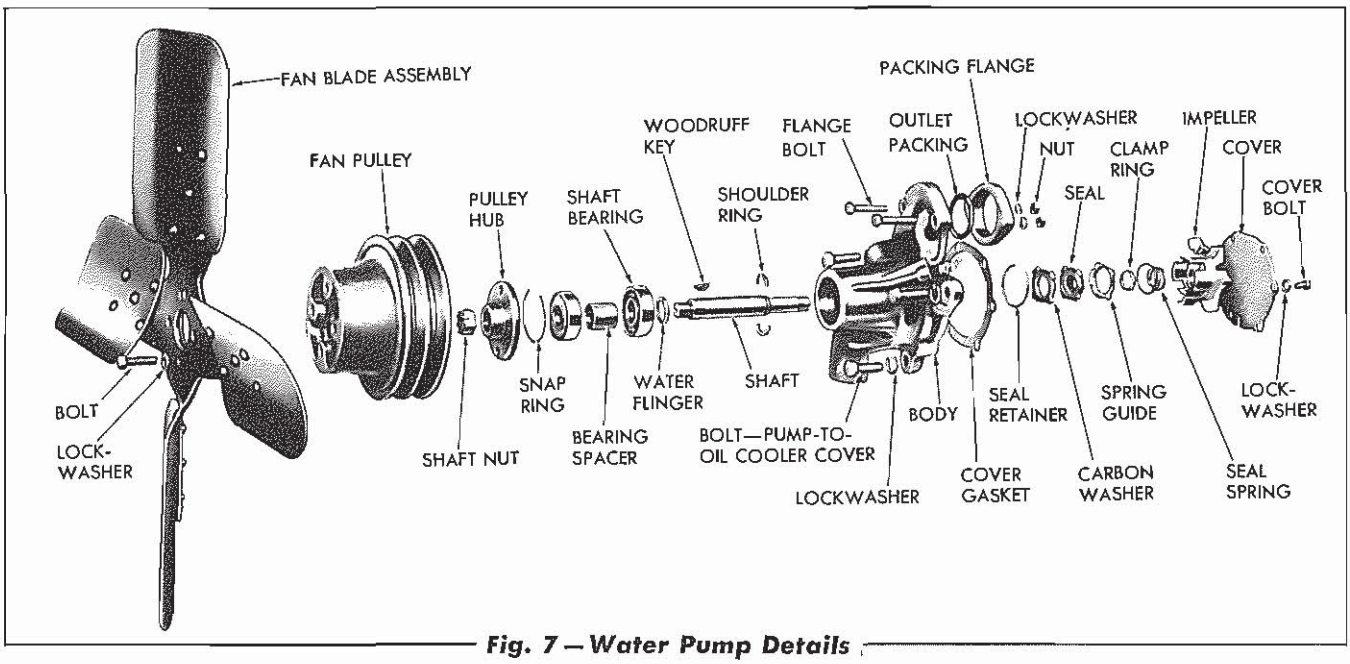


Fig. 7 — Water Pump Details

3. Slide the spacer over shaft next to the bearing; then start the second bearing onto the shaft by hand, shielded side up, and press tight against the spacer.
4. Apply some water pump grease to balls of bearings, also a small amount of engine oil to the outside of the bearings and slide the shaft and bearing assembly into the housing, as shown in Figure No. 4.
5. Replace the snap ring for holding the shaft and bearing assembly in position.
6. Support the impeller end of the shaft on an arbor press. Insert the Woodruff Key in the shaft keyway. Then, with the machined face of the pulley hub bolting flange up (away from bearing) and keyway in line with key, start the pulley hub onto the shaft. Press the hub tight against the inner bearing race and lock with shaft nut.
7. Reverse the position of the pump in the arbor press, that is, with the impeller end up.

   NOTE: The impeller must be a press fit on the shaft, and, once removed, *may not* be satisfactorily replaced, due to material stretch. If the impeller is removed, replace with a new one.
8. Refer to Figure No. 7 and assemble spring guide and seal clamp to the seal; then, with the large end of the spring against the guide, insert seal, clamp, spring, and guide into the impeller, followed by the carbon seal washer. Lock in place with the seal retainer ring, as shown in Figure No. 4.
9. Press the impeller and seal assembly onto and flush with the small end of the shaft.
10. Fill the grease cavity for the bearings with the specified lubricant. Revolve the shaft to check for bind and to assure proper clearances between the impeller and the body.
11. Affix gasket to the pump body and replace the body cover, bolts and lock washers.
12. Bolt the fan pulley and blade to the pulley hub.

H. Assembly of Water Pump to Engine.

1. Inspect the pump outlet packing and replace it if necessary.
2. Place the water pump in position on the bosses of the oil cooler housing cover, at the same time engaging the fan and generator drive belts.
3. Secure the pump to the bosses with the bolts and lock washers.
4. Install the bolts, nuts, and lockwashers attaching the pump outlet packing flange to the pump body.
5. Install the water by-pass tube.
6. Adjust the generator and fan drive belts as outlined under "Drive Belt Adjustment."
7. Install the radiator and shell by direct reversal of the removal procedure. Coat the ends of the radiator hoses with gasket cement or sealing compound before connecting them.
8. Close the cooling system drain cocks and fill the system. Close the thermostat vent valve after filling. Check the cooling system for water leaks.
9. Install the engine hood and engine precleaner.

7. THERMOSTAT AND THERMOSTAT HOUSING

A. Description.

The water temperature is automatically controlled by a blocking type thermostat mounted in the by-pass housing, as shown in Figure No. 2. The thermostat starts opening at approximately 158° F. and is fully opened at 180° F. Before the thermostat starts opening, water circulation takes place in the cylinder block, cylinder head and oil cooler only, through a water by-pass tube connecting the by-pass housing with the water pump.

After the thermostat starts opening and after it has fully opened (180° F.), water circulation takes place through both the by-pass tube and through the radiator.

Therefore, before the thermostat starts opening

(during the warm-up period of the engine), the lubricating oil passing through the oil cooler is rapidly warmed due to the warm water circulating through the by-pass tube, thus insuring positive engine lubrication at all times, regardless of the outside temperature at which the engine is being operated. Also, by means of by-pass circulation, normal engine operating temperatures are reached with a minimum warm-up period.

B. Service.

Replacement of the thermostat will be necessary when the thermostat becomes corroded and sticks in the open or closed position, or when the bellows of the thermostat becomes ruptured and fails to operate.

C. Thermostat Replacement.

1. Drain the cooling system. Disconnect the radiator inlet hose from the thermostat housing cover.
2. Remove the capscrews used to attach the thermostat housing cover to the thermostat housing. Remove the housing cover.
3. Remove the sealing gasket from the housing and remove the thermostat.
4. Clean the thermostat seat in the housing.
5. Place the thermostat in the housing (bellows end down), then cement a new gasket to the housing.
6. Install the thermostat housing cover and tighten the attaching capscrews securely.
7. Install the radiator inlet hose on the thermostat housing cover. Coat the end of the hose with gasket cement or sealing compound before installing.
8. Close the cooling system drain cocks and fill the system. Close the thermostat vent valve after filling. Check the cooling system for water leaks.

8. FAN AND BELTS

A. Description.

A cooling, suction type, four-bladed fan is mounted together with the fan pulley on front of the water pump assembly and is bolted to the fan pulley hub. The pulley hub is keyed and secured with a lock nut to the water pump shaft, which in turn is supported on two semi-shielded ball bearings.

The fan is driven from the crankshaft by dual "V" belts which also drive the battery charging generator.

B. Lubrication.

The semi-shielded ball bearings supporting the water pump shaft are lubricated as outlined in the Operator's Manual.

C. Drive Belt Adjustment.

The "V" type fan and generator drive belts should be neither too tight nor too loose. Belts which are too tight impose undue load on the generator bearings and wear out more rapidly. Loose belts allow slippage, resulting in lower generator and fan speeds.

The generator and fan drive belts may be adjusted by loosening the bolts holding the generator to the generator bracket. Then loosen the adjusting link bolt and move the generator toward or away from the engine to obtain the desired tension. The fan belts are correctly adjusted when the straight (left) side of the belts can be pressed inward approximately 1 inch at a point halfway between the crankshaft and fan pulleys.

D. Service.

The fan blades require no service; however, bent

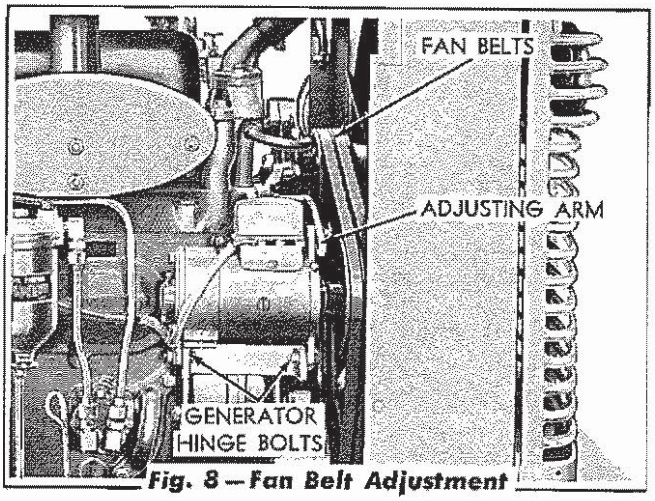


Fig. 8—Fan Belt Adjustment

blades are conducive to inefficient cooling and in case of damage should be removed and restored to their original contour or replaced by a new blade assembly.

E. Removal of Fan.

1. To remove the fan from the engine, it is necessary to remove the radiator and shell from the tractor. Refer to "Radiator Removal."

2. Remove the capscrews attaching the fan and fan pulley to the pulley hub. Lift the fan and pulley away from the pulley hub.

F. Installation of Fan.

1. Place the fan pulley and fan in position on the pulley hub and secure with capscrews and lockwashers.

2. Install the radiator and shell by direct reversal of the removal procedure. Coat the inside of the radiator hoses at each end with gasket cement or sealing compound before connecting them.

3. Close the cooling system drain cocks and fill the system. Close the thermostat vent valve after filling. Check the cooling system for water leaks.

SECTION V — ENGINE LUBRICATION SYSTEM

1. DESCRIPTION OF SYSTEM

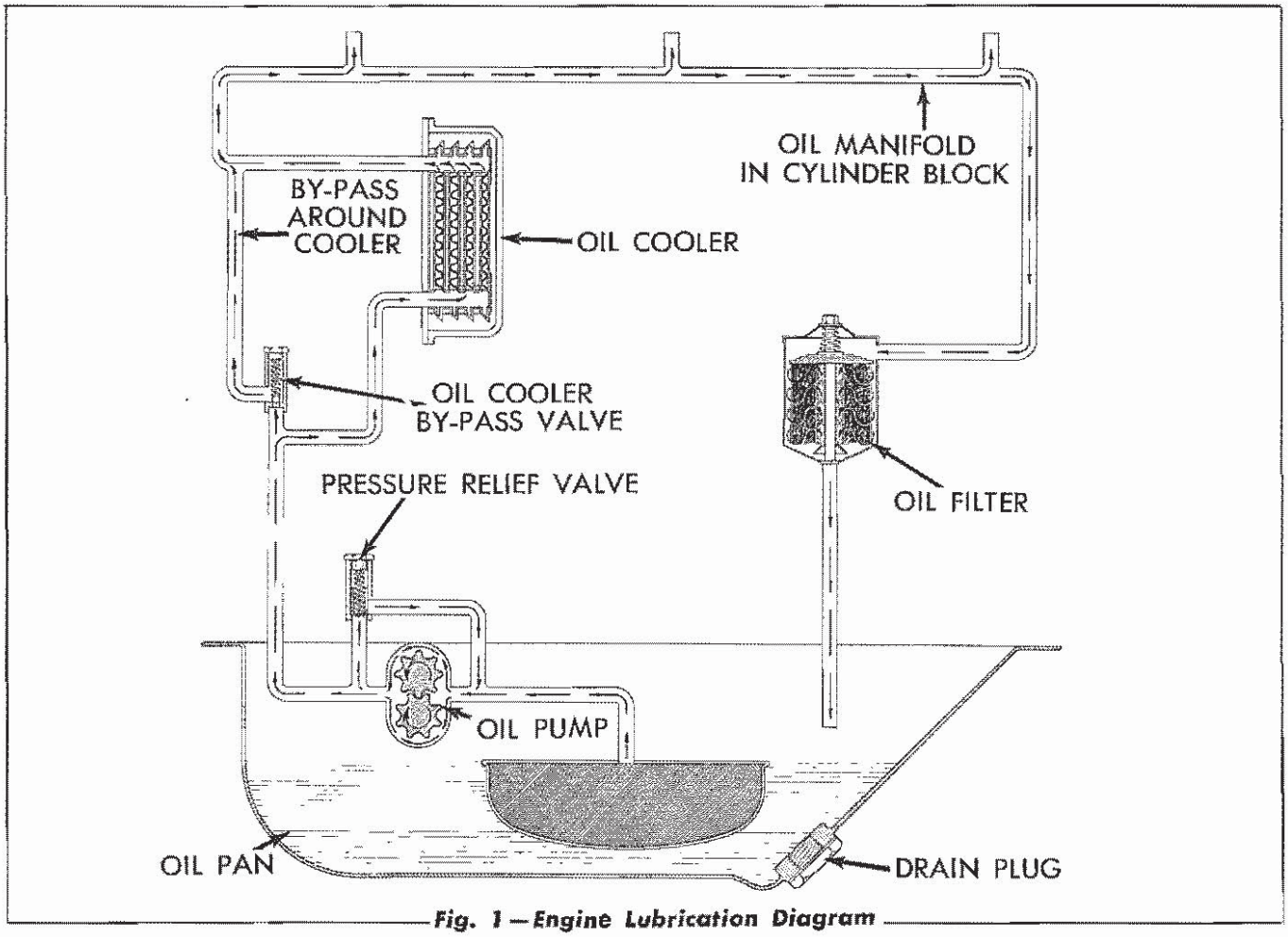


Fig. 1 — Engine Lubrication Diagram

The engine lubrication system shown schematically in Figure No. 1, consists of a gear driven oil pump, oil filter, oil cooler, oil by-pass valve, and oil passages in the engine block.

A spring-loaded relief valve in the oil pump body, and a by-pass valve between the oil pump and the oil cooler, control the engine lubricating oil pressure.

The oil pump, together with a suitable screen on the intake pipe, is located at the front end of the oil pan from which the oil supply is furnished.

The oil cooler, consisting of a cooler element inside a sealed housing, and surrounded by the engine cooling liquid, is included in the cooling system between the oil pump and the cylinder head oil gallery. All oil delivered by the pump passes through the cooler.

The oil filter, of the replaceable element type, is placed in the lubrication system beyond the oil cooler, and only a portion of the oil delivered from

the pump passes through this unit. Oil entering the filter is by-passed from one of the oil passages in the cylinder block, forced through the filter element, and is returned directly to the engine crankcase.

The lubricating oil, drawn from the engine oil pan by the oil pump, is discharged into a vertical oil passage at the front end of the cylinder block leading to the oil cooler spring-loaded by-pass valve. The by-pass valve, located in a semi-circular housing on the right hand side of the engine, by-passes the oil directly from the pump to the oil cooler. If the oil passages in the cooler become clogged or, if in cold weather, the oil is too thick to circulate freely through the cooler, the by-pass valve by-passes the oil directly from the pump to the lubricating system.

Oil leaving the oil cooler by-pass valve is forced into a short horizontal passage, then to a vertical passage leading to the oil cooler, the oil is conducted through a second vertical passage at the front end of the cylinder block where the supply divides. One portion of the oil is then forced into the cylinder head main gallery and the other portion into a vertical passage in the cylinder block leading to the front main crankshaft bearing and the front camshaft and balancer shaft bearings.

The center and rear main crankshaft bearings, and the center and rear camshaft and the rear balancer shaft bearings, are lubricated through two vertical passages leading from the cylinder head main oil gallery.

The rocker shaft bracket bolt holes are drilled through to the main oil gallery in the cylinder head. Oil flows through the hollow rocker shaft bracket bolts into a drilled passage in each rocker shaft. Feed holes in the rocker shaft supply oil to each rocker arm bushing. From each rocker arm clevis an oil hole is drilled to the rocker shaft hole. Excess oil from the rocker arms lubricates the exhaust valves, injectors, and upper push rod seats. Oil on the top deck of the cylinder head drains into the push rod wells, in which are located the push rod seat bosses.

A cored opening at the front end of the chamber provides a drain from which oil flows into the gear train cavity over the blower gears and into the oil pan. Oil from the push rod seats lubricates the cam followers, and then drains through the push rod covers. The cams and cam rollers are lubricated by crankcase oil spray.

The gear train, including the blower gears and blower front bearings, is lubricated by oil draining from the cylinder head. The blower rear bearings, governor weights, and carrier assembly are also provided with gravity feed lubrication from the cylinder head. The oil flows from the push rod wells into a vertical drilled passage in the cylinder block, through a crosswise hole to the blower housing. Cored and drilled openings in the blower housing provide an oil passage to the top of the blower rear end plate, from where the oil flows over the blower shaft rear bearings, and is splashed on the governor weights and carrier shaft bearings. The oil then drains to the crankcase through openings in the blower rear end plate and cylinder block.

Drilled passages in the crankshaft provide oil flow from the main journals to the crankpins. A rifle drilled passage in each connecting rod is provided for delivery of cooling oil to the piston head, as well as for lubrication of piston pin and bushings.

2. LUBRICATING OIL PUMP

A. Description.

The gear type oil pump is mounted to a flange on the right-hand side of the cylinder block crankcase, over hollow locating dowels in the bolt holes. The oil pump driving gear meshes directly with the crankshaft gear, and is driven at 1.45 times the crankshaft speed.

The oil pump driving gear and the drive gear (internal) are keyed as well as pressed onto the drive shaft. The driven gear (internal) rotates as an idler on a stub shaft pressed into the pump body. Bushings having helical oil grooves are provided in the idler gear, as well as in the pump body and the cover for the drive shaft.

A plunger type relief valve in the pressure side of the pump body by-passes excess oil to the inlet

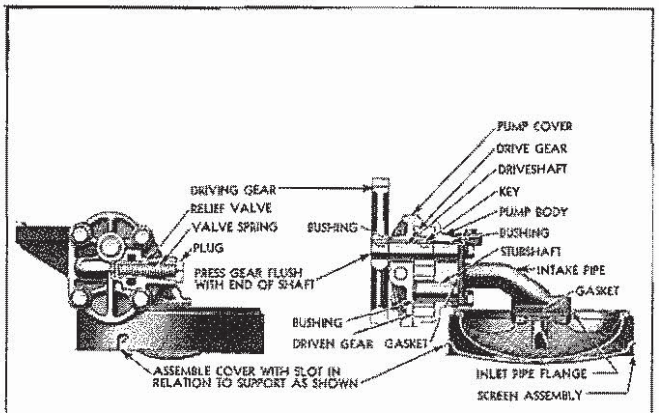


Fig. 2—Lubricating Oil Pump Assembly

side of the pump when the discharge pressure exceeds 100 lbs. per square inch. To protect the oil pump gears, a screen is attached to the oil pump inlet pipe. To prevent the pump from losing its prime, the pump inlet pipe is partially immersed in the lubricating oil contained in the oil pan.

B. Oil Pump Removal.

1. Remove the engine crankcase guard.
2. Drain the engine lubricating oil and remove the oil pan.
3. Remove the oil pump screen and support by removing the two bolts which attach the screen support to the oil pump intake pipe.
4. Remove the four bolts from the oil pump attaching flange, then pull the pump off the locating dowels. Wash the pump thoroughly.

C. Disassembly of Oil Pump.

Inspection of the pump is advisable when the engine is overhauled, ar after a long period of service. To disassemble the pump proceed as fallows:

1. Remove the oil pump driving gear and extract the Woodruff Key from the shaft. File off any burrs on the shaft.
2. Remove the four cover bolts, then tap the cover lightly to loosen it from the locating dawels. Pull the cover from the pump body.
3. Remove the drive shaft assembly.
4. Remove the driven gear.
5. Remove the relief valve plug, spring, and valve from the pump cover.
6. Remove the intake pipe.

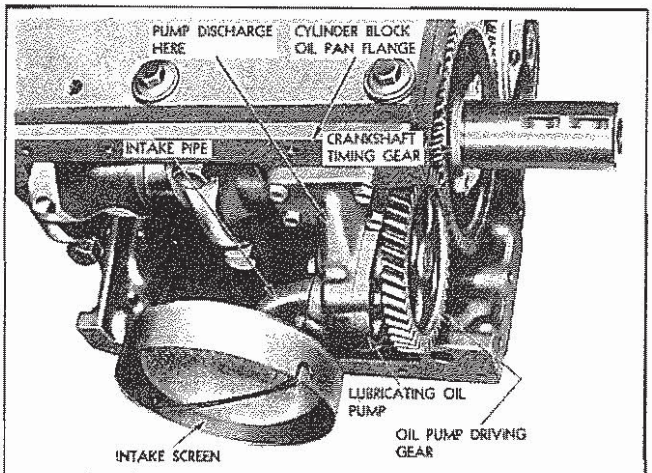


Fig. 3—Lubricating Oil Pump Mounting

NOTE: The oil pump driving gear, on engines prior to Serial Number 271-14721, is pressed on the drive shaft but is not keyed to the shaft. When the oil pumps on these engines are disassembled for inspection or repair, a new driving gear and drive shaft having a Woodruff Key slot should be installed so the gear can be keyed to the shaft. Use a No. 3 (1/8" x 1/2") Woodruff Key.

D. Cleaning and Inspection of Oil Pump Parts.

1. Wash all the oil pump parts in clean solvent and thoroughly inspect all the parts before re-assembly of the pump is made.

   The principal wearing parts of the oil pump are the internal pump gears. If dirt and sludge have been allowed to accumulate in the lubricating system, the oil pump gear wear may be rather pronounced in a comparatively short time. When the oil has been kept clean and the oil filter has been properly serviced, the wear on these parts will be very slow.

2. Inspect the pump gear teeth and the inside of the pump housing for wear and scoring. The gear teeth and the inside of the pump housing must be smooth, having no scratches, score marks, or rough spots. When the gear teeth or the inside of the pump housing are scratched or scored, they must be discarded and replaced with new parts.

   The radial clearance between the gears and the pump housing should not exceed .0045" or be less than .002". The end clearance between the face of the gears and the pump

housing should be between .001" and .004". When these clearances are exceeded, it will be necessary to replace the affected parts. If replacement of the oil pump gears is necessary, the oil pump drive gear must be pressed off the drive shaft. When assembling a drive shaft and drive gear, press the shaft into the gear to the dimension shown in Figure No. 4.

3. Inspect the pump shafts and the bushings in the pump body for excessive wear or scoring. Replace if it is necessary.

4. Inspect the oil pump relief valve. The valve must slide smoothly in the oil pump cover. When the valve or the bore for the valve in the pump cover shows excessive wear or roughness, they must be replaced.

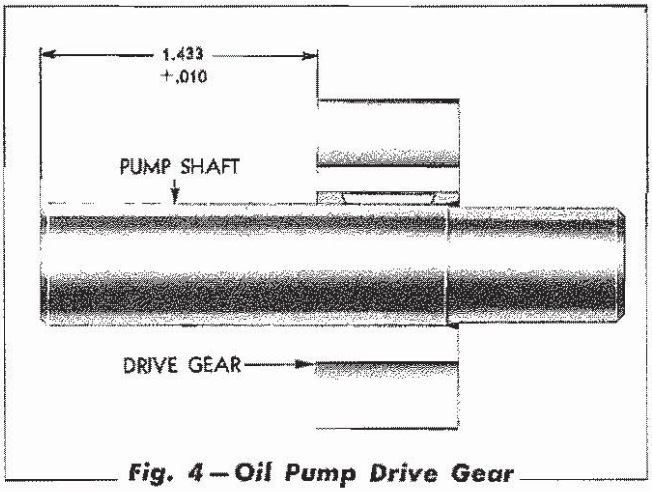


Fig. 4—Oil Pump Drive Gear Assembled To Shaft

E. Assembly of Oil Pump.

The pump drive has two keyways; the keyway nearest the end of the shaft is used to key the driving gear. The keyway farthest from the end of the shaft is used to key the pump drive gear in position on the shaft. To assemble the pump proceed as follows:

1. Place the driven pump gear in position on the stub shaft in the pump body.
2. Insert the pump drive shaft, with the drive gear in position on the shaft, into the pump body.
3. Check the clearance between the ends of the pump gear teeth and the inside of the housing. This clearance must be between .002" and .0045". The end clearance between the face of the gears and the pump housing should be .001" to .004".
4. Assemble the pump cover over the hollow dowels in the pump body, and tighten in position with the four attaching bolts.
5. Install the Woodruff Key in the drive shaft and press the driving gear into position on the shaft. *NOTE:* Press the driving gear on the drive shaft so that the face of the gear is flush with the end of the shaft.
6. Install the relief valve, spring, and plug.
7. Install the oil inlet pipe to the oil pump using a new gasket.

F. Oil Pump Installation.

1. Place the oil pump in position on the locating dowels and tighten in position with the four attaching bolts. *NOTE:* The backlash between the oil pump driving gear and the crankshaft gear should be .002" to .007".
2. Install the oil pump screen assembly in the inlet pipe using a new gasket.
3. Install the oil pan using a new gasket, then fill the engine with the proper viscosity oil to the full mark on the oil level gauge rod.
4. Install the engine crankcase guard.

3. LUBRICATING OIL COOLER

A. Description.

The oil cooler consists of a multiple plate, single pass, corrosion resistant cooling element contained in a cast iron housing bolted to the front of the cylinder block. The water pump attached to the front of the cooler housing, circulates the engine cooling liquid around the cooler element, thereby controlling the oil temperature as the oil travels through the small passages within the cooling unit. The hot oil enters the cooling unit at one end,

flows through the inside passages, and is discharged at the opposite end into a vertical passage leading to the cylinder head oil gallery.

A water by-pass tube is attached to the thermostat housing at the upper end, and to the water pump housing at the lower end. During the engine warm-up period, while the thermostat is still closed, water circulates through the by-pass tube, through the oil cooler housing and around the cooler element, and returns to the cylinder block; thus quickly raising the engine oil temperature during the engine warm-up period.

Should the oil cooler element become clogged, the oil cooler by-pass valve, enclosed in a semi-circular cast iron housing located on the right-hand side of the cylinder block, by-passes the oil around the cooler and directly to the oil galleries in the cylinder block and head.

B. Removal of Oil Cooler.

1. Drain the cooling system. Open the thermostat air vent valve when draining system.
2. Remove the engine air pre-cleaner from the air cleaner tube, then remove the engine hood.
3. Loosen the hose clamps attaching the radiator inlet and the outlet hose to the radiator.
4. Disconnect the head light cable from the main wiring harness and remove the fuse.
5. Remove the bolts attaching the front fenders to the radiator shell, then remove the cap-screws attaching the radiator to the main frame. Remove the front nut on the radiator bracing rod, then remove the radiator and shell assembly.
6. Loosen the generator mounting bolts and move the generator toward the engine, thus freeing the drive belts. Remove the fan and generator drive belts.
7. Remove the water pump and fan pulley assembly. Refer to "Water Pump Removal," Section IV.
8. Remove the bolts holding the oil cooler cover to the cylinder block and remove the oil cooler element and housing.

C. Cleaning of Oil Cooler.

If the oil passages in the cooler element become clogged, the oil flow will be restricted or stopped, and the oil temperature will rise. When this occurs the viscosity of the oil decreases, with a resulting drop in oil pressure. *IT IS ABSOLUTELY NECESSARY THAT THE OIL COOLER UNIT BE KEPT CLEAN FOR PROPER OIL COOLING.*

If live steam is available, a jet of steam, mixed with a soapy substance is a very effective cleaner. After cleaning remove all traces of water by warming the cooler unit.

If steam is not available, place the cooler unit in a vessel and fill with carbon tetrachloride, or any other suitable cleaner, to a level of at least one inch above the openings in the unit plate. A force pump is suggested as a means of forcing the cleaning solution back and forth through the plates. This operation should be continued until the unit is clean. *CAUTION:* Cleaning with carbon tetrachloride is to be done in the open air or with adequate ventilation due to the toxic qualities of the chemical.

Other solvents which have been found effective when used according to their manufacturers' directions are as follows:

Excello floor cleaning compound
Turco cleaning compound
No. 70 stripper
Mixture of 3 parts Oakite No. 7 and 5 parts fuel oil
Bendix cleaning compound

To use the last named solvent, merely submerse the element in the solution for a sufficient length of time to allow the chemical action of the compound to dissolve or loosen the sludge or other foreign matter from the cooler.

Flush the element thoroughly with live steam or spirits after cleaning, regardless of the type of cleaner used.

Cement the gaskets to both sides of the flange of the cooler element and coat both sides of the gaskets with cement when the element and housing are again installed after cleaning.

D. Installation.

1. Cement a new gasket to the rear face of the

oil cooler housing. Coat the other side of the gasket with cement and install the oil cooler housing in place on the cylinder block using the two oil cooler housing to cylinder block bolts.

2. Cement new gaskets to both sides of the flange of the oil cooler element and coat the other sides of the gaskets with cement before installing the oil cooler element. Place the element in the housing and install the oil cooler cover. *NOTE:* When assembling the cover to the housing, care must be taken in tightening the bolts uniformly around the entire cover so that the final seal will be even and leakproof.
3. Install the water pump and fan pulley assembly in place on the oil cooler housing cover. Refer to "Assembly of Water Pump to Engine," Section IV.
4. Install the thermostat housing to the water pump by-pass tube. Install the fan and generator drive belts and adjust. Refer to "Drive Belt Adjustment," Section IV.
5. Install the radiator and shell assembly by direct reversal of the removing procedure.
6. Close the cooling system drain cocks and fill the system. Close the thermostat vent valve after filling. Check the cooling system for water leaks.
7. Install the engine hood and engine air precleaner.

4. LUBRICATING OIL FILTER

A. Description.

The lubricating oil filter, mounted on the left side of the engine, has a replaceable element. A drain cock in the bottom of the filter shell allows draining of the filter. A new element must be installed each time the oil in the crankcase is changed or more often if conditions warrant.

B. Changing Oil Filter Element.

1. Open the filter cock and drain the filter.
2. Remove the filter cover from the filter shell by removing the cover screw from the center of the filter cover.
3. Lift out the spring and element and wash the inside of the filter shell.
4. Install a new element in the shell. Place the new filter element gasket and washer on top of the element then install the spring. Remove the old gasket in the filter cover and install the new gasket furnished with the kit.
5. Install the filter cover on the filter shell and tighten the cover screw.
6. Start the engine and check for oil leakage around the filter cover.

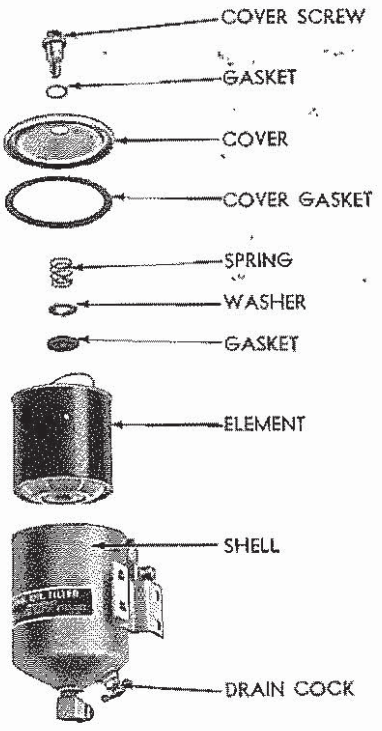


Fig. 5 — Lubricating Oil Filter

5. OIL COOLER BY-PASS VALVE

A. Description.

A spring-loaded by-pass valve is enclosed in a semi-circular cast iron housing which is bolted to the right-hand side of the cylinder block, beneath the muffler and forward of the fuel pump.

In case the oil passages in the cooler become clogged or, if, in cold weather, the oil is too thick to circulate freely through the cooler, the by-pass valve opens and by-passes the oil directly to the oil galleries in the cylinder block and head.

B. Service.

Under normal conditions, the valve should require very little attention. If the lubricating system has been allowed to sludge the valve may not work freely, thereby remaining open at the normal operating pressure or failing to open when the oil pressure increases above normal.

Whenever the oil cooler is removed for inspection or cleaning, the valve assembly should also be removed, thoroughly cleaned in fuel oil and inspected.

C. Removal of Oil Cooler By-Pass Valve.

1. Remove the two bolts attaching the housing to the cylinder block and remove the housing.
2. Remove the by-pass valve plug from the housing, then remove the spring and valve.

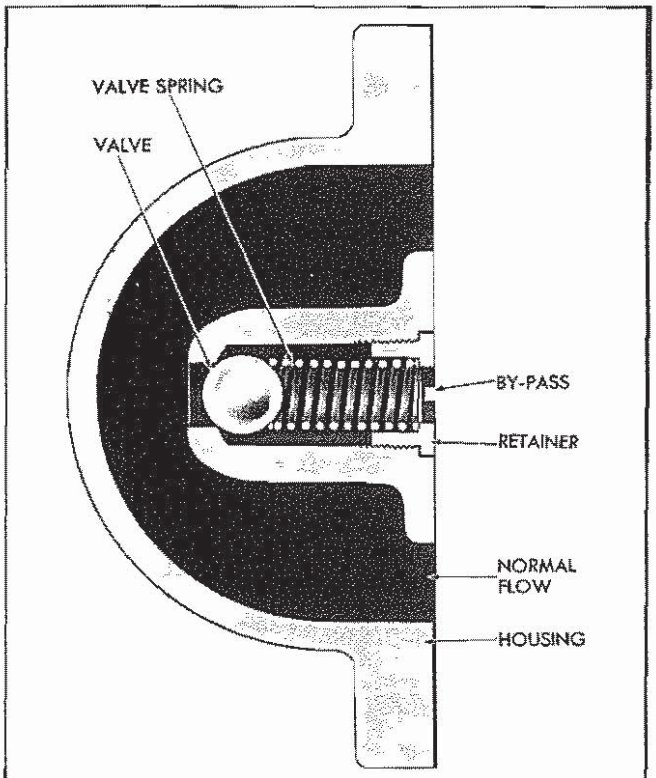


Fig. 6—Oil Cooler By-Pass Valve Assembly

3. Wash the parts thoroughly and inspect.

D. Assembly of Oil Cooler By-Pass Valve.

The by-pass valve may be assembled and installed on the cylinder block by reversing the sequence of operations for removal. Use a new gasket between the cylinder block and by-pass valve housing when installing.

