AIR COMPRESSOR

The air compressor (Fig. 1) may be mounted on a bracket attached to the cylinder block of the engine and belt-driven from the crankshaft pulley, or it may be flange-mounted to the flywheel housing and gear driven by means of an accessory drive attached to the camshaft or balance shaft gear on In-line engines, or on either camshaft gear on V-engines.

A six bolt design air compressor mounting base, mounting bracket and gasket are used on current engines equipped with a belt-driven air compressor. Formerly, the air compressor was attached to the base and bracket with four bolts. When installing a new air compressor, it is recommended that the new mounting parts be used to eliminate