1. ENGINE CONTROLS

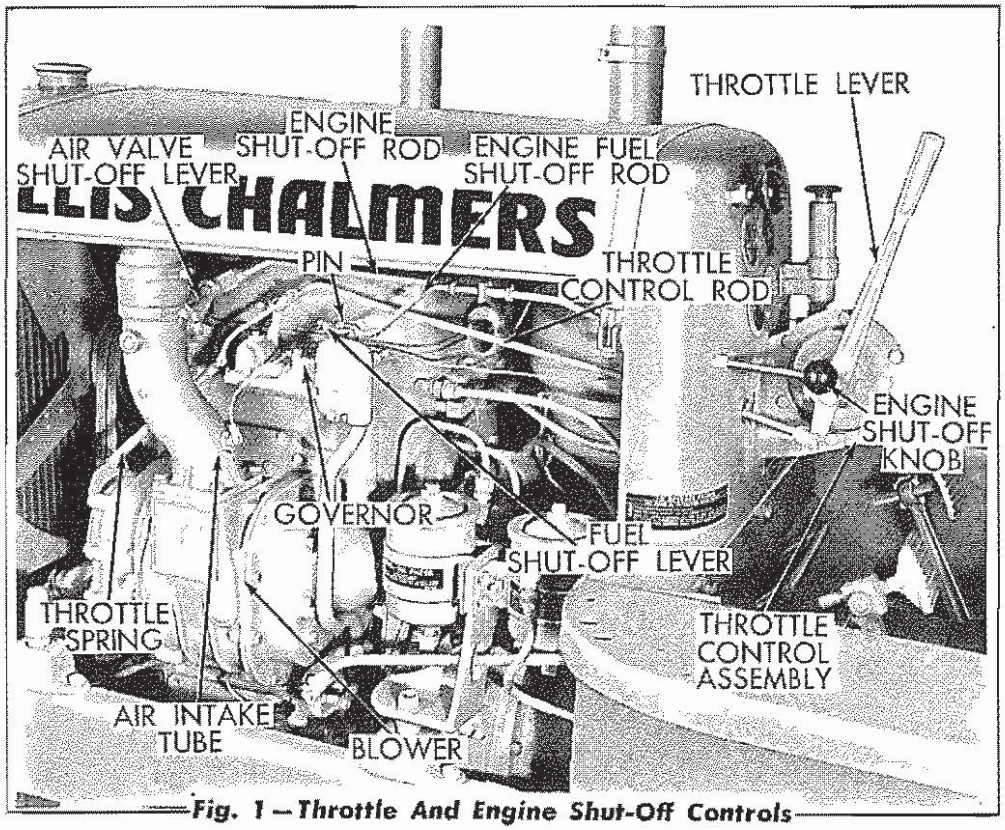


Fig. 1 — Throttle And Engine Shut-Off Controls

A. Description.

The throttle control lever is used to regulate the speed of the engine. A throttle control rod connects the throttle lever with the variable speed control lever on the governor. The throttle control rod is of a pre-determined length, therefore, no rod linkage adjustment is necessary. The engine runs at full governed speed when the throttle control lever is pulled all the way back and runs at idling speed when the throttle control lever is pushed all the way forward.

The throttle control lever is attached to the shaft of the throttle control assembly mounted to the cowl. The throttle control assembly consists of two spring loaded friction discs and two pressure plates enclosed in a cover assembly. This friction assembly acts as a brake and holds the throttle lever in any desired position, therefore, an infinite range of engine speed is obtained between idle and wide open. A throttle retracting rod and spring, extending from the front of the throttle control rod to the blower housing, is used to prevent the controls from creeping from low idle position when idle speed is desired. The distance the throttle lever travels (from idle to wide open) is controlled by the governor variable speed lever.

The engine shut-off control rod opens and closes an air valve in the blower air intake tube and also moves the governor fuel shut-off lever to its open and closed positions. When the shut-off control rod is pushed in (forward) as far as it will go (running position), the air valve and the governor fuel shut-off lever are moved to their full open position. When the shut-off control rod is pulled out

(back) as far as it will go the air valve and the governor fuel shut-off lever are moved to their closed position.

B. Adjustment of Engine Shut-Off Controls.

1. To adjust the engine air shut-off control linkage, push the engine shut-off control rod into running position (all the way in) and check the air shut-off valve lever to see if the ball in the lever stop assembly is centered in the hole in the shut-off valve lever. If not, lengthen or shorten the rod by adjusting the lever block on the end of the rod. The ball is used to hold the shut-off valve lever in position.
2. To adjust the governor fuel shut-off control, push the engine shut-off control rod into running position (all the way in) and remove the pin connecting the governor fuel shut-off rod to the governor fuel shut-off lever. Hold the governor fuel shut-off lever in its forward position (as far as possible) and check to see if the hole in the fuel shut-off rod lines up with the hole in the fuel shut-off lever. If not, loosen the capscrew clamping the governor fuel shut-off lever to the shaft, and move the position of the lever on the shaft so that the holes line up when the lever is in its extreme forward position. Tighten the capscrew used to clamp the lever to the shaft and install the connecting pin.

2. GOVERNOR

A. Description.

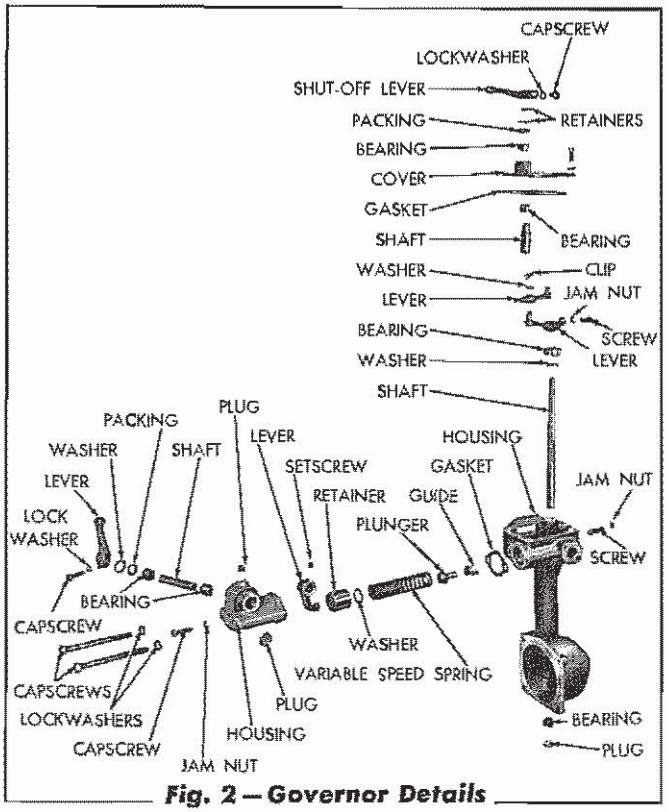


Fig. 2—Governor Details

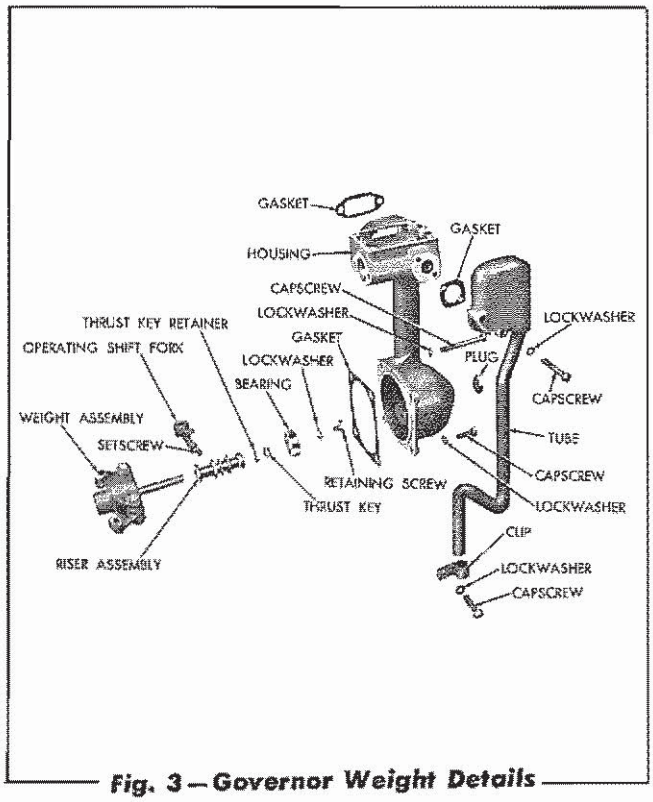


Fig. 3—Governor Weight Details

The governor, mounted to the rear of the blower, consists of three sub-assemblies. The sub-assemblies are: the weights, shafts, and bearing assembly: the vertical shaft control mechanism assembly: and the cover assembly.

A pair of weights are carried on a horizontal shaft inside the governor weight housing. The weight carrier shaft is mounted on a ball bearing at the rear of the shaft and is supported inside of, and driven by, the splines upper blower rotor shaft.

The control mechanism transmits the motion of the governor weights to the injector racks. This mechanism consists of a vertical shaft mounted inside

a housing with a fork fixed at the lower end, an operating lever fixed at the upper end, and a speed governing spring with adjustments. The vertical shaft is mounted in a ball bearing at the upper end and in a needle roller bearing at the lower end.

The centrifugal action of the governor weights is transmitted to the vertical operating shaft through a movable riser and thrust bearing on the weight carrier shaft and the fork on the lower end of the vertical shaft. This motion is, in turn, transmitted to the injector control tube by the operating and differential levers on the upper end of the vertical shaft.

The governor cover assembly serves as a carrier for the governor fuel shut-off lever. *NOTE:* The earlier engines are equipped with a cast type governor cover and the manual movement of the governor fuel shut-off lever was limited by a cam type lever stop located on the top of the cover assembly. The later engines are equipped with a stamped type governor cover and the manual movement of the governor fuel shut-off lever is limited by a slot spotfaced in the underside of the cover itself.

The plunger at one end of the variable speed spring in the top of the governor control housing bears against the operating lever on the vertical operating shaft. The opposite end is retained and guided inside a spring retainer which in turn bears against a variable speed spring lever controlled by the variable speed control lever and by the linkage to the throttle control lever. The governor is designed to control the engine at any constant speed (within the limits of the governor spring) that the operator may desire. Such control is made possible by the idle adjusting screw for the low engine speeds; and by imposing more or less tension on the spring by means of the throttle linkage and variable speed spring lever for higher speeds. The greater the tension on the spring, the higher the engine speed.

For starting, the engine shut-off lever is moved to running position (pushed all the way in). This moves the injector control racks to "FULL FUEL" position and also opens the engine air shut-off valve in the blower intake tube. As soon as the engine starts, the governor moves the injector racks OUT to the position required for idling. The engine can then be brought up to any desired operating speed; within the limitations of the spring, by opening the throttle and increasing the tension on the spring. The engine speed control is entirely automatic from this point on, depending upon spring tension.

B. Governor Inspection and Service.

The governor was adjusted at the factory to provide the full governed engine speed (under load) of 1800 R.P.M. and an idling speed of 500 R.P.M. which should be maintained at all times. The governor very seldom gets out of order. If the engine speed is irregular check for the following before changing the governor setting.

1. Be sure that the speed changes are not the result of load fluctuation.
2. Be sure that the cylinders are firing properly.
3. See that no bind exists in the governor mechanism or operating linkage between the governor and the engine; also, that no bind exists in the injector control rack shaft or its mounting brackets. The injector control mechanism must move freely throughout the entire travel of the injector racks. Should binding exist in the mechanism it may be located and eliminated as follows:
   a. If the injector racks stick or move too hard, inspect them for an accumulation of gum or sludge. Sticking from this cause can usually be corrected by washing the parts in clean solvent. If an injector rack sticks as a result of a "cocked" or "cramped" rack control lever, loosen the attaching screws in the rack control lever and move the lever endwise on the control shaft until the lever no longer cramps the injector rack. After the trouble has been remedied, adjust the lever to equalize the affected injector with the other (see "Injector Equalizing").
   b. Be sure that the injector control shaft turns freely in its bearings. Binding due to poor alignment of the bearing supports can be corrected by loosening the support capscrews and re-aligning the shaft supports with the control shaft. The shaft must turn freely to the "NO FUEL" position by the action of the return spring only. *CAUTION: Never stretch or tamper with the rack control spring to change the tension.*

If the spring is not standard, replace it with a new one.

c. Remove the bind from the pin in the link that connects the governor control rod to the injector control shaft lever if any bind is evident.

If the engine does not reach its maximum rated speed (1800 R.P.M. at full load), inspect the governor variable speed spring lever as it may be loose on its shaft. Remove the slotted pipe plug in the top of the spring housing, and, with the throttle lever pulled all the way back (wide open), tighten the Allen setscrew that holds the lever tight on the shaft. Wear on the shaft, lever, and setscrew will cause loss of engine speed and new parts should be installed if wear is excessive. Also make sure the engine shut-off control rod pushes the governor fuel shut-off lever all the way forward (run position).

If the governor still fails to control the engine properly after all the above inspections have been made, and all causes of failure other than the governor have been eliminated, the governor may be worn or otherwise unfit for further use. The governor must then be removed, disassembled, and inspected.

C. Governor Removal.

1. Remove the left front fender. Remove the engine air pre-cleaner from the air cleaner tube, then remove the engine hood.
2. Clean off the rocker arm cover and remove it from the cylinder head. Disconnect the governor control link from the injector control shaft lever.
3. Disconnect the engine control rods from the governor variable speed control lever and the governor fuel shut-off lever.
4. Remove the cover assembly from the governor control housing and disconnect the governor control link from the differential lever and remove the link.
5. Remove the capscrews attaching the governor breather tube to the governor housing and the capscrew attaching the breather tube clip to the cylinder block. Remove the breather tube.
6. Remove the capscrews attaching the governor housing to the blower and to the cylinder head. Remove the governor assembly from the blower by pulling it straight back from the end of the blower.

After removing the governor assembly from the engine, the governor assembly should be thoroughly washed, dried with compressed air, and inspected carefully for worn, damaged parts, or bind in any of the parts. Disassembly of the governor need be carried out only far enough to correct the difficulties which interfere with proper operation.

D. Disassembly of Variable Speed Spring Housing.

1. Remove the capscrews attaching the variable speed spring housing to the governor housing.
2. Remove the variable speed spring housing; hold the variable speed spring in place in the spring retainer so that the adjusting washers in the spring retainer will not fall out when removing.
3. Remove the variable speed spring, adjusting washers, and spring retainer from the housing. Do not loose the adjusting washers. Remove the low idle screw and jam nut.
4. Remove the variable speed lever and its key from the variable speed lever shaft. Remove the slotted head pipe plug from the top of the speed spring housing. Insert an Allen setscrew wrench through the pipe plug hole and remove the Allen setscrew holding the governor variable speed spring lever in place on the shaft. Remove the variable speed shaft, spring lever, washer, and shaft packing.
5. Remove the variable speed shaft bearings from the housing.

E. Removal and Disassembly of Weight and Carrier Assembly.

1. Remove the variable speed spring plunger

and drive the plunger guide out of the housing. This will allow the vertical shaft lever to revolve far enough so that the weight and carrier assembly can be removed and disengaged from the lower fork on the vertical shaft.

2. Using a punch, drive against the expansion plug, enclosing the governor weight shaft bearing, and remove the weight and carrier assembly.

3. Unlock the governor weight shaft bearing retaining screw and remove the retaining screw and lock from the shaft. Remove the bearing, then, the thrust key retainer and the thrust keys from the shaft.

4. Remove the (2) two pins used to attach the weights to the weight carrier and shaft assembly and remove the weights. The riser and thrust bearing assembly can now be removed from the shaft.

F. Disassembly of Operating Shaft.

1. Using an Allen setscrew wrench, remove the Allen setscrew holding the governor operating shaft fork in place on the lower end of the operating shaft.

2. Remove the round head machine screw, lockwasher, and plain washer used to hold the governor operating shaft upper ball bearing in place in the governor housing.

3. Remove the expansion plug, located under the lower end of the operating shaft, from the governor housing. Insert a punch through the expansion plug hole and drive the operating shaft out of the operating shaft fork, then, remove the operating shaft assembly.

4. Remove the jam nut from the differential lever stop screw and remove the stop screw from the governor housing.

5. Remove the differential lever from the operating shaft lever, then, press the operating shaft out of the shaft lever and the operating shaft upper ball bearing.

6. Remove the operating shaft lower needle bearing from the governor housing.

G. Disassembly of Governor Control Housing Cover.

1. Remove the governor shut-off lever from the shut-off shaft, then, remove the snap ring from the shaft and remove the flat washer.

2. Remove the shut-off shaft assembly from the cover.

3. Remove the shut-off shaft packing and remove the bearings from the cover.

H. Inspection of Governor Parts.

Clean the parts thoroughly, inspect for wear, and replace with new parts where needed.

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

I. Assembly of Governor.

1. To ossemble the governor, reverse the disassembling procedure. Refer to Figures No. 2 and No. 3 showing the parts in their relative position. When assembling the variable speed spring, be sure to install the same total thickness of variable speed spring washers as were removed at the time of disassembly. These washers are installed to obtain the correct high idle speed. *CAUTION:* When assembling, make sure that the lower fork on the vertical shaft is installed in front of the three (3) piece ball bearing used on the governor weight shaft assembly. Install new gaskets where necessary.

2. Before installing the governor housing cover assembly test the governor for adjustment as outlined in "Governor Adjustment."

J. Governor Installation.

1. Cement the governor to blower gasket in place on the governor housing. Cement the governor to cylinder head gasket in place on the cylinder head.

2. Place the governor assembly in mounting position inserting the splined end of the weight carrier shaft on the splined upper blower rotor shaft. Install the attaching capscrews, finger tight only.

3. Install the capscrews attaching the governor housing to the cylinder head, finger tight only.

4. Tighten the governor housing to blower attaching capscrews, then, tighten the governor housing to cylinder head attaching capscrews. Pour 1/2 pint of engine oil SAE 10, into the top of the control housing to lubricate the parts.

5. Insert the end of the control link assembly (end opposite the adjusting end) through the hole in the cylinder head into the governor control housing and place the end of the link on the pin of the differential lever. Secure this in place with a flat washer and a spring clip. Place the other end of the link on the pin of the injector control shaft lever and secure in place with a flat washer and spring clip.

   Before installing the governor housing cover assembly test the governor for adjustment as outlined in "Governor Adjustment."

6. Place a gasket and cover assembly on the top of the governor control housing with the pin on the fuel shut-off lever engaging in the yoke of the differential lever. Secure the cover with the four attaching screws. Connect the governor fuel shut-off rod to the fuel shut-off lever with a pin and cotter pin. Check the travel of the fuel shut-off lever. Replace the rocker arm cover.

7. Install the left front fender, engine hood, and engine pre-cleaner.

K. Governor Adjustment.

If the governor has been dismantled for repairs or if a new governor is installed, certain adjustments should be checked and engine speed adjustments made if necessary. Proceed as follows to check the governor adjustments:

1. Refer to "Injector Equalizing" and be sure that the injectors are properly adjusted.

2. Remove the cover assembly from the governor.

3. Pull the throttle control lever back as far as possible (wide open).

4. Loosen the locknut on the operating lever gap adjusting screw and turn the gap adjusting screw in or out to obtain a gap of .005" to .007" between the spring plunger shoulder and seat. Tighten the lock nut and check to see that the clearance did not change. If an adjustment was made to obtain this clearance, re-check the injector rack adjustment.

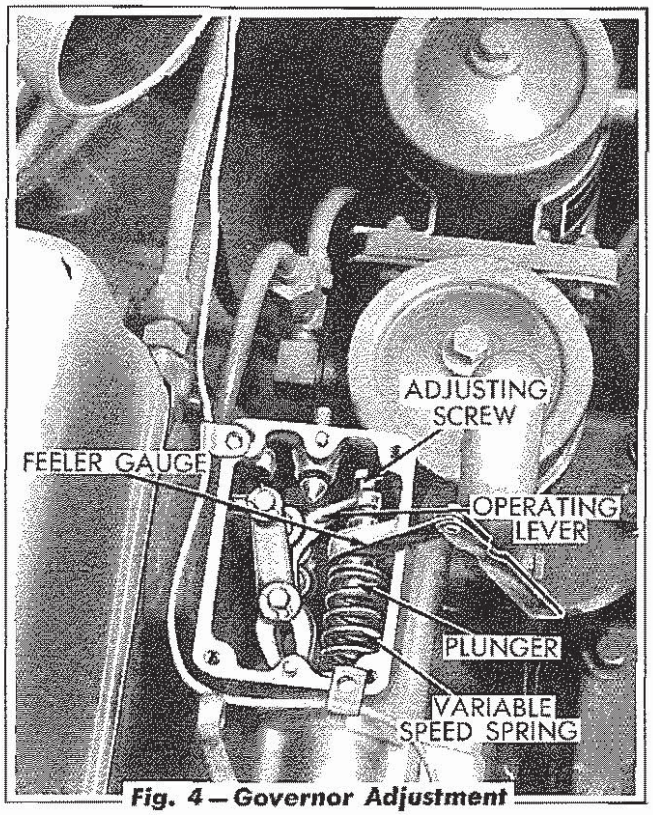


Fig. 4 — Governor Adjustment

5. Install the cover assembly on the governor housing. To adjust the governor to obtain the proper low idle engine speed of 500 R.P.M. proceed as follows:

   a. Start and operate the engine until it has reached its normal operating temperature 160 to 185° F.

   b. With the throttle control lever in idle position (all the way forward), loosen the lock nut at the front end of the variable speed spring housing. Turn the adjusting screw in (clockwise) to raise the engine idle speed, or out (counter clockwise) to lower the engine idle speed.

      The speed may be checked by unlatching the radiator grille and opening, then, using a tachometer, check the revolutions per minute of the crankshaft. If the tractor is equipped with front mounted equipment, remove the small cover from the rear

of the generator then, using a tachometer check the revolutions per minute of the generator. The generator runs at 1.55 times engine speed. Therefore, for the engine to run at 500 R.P.M. the generator must turn 775 R.P.M. Be sure that the fan and the generator drive belts are correctly adjusted so that no slippage of the belts will occur when checking the speed at the generator.

6. The adjustment for high idle speed is made by adding adjusting washers to those in the variable speed spring retainer at the front of the spring to increase the engine speed or by removing adjusting washers to decrease the engine speed. *NOTE:* In most cases, the cause for the engine not reaching the proper high idle speed (1875 R.P.M.) will be found due to loose, or incorrectly adjusted throttle linkage and not due to the governor being out of adjustment. For this reason, before changing the adjustment of the governor, check the following:

   a. Be sure that the governor fuel shut-off lever on the governor control housing moves to its extreme forward position (as far as it will go) when the engine shut-off control rod is pushed into running position. If it does not, adjust as is explained in Topic 1.

   b. Remove the pipe plug in the top of the variable speed spring housing, and check to be sure that the setscrew in the variable speed spring lever has not loosened, permitting the lever to turn on the shaft. Tighten it firmly so that the screw is drawn down tightly on the seat in the shaft. Replace the pipe plug. If the injectors have been properly timed and equalized and all the adjustments and inspections listed above have been made and the engine still fails to attain its proper high idle speed of 1875 R.P.M. (2905 R.P.M. of generator), addition of adjusting washers in front of the variable speed spring will be required.

   The adjusting washers are installed by removing the variable speed spring housing from the governor control housing, lifting the spring from the spring retainer and inserting the additional adjusting washers in the spring retainer. Each .010" shim will increase the engine speed approximately 25 R.P.M. After the high idle speed has been adjusted, adjustment of the idle adjusting screw will be required for the proper low idle speed.

SECTION VII — ELECTRICAL SYSTEM

1. DESCRIPTION OF SYSTEM

The electrical system, which includes the starter, generator, generator regulator, batteries, headlights, and wiring, is a 12-volt system throughout. Current for the operation of the system is supplied by two 6-volt wet cell storage batteries located in compartments at the ends of the seat.

Electrical energy drained from the batteries through the operation of the above named units is replaced by the generator. The output of the generator is controlled by the generator regulator to prevent over-charging of the batteries.

2. WARRANTY AND ADJUSTMENT POLICY

Manufacturers of the batteries, starter, generator, and generator regulator used on the tractor are responsible for this equipment during the warranty period. Any claim for replacement or repair of any of these units must be presented to the manufacturer, not to Allis-Chalmers Manufacturing Company. All the suppliers of such equipment are represented by distributors or dealers in nearly all cities. They are authorized to make reasonable adjustments or replacements for their respective companies. Always give the serial number of the tractor and the date that the machine was delivered when presenting a claim of this nature.

3. WIRING SYSTEM

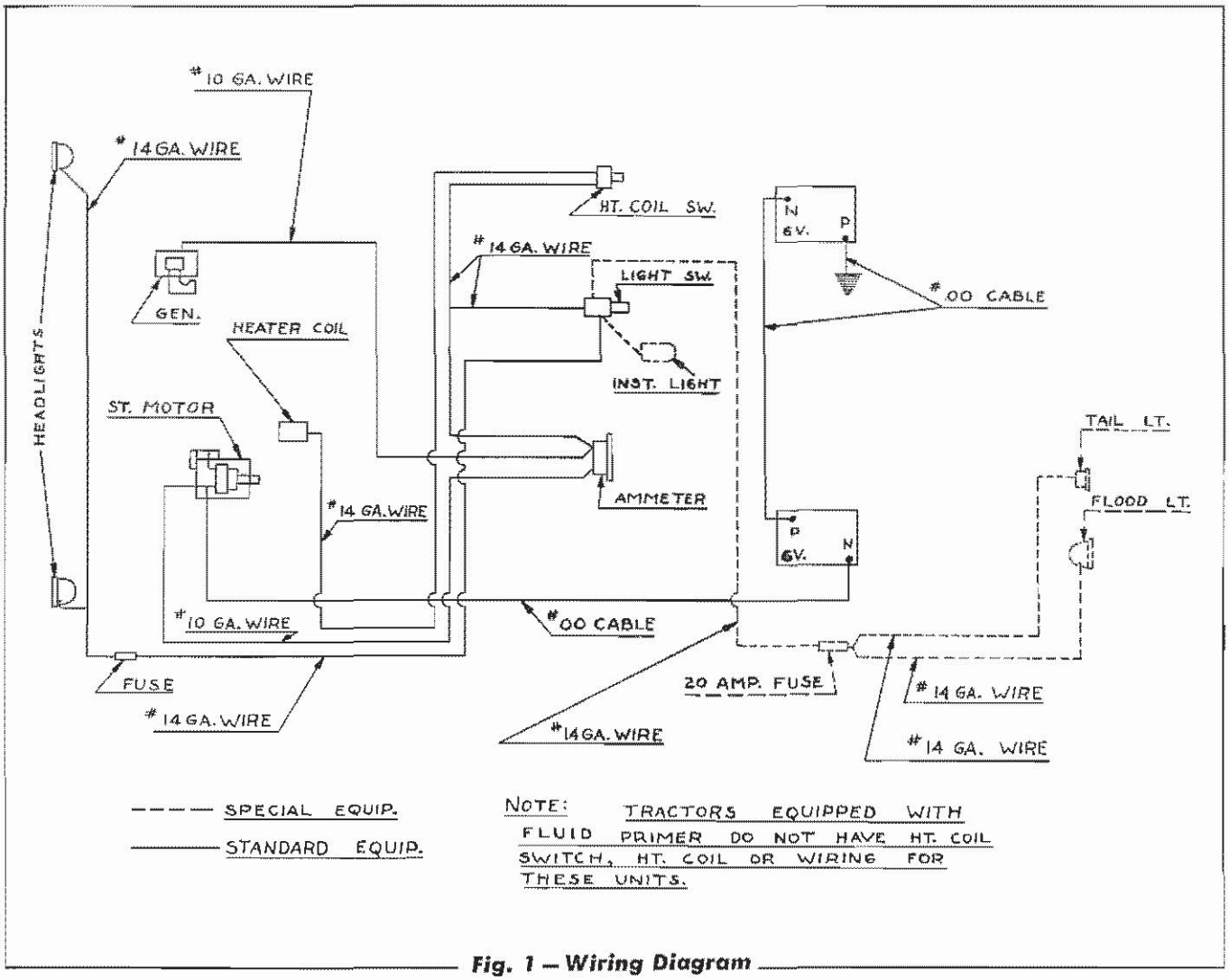


Fig. 1 — Wiring Diagram

Heavy cables connect the batteries and the starter; a wiring harness is used to connect the ammeter, head light switch, air pre-heater and pre-heater switch (if the tractor is equipped with ignition type heater) to the electrical system. Ten (10) gauge wire is used to connect the generator to the ammeter, and fourteen (14) gauge wire is used to connect the headlights to the wiring harness. A 20-ampere fuse, introduced in the wire leading to the headlights and located under the lower left corner of the radiator, prevents burning out the lights in event of a short-circuit.

Inspect the wiring frequently to detect any loose connections or frayed insulation. Tighten the connections and wrap any frayed spots on the wires with friction tape to prevent short circuits.

4. BATTERIES

A. Description.

The batteries are 6-volt, wet cell type, and are located in compartments at the ends of the seat. The batteries are connected in series to provide 12-volt current. The batteries are set on wood blocks and held solidly in place by special hold-down assemblies.

B. Service.

Check the level of the electrolyte in the batteries

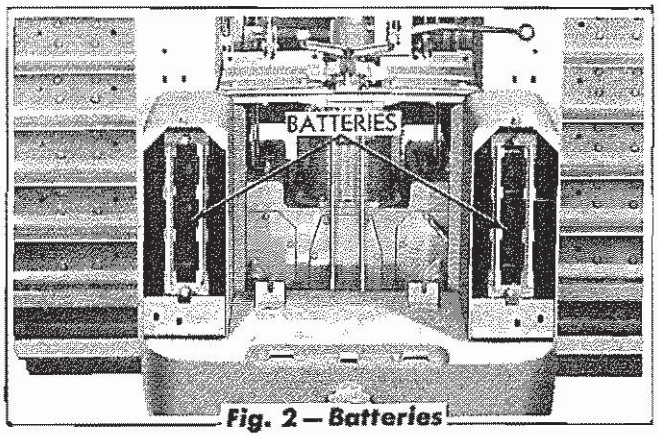


Fig. 2 — Batteries

weekly or as often as operating conditions prove it necessary. Maintain the level of the solution 3/8" above the plates by the addition of clean distilled water. DO NOT OVERFILL. Keep the battery and cable terminals tight and clean. If corrosion occurs, clean the battery posts and terminals with a strong soda solution and coat the terminals lightly with vaseline before connecting them again. The vaseline will prevent further corrosion.

When air temperature is below the freezing point, special attention should be given to hydrometer readings of the batteries. The electrolyte in full charged batteries will have a hydrometer reading of 1.275 to 1.285 specific gravity when corrected to 77° F. Specific gravity readings without correction for temperature are practically meaningless. For each 30 degrees that the temperature of the electrolyte is above 77° F., add 10 points to the hydrometer reading and for each 30 degrees below 77° F., subtract 10 points to get the true specific gravity. For example, if the hydrometer reading is 1.250 and the electrolyte temperature is 17° F. (60 degrees below 77° F.) 1.250 minus 20 points equals 1.230 — the true specific gravity.

If the corrected readings are below 1.240, the batteries are not receiving sufficient charge. This might indicate that the generator or regulator requires attention. If these units prove satisfactory, inspect the system for short circuits, loose connections or corroded connections. In zero weather there is danger of batteries freezing if the specific gravity is below 1.175. Batteries with a specific gravity of 1.225 will freeze at 35° below zero F.

During freezing weather, any addition of water to the cells should be made after the engine is started at the beginning of an operating period to make certain that the water and electrolyte solution will be thoroughly mixed; otherwise it may freeze. The filler caps must be kept tight at all times and the tops of the batteries kept clean and dry.

5. GENERATOR AND GENERATOR REGULATOR

A. Description.

The generator is a bi-polar unit, controlled internally by an adjustable third brush and externally by a step-voltage control. The armature shaft is supported at both ends by ball bearings. The brushes are held in reaction type holders and bear on the commutator with a pressure of 25 ounces. The third brush bears on the commutator with a pressure of 17 ounces.

The generator is hinged from a bracket attached to the right side of the cylinder block, and is driven by a V-belt from a pulley on the end of the crankshaft. The generator revolves at approximately 1.55 times engine crankshaft speed.

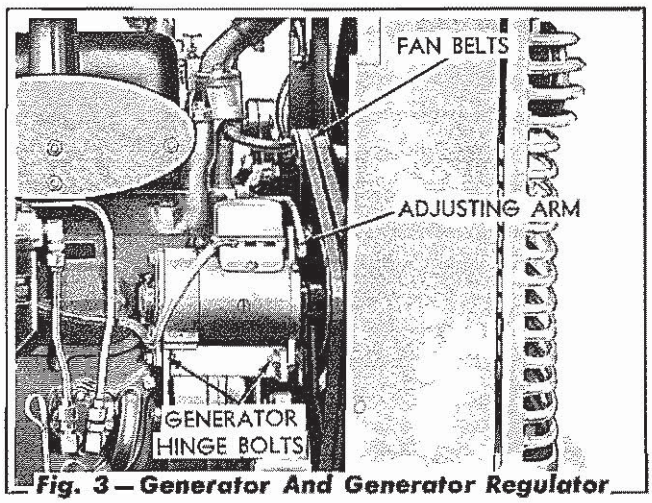


Fig. 3 — Generator And Generator Regulator

The output of the generator is 8-10 amperes when cold and 6-8 amperes when hot at 2400 armature R.P.M. (approximately 1550 engine R.P.M.). As a steady charging rate of 6-8 amperes would soon destroy the storage batteries, an output controlling device becomes necessary. To accomplish this, a step-voltage control together with a cut-out relay is wired to the generator circuit.

1. **Step-Voltage Control.**

This unit is mounted on the generator field frame as shown in Figure No. 3 and connected into the circuit as shown in the wiring diagram Figure No. 1.

The purpose of the step-voltage control is to increase or decrease the generator output in accordance with the requirements of the batteries and the connected electrical load. When the batteries become properly charged, a set of contact points in the control opens and shunts the generator field circuit through a resistance unit to the ground.

With the resistance unit in the field circuit, the generator maximum output is reduced approximately 5 to 7 amperes. If the batteries should become partially discharged, the contact points in the control close, removing the resistance from the field circuit, and the generator output increases to its maximum.

The voltage control does not increase the maximum output of the generator, as this is dependent entirely upon the design of the generator and the position of the third brush. Should the generator output be too high, the output should be reduced by adjusting the third brush to just meet the desired output requirements. The voltage control unit will then reduce the output when the batteries become fully charged, and prevent high voltages within the electrical system.

2. **Cut-Out Relay.**

The cut-out relay, a component part of the voltage control unit, closes the circuit between the generator and the batteries only when the generator voltage has built up sufficiently to charge the batteries. The cut-out relay opens the circuit when the generator slows or stops and the current begins to flow back from the batteries into the generator. Thus, a cut-out relay may be thought of as an electrical check valve which permits current to flow in only one direction, from-the-generator-to the batteries.

B. General Maintenance and Inspection.

Inspection of the generator brushes, commutator and leads should be made periodically.

1. **Brushes.**

The original length of the main brushes is 13/16", the third brush 23/32". Replace the brushes if they are worn down to a length of 7/16". The brush spring tension must be sufficient to give good clean contact of the brushes on the commutator, and the brushes must be free to slide in their brush holders. The pig tail leads in the brushes must be tight and the lead clips fastened well to the brush holders.

2. **Commutator.**

The commutator must be smooth, round, without excessive roughness, dirt, gum or burned areas. The slots between the segments must be open and not filled with carbon or copper dust. The armature leads must be properly soldered to the commutator segments. If the condition of the commutator does not meet with the above requirements, the generator must be removed for repair.

3. **Drive Belts.**

Keep the drive belts in proper adjustment. They are correctly adjusted when the straight (left) side of the belts can be pressed inward approximately 1" at a point halfway between the crankshaft and fan pulleys.

To adjust the belts, loosen the capscrew in the adjusting arm at the front of the generator and the generator hinge bolts, then move the generator in or out until the correct tension on the belts is obtained. Tighten the capscrew, and the generator hinge bolts. Excessive belt tension causes rapid wear on the belts and bearings, while low belt tension causes slippage, rapid belt wear, and possible failure of the generator to charge in a normal manner.

4. **Connections.**

The connections at the terminals should be checked to be sure that they are all tight and in good condition. If abnormal operation of the charging system is noted, it is first necessary to determine whether it is the generator, the generator regulator unit or some other part of the electrical system which is at fault.

C. Testing and Adjusting of Generator and Regulator.

Testing and adjustment of the generator or regulator should not be attempted without dependable testing equipment. If such equipment is not available, it is recommended that these units be taken to a United Motors Service Station or other dependable electrical repair shop. To check the generator, an accurate 0-10 or 0-20 ampere ammeter, an accurate 0-20 voltmeter, and a 20-ohm variable resistance of sufficient capacity to carry 10 amperes continuously, are needed.

DO NOT RUN OR TEST THE GENERATOR ON AN OPEN CIRCUIT. TO DO SO MAY DESTROY THE GENERATOR OR THE GENERATOR REGULATOR.

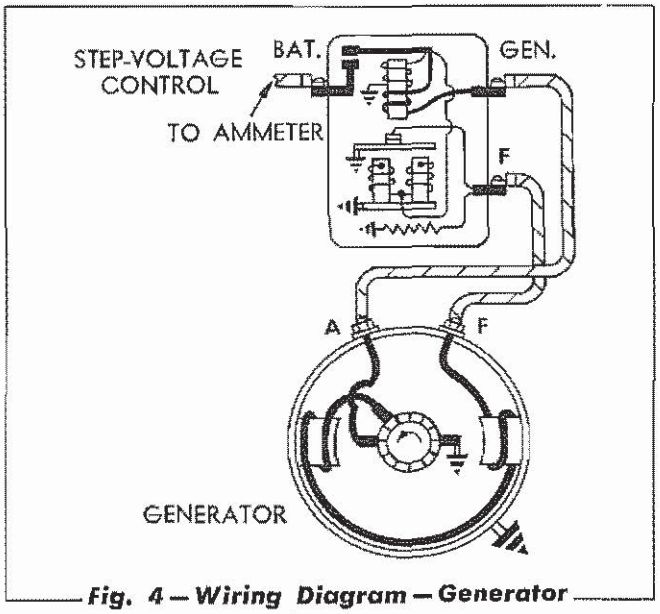


Fig. 4 — Wiring Diagram — Generator And Voltage

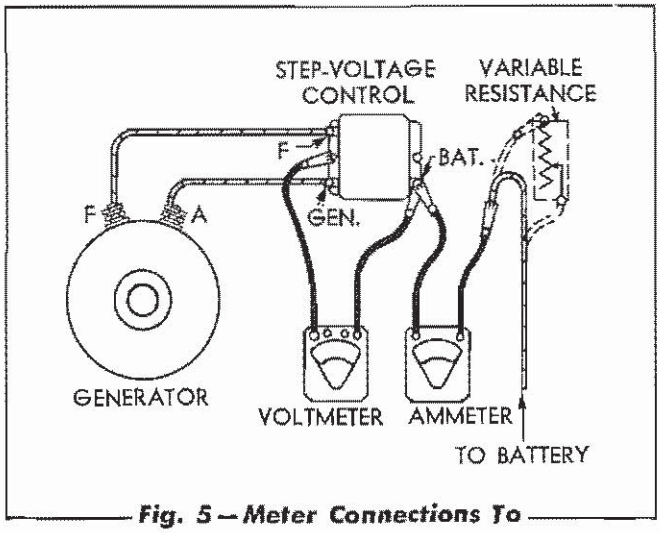


Fig. 5 — Meter Connections To Check Voltage Control

1. Generator Step-Voltage Control Checks.

A low charging rate with fully charged batteries indicates proper operation. Excessive gassing of the batteries indicates overcharge. The voltage control is designed to reduce the generator charging rate to approximately 2 amperes at 2000 generator R.P.M. (approximately 1290 engine R.P.M.) when the batteries have approached a fully charged condition. Check the voltage control action by stopping the engine and connecting the ammeter into the charging circuit, as shown in Figure No. 5. Disconnect the lead from "BATTERY" terminal of voltage control and connect the negative ammeter lead to the 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 charged batteries). As the current used in starting the engine is replaced in the batteries, the batteries will come up in voltage until the voltage control operates. This will reduce the charging rate to about two amperes. Failure of the units to operate in this manner will necessitate their being taken off the engine for a further check and adjustment as described in "Checking Generator Output."

Low batteries and low 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 bottery terminals, may also cause a low charging rate. Connect the ammeter in the charging circuit as described above. With the generator operating at about 2000 R.P.M. (approximately 1290 engine R.P.M.) and low batteries, the output should be 6 to 8 amperes. If less than 5 amperes is obtained, connect a jumper lead from the "F" terminal of the voltage control to the ground (base of voltage control is satisfactory). If the output increases to 6 to 8 amperes, the trouble is in the voltage contral. If the output daes not increase to 6 to 8 amperes with the jumper lead connected from the "F" terminal of the voltage control to the ground, the generator is at fault, and

it must be checked further, as discussed under "Checking Generator Output."

Refer to Figure No. 5 and disconnect the lead from "BATTERY" terminal of the voltage control and connect it to one terminal of the variable resistance. Connect the positive ammeter lead to "BATTERY" voltage control terminal. Connect the negative ammeter lead to the other terminal of the variable resistance. Connect the negative voltmeter lead to the "BATTERY" voltage control terminal and the positive lead to the ground (base of voltage control or generator frame). Connect a jumper lead (not shown in diagram) between the "F" terminal of the voltage control unit and the ground to eliminate the voltage-control resistance.

Set the engine speed for the maximum generator output (approximately 2000 generator R.P.M. or 1290 engine R.P.M.).

Adjust the variable resistance until the 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 the third brush to maintain 14.1 to 14.5 volts before taking the ampere reading.

Before moving the third brush, it is necessary to loosen the clamp screw on the face of the commutator and frame. Do not loosen this screw more than one or two turns. Considerable force may be required to move the third brush due to the construction of its mounting. *CAUTION: Never under any circumstances, set the generator output above 8 amperes at 14.1 to 14.5 volts.*

If unable to obtain 6 to 8 amperes by shifting the third brush, remove the generator and voltage control and service them in the manner described in the following pages of this section.

2. Checking Cut-Out Relay.

Connect the test leads of an ammeter and voltmeter into the electrical system as shown

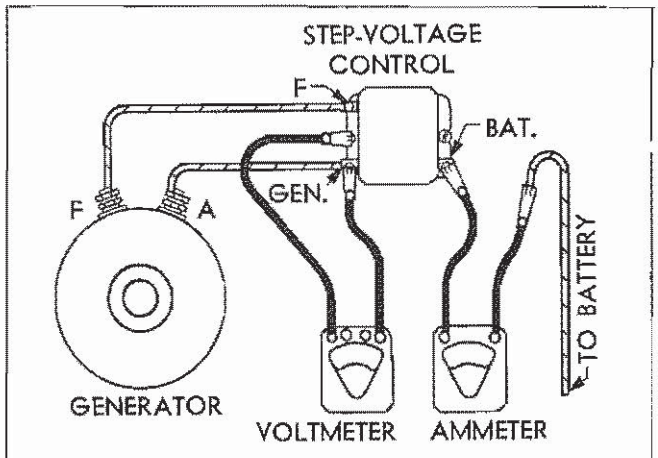


Fig. 6 — Meter Connections To Check Cut-Out Relay

in Figure No. 6. Start the engine, gradually increase the engine speed, and note the relay closing voltage. The reading must be 12.9 to 13.9 volts.

Decrease the engine speed and note on the ammeter the reverse current necessary to open the points, this reading must be from 0 to 4.0 amperes. If any adjustments are necessary, disconnect the regulator, remove the cover and make the adjustments as described under "Cut-Out Relay Adjustments."

3. Cut-Out Relay Adjustments.

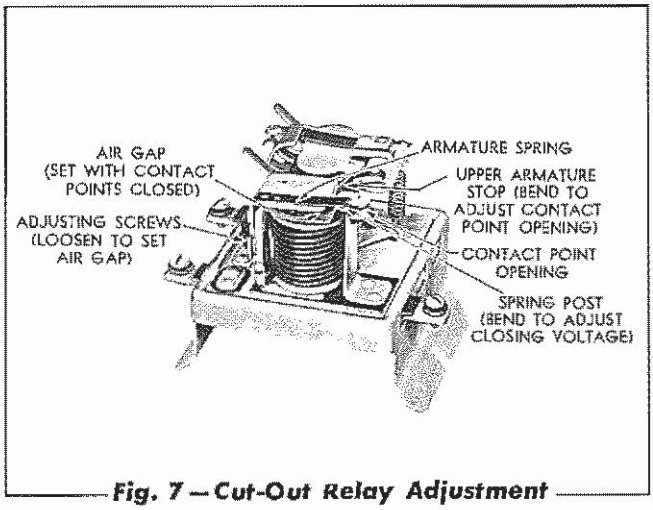


Fig. 7 — Cut-Out Relay Adjustment

a. AIR GAP (.015") With the contact points held closed, check the air gap between the armature and the center of the core. To adjust, loosen the two screws at the back of the relay and raise or lower the armature as required. Tighten the screws securely after adjustment.

b. POINT OPENING (.020") Measure the contact point gap with the points open. Adjust by bending the upper armature stop.

c. CLOSING VOLTAGE (12.9 to 13.9 volts) Connect the voltage control to the generator and batteries in the normal manner to check the relay closing voltage. Connect the voltmeter from the "GENERATOR" terminal to the voltage control base. It is not necessary to connect the ammeter into the circuit unless it is desired to measure the generator output. Gradually increase the generator speed and note the voltage at which the points close. Adjust by bending up on the spring post to increase the spring tension and raise the closing voltage. Bend down on the spring post to lower the closing voltage.

4. **Step-Voltage Control Adjustments.**

a. CONTACT SPRING TENSION (7¼ oz.) The flat contact spring tension is measured at the contacts with the armature and the spring just separated from the upper stop. The pull required to separate the points should be carefully measured with a spring gauge. Adjust the tension by slightly bending the flat spring.

Contact points which are pitted, rough, dirty, or burned may be cleaned with a stroke or two of a clean, fine-cut point file. Blow out all dust. Be careful not to bend or distort the flat armature spring.

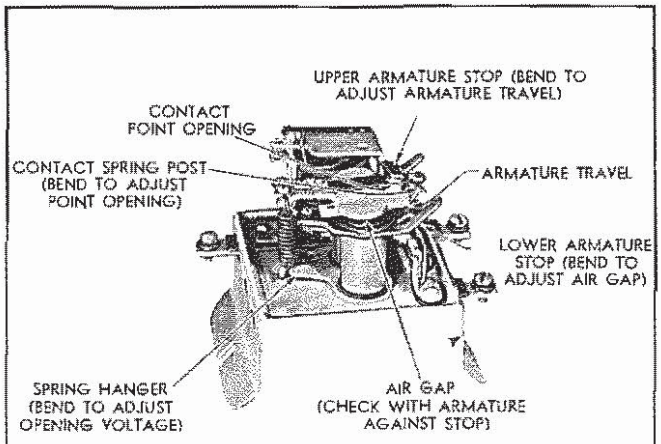


Fig. 8 — Voltage Control Adjustments

b. AIR GAP (.045") The air gap is measured between the center of the core and the armature with the armature held down against the lower armature stop. Bend the lower armature stop to adjust.

c. ARMATURE TRAVEL (.045") Release the armature and gauge the distance between the armature and the lower armature stop. Adjust by bending the upper armature stop.

d. POINT OPENING (.015") With the armature held down against the lower armature stop, measure the contact point opening. Adjust by bending the contact spring post.

e. VOLTAGE SETTING: The opening voltage (14.1 to 14.5 with the unit hot — 180° F.) of the contact points is checked by connecting the meters and a 1/4 ohm variable resistance, as illustrated in Figure No. 5, to the voltage control, generator, and batteries. Increase the generator speed slowly and note the voltage at which the contact points of the voltage control unit open. The moment at which the contact points open will be indicated by a sudden drop in the charging rate as shown by the ammeter. *STEP - VOLTAGE CONTROL MUST BE AT OPERATING TEMPERATURE AND COVER MUST BE IN PLACE WHEN MAKING THIS CHECK.*

If the batteries are low, the voltage control may not operate. To obtain sufficient voltage to cause the voltage control points to open, operate the generator at medium speed and slowly cut in the resistance until the voltage control points open. Note voltage. To adjust, bend the spiral spring hanger down to increase the opening voltage setting and bend it up to lower the setting.

The closing voltage (12.0 maximum volts) is checked by reducing the generator speed or cutting out the resistance so that the voltage drops to the value at which the points close. Adjust by adjusting the air gap, as described above. Increase the air gap to raise the closing voltage,

or decrease the air gap to lower the closing voltage. After adjusting the air gap, adjustment of the contact point opening may be required.

D. Generator Removal and Installation.

1. **Removal.**

   Disconnect lead from the "BATTERY" terminal of the regulator. Remove the belt-adjusting capscrew and the two hinge bolts and lift the generator away from the engine.

2. **Installation.**

   Hang the generator on the mounting bracket with the two hinge bolts. Fasten the belt adjusting link to the bottom extension of the drive end frame and adjust the drive belt tension for approximately 1" deflection of the belt at a point half-way between the crankshaft and fan pulleys. Attach the battery wire to the "BATTERY" terminal of the generator regulator.

   INSTALLATION CAUTION: After the generator has been installed, or at any time after the leads have been disconnected and then reconnected to the generator, a jumper lead should be connected momentarily between the "BATTERY" and armature "GENERATOR" terminals of the voltage control unit before starting the engine.

   This allows a momentary surge of current from the batteries to the generator which correctly polarizes the generator with respect to the batteries it is to charge.

6. STARTER

A. Description.

The starter is an 8-brush, 4-pole, heavy-duty unit, with the armature supported by three bushings at the drive end, center, and commutator end. The unit is equipped with a heavy duty starter switch; a Dyer drive is used at the rear end of the starter and provides for positive engagement of the starter pinion with the engine flywheel gear before the starter switch contacts are closed or the armature is rotated. The pinion is thrown out of mesh with the flywheel gear by the reversal of the torque when the engine starts. A shift lever in the drive housing is connected to the starter rod and pedal. Operation of the shift lever first moves the starter drive pinion into mesh with the flywheel; completion of the shift lever movement closes the starter switch, so that the current can flow from the batteries to the starter.

B. Starter Service.

Field service on the starter will be limited to cleaning of the starter, cleaning and adjustment of the drive assembly, cleaning of the commutator, and replacement of the brushes, brush springs or starter switch. All other adjustments or repairs require the use of special equipment. For this reason, it will be necessary to remove the starter and take it to an authorized United Motors Service Station or other dependable electrical repair shop if repair or adjustment is necessary. With fully charged batteries and normal temperatures of around 70° F., the starter will take hold promptly and spin the engine at a good cranking speed (a minimum of 80 R.P.M. is required for dependable starting). Colder weather will, of course, cause the engine to turn harder and the cranking speed will naturally be decreased. *CAUTION: The starter must never be used for more than 30 seconds at any one time without a pause to allow it to cool. The starter must NEVER be used to move the vehicle.* Failure to observe these rules may result in complete failure of the starter.

1. If the starter fails to operate properly, remove the cover band and inspect the commutator and brush connections. The commutator should be clean, not out of round or excessively worn, and without high mica or burned bars. A glazed or blued commutator does not indicate a condition requiring service, as this is a normal and satisfactory condition on a used unit. All electrical connections should be kept clean and tight, the brush spring tension should be from 34 to 40 ounces, and the brushes must not be worn shorter than half their original length of 1/2". The brush spring tension can be tested by attaching

a small spring scale to each brush directly under the head of the screw that holds brush to arm.

2. A dirty commutator should be cleaned with No. 00 sandpaper. *NEVER USE EMERY PAPER TO CLEAN IT.* If dust and dirt have accumulated in the starter, it should be blown out with compressed air; such accumulations are likely to interfere with the operation of both the motor and the drive assembly.

3. 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 slow cranking speed or difficulty in keeping batteries charged may indicate a faulty starting motor switch. The switch is easily disassembled for reconditioning of burned or corroded surfaces.

   a. Disconnect the battery cable at the starting motor; tape the exposed end of the cable.

   b. Remove the switch from the starter, then remove the bottom plate from the switch.

   c. Remove the contact disc from the plunger by removing the castellated nut.

   d. Clean and smooth the contacting surfaces with a file or sandpaper. Be sure that the surfaces contact over the entire area when reassembled.

C. Starter Drive Assembly.

1. Disassembly, Cleaning and Reassembly.

If hard dirt or grease accumulates on the splined part of the armature shaft or in the drive mechanism, the drive may "seize" to the shaft or lock, or the pinion might fail to mesh properly with the flywheel ring gear. If the pinion "seizes" while it is in mesh with the gear, considerable damage to the starter will result. The drive assembly must be disassembled for cleaning or adjustment.

   a. Remove the starter. Refer to "Starter Removal and Installation."

   b. Separate the drive housing from the field frame after removing the capscrews that hold them together. Mark both housings before they are separated to establish relationship of one with the other.

   c. Remove the cotter pin from the pinion stop, then remove the pinion stop, pinion, spring, pinion guide, shift sleeve and the spacer washers from the armature shaft.

   d. Clean all the parts thoroughly and inspect them.

   e. Reassemble as follows: Place the following parts, in the sequence given, on the drive end of the armature shaft — plain spacer washer, cupped washer (cup side away from field frame), and shift sleeve. Place the spring inside of the hollow pinion with the drive pinion guide next to the spring with the ears on the outside diameter of guide facing the pinion. Start the ears into the slots in the pinion and hold the guide approximately half the distance down the slots, then start the pinion guide and the spring assembly on the splines of the armature shaft. The pinion and guide assembly cannot be started on the shaft unless the ears on the guide are held down in the slots in the pinion. Slip the pinion stop in place with the cotter pin hole toward the end of the shaft. When the lugs on the stop enter the groove in the shaft, rotate the stop until the cotter pin holes align. Insert a cotter pin and secure in place.

   f. Place the drive end housing assembly over the end of the armature shaft and against the center bearing plate, guiding the finger of the shift lever into the slot of the shift sleeve.

2. Starter Drive Adjustments.

The Dyer drive was properly adjusted at the factory and seldom requires readjustment. Failure to operate properly will usually be caused by dirt or damaged parts.

When the shift lever is moved to where the starter switch contacts are closed, there should be 1/8" to 3/16" travel of the pinion against the spring pressure. The pinion travel can be

checked by pushing the pinion back against the spring pressure.

A test can be made to determine if the engagement action is being completed before the switch contacts are closed. This can be done by placing a 3/4" spacer between the pinion and the pinion stop. The shift lever can then be moved forward, forcing the pinion against the spacer. It should not be possible to close the switch contacts with the spacer inserted. When the pinion is in the driving position, there should be clearance between the pinion guide and the bottom of the slot, as indicated. If there is no clearance at this point, the drive will be taken directly from the lugs on the pinion guide, rather than from the heavy spline in the pinion itself. If there is no clearance at this point, the pinion and the pinion guide should be replaced. The pinion with its lock and lock spring is released by moving the pinion shift sleeve forward and along the splines of the shaft. In reassembling the parts, the pinion lock lugs should be in the slots in the pinion hub with the lugs toward the pinion, or it will not be in the proper position to lock on the shaft. Lubricate the three (3) starter bearings with light engine oil.

D. Starter Removal and Installation.

1. Remove the left front fender. Disconnect the starting motor operating rod from the starter shift lever.
2. Disconnect the battery ground cable from the steering clutch housing and tape the loose cable end to prevent a short circuit in the electrical system when removing the starter motor cable from the starter switch.
3. Disconnect the starting motor cable and the wire leading to the wiring harness from the starter switch.
4. Remove the two upper capscrews attaching the starter to the flywheel housing.
5. Remove the capscrews attaching the engine crankcase guard to the main frame and remove the guard.
6. Remove the lower capscrew attaching the starter to the flywheel housing and pull the starter out of the flywheel housing.
7. Install the starter by direct reversal of the removal procedure.

SECTION VIII — INSTRUMENTS

1. DESCRIPTION

The instruments which are standard equipment on the tractor, consist of the engine oil pressure gauge, engine temperature gauge and the ammeter, and are mounted on the instrument panel of the cowl.

The fuel pressure gauge, that can be obtained as special equipment, is mounted in a hole provided for this purpose in the instrument panel. When a tractor is purchased as a standard model, without the fuel pressure gauge, the hole in the instrument panel is closed with a cover.

The hour meter, also obtained as special equipment, is mounted in a bracket bolted to the left rear engine support.

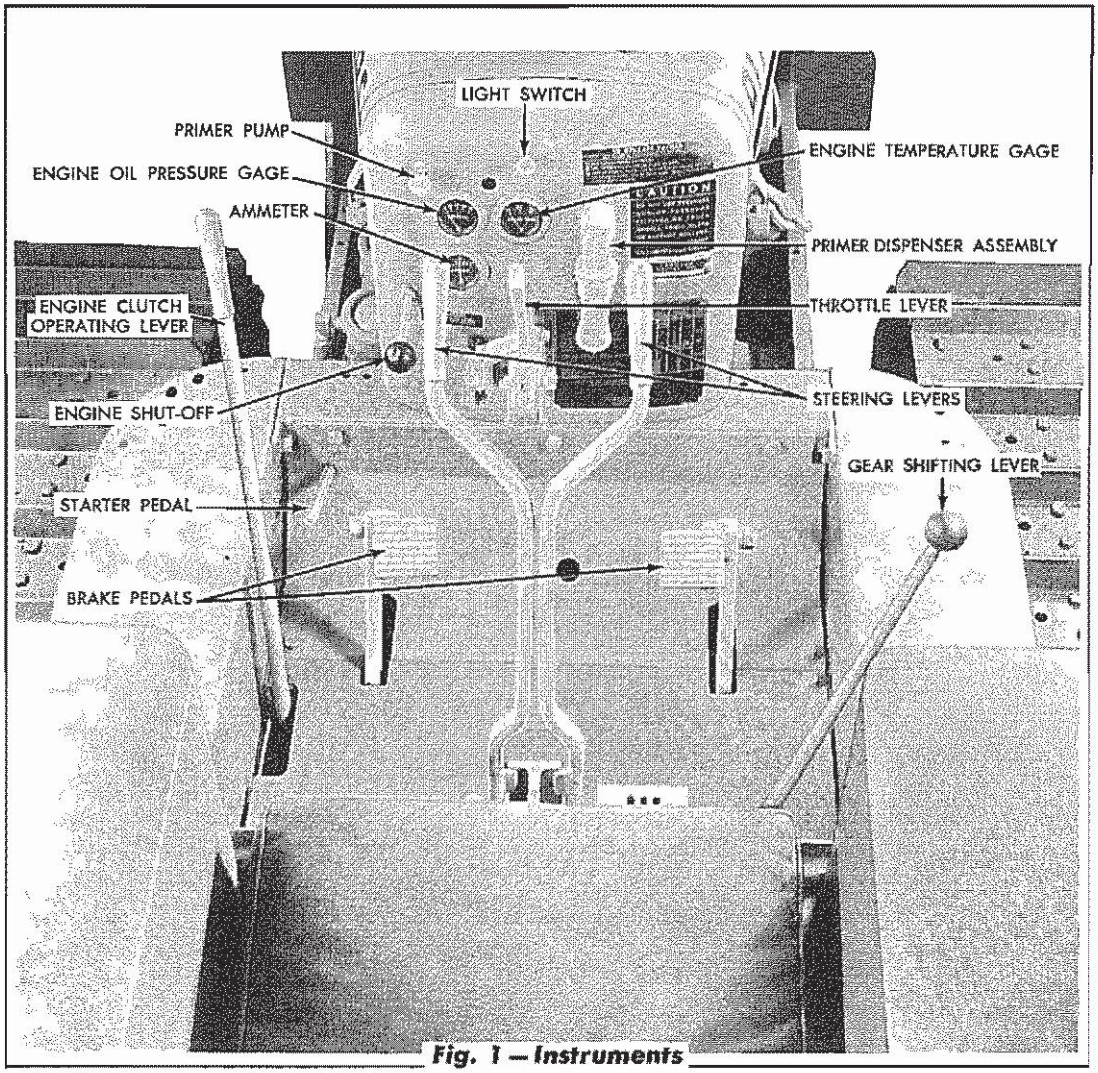


Fig. 1 — Instruments

2. ENGINE OIL PRESSURE GAUGE

This gauge registers the pressure at which the oil is circulated through the engine. The oil pressure gauge hose is connected to a fitting on the engine oil filter located on the left side of the engine. With the engine running at full throttle, the engine oil pressure should be between 25 and 35 pounds at normal engine operating temperature. *CAUTION:* If no pressure registers on the gauge or if the pressure is excessive (with the engine at normal operating temperature), the engine should be stopped immediately and the cause determined.

3. ENGINE TEMPERATURE GAUGE

The end of the engine temperature gauge tube is inserted in and connected to the rear of the cylinder head. This gauge registers the engine temperature, which should be maintained between 160° F. and 185° F. at all times. The temperature is controlled by a thermostat located in a thermostat housing mounted on the front of the cylinder head.

4. AMMETER

The ammeter registers the charging rate of the generator. When the batteries are in a discharged condition, the ammeter should register from 4 to 8 amperes until the batteries approach a charged condition. When the batteries are fully charged, the ammeter will register nearly zero through the action of the generator regulator except for a short time after the starter has been used.

5. FUEL PRESSURE GAUGE (SPECIAL EQUIPMENT)

The fuel pressure gauge registers the fuel oil pressure in the fuel system. The fuel gauge is mounted in the instrument panel and the fuel gauge hose is connected to a fitting located in the rear of the head of the second stage fuel filter located on the right side of the engine. With the engine running at full throttle the fuel pressure should be between 25 and 45 pounds. With the engine running at idle speed, the pressure should not be less than 5 pounds. *CAUTION:* If no pressure registers on the gauge or if the pressure is excessive, the engine should be stopped immediately and the cause determined.

6. HOUR METER (SPECIAL EQUIPMENT)

The hour meter registers the number of hours that the engine has operated. For instructions on how to read the hour meter see "Hour Meter" in the Special Equipment Section.

7. INSTRUMENT SERVICE

Any one of the various instruments can be removed from the instrument panel by removing the attaching screws and disconnecting them from the wiring, hoses, etc., to which they are connected.

Minor repairs on any of the instruments with the exception of the hour meter, are available at any United Motors Service Station.

Do not attempt to repair an hour meter. Return it to your dealer or branch for a trade-in allowance on a new meter.

SECTION IX — ENGINE

1. DESCRIPTION

A. The Diesel Principle.

The Diesel Engine is an internal combustion power unit. Fuel is atomized as it is injected into the cylinders and is ignited by the heat generated by compression of the air within the cylinders. The expanding gases generated by the burning fuel are converted into work in the cylinders of the engine. The principal difference between the Diesel Engine and the conventional gasoline engine is in the method used to introduce and ignite the fuel.

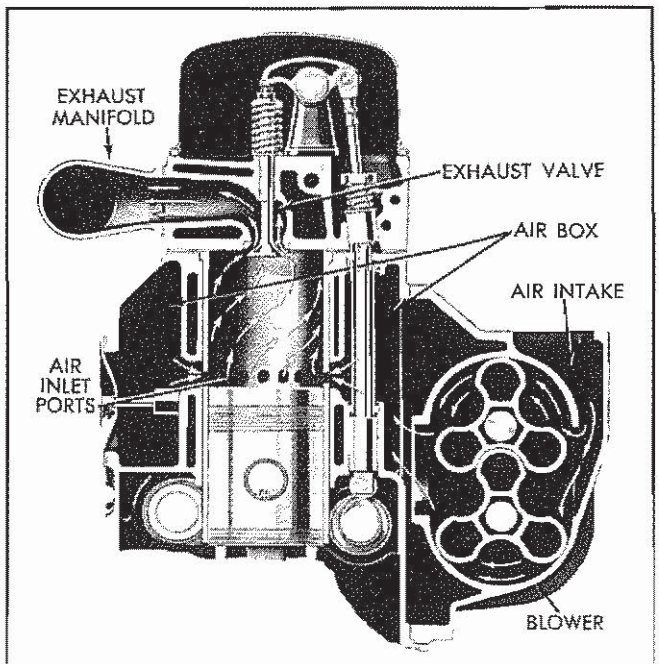


Fig. 1 — Air Flow Through Engine

Gasoline engines draw a mixture of fuel and air from the carburetor into the combustion chamber, where it is ignited by an electric spark. In Diesel Engines, air alone is compressed in the cylinder; then a charge of fuel is sprayed into the cylinder, after the air has been compressed, and ignition of the fuel is accomplished by the heat of the compressed air.

The engine in the HD-5 Tractor is a water cooled, 2 cylinder, 2-cycle, Diesel Engine.

B. The Two-Cycle Diesel Engine.

In the 2-cycle engine, intake and exhaust take place during part of the compression and power strokes. A 2-cycle engine, therefore, does not function as an air pump, so an external means of supplying the air is provided. A specially designed blower, bolted to the side of the engine, forces air into the cylinders in order to expel the exhaust gases and fill the cylinders with fresh air for combustion, as shown in Figure No. 2.

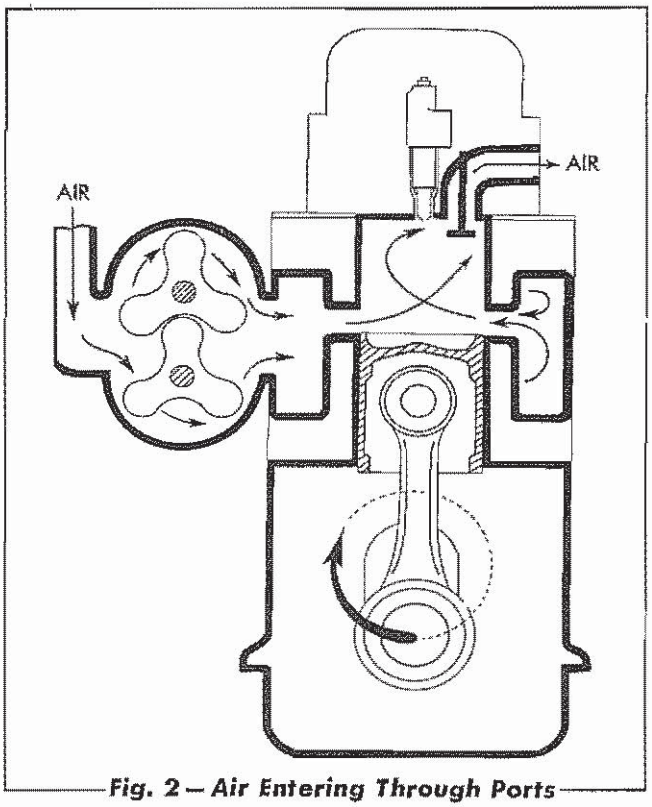


Fig. 2 — Air Entering Through Ports To Combustion Chamber

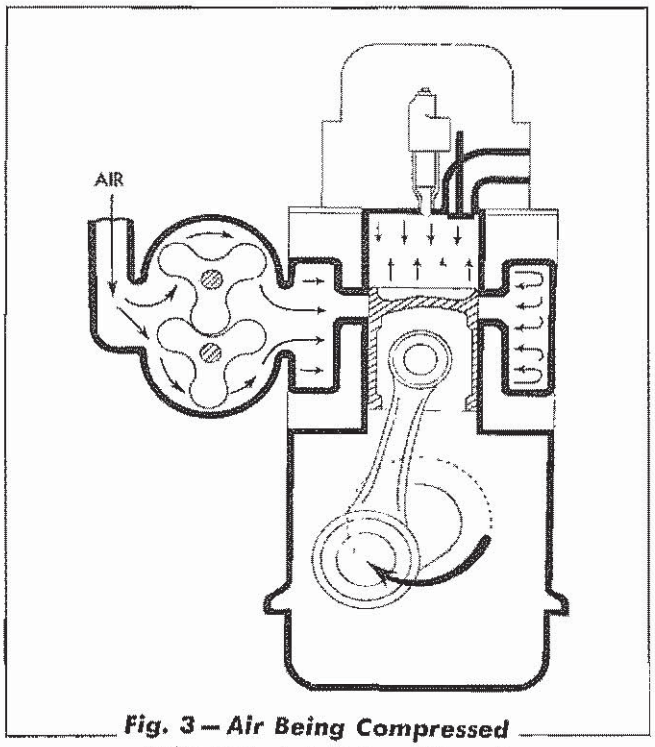


Fig. 3 — Air Being Compressed With Exhaust Valves Closed

A series of ports cut into the circumference of the cylinder wall, above the piston, in its lowest position, admits the air from the blower into the cylinder as soon as the top face of the piston uncovers the ports as shown in Figure No. 2. The flow of air towards the exhaust valves produces a scavenging effect, leaving the cylinders full of clean fresh air

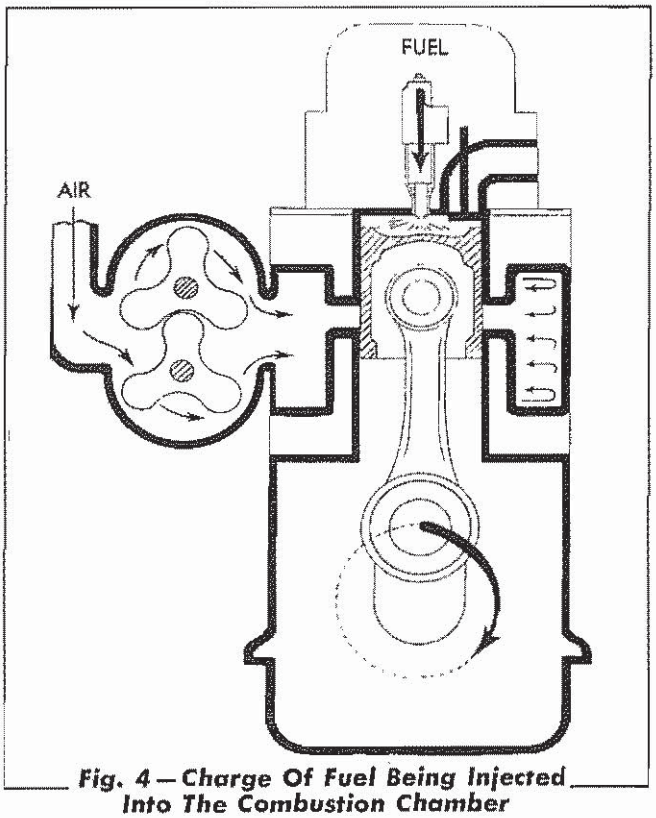


Fig. 4 — Charge Of Fuel Being Injected Into The Combustion Chamber

when the piston again covers the inlet ports.

As the piston continues on the upward stroke, the exhaust valves close and the charge of fresh air is subjected to the final compression, as shown in Figure No. 3. This engine is designed for a highly efficient 16 to 1 compression ratio.

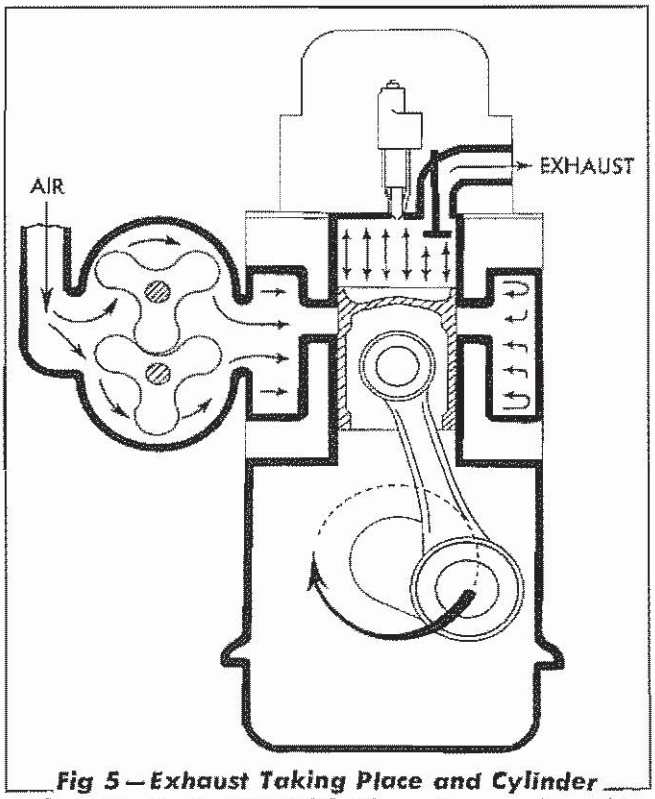


Fig 5 — Exhaust Taking Place and Cylinder About To Be Swept With Clean Scavenging Air

Shortly before the piston reaches its highest position, the required amount of fuel is sprayed into the combustion space by the unit fuel injector, as shown in Figure No. 4. The intense heat generated during the high compression of the air ignites the fine fuel spray immediately, and the combustion continues as long as the fuel spray lasts. The resulting pressure forces the piston downward until the exhaust valves are again opened. As shown in Figure No. 5, the burned gases escape into the exhaust manifold as the downward moving piston is about to uncover the inlet ports.

When these ports are uncovered, the entire cylinder is again swept with clean scavenging air, as shown in Figure No. 2. This entire combustion cycle is completed in each cylinder for each revolution of the crankshaft, or in other words, two strokes; hence, the "2-stroke cycle."

2. CYLINDER HEAD

A. Description.

The cylinder head is a one-piece alloy iron casting which can be removed from the engine as an assembly containing the injectors, guides, rocker arms, and valves. The head is securely held to the upper part of the cylinder block by heat-treated alloy steel bolts.

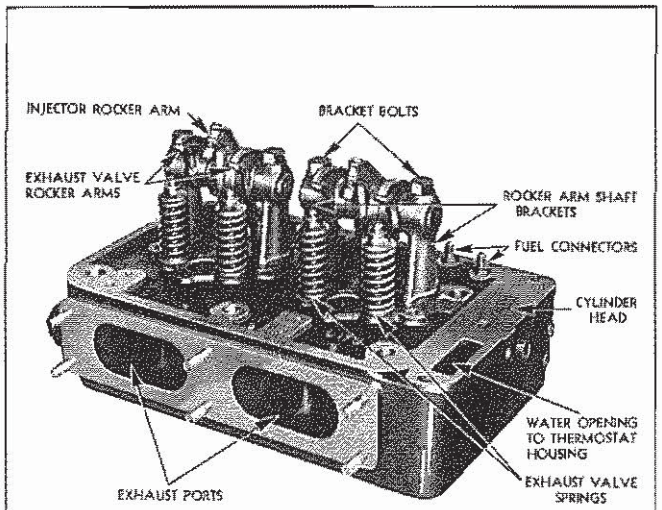


Fig. 6 — Cylinder Head Assembly

Located in the head are two exhaust valves, two valve seats, two valve guides, a fuel injector, and three rocker arms, for each cylinder. One rocker arm operates the injector plunger; the other two operate the exhaust valves. The valve guides are pressed into the cylinder head and hold the valve heads in accurate alignment with the valve seats which are also pressed into the head.

To provide efficient cooling, each fuel injector is inserted into a thin walled copper tube passing through the water space in the 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 the sealed upper end prevent any water leaks around the copper tube.

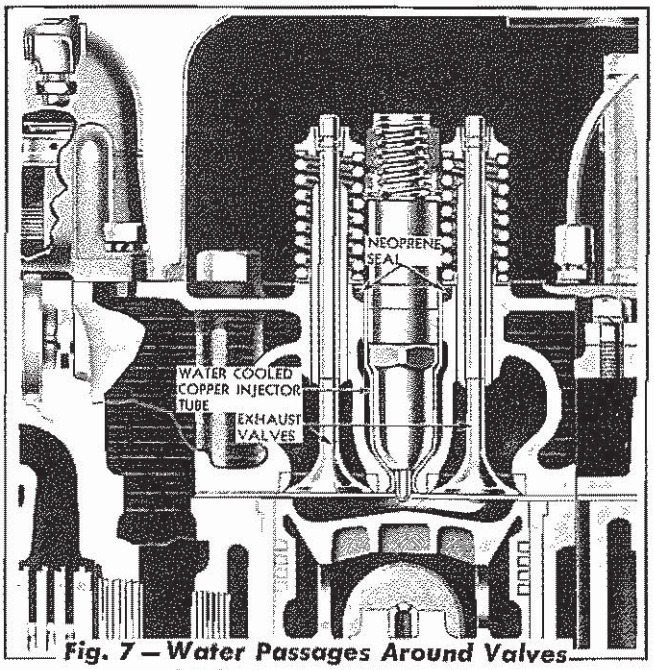


Fig. 7 — Water Passages Around Valves and Injector In Cylinder Head

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

To seal the compression, a flat laminated gasket composed of steel sheets is installed, between the cylinder head and the top of the cylinder block.

A gasket around the outer rim of the cylinder head provides an oil seal. The top of the cylinder head is completely enclosed by a pressed steel valve rocker cover, which is held in place by screws fitted with hand knobs. The cover is sealed against leaking by a gasket which is held in place by the flanged edge of the cover.

B. Service of Parts Contained in Cylinder Head.

Service on some of the parts contained in the head can be accomplished with the head installed; for others, the head must first be removed from the engine.

1. Operations not requiring the removal of the head.
   a. Timing, equalizing, or replacement of injectors.
   b. Adjustment of valve lash.
   c. Replacement of valve springs, rocker arms, or rocker arm shafts.
   d. Replacement of the upper and lower push rods or upper push rod seats.
   e. Replacement of injector fuel pipe connectors.
2. Operations requiring the removal of the head.
   a. Grinding, reseating, or replacement of the valves and valve seats.
   b. Replacement of the valve guides.
   c. Replacement of the injector copper tubes.
   d. Replacement of the lower push rod covers and camshaft follower assemblies.

C. Cylinder Head Removal.

1. Remove the pre-cleaner from the air cleaner tube, then remove the engine hood.
2. Open the cooling system drain cocks, one located on the right side of the engine block and the other at the bottom of the radiator. Open the thermostat air vent valve when draining system.
3. Clean the dirt from the upper part of the engine, then disconnect the fuel feed line and return line from the cylinder head and remove the rocker arm cover.
4. Remove the nuts from the exhaust muffler attaching studs and remove the muffler from the head. *NOTE:* While this is not essential for removal of the head, it will simplify handling after removal.
5. Remove the water by-pass tube from the water pump and thermostat housing. Disconnect the radiator inlet hose from the thermostat housing cover.
6. Remove the engine temperature gauge tube from the lifter bracket on the rear of the cylinder head. Remove the capscrew used to clip the generator to ammeter wire to the engine lifting bracket. Reinstall the capscrew in the lifter bracket after removing the clip.
7. Remove the capscrew attaching the supporting plate, for the clip on the fuel filter to pump tube, to the engine lifting bracket. Reinstall the capscrew in the lifter bracket after removing the supporting plate.
8. Remove the governor cover and then remove the control rod leading from the governor to the lever on the injector control shaft. Remove the injector control shaft assembly from the head.
9. Remove the twa bolts inside the cylinder head which attach the governor assembly to the head, and loosen the bolts holding the governor to the blower just enough to completely free the governor from the head.

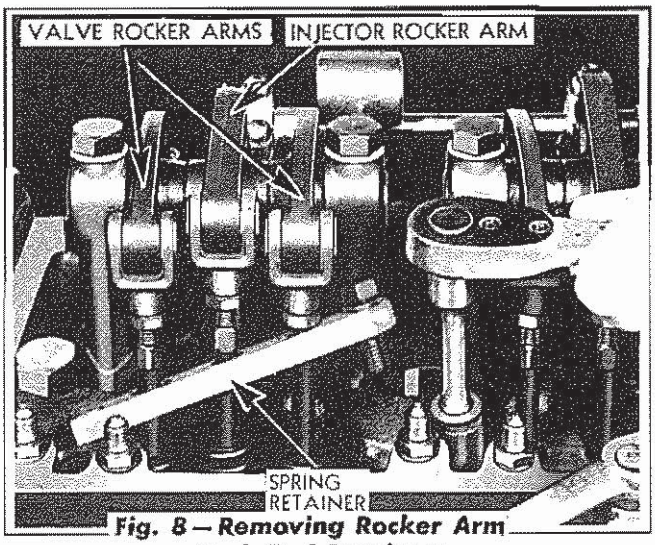


Fig. 8 — Removing Rocker Arm Push Rod Retainers

10. Remove the injector fuel lines and cover the openings in the injectors with shipping caps. Then remove the rocker arm push rod spring retainers.

11. Unscrew the rocker arm shaft bracket bolts and lift the complete rocker arm, bracket, upper push rod assemblies, and upper push rod seats from the cylinder head.

12. Remove the fuel injectors and injector control shaft assembly. Remove the cylinder head bolts and lift the cylinder head from the engine block with a chain hoist or similar equipment.

13. If the cylinder head is to be completely stripped as for a head replacement, proceed as follows: Remove the fuel line connectors, front lifter hook and thermostat housing, rear lifter hook and heat indicator flange, exhaust muffler studs, injector clamp studs, and the pipe plugs. If the head was removed for a valve job, these parts need not be removed.

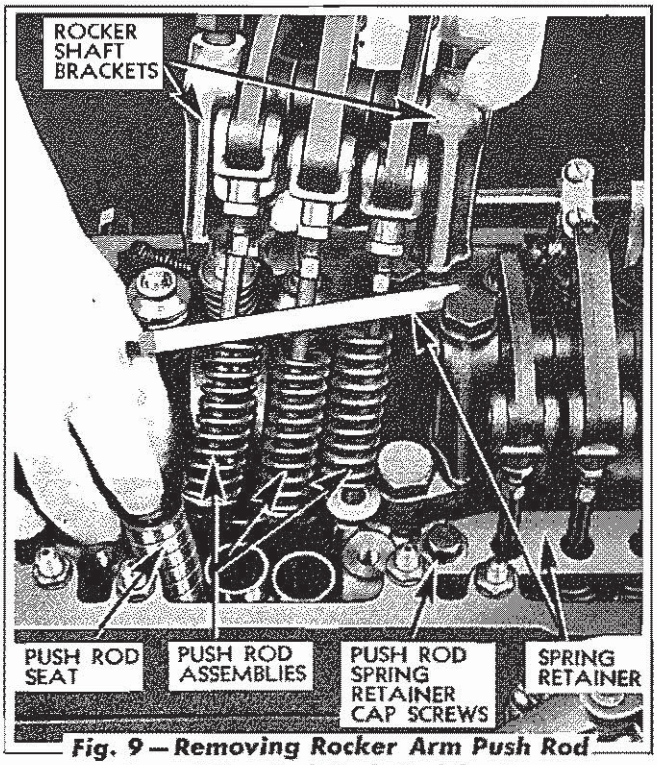


Fig. 9—Removing Rocker Arm Push Rod Assemblies And Push Rod Seats

D. Inspection.

In case of a cylinder head change, the working parts removed from the old head must be thoroughly inspected before installing them in a new head. The proper procedure to be followed in making the inspection and installation of the various parts of the cylinder head will be found under "Exhaust Valves and Operating Mechanism" in this section and "Engine Fuel System," Section II.

E. Cylinder Head Installation.

1. Remove all traces of the old oil gasket from the top of the cylinder block and from the bottom of the head. With both surfaces clean, install a new cylinder head compression gasket to the top of the block with the side of the gasket marked "Top" up. Install two head guide studs (5/8" x 6½" with one end of the guide studs threaded for distance of 1" with 5/8" x 11NC thread) in diagonal holes on each end of the cylinder block. The guide studs will assist in lining up the head to the block.

2. The engine may have been equipped with a 3-piece cork oil seal head gasket set or a one piece "Buna" (grey in color) oil seal head gasket. When installing the "Buna" gasket install it dry, do not use gasket cement or any adhesive agent. When installing the cark gasket (3 piece set), cement it on both sides with No. 2 Permatex or its equivalent. Do not use a cork gasket set if the "Buna" gasket is available.

3. Lower the cylinder head in place over the guide studs, remove the guide studs, install and draw the cylinder head bolts down evenly, rotating from one bolt to another. Tighten the bolts to 180-190 foot pounds torque by starting at the center bolts and working toward each end, tightening each bolt a little at a time. Refer to Figure No. 10.

4. Install the gasket, between the governor housing and cylinder head, and start the two attaching capscrews. Tighten the governor housing to blower attaching capscrews, then, tighten the governor housing to cylinder head capscrews.

5. Install the control rod connecting the governor differential lever to the injector control shaft lever.

6. Attach the supporting plate, for the clip on the fuel filter to pump tube, to the engine

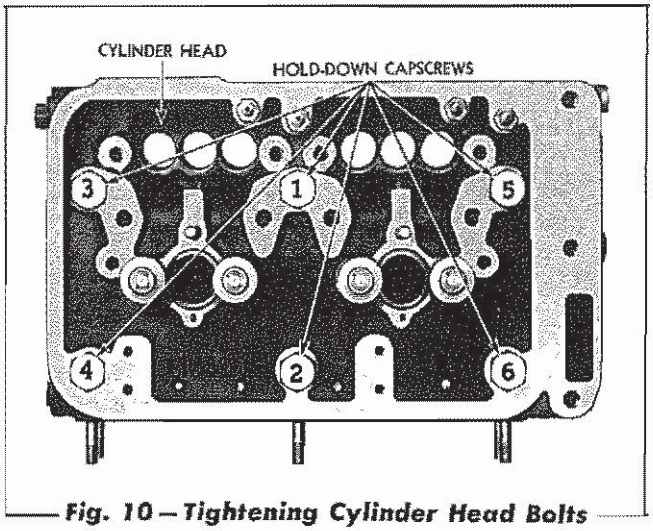


Fig. 10 — Tightening Cylinder Head Bolts

lifting bracket. Tighten the attaching capscrew securely. Connect the fuel feed line and the return line to the cylinder head.

7. Attach the generator to ammeter wire clip to the engine lifting bracket clip. Tighten attaching capscrew securely.
8. Coat the inside of the radiator inlet hose with gasket cement or sealing compound and connect the hose to the thermostat housing cover. Tighten the hose clamp securely.
9. Install the water by-pass tube to the water pump and thermostat housing.
10. Install the engine temperature gauge tube in the lifter bracket on the rear of the cylinder head.
11. Install the exhaust muffler.
12. Close the cooling system drain cocks and fill the system. Close the thermostat vent valve after filling. Check the cooling system for water leaks.
13. After the assembly of the cylinder head is completed, adjust the valve lash. Refer to "VALVE LASH ADJUSTMENT" in this section. Time and equalize the injectors. Refer to "INJECTOR TIMING" and "INJECTOR EQUALIZING," Section II.
14. Install the injector fuel lines. Start the engine and inspect the connections to be sure that there are no fuel leaks from the injector fuel lines or lubricating oil leaks from the head gasket.
15. Install the rocker arm cover and the engine hood. Install the pre-cleaner on the air cleaner tube.

3. EXHAUST VALVES AND OPERATING MECHANISM

A. Description.

The exhaust valves are made of silichrome steel, carefully heat-treated to develop the special properties required for valve service. The valve stems are ground to size and hardened at the ends.

The hardened valve seats, installed in the cylinder head, are accurately ground to very close limits and their freedom from warpage under ordinary working conditions reduces valve grinding to a minimum. The valve guides, made of fine-grained cast iron, are pressed into the cylinder head and then reamed for the desired fit.

Cylindrical valve springs, made of alloy steel, are held in place by a retainer and a tapered two piece seat lock.

The rocker arm assembly of each cylinder consists of three drop forged rockers mounted on a common shaft supported at each end by malleable iron brackets which bolt to the cylinder head.

The upper push rod assemblies, consisting of the upper push rods, spring retainers, follower springs and spring seats are attached to the rocker arm clevises. Between the rocker arm assemblies and the cam roller followers are the lower push rods, which are guided between seats in the followers and the upper push rod seats.

The valve end of each valve rocker arm is hardened and ground to a cylindrical surface which bears directly on the end of the valve stem. The injector end of each injector rocker arm is fitted with a hardened ball stud and ball seat which form a flexible joint. The ball seat transmits the rocker arm motion to the fuel injector.

Each cam roller follower consists of a hardened steel roller supported on a plain bearing that rotates on the pin which attaches the roller to the roller follower. The cam rollers are held square

with the cam surfaces by steel follower roller guides bolted to the cylinder block.

The lower push rods extend upward through the air box and are enclosed by the push rod covers which are steel tubes supported between two composition rings in the cylinder block. The rings effectively seal the air box around the push rod openings.

Oil for the valve operating mechanism is pumped through a longitudinal oil passage in the cylinder head, entering the hollow rocker arm shafts through the hollow shaft bracket bolts. Excess oil from the rocker arms, returning to the oil pan, lubricates the valves, injectors, push rod seats, seat bosses, cam followers and the blower gears.

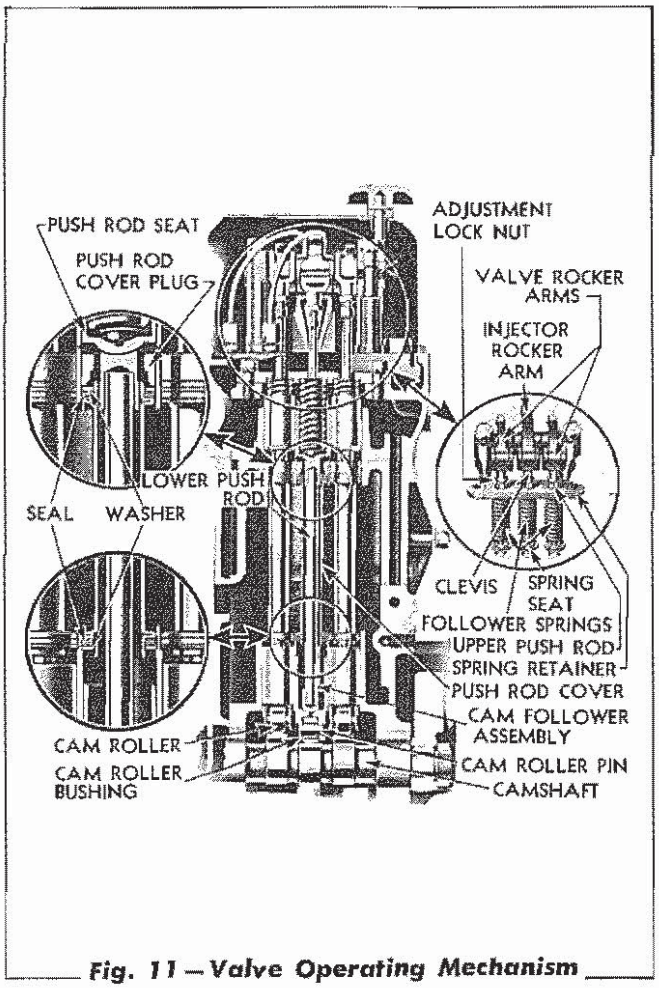


Fig. 11 — Valve Operating Mechanism

B. Service.

Several operations on the valve mechanism may be performed without removing the cylinder head, while the head must be removed for certain other operations. The operations not requiring head removal are:

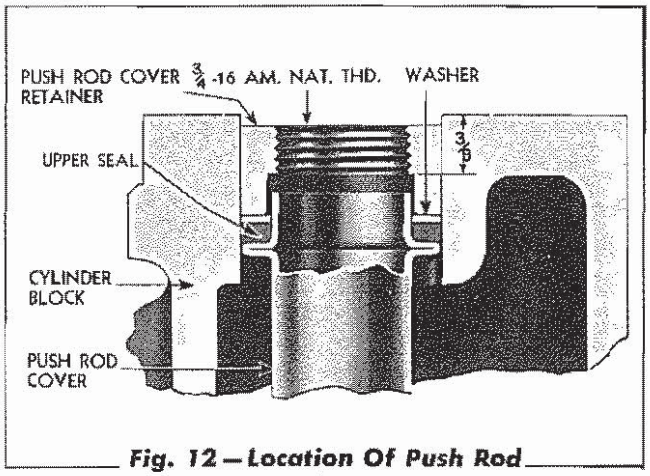


Fig. 12 — Location Of Push Rod Cover Retainer And Seal

1. Adjustment of valve lash.
2. Valve spring replacement.
3. Upper push rod assembly replacement (rocker arm, push rod, push rod seat, follower spring, etc.).
4. Lower push rod replacement.

The cylinder head must be removed to perform the following valve operations:

1. Replace a valve.
2. Replace a valve guide.
3. Grind or re-seat valves.
4. Replace a cam follower.
5. Replace lower push rod cover and seals.

C. Valve Lash Adjustment.

The correct clearance between the ends of the valve stems and the rocker arms is very important in a Diesel Engine because of the high compression pressures developed. Insufficient valve clearance will result in noisy engine operation and rapid wear on the valve mechanism. The proper valve lash is .009" with the engine at operating temperature.

After any mechanical work has been done which would disturb the valve setting, the valves may be set "cold" to .012" clearance so that the engine may be run and allowed to warm up to operating temperature in preparation to the final correct adjustment.

1. Remove the hood and the rocker arm cover.
2. Rotate the engine with the starter until the

injector rocker arm for one cylinder is down and the injector plunger is at the bottom of its stroke. The valves will then be closed and the valve rocker arms raised off the valve stems.

3. Check the clearance between the valve stems and the rocker arms. When adjusted properly a .009" feeler ribbon should pass between them with a slight drag. Adjust each valve by loosening the lock nut and turning the push rod clockwise to increase the clearance or counter clockwise to decrease the clearance. When proper clearance is obtained, tighten the lock nut on the push rod. Re-check the clearance to make certain the clearance was not changed by tightening the lock nut.

4. Rotate the engine and repeat the operation on the remaining cylinder. Replace the rocker arm cover and engine hood.

CAUTION: Whenever a push rod has been disconnected from a push rod clevis, the rod must be screwed back into the clevis the entire length of the thread before the engine is rotated. If this is not done, the piston may strike the head of the valve when the engine is turned, and damage to the piston, valve, or push rod may result.

D. Rocker Arm Removal, Inspection and Installation.

1. Remove the engine hood, clean all dirt from around the rocker arm cover and remove the cover.

2. Rotate the engine until all three of the rocker arms for one cylinder are in line.

3. Disconnect and remove the injector fuel lines. Place shipping caps on the fuel connectors to prevent dirt entering the fittings and to prevent fuel from running out of the fittings into the head.

4. Remove the two capscrews from the rocker arm shaft brackets. Remove the brackets from the shaft and remove the shaft from the rocker arms.

5. Loosen the lock nuts at the upper ends of the push rods and unscrew the rocker arms from the push rods.

6. Inspect the bushings inside the rocker arms for wear. Normal clearance between the shaft and the bushings is .001" to .0025" and must not exceed .004". Replace the bushings if they are excessively worn. After the bushings are installed, ream them to allow .001" to .0025" clearance with the shaft. Clean out the oil holes in the rocker arms, hollow bracket bolts, and rocker shafts with solvent, small wire, and compressed air. Smooth the ends of the rocker arms if they are worn and cupped by contact with the valve stems.

7. Lubricate the outside of the rocker arm shaft with light engine oil and install the rocker arms and the shaft by reversing the sequence of operations for removal. The center (injector) rocker arm can be identified by the ball stud and ball seat. Install each valve rocker arm on the shaft with the longest boss of each toward the injector rocker arm (toward the inside of the rocker arm assembly). Place the shaft brackets on the shaft with the machined side of each bracket toward the valve rocker arms.

8. Before tightening the capscrews in the rocker arm shaft brackets, hold the three rocker arms and the two brackets together so that, when the capscrews are tightened, a total of .004" to .006" clearance will be allowed between the rocker arms and the brackets. Excessive clearance between these parts will allow too much oil to emerge from between the rocker arms instead of being forced through the drilled oil passages in the rocker arms to lubricate the push rod and cam follower assemblies.

CAUTION: After a rocker arm has been disconnected from a push rod, be sure that, when reinstalled, the clevis on the rocker arm is screwed on the upper end of the rod until the end of the rod is flush with the inside of the clevis yoke. If it is not, the valve will open too far when the engine is turned and the piston will strike the valve, and damage to the valve, push rod, or piston will result.

E. Cam Follower and Lower Push Rod Removal, Inspection, and Installation.

Whenever any engine is removed for overhaul, it is desirable to remove the cam followers for inspection. This operation can be done as follows:

1. Remove the cylinder head (refer to "CYLINDER HEAD REMOVAL" in this section). Remove the governor (refer to "GOVERNOR REMOVAL," Section VI). Remove the engine blower (refer to "BLOWER REMOVAL," Section III).
2. Lift the lower push rods out of the cylinder block and pull the push rod cover retainers from position by screwing a 3/4" — 16NF thread bolt into the top of the retainers and using the bolt as a puller. Refer to Figure No. 12.
3. Remove the push rod covers, lower seals, washers and cam followers from the engine block.
4. After the cam followers have been removed, they should be cleaned in a solvent, thoroughly dried with compressed air, and inspected before being reassembled into the cylinder block.
5. The cam rollers must rotate smoothly and freely. If the cam rollers, bushings or pins are worn sufficiently to allow more than .005" radial movement of the rollers, the follower assemblies should be replaced. Rollers must be free of flat spots or scuff marks. The presence of such marks are indications that the rollers have not been rotating freely. If such marks exist on the rollers, inspect the cams on which the rollers have operated. If the noses of the cams are worn or scuffed, replace the camshaft. *NOTE:* New or solvent cleaned, bushing type cam follower assemblies must be immersed in clean lubricating oil for at least five minutes before installing the follower assemblies into the cylinder block. This will insure initial lubrication of the follower assemblies which is essential to satisfactory follower performance.
6. Install the lower push rods and cam followers in the block by first bolting the two cam follower retainers in place on the inside of the block, drop a cam follower assembly (saturated with oil) into each bore, guiding the roller into its notch in the retainer and against its cam on the camshaft.
7. Install the push rod covers as follows:
   a. Place a washer into each cavity above the cam follower assembly.
   b. Slip a seal on each end of the push rod cover and push the cover into place through the bore in the top of the block.
   c. With the seal already in place on the top flange of the cover, set a washer in place over each seal.
   d. Start a cover retaining plug squarely into the bore and tap it carefully down to 1/16" below the top surface of the block. A steel washer of the proper thickness placed on top of the plug will assist in driving the plug to the proper depth. With the plug in place, take hold of the push rod cover with pliers and try it for looseness; if it is loose, drive it down an additional 1/32" to tighten.
8. Drop a lower push rod into each cover with the convex end of the push rod down, contacting the cam follower assembly.
9. Install the cylinder head (refer to "CYLINDER HEAD INSTALLATION" in this section). Install the engine blower (refer to "ATTACH BLOWER TO CYLINDER BLOCK," Section III). Install governor (refer to "GOVERNOR INSTALLATION," Section VI).

F. Exhaust Valve Spring Removal and Installation.

Removal of the cylinder head is not necessary if disassembly of the exhaust valve springs only is desired. However, special care should be taken to prevent the valves from falling into the cylinders when the springs are removed. If this should occur, it would be necessary to remove the cylinder head in order to retrieve the fallen valve.

1. Remove the rocker arm cover and crank the engine until the piston is at the top of its stroke, which is indicated when the injector rocker arm is down.
2. Remove the injector fuel lines and install shipping caps on the fuel connectors to pre-

vent entrance of dirt and to prevent fuel oil from running out of the fittings into the head.

3. Remove the rocker arm and push rod assemblies as instructed previously in this section and with the use of a combination injector remover and valve spring compressor (or any other suitable tool), compress the valve spring. Remove the valve spring retainer split locks.

4. Remove the spring retainer, valve spring, and spring seat. Re-assembly of the valve should be completed before the valve springs are removed from the other cylinder.

5. The valve springs are re-assembled by reversing the sequence of operation for their removal. After assembly is completed, it is necessary to adjust the valve lash, time the injectors, and check for fuel line leaks after starting the engine.

G. Exhaust Valves, Guides and Seats, Removal and Installation.

When removal of the exhaust valves, guides, or valve seats is desired it will be necessary to remove the cylinder head from the engine.

1. Remove the cylinder head from the cylinder block (refer to "CYLINDER HEAD REMOVAL" in this section).

2. Remove the valve springs as previously instructed and remove the valves from the cylinder head. Place the valves in a rack so that they can be reinstalled to the same valve seat from which they were removed.

3. Clean the carbon from the valves and seats and ream the carbon from the valve guides with a valve guide cleaner. Refer to Figure No. 13.

4. Replace the valves if they are bent or worn. The valve stem diameter is .3415" to .3425"; the clearance between the valve stems and valve guides is from .001" to .003" when new and should not exceed .006".

5. If inspection shows that replacement of a valve guide is necessary it may be removed from the head by placing the head on wood blocks, a suitable distance above the top of the work bench, and driving the guide out from the top of the head with a valve guide driver.

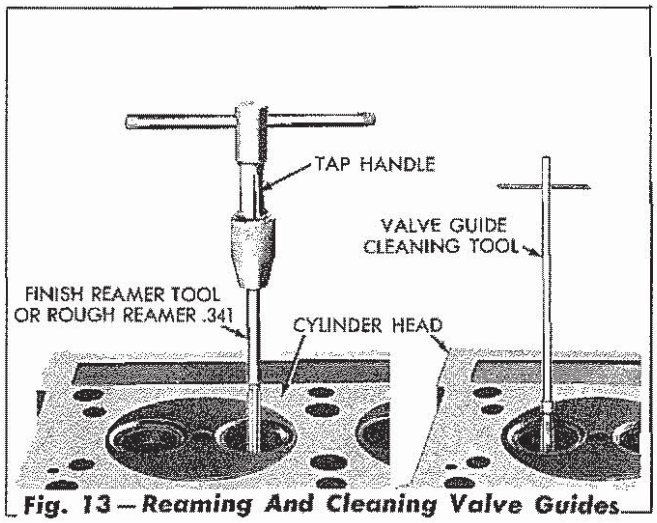


Fig. 13 — Reaming And Cleaning Valve Guides

6. New guides are installed by driving them into the head from the bottom, with the same tool used for their removal. A shoulder on the tool serves as a stop for properly positioning the guides in the head (refer to Figure No. 14). When the valve guides are properly installed, they will stand out 1⅝" above the top face of the cylinder head (refer to Figure No. 15).

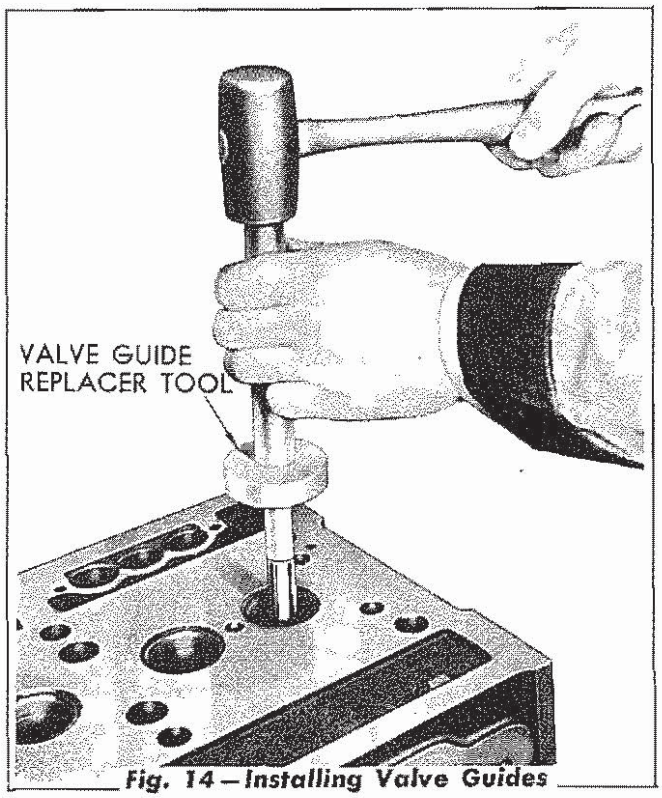


Fig. 14 — Installing Valve Guides

7. After the valve guides have been driven into position they must be reamed to size by use

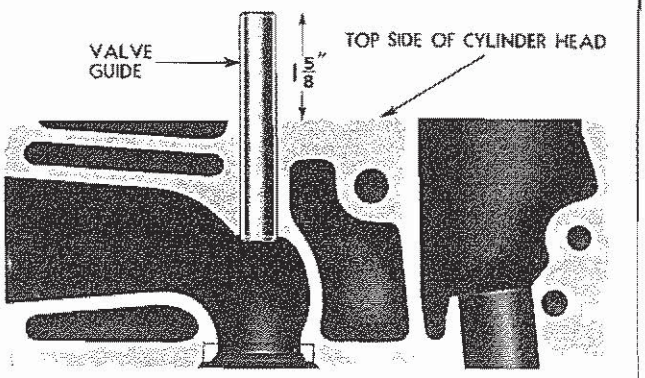


Fig. 15—Location Of Valve Guides

of the roughing and finishing reamers as shown in Figure No. 13.

8. Inspect the valve seats. If they are loose, cracked or pitted, new ones should be installed. The hardened seat inserts are shrunk into the cylinder head. To prevent damage to the head, they must be removed with a special tool provided for that purpose; also, unless the new inserts are installed with care, and according to the following instructions, the results will be unsatisfactory.

9. Remove the inserts as follows:

   a. Place the cylinder head on a bench and insert the collet of the remover tool in the valve insert so that the lip at the bottom of the collet flange is flush with the bottom side of the valve insert. Hold the collet in this position and expand the collet by turning the nut at the top of the tool. *Be sure that the flange of the collet is firmly entered just below the valve insert.*

   b. Slide the tool body over the top of the collet with the Allen screw of body in line with slot below the threads on the collet. Turn the Allen screw *IN* to engage the slot in the collet and lock the screw on the collet.

   c. Put the thrust bearing over the collet and on top of the body. Start the screw head on the threads of the collet and turn the head until the valve insert is pulled from its seat. Refer to Figure No. 16.

10. Particular care must be exercised when re-

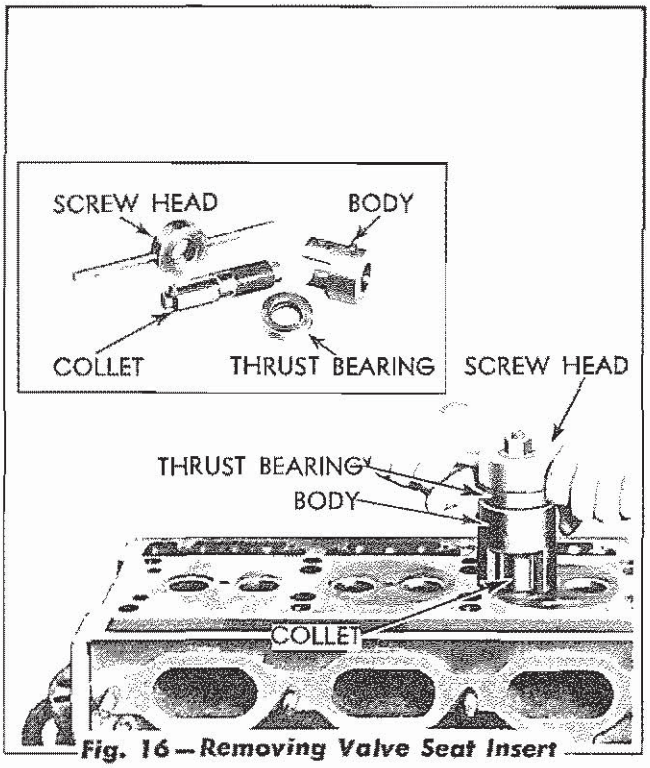


Fig. 16—Removing Valve Seat Insert

placing valve seat inserts. The inserts are installed in the head with a drive-shrink fit (.0025" to .005" tight), and must be started in place true with the counterbore in the head.

   a. Clean the cylinder head thoroughly, particularly the insert counterbores, and immerse the head for 30 minutes in water heated to boiling temperature, or pack the insert in dry ice for 30 minutes.

      NOTE: Several variations of this method of expanding the insert counterbores and shrinking the inserts exist, such as placing the head on a radiator or any other warm location and placing the inserts outside in cold weather.

   b. With the cylinder head bottom side up, lay an insert in the counter bore (valve side up) and drive it in position with the insert installing tool. Refer to Figure No. 17.

      NOTE: This operation must be done quickly while the insert is cold and the head is still warm. Do not allow the insert to become heated before it is driven into position.

11. Grind the valve seats and check them for

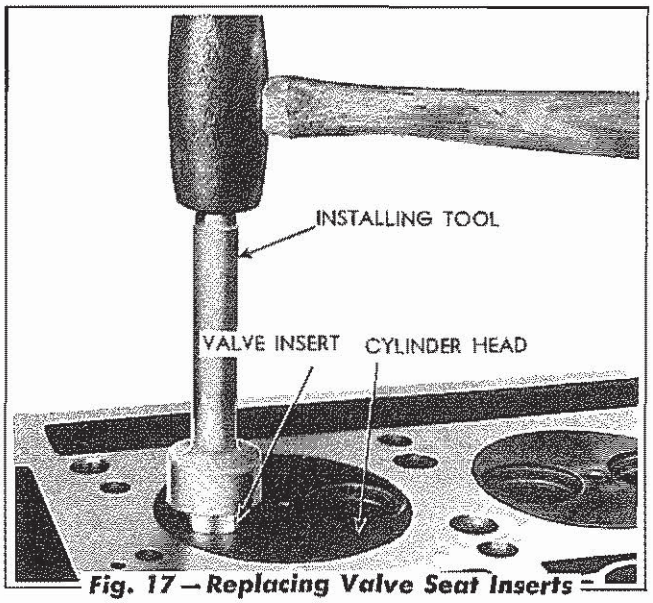


Fig. 17 — Replacing Valve Seat Inserts

concentricity with the valve guides, as outlined below:

H. Valve and Valve Seat Reconditioning.

1. Before either a new or used valve is installed, the seat for the valve should be examined for proper valve seating. Furthermore, if a 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. If the bore in the valve guide is worn oblong, or if the valve head is warped relative to the stem, the parts should be replaced.

2. The width of the valve seat must be between 3/64" and 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 grinding valve seats is ineffective for the operation because of the very hard insert material.

3. The usual equipment furnished with a valve grinding set consists of a grinder, dial gauge, pilot and three grinding wheels 30° — 45° — and 60°. The 45° grinding wheel is used for refacing the valve seats, the 30° and 60° wheels are used for narrowing the seats to the standard 3/64" to 5/64" width.

4. After the valve seats have been dressed with the grinding wheel, they must be checked for concentricity relative to the valve guides. This is done with a dial gauge, similar to

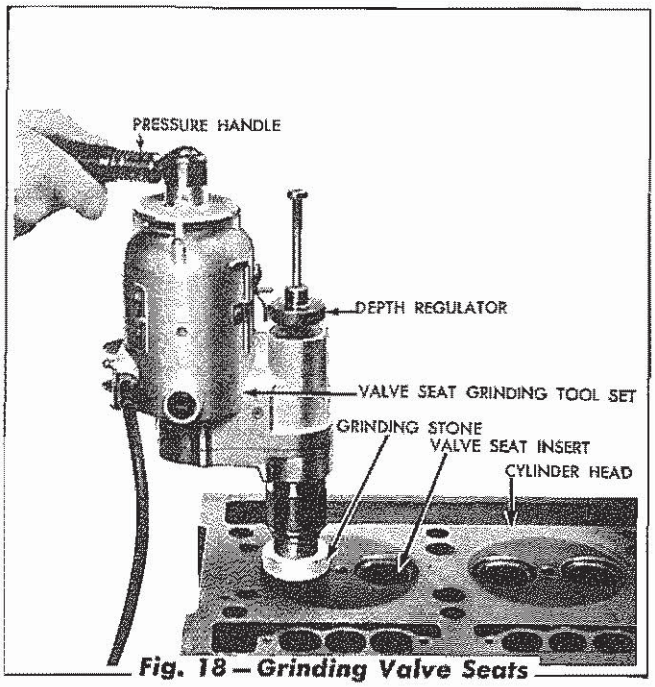


Fig. 18 — Grinding Valve Seats

the one shown in Figure No. 19. The total runout for a good seat must not exceed .002".

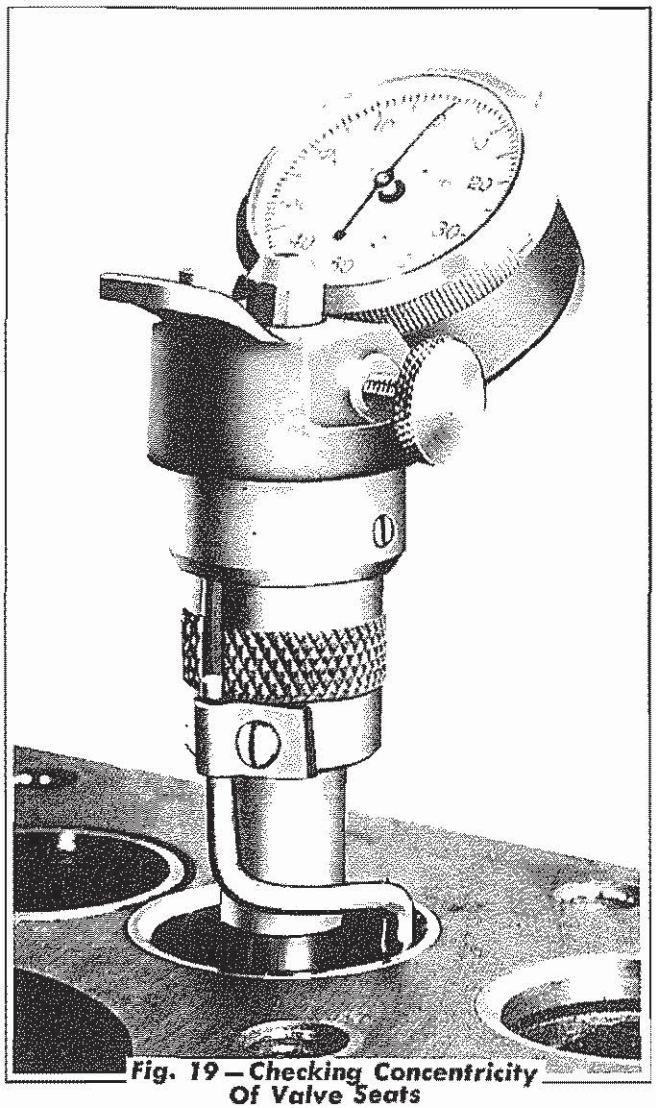


Fig. 19 — Checking Concentricity Of Valve Seats

5. After the valve seats have been ground several times, the seat diameter becomes enlarged allowing the valve to seat farther down in the head. In order to keep the central portion of the valve face in contact with the ground portion of the insert, and at the same time retain the 3/64" to 5/64" seat width, the seat must be narrowed.

   This is done by use of the 60° wheel to open the throat of the insert below the seat and the 30° wheel to narrow the seat from the top of the insert. Refer to Figure No. 20.

6. After the valve seats have been ground, checked for concentricity, and, if necessary, narrowed, the valves may be put in place and lapped in the regular manner to obtain perfect seats. After lapping, the contact between the valves and the seats may be checked by wiping a thin film of Prussian Blue on each valve seat, setting the valves in place, and bouncing each valve on its seat. If the valve seats have been properly ground, a continuous, thin, blue line will be evident around the face of the valve.

7. Clean the head and valves thoroughly after lapping and install the valves, holding them in place with a piece of tape fastened across the heads of the valves and the cylinder

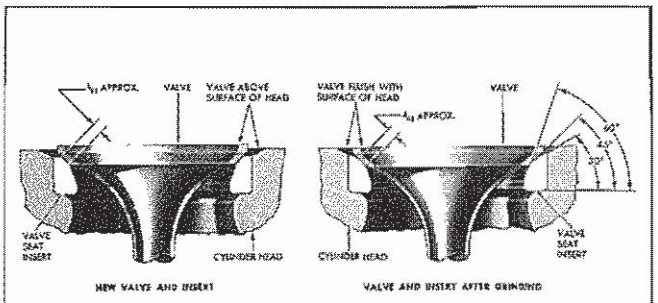


Fig. 20 — Valve And Insert Relationship

block. Then turn the head right side up and place a spring seat, spring, and spring retainer over each valve stem. Compress the springs and install split locks in position on the valve stems.

8. Install the other components in the cylinder head as follows:

   a. Insert the fuel injectors in the head, the dowel on the bottom of the injector body must enter the locating hole in the cylinder head. Place the injector clamps on the injector clamp studs and center the side arms of the clamps as well as possible in the machined recesses of the injector body. Drop the special washers over the studs with the rounded side of the washers down. Tighten the injector clamp nuts using 20 to 25 foot pounds torque.

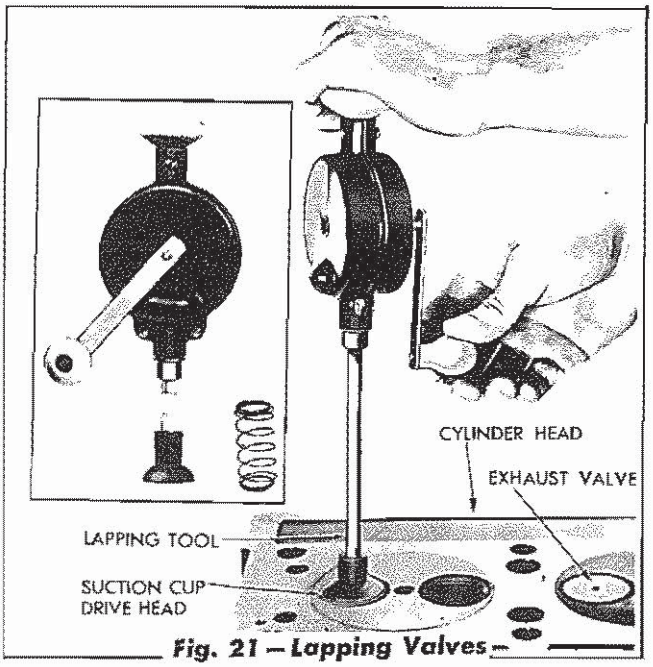


Fig. 21 — Lapping Valves

   b. Install the injector control shaft assembly engaging the control levers with the injector control racks.

   c. Inspect the bushings inside the rocker arms for wear. Normal clearance between the shaft and bushings is .001" to .0025" and must not exceed .004". Replace the bushings if they are excessively worn. After the bushings are installed, ream them to allow .001" to .0025" clearance with the shaft. Clean out the oil holes in the rocker arms, hollow bracket bolts, and rocker shafts with solvent, small wire, and compressed air. Smooth the end of the rocker arms if they are worn and cupped by contact with the valve stems.

   d. Place the upper push rod seats in position in the cylinder head. Lubricate the outside of the rocker arm shafts with light engine oil and install the rocker arm assemblies (complete with brackets, upper push rod assemblies, and rocker arm shafts) on the

cylinder head. The center (injector) rocker arm can be identified by the ball stud and ball seat. The valve rocker arms are installed with the longest boss toward the injector rocker arm (toward the inside of the rocker arm assembly). Install the shaft brackets with the machined side of each toward the valve rocker arms.

e. Before tightening the capscrews in the rocker arm shaft brackets, hold the three rocker arms and two brackets together so that, when the capscrews are tightened a total of .004" to .006" clearance will be allowed between the rocker arms and brackets. Excessive clearance between these parts will allow too much oil to emerge from between the rocker arms instead of being forced through the drilled oil passages in the rocker arms to lubricate the push rod and cam follower assemblies.

CAUTION: Make certain that the clevis on each rocker arm is screwed on the upper end of the push rod until the end of the rod is flush with the inside of the clevis yoke. If it is not, the valve will open too far when engine is turned and the piston will strike the valve, and damage to the valve, push rod, or piston will result.

9. Install the cylinder head on the cylinder block (refer to "CYLINDER HEAD INSTALLATION" in this section).

4. CYLINDER BLOCK AND LINERS

A. 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 rigidity and strength, insuring perfect alignment of the bores and bearings under all loads. The cylinders are bored to receive the cylinder liners.

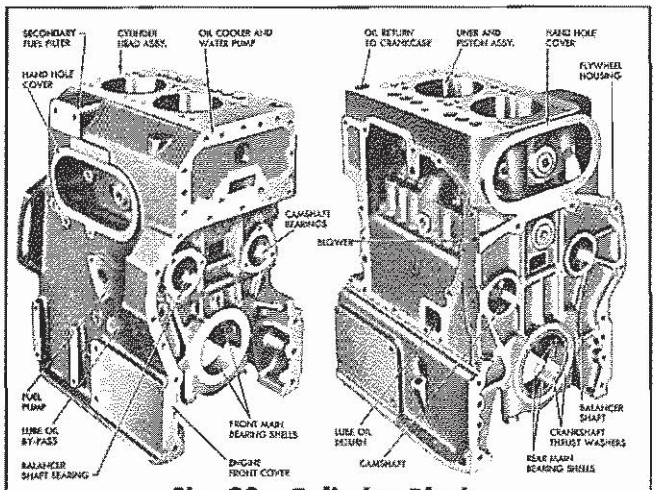


Fig. 22 — Cylinder Block

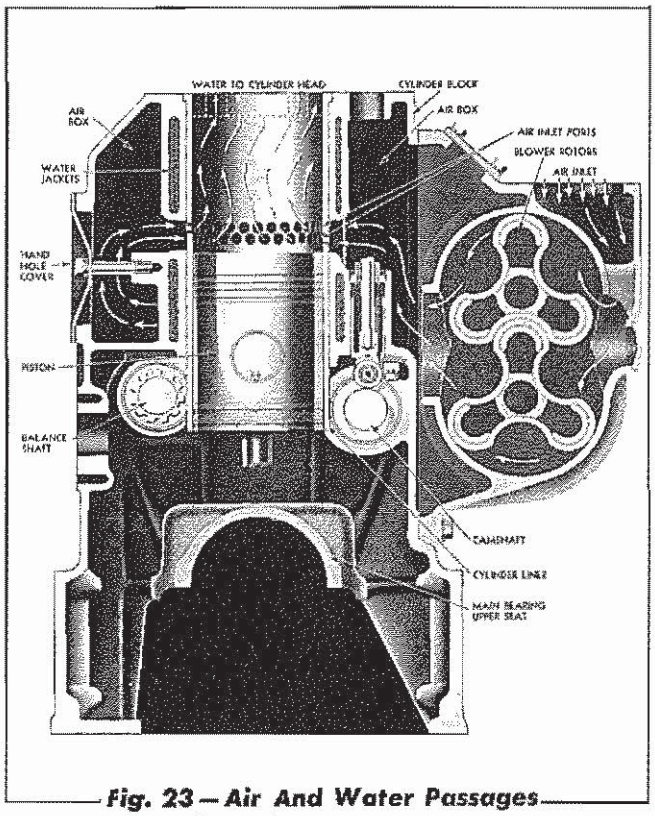


Fig. 23 — Air And Water Passages Through Cylinder Block

The water jackets extend the full length of the bores and are divided into upper and lower sections, which are connected by hollow struts. Coolant enters at the bottom of the water jacket, 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 (air box) which conducts the air from the blower to all of the inlet ports in the cylinder liners.

The upper halves of the main bearing seats are cast integral with the cylinder block. Drilled passages in the block carry lubricating oil to all in-

ternal moving parts. A hand-hole plate on the side of the block opposite the blower permits access to the air chamber, and inspection of pistons and rings through the intake ports in the cylinder walls. Cylinder blocks ordered for service are furnished with main bearing caps, studs, and the necessary plugs. Cylinder liners are serviced separately.

The replaceable cylinder liner, made of hardened alloy cast iron, is accurately honed to a very smooth finish. 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 cooling each liner over its entire length with water except at the ports. The liners are cooled at the ports by scavenging air from the blower. To permit introduction of fresh air into the cylinder, ports are drilled into the circumference of each cylinder liner. The engine may be equipped with liners having 2 rows of holes 5/16" in diameter, or liners having one row of holes 5/8" in diameter as shown in Figure No. 24.

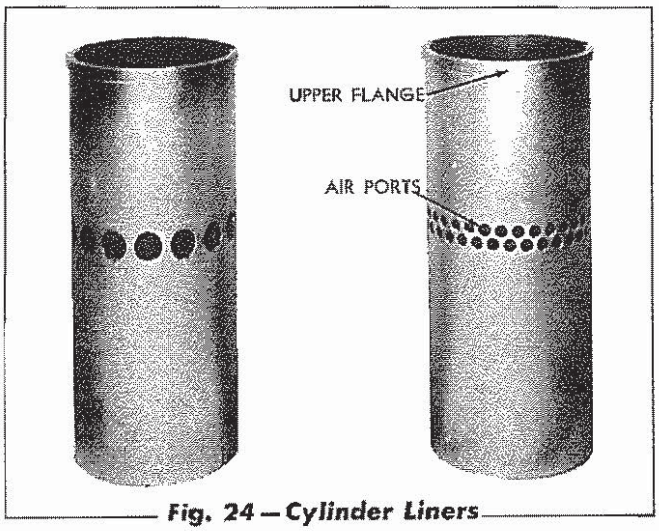


Fig. 24—Cylinder Liners

B. Cylinder Liner Service.

The cylinder liners will render satisfactory service for extended periods if the engine has proper care. The wear on a cylinder liner and piston is directly related to the amount of dust and dirt (abrasive) introduced into the engine combustion chambers through the air intake. Dust combined with lubricating oil on the cylinder walls forms an ideal lapping compound. To avoid such a condition the air cleaner provided on the tractor must be serviced regularly.

The air ports in the cylinder liners sometimes become clogged with sludge or hard carbon. Inspection should be made of their condition at least every 500 hours of engine operation, and if the openings are restricted as much as 30%, the ports should be cleaned as outlined in "Air Intake System," Section III. If the engine has been disassembled and the cylinder liners removed, the ports may be cleaned by inserting the pointed end of a piece of wood in each port and twisting. Avoid using a tool which will cause burrs around the ports on the inside of the liner.

An alternate method of cleaning air inlet ports is to soak the liner in a hot caustic soda or lye solution long enough to loosen the carbon deposits. Final cleaning can then be accomplished with a bristle brush.

C. Cylinder Liner Removal.

The liners will, in most cases, slide out of the block when the pistons are removed. Liners that stick in the cylinder block may be loosened and removed by placing the end of a hardwood block against the bottom of the liner and striking the block sharply with a hammer.

D. Cylinder Liner Cleaning and Inspection.

1. Remove all dirt, carbon, or grease from the liners and the liner bores in the cylinder block. Discard the liners if they are scored, cracked, or worn beyond the allowable limits. Slightly scuffed liners, if not worn, may sometimes be made usable by polishing or lapping to remove the surface irregularities. Clean the air inlet ports, removing any burrs made in the cleaning of the ports, with No. 250 grit emery paper. Failure to remove all the burrs from the inside of the liners can result in the early failure of an engine.
2. Check the liners for roundness, taper, and the amount of wear by means of a gauge similar to the one shown in Figure No. 25. Measure each liner for taper and roundness as outlined in the diagram in Figure No. 26. Do not install liners that have more than .001" taper or that are more than .0015" out of round when installed. Be sure that the liners slide into the cylinder block bores freely to insure a loose fit. If the bores in the block are in a tapered or out-of-round

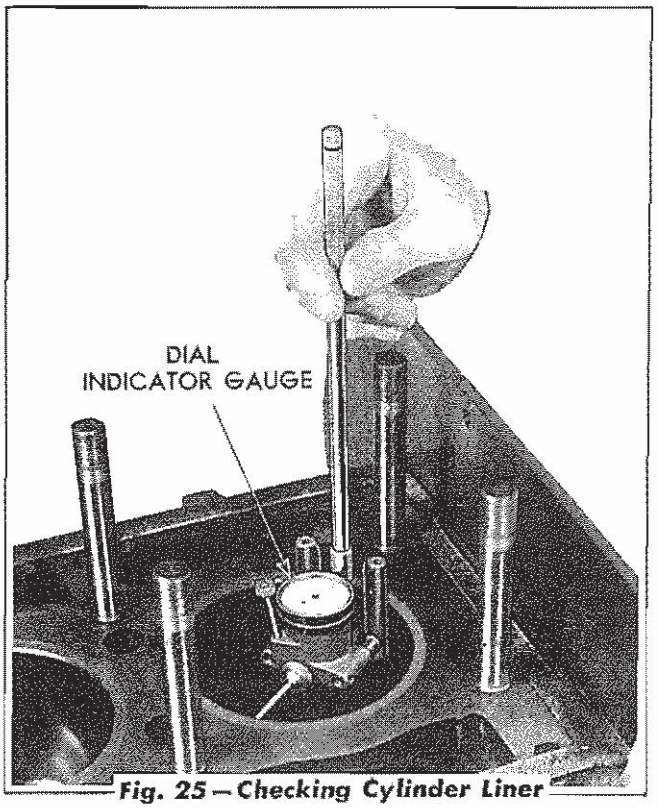


Fig. 25 — Checking Cylinder Liner

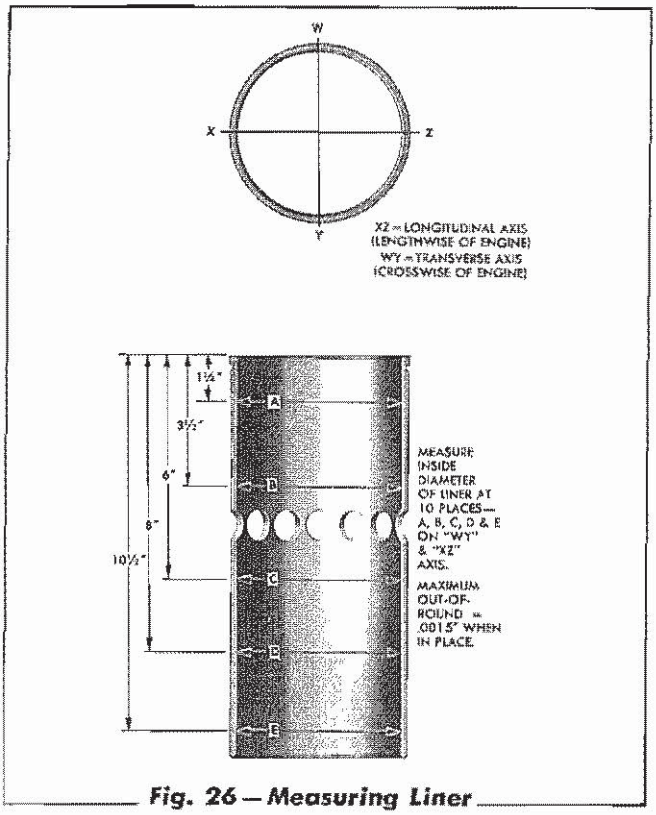


Fig. 26 — Measuring Liner

condition, they should be honed slightly with a fixed-stone hone to remove the high spots.

3. Measure the new liners after they are installed, in the manner described above. Due to their thin walls, it is possible for the liners to go out of round while in stock or through careless handling.
4. Refer to "FITTING PISTONS WITH LINERS" in this section, for fit of the pistons with the liners.

E. Cylinder Liner Installation.

1. Clean the liner and the bore in the cylinder head thoroughly making sure that the bottom of the flange on the liner and counterbore for the flange are clean.
2. Drop the liner in position and check the stand-out of the liner flange above the top surface of the cylinder block. This distance must be from .002" to .006" and the difference in stand-out between the two liners must not exceed .002".

   CAUTION: These dimensions must be held in order to obtain proper sealing of the cylinder head compression gasket, between the cylinder liner and the head, when the head is bolted in place.
3. If the height of a liner flange does not fall within the .002" to .006" range, or if the difference between the two liners exceeds .002", cylinder liner shims, made of shim steel .003" thick, must be installed accordingly. Before installing a cylinder liner shim, make certain that its surfaces are smooth and entirely free from burrs and wrinkles.

F. Cleaning and Inspection of Cylinder Block.

Since the cylinder block is the main structural part of the engine, whenever the engine is being overhauled, the block should be thoroughly inspected for any conditions that would render it unfit for further use. Such inspection must be made after all the parts have been removed from the block and it has been thoroughly cleaned with live steam or a suitable solvent and dried with compressed air.

Inspect the entire block for cracks or damage. If the cylinder liners are not to be changed and are left in the block, clean all the air ports in the liners as outlined in "AIR INTAKE SYSTEM," Section III.

All the oil passages in the cylinder block, must be cleaned before assembling the engine. Effective cleaning of these passages can be accomplished

only with the use of high steam pressure, with a solvent used in the water, to dissolve the sludge and foreign material that has collected, as these would not be removed if only a brush and solvent or similar cleaning method were used. Remove the various plugs at the ends of the oil galleries to clean the passages. After cleaning, flush the passages in the block with clean water under pressure to remove all traces of the solvent.

To clean the water jacket of the block, remove the brass plugs from the jacket. Apply high pressure steam and water through these openings; turn the block in various positions while this is being done so that the loose scale will be washed out.

IMPORTANT: Note the location of the plugs removed for cleaning of the oil and water passages in the cylinder block and make certain all these plugs are installed in their proper places after the block has been cleaned and dried. Coat the threads of all the plugs with white lead to insure a tight seal. The plugs must be installed so that they do not project from the block to interfere with the fit of the attached parts.

G. Air Box Drain Tubes.

Two drain tubes, one located under the engine blower housing and the other on the right side of the cylinder block, provide drainage from the air box of fuel oil and sludge that might otherwise collect in it. The tubes must be kept open at all times. Remove the tubes and elbows and clean them if clogging occurs. Air emerging from the tubes while the engine is operating will indicate that the tubes are open.

5. CRANKSHAFT, FLYWHEEL, AND MAIN BEARINGS

A. Description.

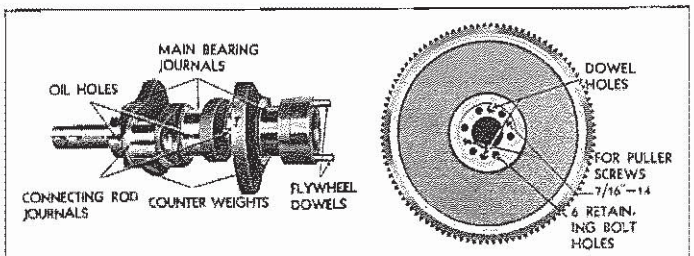


Fig. 27 — Crankshaft And Flywheel

1. **Crankshaft:** The rigid crankshaft is a high alloy steel drop forging, carefully heat treated to insure utmost strength and durability. All the main and connecting rod bearing journals are hardened and ground to a smooth finish of utmost wear-resistant quality. Complete static and dynamic balance of the rotating parts has been achieved by counterweights incorporated with the crankshaft as shown in Figure No. 27.

   The end thrust of the crankshaft is taken through two piece bronze washers on each side of the rear main bearing. The crankshaft is drilled for full pressure lubrication to the main and connecting rod bearings.

2. **Main Bearings:** There are 3 main bearings 3½" in diameter and 1⅛" long. These are of the precision type, 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 numbered and when removed should always be replaced in its respective position (numbers on bearing caps located on blower side of the engine).

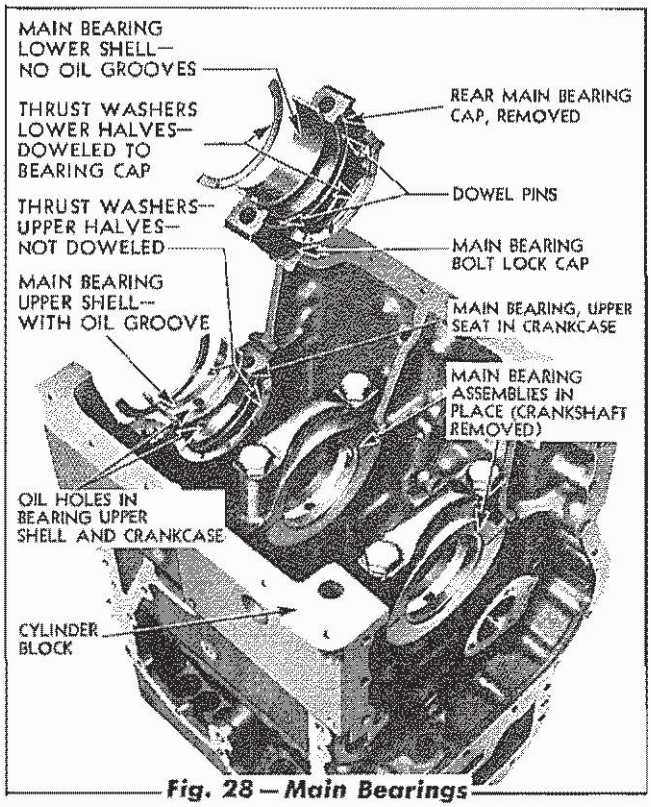


Fig. 28 — Main Bearings

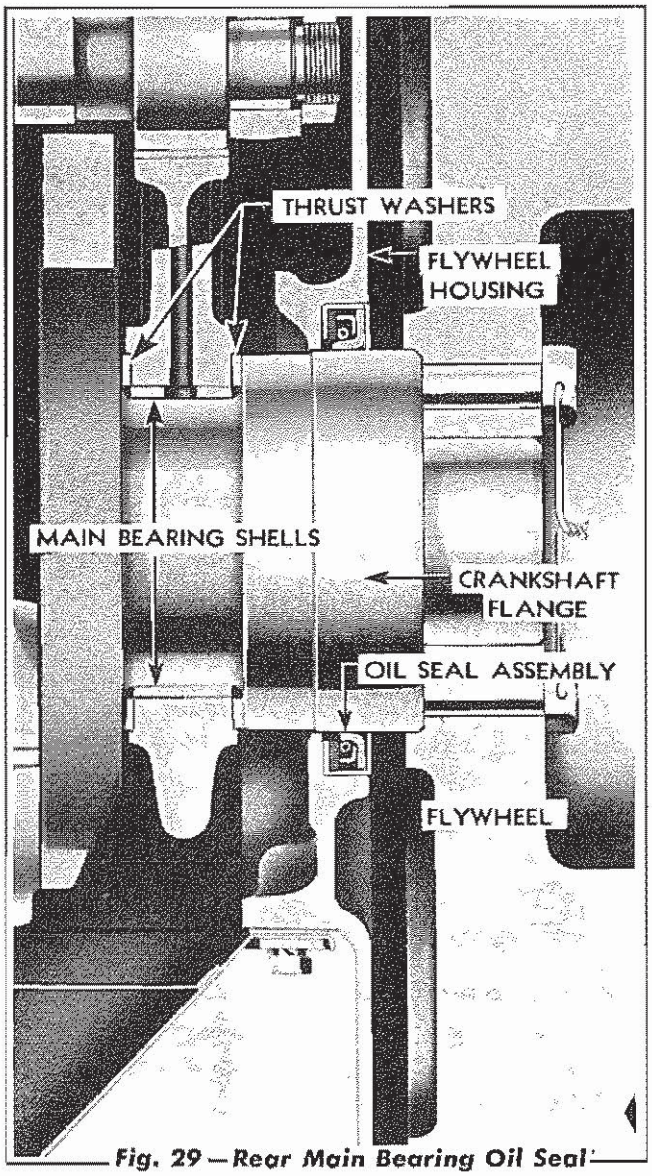


Fig. 29—Rear Main Bearing Oil Seal

The upper halves of the main bearing shells are seated in the crankcase. The lower halves are held in place by the main bearing caps, each of which is bolted to the crankcase 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 line-to-line fit between the bearing cap and bolt.

A spring loaded, lip type oil seal at the rear main bearing consists of a special treated leather ring (seal) set into the flywheel housing. The rolled-over inner diameter of the leather is held against the crankshaft journal by a coil spring, to prevent oil from creeping along the journal into the flywheel compartment.

A spring loaded, lip type oil seal is also used at the front main bearing. This seal is pressed into the timing gear cover; and the leather lip of the seal bears against a removable sleeve on the end of the crankshaft, next to the crankshaft gear.

3. **Flywheel:** The even torque of the engine permits the use of a relatively light, cast iron flywheel, which insures exceptional operating flexibility. The flywheel is bolted securely to a flange on the rear end of the crankshaft and doweled in two places. One of the capscrew holes is off-set and the flywheel can be attached to the crankshaft flange in only one position.

   A starter ring gear made from heat-treated steel is shrunk on the rim of the flywheel. A pilot bearing for the front end of the engine clutch shaft is pressed into a counterbore in the center of the flywheel.

   The engine clutch shaft front ball bearing (clutch pilot bearing), located in the flywheel, is lubricated by an oil wick assembly installed in the rear of the crankshaft.

B. Removal, Inspection, and Installation of Crankshaft:

1. Inspection can be made of the crankshaft main bearings and journals by removing the oil pan and removing the bearing caps one at a time (refer to "REPLACEMENT OF CRANKSHAFT MAIN BEARINGS" in this section). However, if the crankshaft has been damaged, removal of the engine will be required for its replacement. A complete inspection should be made of the other parts of the engine at the same time. After the crankshaft has been removed, inspect it as outlined in the following discussion.

2. Inspect the crankshaft for scoring, chipping, cracking, or signs of over heating. If the crankshaft has been overheated (usually indicated by discolored or blue bearing journal surfaces), or is scored or excessively worn, reconditioning or replacement will be required. Examine the bearing journals for cracks if overheating has occurred.

3. If oil leakage into the flywheel housing has

been noted, inspect the crankshaft at the point of contact with the lip of the rear oil seal. If the crankshaft is scored or excessively worn at this point, do not discard the crankshaft. An oil seal spacer is available and may be installed in front of the oil seal to change the contact position of the seal lip on the crankshaft.

If the rear oil seal is in good condition and the crankshaft is not worn at the point of contact with the oil seal, the presence of oil in the flywheel housing may be due to the oil wick assembly used in the rear of the crankshaft. The oil wick may be allowing too much oil to flow to the clutch shaft pilot bearing. The wick assembly must be replaced.

4. 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. The original diameter of the main bearing journals is 3.499" to 3.500", the connecting rod journals are 2.749" to 2.750".

5. All main and connecting rod bearings surfaces are hardened to a depth of approximately .0625". If regrinding becomes necessary, the work should be done by some reputable machine shop that has suitable equipment to handle precision work of this type. Main bearing inserts of .010", .020", and .030" undersize can be obtained, and if the crankshaft is ground, the diameter of the journals should be reduced in steps to .010", .020" and .030" below 3.500" to fit the undersize bearing shells.

6. Remove the slotted head pipe plugs from the crankshaft and blow out all the oil passages in the crankshaft with compressed air. Coat the threads of the plugs lightly with white lead when installing them and tighten them securely.

C. Main Bearing Inspection.

1. Any bearings that are scored, chipped, pitted, or worn beyond the prescribed limits given below must be replaced. Inspect the backs of the shells for bright spots. Bright

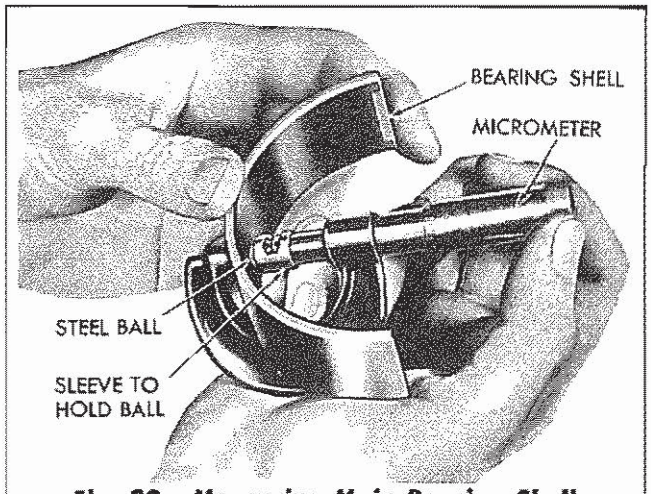


Fig. 30 — Measuring Main Bearing Shells

spots on the backs of the shells indicate they have shifted in their supports and are unfit for further use. If all shells are worn beyond the specified limit, they all must be replaced. Only the lower (non-grooved) shells are loaded and subject to wear; therefore, if the upper shells (grooved) are serviceable and not scored, the lower halves only may be changed. In a majority of cases, however, it will be wise to replace all the shells when rebuilding an engine.

2. The running clearance between the main bearing shells and the crankshaft journals is from .002" to .004" in a new engine. New bearing shells must be installed when this clearance exceeds .006". The amount of wear on the bearing shells may be determined by measuring each shell with micrometers as shown in Figure No. 30. New shells, measured at the point shown (C, in Figure No. 31) are .155" thick, and any variation from .155" will show the amount of wear on the particular shell being measured. Those less than .153" are worn beyond the allowable limits and must be replaced.

3. As will be seen from Figure No. 31, the bearing shells (when in place) are .001" larger in diameter at the parting line than they are 90° from the parting line. The 2 shells do not form a true circle when not installed and, when measured for inside diameter, they should be installed in the cylinder block and the caps bolted tightly in place (crankshaft removed). The 2 halves of the shells have a squeeze fit in the seat and cap, and must be

tight when the cap is drawn down. Draw each cap down with 180 to 190 foot pounds pull on a torque wrench. Drawing the caps any tighter will distort the bearings.

4. A recommended method of determining the running clearance between the bearings and journals is to insert a 1/32" diameter soft lead wire or foil across the center of each lower bearing shell by removing and replacing one bearing cap at a time. When the lead wire or foil insertions have been made, tighten the bearing cap bolts, to 180 to 190 foot pounds torque, thus "squeezing" the wire or foil to shim thickness between the shells and the crank journals. Remove the lead shims and measure them for thickness; the clearance between the shells and the journals should be from .002" to .006."

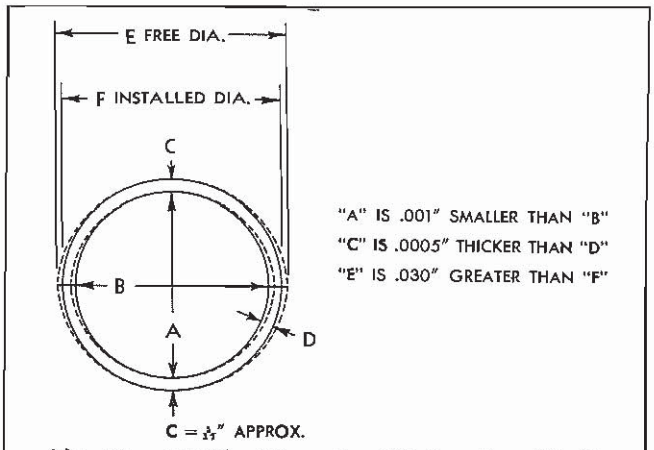


Fig. 31 — Inside Diameter Of Bearing Shells

5. Check the end thrust of the crankshaft, which is taken on rear main bearing. The minimum end play should be .004" to .011" and should not exceed .018"; replace the thrust washers if the play exceeds .018".

D. Main Bearing Replacement.

The main bearings may be replaced with the engine in the tractor as explained in "REPLACEMENT OF CRANKSHAFT MAIN BEARINGS" in this section. However, it is not advisable or recommended that the work be done in that manner except in emergency cases. Installation of the bearings with the engine disassembled is described in "ASSEMBLY OF ENGINE" in this section.

E. Replacement of Crankshaft Oil Seals.

Drive or press the oil seals from the flywheel housing and the timing gear cover and install new ones each time that the engine is disassembled. Use a flat piece of metal to press the new seals into place to prevent damaging the seal. The lip side of each seal should be toward the inner side of the housing and the cover. The lips must face each other when the housing and the cover are installed on the engine.

Effective on Engine Serial Number 2A-2129, the crankshaft incorporates an oil slinger to improve the oil sealing at the rear end of the crankshaft. This oil slinger can be made adaptable to engines prior to 2A-2129 by machining the flywheel housing opening, for the crankshaft, to 5½" diameter to provide clearance for the oil slinger. To facilitate installation, heat the slinger in oil approximately 250° F., then install it on the crankshaft so that the tapered side of the oil slinger is toward the rear of the crankshaft and is located 1-3/32" from the end face of the crankshaft.

NOTE: When the engine is being rebuilt it is recommended that the flywheel housing be reworked and the oil slinger be installed, particularly if excessive oil leakage at this point has been experienced.

F. Replacement of Pilot Bearing Oil Wick.

Turn the wick holder out of the crankshaft, then pull the wick out of the crankshaft. Since the outside diameter of the wick is approximately 5/64" larger than the inside diameter of the wick holder, difficulty has been experienced in the field when assembling the wick in the holder. Therefore, the complete assembly is recommended for replacement. The new wick assembly should be soaked in engine oil for 24 hours before it is assembled.

1. Coat the threads of the wick holder with "Permatex" or its equivalent, then insert the wick into the crankshaft and tighten the holder securely.

   It is important that the wick fits tightly in the hole in the crankshaft and also in the holder. Use a small punch and hammer to pack the wick tightly in the hole.

2. The flywheel end of the wick should extend out 5/8" from the rear face of the crank-

shaft. Trim the wick to this dimension if necessary.

3. Check the inner end (front end of the wick). The end of the wick should be flush with the crankshaft cheek. Trim the wick if necessary.

G. Flywheel, Ring Gear, and Pilot Bearing Inspection and Replacement.

To remove these parts from the engine with it assembled in the tractor, it is necessary to remove the engine clutch and clutch housing (refer to "ENGINE CLUTCH REMOVAL," Section X).

1. **Flywheel:** Inspect the clutch wearing surface of the flywheel and make sure that the surface is flat and smooth. If it is scored and heat checked it may be machined smooth. Replace the flywheel if more than 1/16" stock must be removed to smooth it up.

   It is very important that all burrs and nicks be removed from the front surface of the flywheel that fits up against the flange of the crankshaft. If the surface is not smooth and true, the flywheel will have a slight wobble which will result in improper clutch operation, clutch wear, and engine vibration.

2. **Ring Gear:** Inspect the flywheel ring gear for general condition and wear. Replace the gear if it is not in good condition. Remove the ring gear from the flywheel by grinding a notch through the ring at the root of one of the teeth, then expand the ring and drive it from its position. Do not attempt to remove the ring gear without first expanding it. To install a ring gear, proceed as follows:

   a. The ring gear is shrunk on the flywheel by uniformly heating the gear to 400° F. (red heat visible in the dark), then placing it in position on the flywheel which is at room temperature. *NOTE:* Do not heat ring gear to a bright red as the heat-treatment of the gear will be destroyed.

   b. After heating, start the ring gear on the flywheel so that, when the flywheel is installed, the chamfered ends of the teeth on the ring gear will face the cylinder block. These ends of the teeth engage the pinion of the starter. Drive the ring gear down tight against the shoulder on the flywheel. Allow ring gear to cool slowly. Do not cool it by using water.

3. **Engine Clutch Shaft Pilot Bearing:** Replace the bearing in the flywheel if the balls or the races are worn, corroded, or rough, or if bearing does not roll freely and smoothly. Remove the bearing with an ordinary bearing puller; install the bearing by starting it into place, then using a driver or tube, that will provide for driving against the outer race, drive it into place.

6. PISTONS AND CONNECTING RODS

A. Description of Pistons.

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

To add strength, rigidity, and cooling effect, the head of each piston is cast with ribs on the inside and is connected to the piston pin bosses by vertical struts placed at right angles to the piston pin. The ribbed head (inside of the piston), 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 the 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 of the bottom of the piston skirt to balance the piston.

Each piston is fitted with six cast iron rings of the conventional cut-joint type. Four 1/8" wide, tin-plated, grooved, compression rings are placed above the pin and two 3/16" wide special oil-

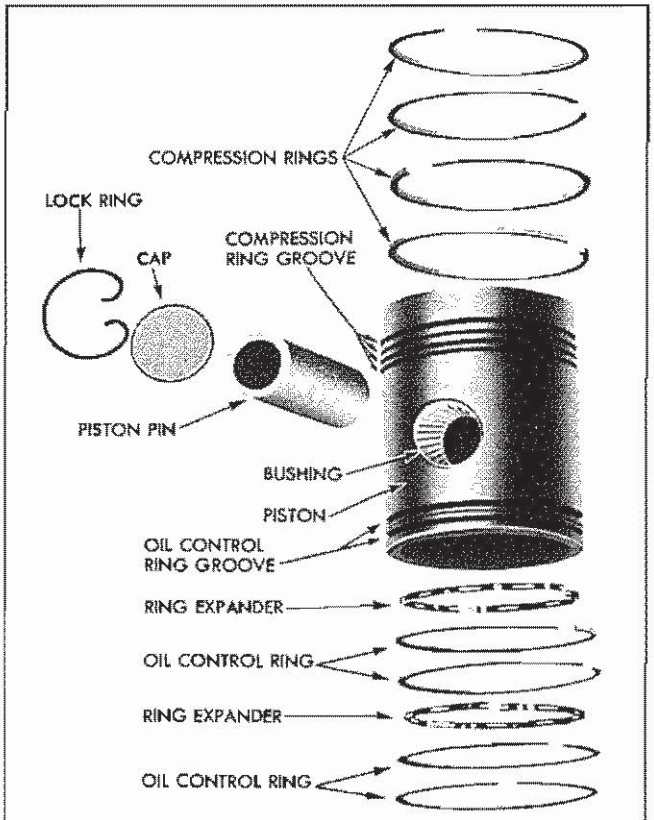


Fig. 32 — Piston Assembly Details

control rings are placed below the piston pin. On later engines the top compression ring is a chrome plated ring identified by the letter "K" stamped near the ring gap.

B. Description of Connecting Rods.

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 the under side 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.

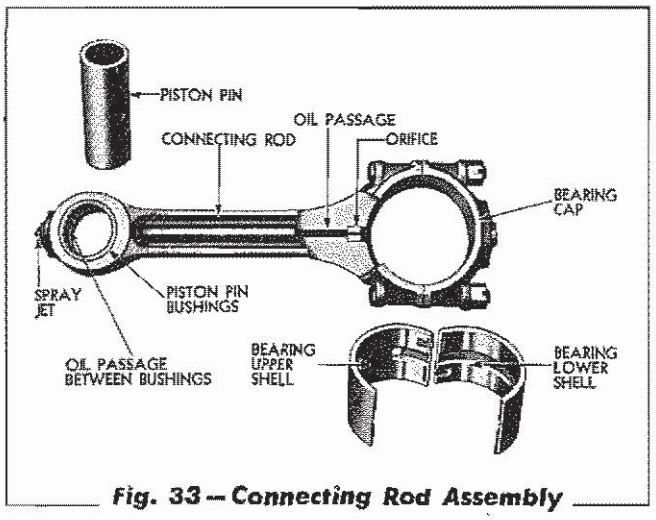


Fig. 33 — Connecting Rod Assembly

The connecting rod bearings are precision type, without shim adjustments. The upper and the lower halves of the connecting rod bearing shells 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 are always in line with the oil holes in the crankshaft, thereby providing a constant supply of oil through the hollow connecting rod to the piston pin bearings and the spray nozzle at the top of the connecting rod.

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

C. Service.

The piston and connecting rod are so closely associated from a service standpoint that one cannot be entirely separated from the other; the two will, therefore, be treated collectively in the following discussion on pistons and connecting rods.

The removal and installation of pistons and connecting rods and the replacement of connecting rod bearings is described in "REPLACEMENT OF PISTON AND CONNECTING ROD," also, in "DISASSEMBLY OF ENGINE" and "ASSEMBLY OF ENGINE" in this section.

A certain amount of inspection to determine the condition of the pistons and the piston rings can be made by removing the hand-hole cover from the side of the engine block and directing a strong light through the air inlet ports in the cylinder

liners. Scored liners may be detected in this manner with the piston at the bottom of its stroke and the air inlet ports uncovered; the pistons may be inspected for score marks or for worn, stuck, or broken rings as each piston is moved upward. The presence of the original tool marks on the piston ring surfaces indicates negligible wear.

The upper part of the piston (above the upper compression ring) is not tin plated 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 on the outside. A thick coating of carbon indicates failure of the cooling oil supply and necessitates the cleaning of the oil passages and of the spray nozzle in the connecting rod.

D. Removal of Connecting Rod and Rings From Pistons.

1. Using a pair of small nose pliers, remove the spring clips at each end of the piston pin.
2. Tap the piston on a wood block and remove the cap and pin through the open pin hole. If the steel cap lodges in the groove for the spring clip, it may be readily removed with a rubber suction cup such as is used for lapping valves.
3. To avoid breaking the piston rings, the use of a ring remover tool is advised when removing or installing piston rings. Care must be taken not to overstress the piston rings by spreading the ends more than is necessary to remove the rings from the piston. Before removing the rings from the pistons, they should be inspected for wear and for the amount of side clearance in the grooves. However, their removal will be necessary in most cases in order to clean the carbon from the grooves.

E. Piston and Piston Ring Inspection.

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

The coating on the skirt of the tin-plated piston is thin and the presence of this coating will, therefore, indicate the absence of wear. If, however, the tin coating is worn off in spots, a careful examination should be made for score marks or other indications of improper piston clearance. A badly scored piston should be discarded.

Examine the inside of the piston for cracks across the struts or ribs. Such cracks make the piston unfit for further use.

Check the piston for wear by inserting the piston in the cylinder liner and measuring the clearance of the piston with the liner. The standard clearance is from .004" to .0072". The piston skirt diameter of a new piston is 4.2433" to 4.2455"; the inside diameter of a new cylinder liner is 4.2495" to 4.2505". Deviations from these measurements will indicate the amount of wear on the piston or liner. The piston or the liner or both must be replaced if the clearance exceeds .010".

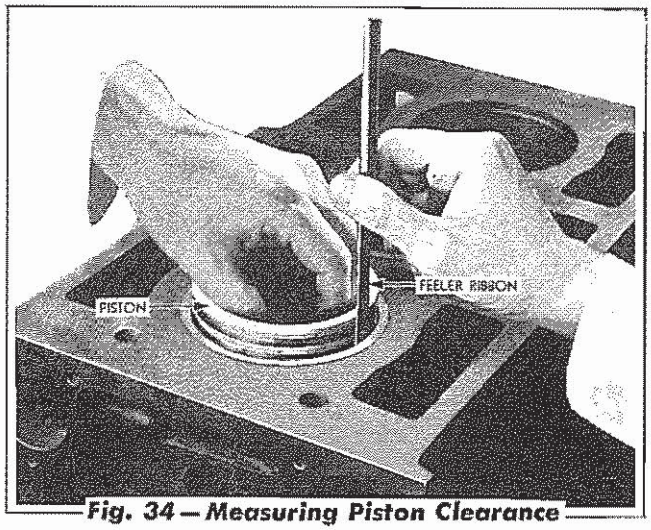


Fig. 34—Measuring Piston Clearance

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 when the engine is again assembled.

The piston pin bushings in the piston are not serviced. A maximum clearance of .010" between the pin and the bushings is allowable. If they are worn beyond this limit, the piston will, in practically all cases, also be worn beyond the limits and require replacement. New pistons include these bushings already installed and reamed to the proper size.

F. Inspection of Connecting Rod Assembly.

After washing the connecting rod assembly in clean solvent or fuel oil, the bushings at the upper end, oil passages, spray nozzle, etc., should be examined.

1. Measure the outside diameter of the piston pin to determine the wear. The standard dimension for the piston pin diameters is 1.500" to 1.4998".
2. The standard inside diameter of the bushing in the connecting rod is 1.5025" to 1.503". These dimensions of the pin and bushings provide a clearance of .0025" to .0032". Clearances up to .010" are permissible. If the wear is close to or beyond this limit, replace the connecting rod bushings (see "REPLACEMENT AND REAMING OF PISTON PIN BUSHINGS IN CONNECTING ROD" in this section).
3. Open the holes in the orifice at the lower end, and the spray jet at the upper end of the connecting rod and blow dry compressed air through the oil passage in the rod. *BE SURE THAT ALL OIL PASSAGES ARE OPEN.*
4. Inspect the connecting rod bearing shells at the lower end of the rod for scoring, chipping, corrosion, cracking, or signs of overheating. Discard shells if any of these conditions are apparent. The backs of the shells should also be inspected for bright spots, and discarded if any bright spots are found as this condition indicates that the shells have been moving in their supports.
5. Inspect the bearing shells for wear. The connecting rod bearing load is on the upper half of the shell. Any wear, therefore, will show only on the upper half. The inside diameter of the shells when installed in the rod is 2.752" to 2.753". The shells may be measured for wear in the same manner as the main bearing shells (refer to "CRANKSHAFT, FLYWHEEL, AND MAIN BEARINGS" in this section). Shells that measure less than .153" at the center should be discarded and new ones installed in their place.

G. Fitting Pistons With Liners.

Measurements of the pistons and the liners and running clearances between the pistons and the liners should be taken at room temperature (70° F.). *PISTONS MUST BE FITTED TO THEIR RESPECTIVE LINERS TO PROVIDE A RUNNING CLEARANCE OF NOT LESS THAN .004".* Insufficient clearance will result in premature failure of these parts.

Measure the liners as described in "CYLINDER LINER CLEANING AND INSPECTION" in this section. The bore of the liners must be round within .001" and the pistons must also be round within .001". Measure each piston its full length both crosswise and parallel with the pin. Measure each liner over its entire length at corresponding points.

Use a .003" feeler ribbon 12" to 18" long to measure the clearance between the pistons and the liners. The ribbon must be perfectly flat and free of nicks or scratches. Hold the feeler ribbon along the side of the cylinder liner wall, then with rod connected to the piston, insert the piston into the liner in running position. With a .004" clearance between the piston and the liner, the .003" feeler ribbon can be withdrawn with a slight pull (not to exceed 6 pounds). Refer to Figure No. 34. Test the clearance at the ends of the piston pin and at points 90° from the ends of the pin. If a bind exists in one place only, turn the liner 90° in the block and check the clearance again. This sometimes eliminates the binding. Also inspect for slight burrs on the piston or the liner if binding exists. Remove the burrs with a honing stone or fine emery paper.

If, after removing the burrs, the piston still fails to fit properly, wire brush the piston area uniformly below the ring lands with a medium bristle wire brush. Continue the brushing until the specified clearance is obtained. Brushing the piston in this manner will remove part of the material with which the piston is coated.

Pistons and cylinder liners are furnished in standard size only. If complete piston and liner kits are ordered for replacement purposes, each piston will be fitted for its respective liner, however, the running clearance should be rechecked as outlined above before installation of the parts. Keep the pistons with their respective liners to be sure they will be installed in the same manner as received.

H. Fitting Piston Rings.

The gap between the ends of the piston rings should be measured before the rings are installed on the pistons. Select the rings that are to be used on each piston and fit them one at a time in the cylinder in which they are to operate. Use a piston to push the ring squarely into the cylinder so that it is parallel with the cylinder head. Push the ring far enough down in the bore to be on the travel area of the cylinder liner when the piston is installed. Check the ring gap with a feeler ribbon as shown in Figure No. 35.

The specified gap of the "chromium plated" piston compression ring, used in the top position, is .025" to .040". *NOTE:* This ring should never be filed to open the gap because the plating might be loosened by the file and later distributed through the engine or might cause scoring of the piston and cylinder liner.

The specified gap of the "tin plated" piston compression rings, used in the 2nd, 3rd, and 4th positions from the top of piston, is .025" to .035". File the ends of these rings with a flat mill file if necessary to obtain the correct gap. Remove any burrs made by filing.

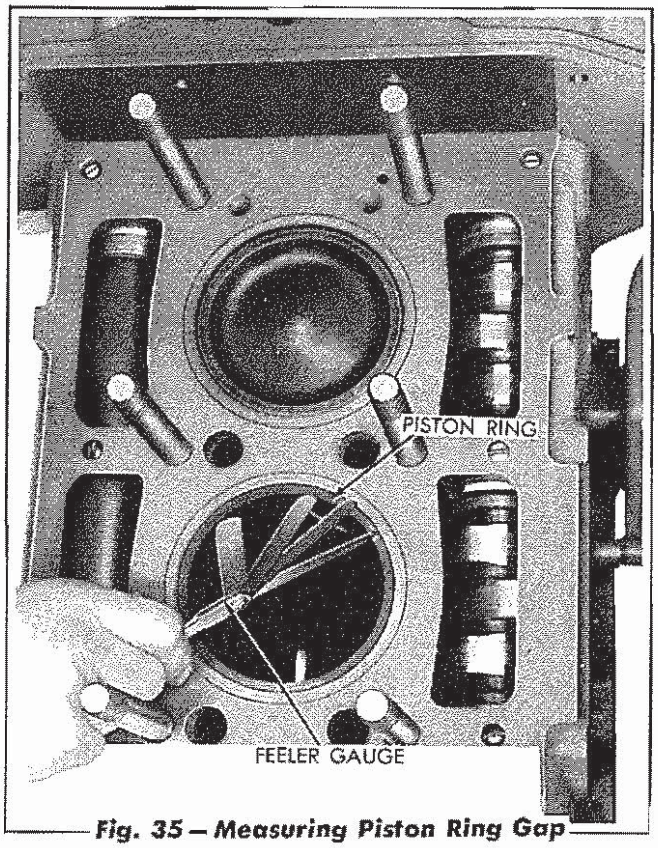


Fig. 35 — Measuring Piston Ring Gap

The piston compression ring-to-groove clearances (top of ring to top of groove) using a new piston and new rings are as follows:

Top Ring (chromium plated)	.010" to .0125"
2nd Ring	.008" to .0105"
3rd and 4th Ring	.006" to .0085"

The piston oil control ring gap specification is .010" to .020". The oil control ring-to-groove clearance (top of ring to top of groove) is .0015" to .0055".

After the rings have been fitted for proper gap, install them on the piston. The oil control rings are the 3-piece type and must be installed in the two lower grooves in the piston skirt in the position shown in Figure No. 32. The expanders must be installed first, then the rings, with the scraper edges down and the chamfered edges toward the top of the piston. This is important to control piston lubrication properly. Stagger the ring gaps evenly around the piston and apply oil to the rings and the pistons before installing them in the cylinders.

IMPORTANT: When installing the rings on the pistons, the rings should not be spread so the gap is opened beyond 1¼". Opening the gap beyond this limit might distort the ring and cause it to take a set, contributing to ring breakage.

I. Replacement and Reaming of Piston Pin Bushings in Connecting Rod.

1. Remove the bushings from the connecting rod with the driving bar and driver block as shown in Figure No. 36.
2. Install the new bushings, pressing one into each side of the connecting rod, with outer end of each bushing flush with the outer edge of the rod and with the joints of the bushings toward the top of rod. This will leave an oil space of approximately 3/16" between the bushings.
3. After the bushings have been installed, they must be reamed. The special reaming fixture and reamer shown in Figure No. 37 must be used to insure proper alignment of the piston with the rod and to obtain proper clearance of the piston pin with the bushings.
   a. Place the bore at the lower end of the rod over the arbor on the fixture, and

draw the bearing cap up tight.

b. Slide the bushing into the rear guide boss of the fixture, with the hollow end facing the slot in the fixture for upper end of the connecting rod.

c. Rotate the connecting rod into position for reaming so that the upper end of the rod rests on the boss of the tool bed.

d. Install the bushing on the reamer. Insert the reamer into the front guide boss and turn it clockwise with a uniform motion. Do not crowd the reamer too hard as better results will be obtained by moderate pressures when turning.

e. After reaming, inspect the bearing between the bushing and pin. If the bushings have been properly reamed, the clearance between the piston pin and bushing will be .0025".

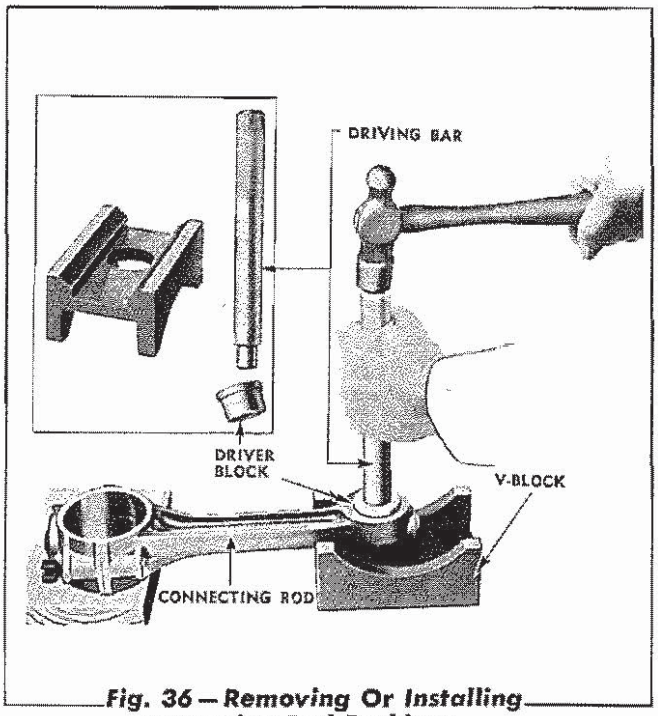


Fig. 36 — Removing Or Installing Connecting Rod Bushings

J. Assemble Connecting Rod and Pistons.

1. Install one of the piston pin retainers and a lock ring in one end of the piston pin hole.
2. Insert the upper end of the connecting rod into the piston. Lubricate the piston pin with light oil and slide the pin through the piston and rod. The pin will slip easily into place without forcing if it has been correctly fitted.
3. Install the second retainer and the lock ring at the opposite end of the pin.

IMPORTANT: Install the piston pin retainer lock rings so that the offset in the tips of the rings will bear against the retainers. This is necessary to keep the retainers from turning and also to hold the retainers tightly in position, thus, preventing oil returning from the sprayed piston head and through the grooves in the piston bushings from reaching the cylinder walls.

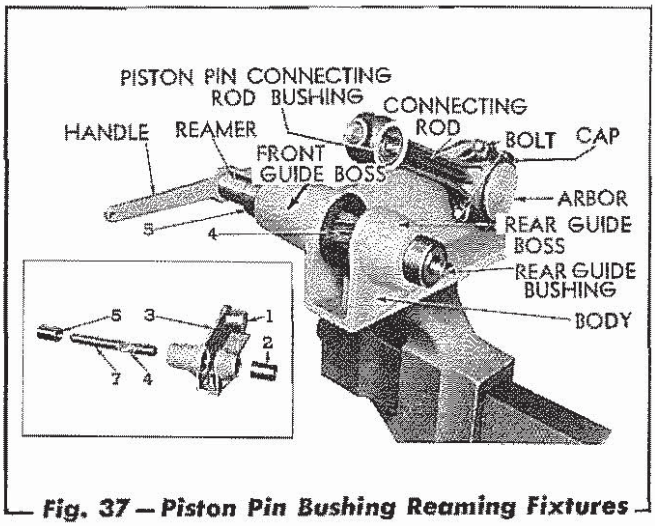


Fig. 37 — Piston Pin Bushing Reaming Fixtures

7. CAMSHAFT AND BALANCER SHAFT

A. Description.

The camshaft is a one-piece drog-forging, case hardened at cams and journals and is located in the cylinder block at the top left-hand side of the crankcase. The balancer shaft runs parallel with the crankshaft through the right-hand side of the cylinder block with the center line slightly higher than that of the camshaft. One-piece steel-back,

copper-lead bearings, replaceable without machining, support the camshaft at the ends and center journals, whereas the balancer shaft is supported at the ends only by bearings identical to those used on the camshaft. A thrust plate is used between the gear and the front end journal on both cam and balancer shafts. This plate is locked to the cylinder block by three retaining screws. Refer to Figure No. 38.

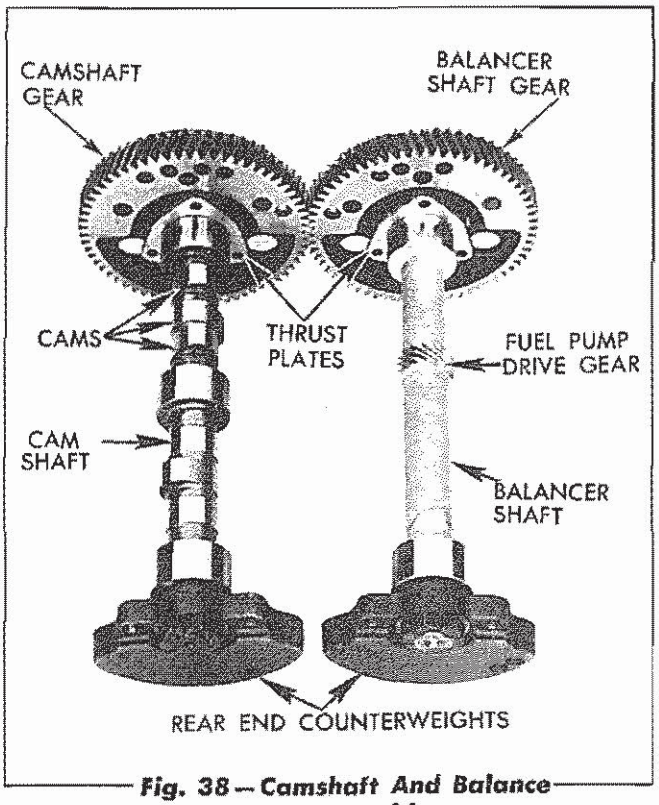


Fig. 38 — Camshaft And Balance Shaft Assembly

Counter-weights are pressed onto the rear ends of both camshaft and balancer shaft. The rear counter-weights are keyed to the shafts at 180° out-of phase with counterweights riveted to the gears on the front ends of the shafts.

A helical gear, machined integrally with the balancer shaft, provides a drive for the fuel oil pump. The camshaft and balancer shaft bearings are drilled and grooved for lubrication. The bearing shells are pressed into the cylinder block with the drilled holes indexed with the cylinder block lubricating oil passages, which connect all camshaft and balancer shaft journal bosses.

B. Service.

If removal of the camshaft or balancer shaft gear is required, the operation may be best performed, in most cases, by removing the engine from the tractor (refer to "ENGINE REMOVAL AND INSTALLATION" in this section). When this is completed, the operation may be performed as follows:

C. Remove Camshaft and Balancer Shaft.

1. Remove the engine oil pan and the oil pump assembly (refer to "OIL PUMP REMOVAL" in Section V).
2. Remove the cylinder head (refer to "CYLINDER HEAD REMOVAL" in this section).
3. Remove the lower push rods and cam follower assemblies (refer to "CAM FOLLOWER AND LOWER PUSH ROD REMOVAL" in this section).
4. Remove the engine clutch housing and engine clutch (refer to "ENGINE CLUTCH REMOVAL" in Section X).
5. Remove the starter from the flywheel housing. Remove the capscrews attaching the flywheel to the crankshaft. Using two 7/16" — 14 puller screws, 3" long and threaded for at least 2¾" in the puller holes in the flywheel, push the flywheel off the crankshaft dowels by turning in the puller screws. Support the weight of the flywheel when removing it from the crankshaft.
6. Remove the capscrews attaching the flywheel housing to the block and remove the housing.
7. Remove the fuel pump and fuel pump drive (refer to "REMOVAL OF FUEL PUMP AND DRIVE SHAFT ASSEMBLY FROM ENGINE" in Section II).
8. Remove the engine front cover (refer to "REMOVAL OF ENGINE FRONT COVER" in this section).
9. Wedge a clean cloth between the camshaft and the balancer shaft gears to prevent the shaft from turning. Remove the balance weight lock nuts. If the gears are to be removed from the shaft, loosen the gear lock nuts at this time. (DO NOT REMOVE.)
10. Pull the balance weights from the rear ends of the shafts using tapped holes for the puller-bar screw.
11. With a socket wrench inserted through the

holes in the web of the gear, remove the three thrust-plate bolts from the cylinder block at the front end of both the camshaft and the balancer shaft.

12. Withdraw the camshaft or balancer shaft or both from the front end of the engine, carefully guiding the shafts through the bearings.

D. Inspect Camshaft.

The camshaft gear, cams, bearings, followers, and thrust plates should be inspected. After the parts have been cleaned, the cam and journal surfaces must be examined. All working surfaces must be smooth, with no rough spots, scores, or scratches. Small scratches, or scores, may be stoned smooth. However, if the shaft is badly damaged, it must be replaced.

The thrust plate between the gear and front end journal must have .004" to .008" end clearance. Thrust surfaces must be smooth. Scored or scratched plates necessitate replacement.

The camshaft bearings have a nominal journal clearance of .004" to .006". The worn clearance should not exceed .0075". Bearings over the worn limits, or with cracked or corroded copper-lead, must be replaced. All bearings should be replaced at the same time to maintain uniform journal clearances. Otherwise, the bearing load would be largely carried on the new bearing, causing rapid wear.

If the cams are damaged, the cam followers should be inspected. Remove the bolts, follower guides, and cam followers from the bottom of the cylinder block and inspect (refer to "CAM FOLLOWER AND LOWER PUSH ROD REMOVAL, INSPECTION AND INSTALLATION" in this section).

The balancer shaft journals, thrust plates, and bearings, are the same as those of the camshaft; therefore, inspection should be made in a similar manner. The fuel pump drive gear, machined integrally with the balancer shaft, should be inspected for nicked, scored, or broken teeth. If the gear is badly damaged, the balancer shaft must be replaced.

E. Remove Camshaft and Balancer Shaft Gears and Thrust Washers.

1. Remove the camshaft lock nut.
2. Place the camshaft in an arbor press and press the camshaft out of the gear. The thrust plate is now loose on the camshaft.

Removal of the above parts from the balancer shaft may be made in the same manner.

F. Assemble Camshaft and Balancer Shaft Gears and Thrust Washers.

Camshaft gear teeth are right-hand helix. Balancer shaft gear teeth are left-hand helix. The camshaft gear has two timing marks, an "X" and an "O"; the balancer shaft gear is stamped with an "X" only. Refer to Figure No. 40. With these identifying marks in mind:

1. Remove all dirt and burrs from the camshaft side of the gear hub face, as well as from the thrust plate, spacer shoulder on camshaft, and Woodruff Key.
2. Place the thrust plate on the camshaft as shown in Figure No. 38.
3. Start the camshaft gear on the camshaft, with the balance weight side out. Be sure the camshaft key is in line with the keyway in the gear.
4. Using an arbor press, press the gear into place against the shoulder on the shaft.

G. Remove Camshaft and Balancer Shaft Bearings.

The bearings at each end of the cam and balancer shaft and the bearing at the center of the camshaft are all press fitted into the cylinder block and may be removed by driving or pressing endwise on the bushing with a suitable tool. Use care when removing the bushings not to damage the bearing bore in the cast iron block.

H. Install Camshaft and Balancer Shaft Bearings.

The cam and balancer shaft bearings *must be PRESSED* into place. *DO NOT ATTEMPT TO DRIVE THEM.* The tool may be a screw type puller with suitable pilot and arbor.

1. Start the center bearing into its seat by hand so that the oil hole in the bearing is in line with the oil passage in the cylinder block, then force the bearing into the block until

the bearing is recessed 1/32" in the boss.

2. Inspect the bearing oil hole. It must line perfectly with the oil hole in the block, as shown in Figure No. 39.

3. Assemble the remaining camshaft as well as balancer shaft bearings in a similar manner. Bearings are precision finished to obtain proper journal clearances when pressed into the cylinder block; no reaming is required.

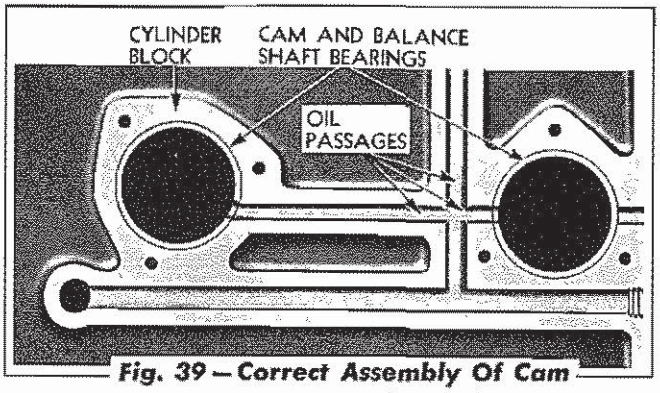


Fig. 39 — Correct Assembly Of Cam and Balancer Shaft Bearings

I. Installation of Camshaft and Balancer Shaft.

The camshaft and balancer shaft, thrust plates, and gears must be assembled before installing the shafts in the block.

1. Oil the camshaft journals and bearings. With the engine laying on the exhaust manifold side, push all the cam followers into the guide holes in the cylinder block.

2. Rotate the crankshaft until the No. 1 crankpin is on top dead center.

3. Assemble the camshaft to the engine. Insert the rear journals through the front bearings; carefully slide it through the center bearing to its proper position in the rear bearing. Avoid bumping the bearings with the cams as the copper-lead bearings may be burred or scored.

   DO NOT POUND THE CAMSHAFT. Bearing clearance is such that camshaft journals can be pushed freely through the bearings. If a bind should develop, remove the camshaft at once and determine the cause; perhaps one of the bearings has been burred and should be scraped lightly until smooth.

4. Before the front camshaft bearing is pushed into place, rotate the camshaft gear until its timing mark, "O," is indexed correctly with the crankshaft gear timing mark (refer to Figure No. 40).

5. Slide the gear and camshaft into place with the "O" timing mark at the root of the camshaft gear tooth in line with the "O" timing mark on the tooth of the crankshaft gear; at the same time engage the blower gear.

6. In a similar manner to the above, install the balancer shaft with the "X" timing mark on the balancer shaft gear in line with the "X" timing mark on the camshaft gear. Check the gear train timing.

7. Bolt the camshaft and balancer shaft thrust plates to the cylinder block.

8. Install the camshaft and balancer shaft front lock nuts, tightening the nuts to a torque wrench pull of 250 to 275 foot pounds. Before tightening the nuts wedge a clean cloth between the gear teeth to prevent turning of the assemblies.

9. Check the gear lash for clearance. The clearance between all gears should be between .002" and .007".

J. Install Camshaft and Balancer Shaft Rear Balance Weights.

1. Inspect the shafts for proper position of the keys in the seats.

2. Tap the balance weights into place on the shafts until they are seated against the face of the rear journal of the camshaft and balancer shaft. The overhanging face of the balance weights must project *AWAY* from the engine.

3. Install lock nuts as described in item "8" above, and reassemble the engine by reversal of the sequence of operations used in disassembling.

8. GEAR TRAIN

A. Description.

Located at the front end of the engine is the train of four helical gears, shown in Figure No. 40. The gear train consists of the crankshaft gear, camshaft and balancer shaft gears, and the lubricating oil pump drive gear.

The camshaft and balancer shaft gears mesh together and run at crankshaft speed. Two blower gears, which are driven from the camshaft, operate at twice crankshaft speed. The lubricating oil pump drive gear, driven from the crankshaft gear, runs at 1.45 times crankshaft speed.

The crankshaft gear, pressed and keyed to the crankshaft, is held against a shoulder on the crankshaft by a sleeve and spacer. The camshaft and balancer shaft gears are located by keys and assembled to the shafts with a press fit. Blower and oil pump gears will be described under "Blower," and "Lubricating Oil Pump," respectively. Balance weights on the camshaft and balancer shaft gears are single steel plates attached securely with rivets. Thrust loads of the camshaft and balancer shaft gears are absorbed by bronze thrust washers bolted to the cylinder block.

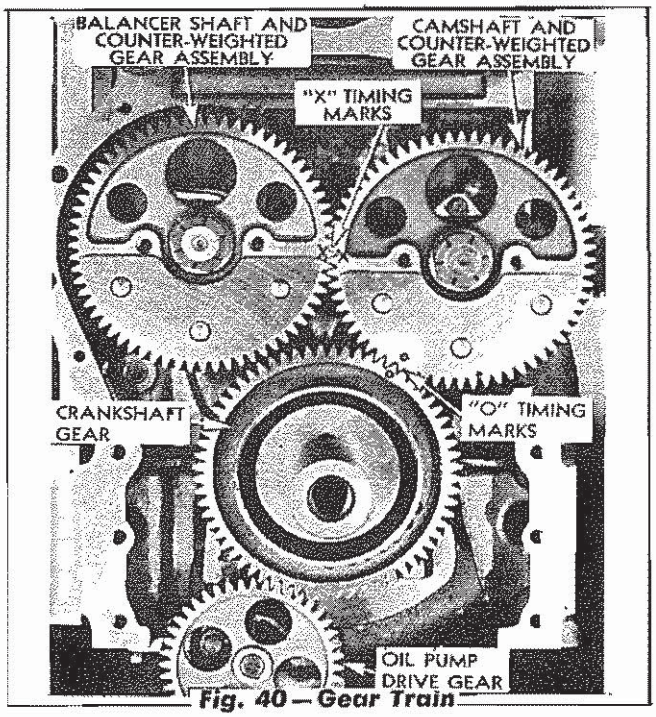


Fig. 40 — Gear Train

The balancer shaft and camshaft must, of course, be timed with respect to the crankshaft. This is accomplished by correctly indexing the timing marks stamped on the gears, as shown in Figure No. 40.

The gear train, including the blower gears and the blower front bearings, is lubricated by oil draining from the cylinder head.

B. Service.

Disassembly of the gear train is described in the discussion of the various parts to which assemblies the gears belong; i.e., camshaft and balancer shaft gears are dealt with under "CAMSHAFT AND BALANCER SHAFT," Topic 7 in this section.

The helical gear train will give trouble-free operation for long periods when properly assembled. Wear, which proceeds very slowly, will, of course, result in gear noise. Nominal backlash between mating gears is .002" to .007" throughout.

The entire gear train is exposed for inspection by the removal of the engine front cover.

C. Removal of Engine Front Cover.

With the engine removed from the tractor, the front cover may be removed as follows:

1. Loosen the belt tension adjusting bracket at the generator and remove both driving belts, then remove the front engine support from the engine.
2. Remove the fan and generator drive pulley from the front end of the crankshaft.
3. Remove the blades of the cooling fan by taking out the four bolts holding the blade assembly to the hub.
4. Remove the oil pan and the bolts of various sizes holding the front cover to the cylinder block and blower. Note carefully the location of the various size bolts.

   Wires to the battery charging generator must be disconnected and the generator and mounting bracket lifted from place when removing the two cover retaining bolts which support the generator.
5. With the crankshaft pulley spacer under the oil seal still in place, tap the cover gently

off the two dowels and away from the cylinder block. Remove the cover and the crankshaft pulley spacer.

6. Clean the cover thoroughly in fuel oil or solvent and scrape all traces of the old gasket from the cover and cylinder block.

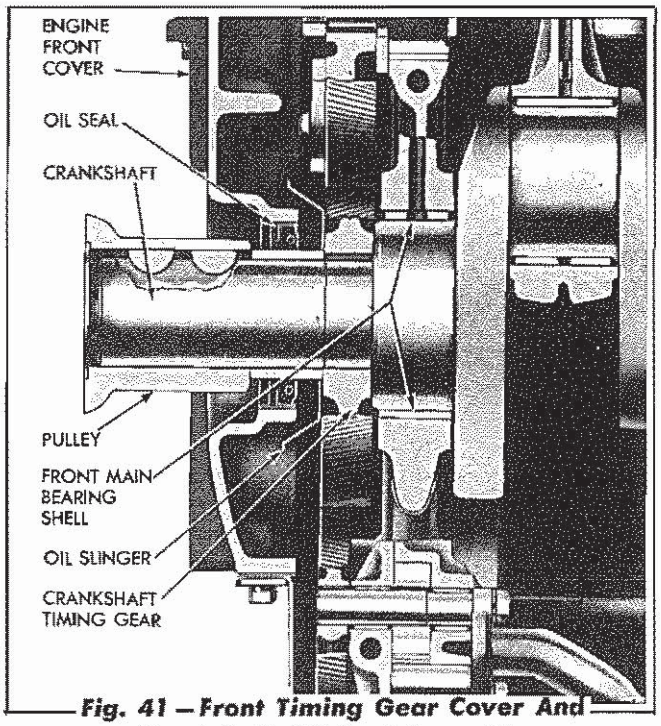


Fig. 41 — Front Timing Gear Cover And Crankshaft Oil Seal Assembly

If the oil seal in the cover is worn, cracked, or shows evidence of leaking, it should be replaced.

D. Remove Crankshaft Front Oil Seal From Gear Cover.

To remove the oil seal from the gear cover, support the inner face of the gear cover on wood blocks at least 1" high, and with a suitable tool, slightly smaller in diameter than the outer diameter of the oil seal assembly, drive the seal assembly from the gear cover.

If this operation is performed with care, the seal assembly will not be destroyed. However, if the old seal is *NOT* to be used again, it should, nevertheless, be driven straight away from the cover so that the bare in the cover will nat be damaged and the new seal will seat properly.

E. Install Crankshaft Front Oil Seal Into Gear Cover.

1. See that the bore in the cover for the seal is not damaged.
2. Position the seal assembly so that the sealing edge of the leather points toward the inside of the cover and start the seal into the cover by hand.
3. Support the gear cover on wood blocks at least 1" high, inner face down, and drive the seal into the cover, flush with inner face, with the same tool that was used for removal.

   A small amount of non-hardening gasket cement may be spread in the bore of the cover before driving the seal into place. *CAUTION: Do not get cement on the face of the seal.*

F. Installation of Engine Front Cover.

1. Using a non-hardening gasket cement, cement a new gasket into place on the flange around the cylinder block and blower.
2. Carefully guide the cover into place over the crankshaft and onto the dowels in the cylinder block. Tap the cover snug against the gasket.
3. Coat the crankshaft pulley spacer with lubricating oil and slip it over the crankshaft and through the oil seal by hand.
4. Refer to Figure No. 42 for the sizes and location of the attaching bolts and install the bolts. Be sure to reinstall the battery charging generator and its mounting bracket at the upper left corner of the front cover. Tighten the cover retaining bolts securely.

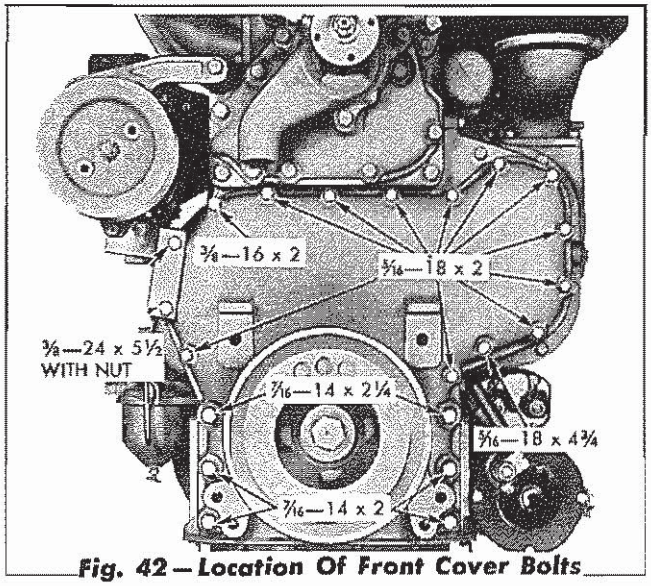


Fig. 42 — Location Of Front Cover Bolts

5. Install the crankshaft Woodruff Keys, the crankshaft pulley, retaining bolt washer, and retaining bolt. Tighten the bolt securely.
6. Using a new gasket if necessary, install the oil pan.
7. Replace the blade assembly on the cooling fan and the two drive belts around the pulleys on the crankshaft, cooling fan, and generator and adjust the belt tension (refer to "DRIVE BELT ADJUSTMENT" in Section IV).

9. REPAIR OF ENGINE WHILE INSTALLED

A. General Information.

Repair or replacement of the crankshaft, camshaft and bearings, balance shaft and bearings, timing gears, and the rear crankshaft oil seal requires the removal of the engine from the tractor. Practically all other parts can be removed and new parts installed with the engine in the tractor, however, IT IS UNWISE PRACTICE TO REPLACE THE CYLINDER LINERS, PISTONS AND CONNECTING RODS, OR THE MAIN AND CONNECTING ROD BEARINGS WITHOUT REMOVING THE ENGINE AND TAKING IT INTO A CLEAN SHOP WHERE IT CAN BE DISASSEMBLED AND ALL PARTS THOROUGHLY CLEANED AND INSPECTED BEFORE THE NEW PARTS ARE INSTALLED. THERE ARE SEVERAL REASONS WHY THIS SHOULD NOT BE DONE, NAMELY:

1. Failure of the parts, needing replacement, may be due to clogged or restricted oil passages or gritty substances in the engine. If the oil passages are not properly cleaned or if all abrasive material is not removed by thorough cleaning, failure may again occur within a short period of operation after the new parts are installed.
2. If some parts have become worn or damaged to the point where replacement of these parts is required, it is only reasonable to assume that other parts may also be worn and, if not replaced at the same time, will result in further shut-down within a short time.
3. When new main and connecting rod bearings are required, the camshaft bearings and balancer shaft bearings must also be inspected at this time, and if excessively worn, they must be replaced. The oil pressure may remain low and the new bearings or pistons and rings may not receive sufficient lubrication, if the camshaft and the balancer shaft bearings are worn close to or beyond the allowable limits and are not replaced.
4. It is impossible to keep the engine or parts clean and free from dust or foreign material if the repair work is performed in the open.

The following procedures describe the replacement of the pistons and the connecting rods, and the main and connecting rod bearings. These instructions are given to provide for emergency repairs when it is impractical to move the tractor to a shop.

B. Replacement of Piston and Connecting Rod.

1. Remove the hood.
2. Remove the cylinder head (refer to "CYLINDER HEAD REMOVAL" in this section). Cover the cylinder head and the top of the engine to prevent dust from blowing on the exposed parts.
3. Remove the engine crankcase guard, then drain the oil from the crankcase and remove the oil pan.
4. Remove the oil pump from the engine block (refer to "OIL PUMP REMOVAL" in Section V).
5. Pull the cotter pins and remove the nuts and the bearing cap from each connecting rod in turn and push the piston and the connecting rod assembly out through the top of the cylinder block. Reassemble the bearing caps on their respective connecting rods as they are removed.
6. Inspect, disassemble, and reassemble the pistons and connecting rods as required. Refer to "PISTONS AND CONNECTING RODS" in this section.
7. Inspect the bearing journals of the crankshaft for scoring, checking, or signs of overheating. If any of these conditions exist, the crank-

shaft will require reconditioning or replacement.

8. Install the pistons and the connecting rods as explained in "ASSEMBLY OF ENGINE" in this section. Be sure that all parts are clean before they are installed.

9. Install the oil pump assembly and the oil pan and fill the crankcase with new oil. Refer to "OIL PUMP INSTALLATION" in Section V.

10. Install the cylinder head and the hood. Refer to "CYLINDER HEAD INSTALLATION" in this section.

11. Check the engine oil pressure immediately after starting the engine and be sure that the pressure is within the normal range before operating the tractor.

C. Replacement of Crankshaft Main Bearings.

1. Remove the hood and the valve rocker arm cover.

2. Close the fuel shut-off valve under the tank, and remove the injectors (refer to "INJECTOR REMOVAL" in Section II). Removal of the injectors is necessary to relieve the compression and allow free turning of the engine and crankshaft.

3. Remove the engine crankcase guard, then drain the oil from the crankcase, and remove the oil pan.

4. Remove the oil pump assembly from the engine block (refer to "OIL PUMP REMOVAL" in Section V).

5. Remove the main bearings caps and install the new inserts *one at a time*. Do not fully tighten the caps until all the bearings have been installed. The lower shell can be removed from the bearing cap after the cap is removed. Remove the upper shell as follows:

   a. Insert a 1/4" x 1" capscrew with a head 7/16" in diameter and 1/16" thick into the crankshaft main bearing oil hole, then revolve the crankshaft in the direction that will turn the head of the bolt against the end of the bearing shell that has no locking tang. Continue to turn the shaft until the shell has been pushed out of position, as shown in Figure No. 43.

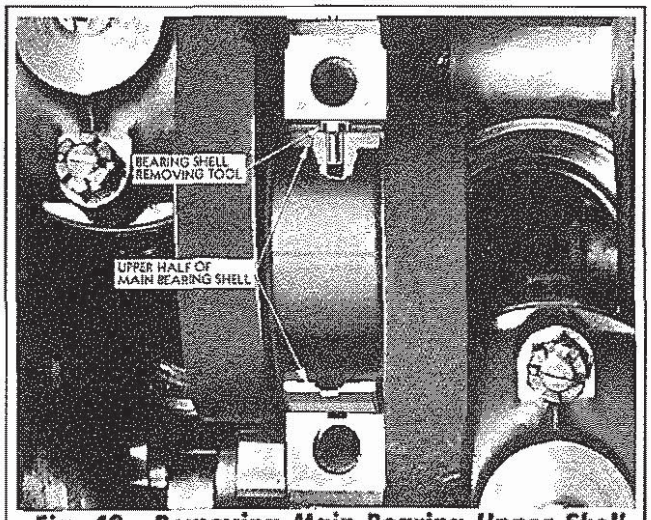


Fig. 43—Removing Main Bearing Upper Shell

   b. The upper half of the rear main bearing must be rolled out of place by driving on the edge of the bearing shell with a small curved rod, while revolving the crankshaft. Refer to Figure No. 44.

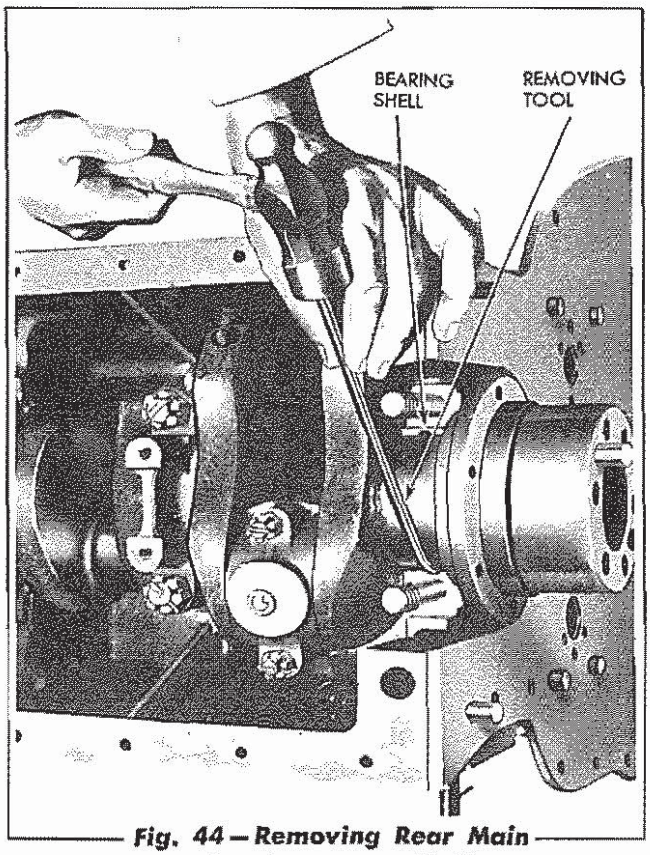


Fig. 44—Removing Rear Main Bearing Upper Shell

6. Inspect the crankshaft and each bearing as explained in "CRANKSHAFT, FLYWHEEL, AND MAIN BEARINGS" in this section. If

the crankshaft is unfit for use, it must be reconditioned or replaced before new bearings are installed.

7. Install the upper (grooved) half of each main bearing as follows: Lubricate the shell and start the end of the shell having no tang around the crankshaft bearing journal, so that when the shell is in place, the tang will fit into the groove in the shell seat.

8. After the upper shell has been installed, place the lower (non-grooved) shell in the bearing cap, lubricate with light engine oil, and install the cap. *NOTE:* The main bearing caps are marked 1, 2, and 3. Whenever the caps are removed, they should be replaced in their original positions with marked side toward blower side of cylinder block.

9. After all of the bearings have been installed, draw the bearing caps tight. Use a torque wrench and tighten the bolts with 180 to 190 foot pounds tension. *Do not overtighten main bearing bolts as bearings will be distorted out of round.* If the bearings have been installed properly, the crankshaft will turn freely with all of the main bearing caps tightened.

10. Install the oil pump and the oil pan and fill the crankcase with new oil. Refer to "OIL PUMP INSTALLATION" in Section V.

11. Install the injectors and make the proper adjustments as explained in "INJECTOR TIMING" and "INJECTOR EQUALIZING" in Section II. Also adjust the valve lash as explained in "VALVE LASH ADJUSTMENT" in this section.

12. Install the rocker arm cover and the hood.

13. After the new bearings have been installed, the engine should be operated on a run-in schedule as outlined in "ASSEMBLY OF ENGINE" in this section.

10. ENGINE REMOVAL AND INSTALLATION

A one ton hoist and about 10 foot of 1/2" cable or a section of 3/8" chain, or equivalent equipment, will be needed to lift the engine from the tractor.

An engine stand or suitable blocks to support the engine after it is removed should also be provided, along with an ample supply of cleaning solvent, wiping rags and at least 6 to 8 boxes or pans to hold the bolts and small parts removed from the engine and the tractor.

It is recommended that the tractor, particularly the engine, be washed before the engine is removed. This will not only prevent dirt from getting on the exposed parts, but will also make the operation much quicker and more easily done.

A. Engine Removal.

1. Remove the engine hood, front fenders, and floor plates.

2. Drain the cooling system. Open the thermostat air vent valve when draining system.

3. Loosen the hose clamps attaching the radiator inlet and the outlet hoses to the radiator.

4. Disconnect the headlight wire from the main wiring harness at the connector at the lower left corner of the radiator and remove the fuse.

5. Remove the capscrews attaching the radiator shell to the main frame, remove the front nut on the radiator bracing rod, and lift the radiator and shell assembly from the main frame.

6. Disconnect the starter rod at the starter and remove the rod.

7. Remove the "U" bolts from the front yoke of the universal joint and push the universal joint together on its splines. Do not allow the universal joint bearings to fall off the journals after removing the "U" bolts. Tape or wire the bearings in place on the journals.

8. Disconnect the governor, air shut-off, and throttle linkage rods at the governor and the air intake tube and remove the rods.

9. Disconnect the engine clutch operating rod from the clutch control lever and let the rod drop down into the bottom of the main frame.

10. Remove the yoke pin connecting the gear shift locking plunger rod to the locking plunger.

11. Remove the capscrew attaching the battery ground cable to the right hand steering clutch cover. Remove the battery cable and ammeter wire from the starter terminal.

12. Remove the generator wire at the generator. Remove the engine temperature gauge tube from the rear of the cylinder head. Also disconnect all other wires, tubes, hoses, etc., from the engine which would prevent its removal.

13. Remove the oil cup from the bottom of the air cleaner.

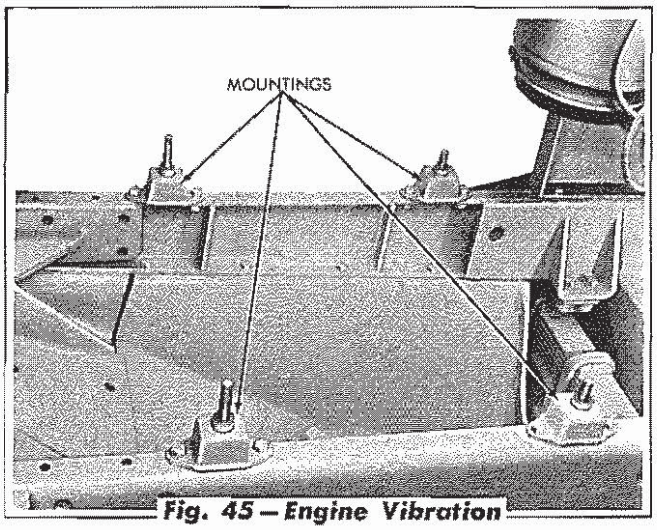


Fig. 45 — Engine Vibration Dampening Mountings

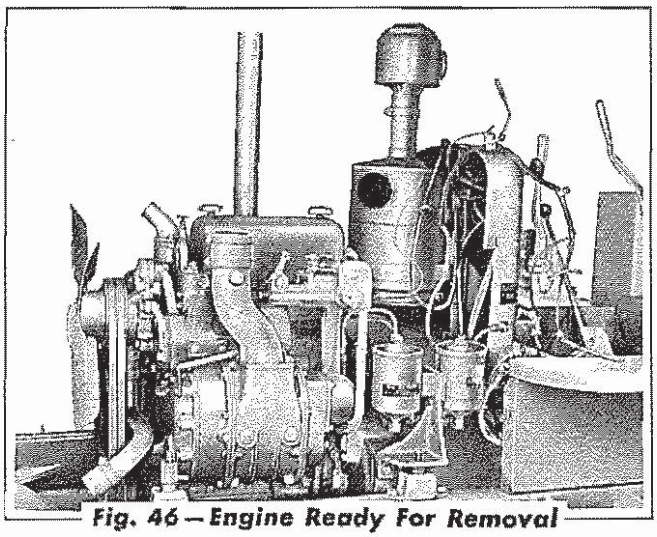


Fig. 46 — Engine Ready For Removal

14. Remove the nuts from the front and rear vibration dampening mounting bolts. Leave the vibration dampeners in place on the main frame.

15. With the hoisting equipment available, raise the engine enough to provide clearance between the engine mounting bolts and the engine supports, then move the engine toward the front of the tractor. Continue raising the engine until it is clear of the main frame and remove the engine, complete with engine clutch and clutch housing, from the tractor. The clutch housing and clutch can be removed from the engine after the engine has been removed.

B. Engine Installation.

The installation of the engine is practically a reversal of the removal procedure, *except that certain inspections and adjustments must be made before installing the engine.*

1. Inspect the vibration dampening mountings to see that the rubbers in the mountings are in good condition. If they are torn loose from around the mounting bolts or if the bolt holes in the rubber blocks are enlarged, the mountings must be replaced.

   IMPORTANT: When installing new mountings or replacing old ones, be sure to install the front mountings with the arrows stamped on the cover pointing away from the engine, and the rear mountings with the arrows pointing toward the engine.

2. Inspect the engine clutch linkage to see that it is working freely, also inspect the clutch pressure plate and the driven plate assembly. Replace all damaged or badly worn parts.

3. Inspect the lining on the engine clutch brake and replace if necessary.

4. Install the engine in the main frame. Install all hoses, cables, wires, etc., in the same locations from which they were removed.

5. Install the "U" bolt on the universal joint assembly, and install the floor plates, radiator and shell assembly, and front fenders.

6. Check the adjustment of the engine control linkage (refer to "ENGINE CONTROLS AND GOVERNOR," Section VI).

7. Check the exhaust valve lash (refer to "VALVE LASH ADJUSTMENT" in this section).

8. Time and equalize the injectors (refer to

"INJECTOR TIMING" and "INJECTOR EQUALIZING" in Section II).

9. Install the engine hood and air pre-cleaner.
10. Be sure to fill the cooling system and the engine crankcase before starting the engine.

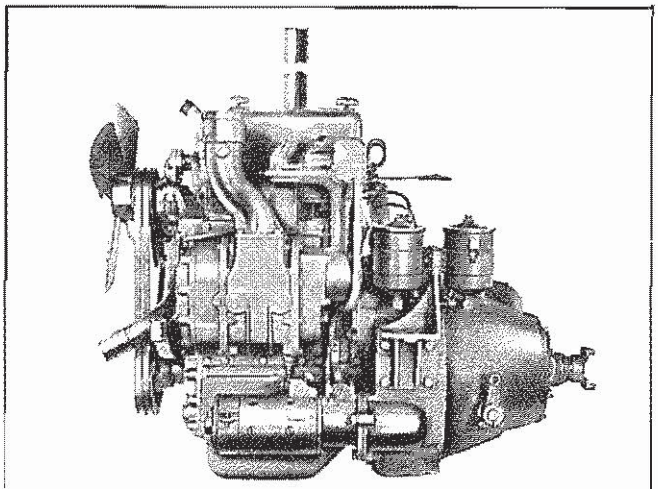


Fig. 47 – Left Side Of Engine

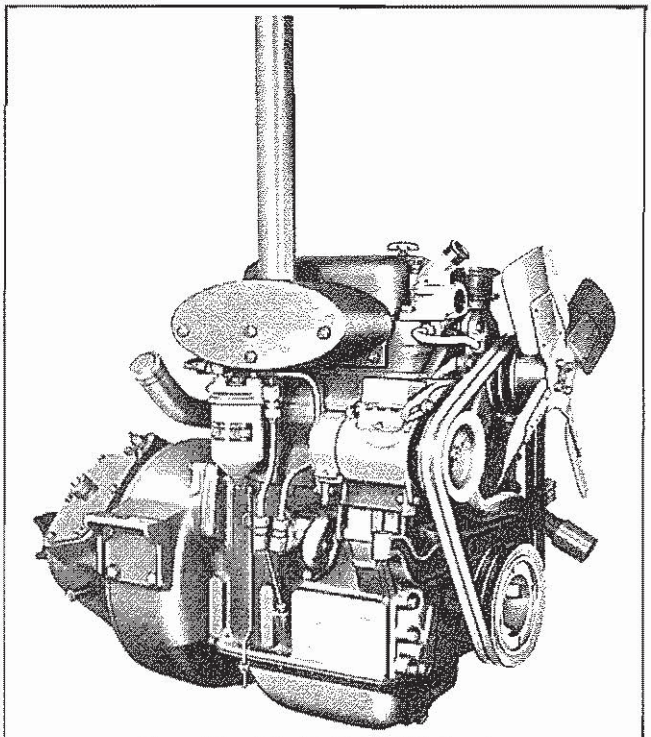


Fig. 48 – Right Side Of Engine

11. DISASSEMBLY OF ENGINE

A. Removal of Accessories From Engine.

Enough pans or boxes should be available so that each of various components removed from the engine can be placed in them and kept separated. Keeping the components and their bolts separated will make the installing easier and quicker.

The following procedure gives the most logical sequence for the removal of the accessories, starting at one side and working around the engine. Refer to Figures No. 47 and 48 when removing the accessories.

1. With the engine suspended from a hoist or supported on blocks, remove the following parts from the right side of the engine so that the engine can be mounted to an engine stand if one is available.

   Remove the generator, generator bracket and adjusting arm, also the second stage fuel filter assembly, the fuel pump, muffler, oil by-pass valve assembly, air box hand hole cover, water drain cock, and air box drain tube and elbow from the right side of the engine.

2. With the above accessories removed the engine can be mounted on a stand similar to one shown in Figure No. 49. With this stand the engine is held by an adapter plate bolted to the fuel filter mounting pad near the top and to two holes near the bottom of the block.

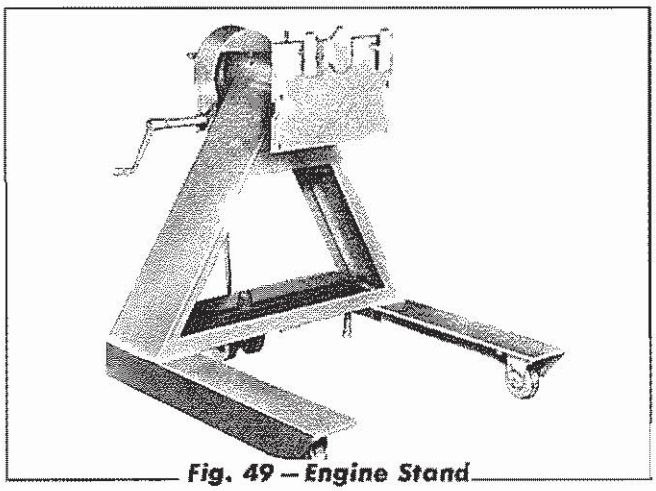


Fig. 49 – Engine Stand

3. Remove the water by-pass tube assembly from between the water pump and the thermostat housing, then remove the bolts used in attaching the oil cooler to the front of the engine block and remove the oil cooler

assembly, water pump, fan pulley and fan as an assembly.

4. Remove the crankshaft pulley retaining bolt and washer, then pull the crankshaft pulley from the crankshaft with a suitable puller. Remove the two Woodruff Keys from the crankshaft.

5. Remove the blower, complete with the governor, governor breather tube and the air heater; if the engine is so equipped; or the governor can be removed first, followed by the removal of the blower. In either case it will be necessary to remove the two governor attaching bolts and the governor-injector control link assembly located inside the cylinder head. The link assembly must also be disconnected from the governor.

6. Remove the starter and all engine mounting brackets. *NOTE:* When removing the left rear mounting bracket from the engine, the lubricating oil filter and first stage fuel filter assemblies may be left on the bracket. Be sure to disconnect all lines leading from these filters to the engine.

7. Remove the engine oil filling tube, and if the engine clutch housing and engine clutch have not been previously removed, remove them at this time.

B. Disassembly of Engine Into Sub-Assemblies.

Refer to pertinent sections of this manual for detailed information on the various engine sub-assemblies. If the engine is mounted on an engine stand turn the engine to the position most convenient for removal of the sub-assemblies.

1. Remove the cylinder head from the engine block.

2. Remove the flywheel from the crankshaft by removing the flywheel attaching bolts and screwing two 7/16" NC capscrews into the two tapped holes in the flywheel. Use the two capscrews as puller studs to force the flywheel from the hub of the crankshaft.

3. Drain the engine oil, then remove the oil pan.

4. Remove the bolts and capscrews attaching the flywheel housing to the rear of the engine block and those attaching the timing gear cover to the front of the block. Remove the flywheel housing and the timing gear cover from the block.

5. Remove the large nuts holding the balance weights to the cam and balance shafts and pull the weights from the shafts. Remove the Woodruff Keys. The shafts can be held from turning while removing the nuts by placing a block of wood between the two balance weights.

6. Remove the thrust plate capscrews from the thrust plates by inserting a socket through the holes in the camshaft and balance shaft gears, then pull the shafts from the cylinder block. The thrust plates will remain on the shafts.

7. Remove the crankshaft gear, the oil pump drive gear and the Woodruff Key.

8. Remove the oil pump assembly from the bottom of the engine and the connecting rod bearing caps, then push the two piston and connecting rod assemblies out, through the top of the cylinders. Reassemble each cap to its respective connecting rod as they are removed.

9. Remove the main bearing caps and lift the crankshaft from the cylinder block. Remove the flywheel bearing wick assembly from the rear end of the crankshaft.

10. Remove the cylinder liners from the block and remove all plugs from oil and water passages so that the block can be thoroughly cleaned.

    CAUTION: Note the location of all plugs removed so that they can be re-installed in their correct positions.

11. Wash and inspect all parts, including the cylinder block. Refer to pertinent sections of this manual for instructions on the disassembly, cleaning and inspection of the various sub-assemblies removed.

12. ASSEMBLY OF ENGINE

A. General.

Make sure all parts are thoroughly cleaned before they are installed in the engine. Use only new gaskets where gaskets are required between attached parts. It is not necessary to cement gaskets used to seal against water leaks; on the other hand, BOTH SIDES of gaskets used to seal against oil or air leakage should be cemented.

Lubricate all bearings or bearing surfaces with light engine oil as the parts are assembled.

Before any parts are installed in the cylinder block, be sure all plugs that have been removed to clean the oil and water passages in the block have been coated with sealing compound, replaced, and securely tightened.

1. Turn the cylinder block upside down and install the upper halves of the main bearing shells in the crankshaft bearing seats of the block. The upper shells have a continuous oil groove extending from parting line and are marked "UPPER." The tangs on the bearing shells must engage in the small slots in the bearing seats. Install the upper halves of the two-piece thrust washers on each side of the rear main bearing.
2. Lubricate all the crankshaft bearing journals and lower the crankshaft into the block with the flywheel flange of the shaft toward the rear end of the block.
3. Place the lower (non-grooved) halves of the bearing shells in the main bearing caps. Place the lower halves of the two piece thrust washers in place on the dowels in the rear bearing cap. The caps are numbered 1, 2, and 3 indicating their respective positions. Install the caps with the numbered side toward the blower side of the block and tighten the cap bolts to 180-190 foot pounds torque. *Do not overtighten.*
4. Turn the cylinder block on end or lay it on its side and install the cylinder liners. Be sure that the recesses in the top of the cylinder bores and the flanges on the cylinder liners are clean so that the liners will seat properly. Check the stand-out of the liner flange above the top surface of the cylinder block. This distance must be from .002" to .006" and the difference in stand-out between the two liners must not exceed .002". These dimensions must be held in order to obtain proper sealing of the cylinder head compression gasket between the cylinder liner and the head when the head is bolted in place.

   If the height of a liner flange does not fall within the .002" to .006" range, or if the difference between the two liners exceeds .002", cylinder liner shims, made of shim steel .003" thick, must be installed accordingly. Make certain that the shim surfaces are smooth and entirely free from burrs and wrinkles.
5. Install the piston and connecting rod assemblies. The lower end of each rod, as well as each cap, is numbered 1 or 2 on one side. These numbers identify the caps with the rods and show the particular cylinder with which each rod is used; the numbered side of the rod always faces the blower side of the cylinder block.
   a. Stagger the piston ring gaps evenly around the piston, apply clean oil to the pistons and rings, then slide a piston ring compressor over the lower end of the piston skirt, with flared end toward the top of the piston. Turn the piston rod so that the identification mark on the lower end of the rod is toward the blower side of the cylinder block. Align the lower end of the rod with the crankshaft before pushing the piston in the cylinder. By tapping on the upper end of piston, drive the piston into the cylinder bore. Be sure the compressor tool is down tight on the top of the liner so that the rings cannot snap out before entering the liner bore.
   b. Install the upper bearing shell, with one short groove at each parting line, in the connecting rod and position the rod on the crankshaft journal.
   c. Install the lower bearing shell, with one continuous groove from parting line to parting line into the bearing cap with tang of shell in the slot of the cap, and put

cap and shell in place.

d. Tighten the connecting rad nuts ta 65-75 foot pounds torque. The crankshaft must turn freely after all of the connecting rod balts have been tightened.

e. Hold the cylinder liners in place while turning the crankshaft. Since the liners are a loose fit in the bores, the drag of the piston rings on the cylinder walls is sufficient to pull them out of the block.

6. Install the crankshaft gear Woodruff Key in the crankshaft and install the crankshaft gear. Install the oil slinger on the front of the crankshaft with the lip facing the cylinder block front cover.

7. Install the camshaft and balancer shaft assemblies (refer to "INSTALLATION OF CAMSHAFT AND BALANCER SHAFT" in this section).

8. Install the cylinder block front cover, crankshaft pulley spacer, and crankshaft pulley (refer to "INSTALLATION OF ENGINE FRONT COVER" in this section).

9. Install the oil pump assembly (refer to "OIL PUMP INSTALLATION" in Section V).

10. Use a flat piece of metal and press the crankshaft rear oil seal into place in the flywheel housing with the sealing lip pointed in towards the cylinder block. Coat the machined gasket surface on the cylinder block with gasket cement and stick the gasket in place over the dowels. Using an oil seal expander tool placed on the dowels in the crankshaft to expand the seal, slide the housing on the crankshaft and into place on the engine block. Use care and do not crimp the oil sealing lip. Install the attaching bolts and capscrews and tighten securely.

11. Install the pilot bearing oil wick (refer to "REPLACEMENT OF PILOT BEARING OIL WICK" in this section).

12. Install the engine flywheel. Due to one offset hole in the flange on the crankshaft, the flywheel can be located in only one position. Be sure the contacting surfaces on the flywheel and the bolting flange of the crankshaft are smooth and free from nicks or burrs. Install the attaching capscrews and tighten securely. Lock the capscrews in position with a continuous wire.

13. Install the pilot bearing in the flywheel if it has been removed.

14. Install the engine lubricating oil cooler (refer to "OIL COOLER INSTALLATION" in Section V).

15. Install the water pump and fan pulley assembly (refer to "ASSEMBLY OF WATER PUMP TO ENGINE" in Section IV).

16. Install the cam followers and lower push rods (refer to "CAM FOLLOWER AND LOWER PUSH ROD REMOVAL, INSPECTION AND INSTALLATION" in this section).

17. Install the cylinder head assembly using a new compression and a new oil gasket (refer to "CYLINDER HEAD INSTALLATION" in this section).

18. Install the engine blower (refer to "ATTACH BLOWER TO CYLINDER BLOCK" in Section III).

19. Install the governor (refer to "GOVERNOR INSTALLATION" in Section VI).

20. Install the engine air heater assembly if engine is so equipped (refer to "AIR HEATER INSTALLATION" in Section III).

21. Install the starter and engine mounting brackets.

22. Install the air box hand hole cover and engine oil filling tube.

23. Install the engine clutch and the engine clutch housing (refer to "INSTALLATION OF ENGINE CLUTCH" in Section X).

24. If the engine was mounted on an engine stand it must now be removed in order to install various parts on the right side of the engine.

25. Install the generator bracket, generator, adjusting arm, and drive belts. Adjust the drive belts.

26. Install the air box drain tube and elbow, also the water drain cock in the cylinder block.

27. Install the second stage fuel filter assembly,

the fuel pump, and oil by-pass valve.

28. Install the muffler, using a new gasket between the muffler and cylinder head.
29. The engine may now be installed in the tractor (refer to "ENGINE INSTALLATION" in this section).
30. Adjust the valve lash (refer to "VALVE LASH ADJUSTMENT" in this section). Time and equalize the injectors (refer to "INJECTOR TIMING" and "INJECTOR EQUALIZING" in sectian II).
31. Fill the engine cooling system and engine crankcase before starting the engine.

B. Engine Run-In Schedule.

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

Before starting engine after overhaul, inspect engine oil level, fuel oil, and cooling system and see that air cleaners have been properly serviced. Start engine and allow it to run at 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 thermostat must function properly to maintain a normal operating temperature of 160° F. to 185° F. Temperatures of 150° F. 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:

1/2 hour at half throttle
3 hours at two-thirds throttle
3 hours at full throttle

After this run-in, inspect engine lubrication 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 the tractor is ready for full load.

SECTION X — ENGINE CLUTCH AND CLUTCH BRAKE

1. ENGINE CLUTCH

A. Description.

The engine clutch is a single plate, dry clutch with an over center cam-engaging action. A shifting sleeve and bearing mechanism, carried on the clutch shaft and connected by linkage to the clutch actuating levers, is operated by the clutch operating lever to engage and disengage the clutch. The operating lever and the clutch operating yoke shafts are assembled on needle bearings that are sealed and grease packed for life. The clutch shifting sleeve bearing and engine clutch shaft rear bearing are the only parts that require periodic lubrication. A cam adjustment between the pressure plate and actuating levers of the clutch provides a means of maintaining the necessary adjustment to compensate for normal wear on the clutch facings.

The main parts of the clutch assembly are: the driven plate with facings bonded to both sides, springs, pressure plate, pressure ring, adjusting ring assembly, back plate, shifting sleeve assembly, clutch brake, and clutch housing. The clutch back plate is bolted to the rear face of the engine flywheel and carries most of the clutch weight, thus adding to the flywheel effect. The pressure plate is driven by lugs which engage in slots in the clutch back plate. The clutch driving plate, which is splined to the clutch shaft, is engaged between the pressure plate and the rear face of the flywheel by pressure exerted against the back of the pressure plate by springs in the pressure ring. The pressure ring is actuated by the over center action of the clutch actuating levers when the clutch operating lever is pulled into its engaged position. When the clutch is disengaged, the friction between the pressure plate, driven plate, and flywheel are relieved and the clutch brake stops rotation of the driven plate and clutch shaft. The other clutch parts continue to turn with the engine flywheel, and the clutch shifting sleeve bearing turns on its sleeve.

The front end of the clutch shaft is mounted in the pilot bearing inside the flywheel and the rear end of the shaft in a ball bearing mounted inside the clutch housing. The clutch shaft is connected to the transmission input shaft by a universal joint assembly. By removal of the universal joint assembly, the engine clutch can be removed without disturbing the engine or the transmission.

B. Clutch Service.

Specified time intervals between clutch adjustments can not be established because of the variable operating conditions which determine the amount of clutch facing wear. Keep the clutch adjusted so that it requires approximately 50 pounds pull on the clutch operating lever for its engagement (engine running at high idle). This adjustment of 50 pounds pull, should be maintained to obtain maximum clutch life. If clutch slippage is evident, immediate adjustment is necessary.

The correct method for checking the pounds pull required on the operating lever to engage the clutch is to use a spring scale and weigh the pull required. This pull should be checked from the

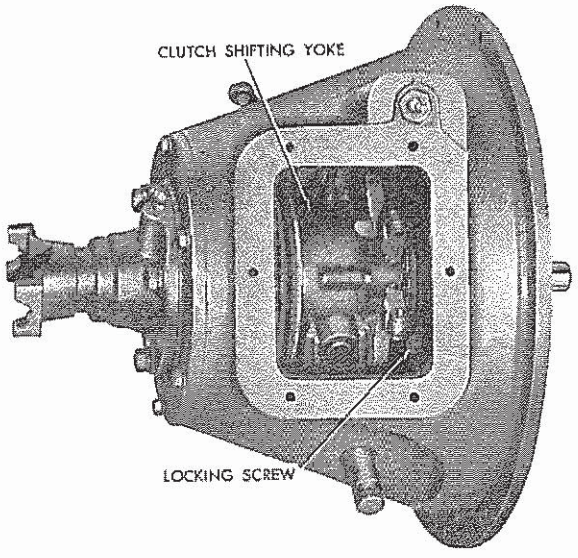


Fig. 1 — Engine Clutch Adjustment

bottom of the hand grip on the clutch operating lever.

Repeated adjustments at short intervals may be an indication that the clutch adjusting ring locking screw is not tightened securely and is allowing the adjusting ring to turn out of adjustment during operation. Frequent adjustments may also be an indication that the facings on the driven plate are worn out. A new driven plate assembly must be installed because the facings are bonded to the driven plate and are not serviced separately.

C. Clutch Adjustment.

1. Remove the clutch inspection cover from the upper right side of the clutch housing.
2. With the clutch disengaged, revolve the engine until the clutch adjusting ring locking screw can be reached through the inspection hole.
3. Loosen the locking screw but DO NOT REMOVE IT. DO NOT LOOSEN THE TWO SLOTTED SCREWS.
4. Tighten the clutch by turning the notched adjusting ring clockwise with a large screwdriver or short pry bar until the proper adjustment is obtained. Moving the adjusting ring 2 or 3 notches is generally sufficient.
5. Tighten the adjusting ring locking screw securely. Attach a spring scale to the clutch operating lever (attach scale just below the lever hand grip) and weigh the pull required to engage the clutch. When the clutch is properly adjusted, a maximum pull of 50 pounds is required on the operating lever for its engagement (engine running at high idle).
6. Replace the clutch inspection cover.

D. Clutch Linkage Adjustment.

The engine clutch operating rod should be adjusted to give a clearance of 1/4" between the front of the clutch operating lever (lever in its disengaged position) and the angle on the left rear fender used for attaching the floor plates.

Adjust the clutch operating rod by turning the front adjusting yoke to lengthen or shorten as required to obtain the 1/4" clearance between the operating lever and angle.

E. Washing Engine Clutch.

Oil leaks or over-lubrication of the clutch shifting sleeve bearing may cause the clutch facing to become coated with oil or grease. This will cause the clutch to slip even though it is properly adjusted. In this event, the clutch must be washed.

1. If a drain plug is installed in the bottom (front) of the engine flywheel housing, remove the plug and drain the clutch and flywheel housings. If a drain plug has not been installed in the housing, this step is unnecessary.
2. Re-install the drain plug in the bottom of the flywheel housing. Remove the clutch inspection cover from the upper right side of the clutch housing.
3. Pour cleaning solvent into the housing until the level is 1¼" below the clutch shaft. Install the inspection cover and operate the engine at low idle speed for approximately 5 minutes with the clutch disengaged.
4. Stop the engine, remove the drain plug, and drain the solvent. If the solvent is excessively dirty, refill the housing and repeat the washing process. CAUTION: LUBRICATE THE CLUTCH SHIFTING SLEEVE BEARING THOROUGHLY AFTER THE CLUTCH HAS BEEN WASHED AND THE HOUSING DRAINED AS THE LUBRICANT WILL BE WASHED OUT OF THIS BEARING IN THE WASHING PROCESS.
5. Operate the tractor with no load or with a light load in low gear for a short period (until the clutch dries) to prevent slippage due to solvent on the clutch parts.

F. Clutch Removal.

1. Remove both brake pedal pads from the brake pedals and remove the front and rear floor plates.
2. Remove the yoke pin connecting the gear shift locking plunger operating rod to the locking plunger assembly.
3. Remove the yoke pin connecting the clutch operating rod to the clutch shaft control lever.
4. Remove the four "U" bolts, connecting the

universal joint assembly to the engine clutch shaft and the transmission input shaft, and remove the universal joint assembly.

CAUTION: Tie or tape the four roller bearings in place on the journal assemblies, when removing the "U" bolts, so that the bearings will not fall off.

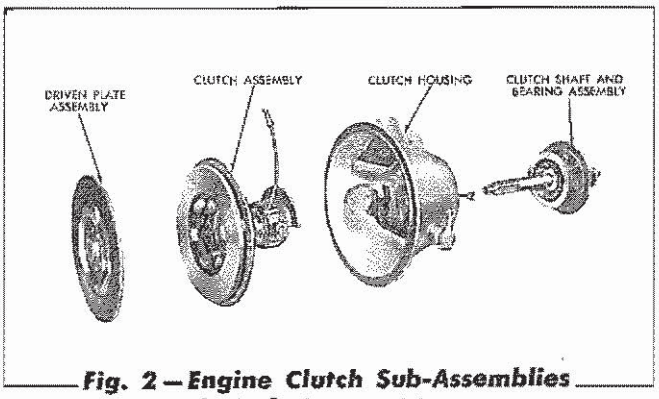


Fig. 2 — Engine Clutch Sub-Assemblies In Relative Position

5. Remove the capscrews attaching the engine clutch shaft rear bearing retainer to the rear of the clutch housing, then, pull the clutch shaft assembly, complete with its components from the clutch housing. (Refer to Figure No. 2.)
6. Remove the engine clutch inspection cover from the clutch housing. Remove the nut attaching the clutch shifting sleeve bearing lubricating tube on the top of the clutch housing, then, place the end of the tube down inside the clutch housing so that the housing can be removed.
7. Remove the capscrews attaching the clutch housing to the engine flywheel housing and remove the clutch housing leaving the clutch assembly attached to the engine. *CAUTION:* When removing the clutch housing use care and do not damage the fuel lines.
8. Remove the capscrews attaching the clutch assembly to the engine flywheel and remove the clutch assembly. *CAUTION:* When removing the clutch assembly, use care and do not drop or damage the driven plate assembly. Remove the driven plate assembly.

G. Clutch Disassembly.

1. Remove the pressure plate retracting spring capscrews and remove the retracting spring retainers and springs. Remove the pressure plate and pressure ring from the clutch assembly.
2. Remove the capscrews attaching the pressure ring to the pressure plate, then remove the pressure ring capscrew spacers. Remove the pressure ring from the pressure plate and remove the pressure springs and spring cups.
3. Remove the pins connecting the actuating lever links to the actuating levers.
4. Remove the adjusting ring locking screw and locking screw plate, then, remove the two slotted head adjusting ring guiding spacer capscrews and guiding ring spacers. Remove the adjusting ring assembly and the back plate.
5. Remove the pins attaching the actuating levers and actuating lever links.
6. Remove the capscrews attaching the clutch brake grease shield and the clutch brake front disc assembly to the shifting sleeve and remove the shield and brake disc.
7. Remove the capscrews attaching the shifting sleeve bearing retainer to the front of the shifting sleeve yoke, then press the sleeve and bearing out of the shifting sleeve yoke.
8. Remove the shifting sleeve bearing locking ring from the sleeve and remove the bearing, bearing retainer, and sealing ring.
9. Unlock and remove the capscrew used to hold the universal joint yoke to the rear end of the engine clutch shaft. Remove the retaining washer and rubber seal. Remove the universal joint yoke from the shaft.
10. Remove the clutch shaft rear bearing cap from the bearing retainer. Unlock and remove the clutch shaft rear bearing nut and locking washer. Drive or press the clutch shaft out of the rear bearing and bearing retainer.
11. Remove the clutch shaft rear bearing from the retainer.

H. Clutch Inspection and Repair.

1. Wash all the clutch parts and inspect them

to see that they are in good condition.

2. Inspect the facings on the driven plate for wear and looseness of the facings on the plate. Also check the condition of the splines in the hub of the plate. Replace plate if necessary.
3. Inspect the face of the pressure plate for roughness, heat cracks or warpage. If the face of the pressure plate is in bad condition it may be machined smooth. Replace the pressure plate if more than 1/16" stock must be removed to smooth it up.
4. Inspect the springs for breakage. Replace if necessary.
5. Inspect the levers, links, pins, and bushings for wear. Install new parts where necessary.
6. Check the clutch back plate for cracks.
7. Inspect the bushings in the shifting sleeve for roughness or wear. Replace the sleeve assembly if necessary.
8. Check the shifting sleeve bearing for roughness or wear. Replace if the bearing is worn excessively or if it does not turn smoothly when rotated by hand.
9. Inspect the clutch operating yoke needle bearings, dust seals, and the sliding blocks for wear. If the parts are excessively worn they should be replaced.
10. Inspect the clutch wearing surface of the flywheel and make sure that the surface is flat and smooth. If it is scored and heat checked it may be machined smooth. Replace the flywheel if more than 1/16" stock must be removed to smooth it up.
11. Inspect the clutch shaft front bearing (pilot bearing) for wear and lubrication. In case of improper lubrication, install a new oiling wick assembly. Refer to "REPLACEMENT OF PILOT BEARING OIL WICK" in Section IX.
12. Inspect the clutch shaft rear bearing for roughness or wear. Replace if the bearing is worn excessively or if it does not turn smoothly when rotated by hand.
13. Inspect the clutch shaft. If the shaft is excessively worn at the location of the clutch shifting sleeve or if the splines show excessive wear, replace the shaft.

I. Clutch Assembly.

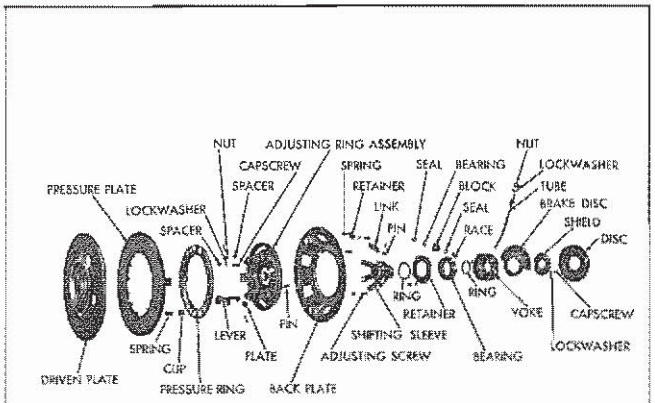


Fig. 3 — Engine Clutch Details

Refer to Figure No. 3 and 4 and assemble the clutch by direct reversal of the disassembly procedure. When assembling the pressure ring to the pressure plate, position the pressure ring so the "XX" identification marks on the pressure ring correspond with the lug on the pressure plate that lines up with the tapped hole used to secure the ring to the plate. When installing the shifting sleeve bearing in the shifting sleeve yoke, install the bearing so that the shielded side is to the rear. *IMPORTANT:* When installing the actuating lever pins and the link pins, make certain that they are installed so that the heads of the pins are located on the left side when viewed from the rear of the clutch. Grease the clutch linkage and pins sparingly when assembling.

J. Inspection and Replacement of Clutch Operating Yoke.

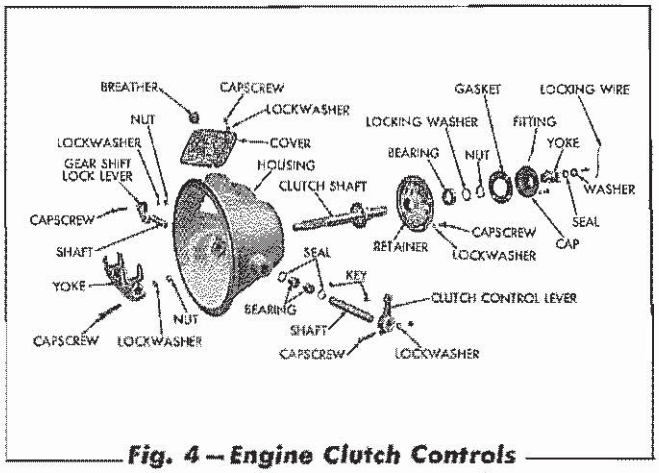


Fig. 4 — Engine Clutch Controls And Clutch Shaft Details

1. Place the operating yoke sliding blocks in position in the operating yoke. If there is excessive looseness between the parts due to wear, replacement of both yoke and sliding blocks are necessary.
2. Replace the operating yoke as follows:
   a. Remove the two bolts clamping the yoke to the yoke shafts.
   b. Spread the yoke open using a broad faced chisel to free the yoke on the shafts.
   c. Pull the shafts out of the yoke and remove the Woodruff Keys from the inner end of the shafts.
   d. Pull the shafts out of the needle bearings and inspect the bearings and shafts for wear. Replace the necessary parts.
   e. Lubricate the yoke shaft needle bearings with grease and start the shafts in place.
   f. Install the new operating yoke by reversal of the removal procedure. *IMPORTANT:* Install the operating yoke so that the jaws for the sliding blocks angle towards the front (refer to Figure No. 4).

K. Clutch Installation.

1. Place the driven plate assembly in the flywheel with the oil slinger on the plate toward the flywheel.
2. Place the clutch assembly in position on the flywheel. Start all the attaching capscrews then tighten evenly so that the clutch back plate enters the recess in the flywheel. *IMPORTANT:* If the clutch brake front disc assembly is attached to the shifting sleeve yoke, the brake disc should be removed before installing the clutch housing. With the brake disc removed, the operating yoke sliding blocks can be lined up and inserted in the operating yoke more easily.
3. Install the engine clutch housing inserting the operating yoke sliding blocks in position in the operating yoke. Use two 3/8 N.C. bolts 5½" in length with the heads cut off to line up and hold the housing in place when installing. Make certain that the needle bearings in the sliding blocks are packed with grease before installing the housing.
4. Attach the shifting sleeve bearing lubricating tube in position in the clutch housing.
5. Install the clutch brake front disc assembly and brake grease shield on the shifting sleeve yoke.
6. Lubricate the inside of the bushing in the shifting sleeve with grease, then install the clutch shaft assembly (complete with its components) in the clutch and clutch housing. To install, insert the end of the shaft through the shifting sleeve assembly until it contacts the hub of the driven plate. Push in on the shaft and turn to engage the shaft splines with the splines in the driven plate hub. Tap lightly on the rear end of the shaft to drive the frant end of the shaft into the clutch shaft front bearing (pilot bearing). Position the clutch shaft rear bearing retainer so that the lubricating fitting is to the top and install the capscrews.
7. Lubricate the clutch shaft rear bearing and the shifting sleeve bearing.
8. Install the universal joint assembly to the clutch shaft and transmission input shaft. Tighten the "U" bolts securely.
9. Adjust and connect the clutch operating control rod to the clutch shaft control lever (refer to "CLUTCH LINKAGE ADJUSTMENT" in this section).
10. Connect the gear shift locking plunger operating rod to the locking plunger assembly.
11. Adjust the engine clutch (refer to "CLUTCH ADJUSTMENT" in this section).
12. Install the floor plates and brake pedal pads.

2. ENGINE CLUTCH BRAKE

A. Description.

The purpose of the clutch brake is to stop rotation of the engine clutch shaft and the transmission input shaft when the clutch is disengaged to shift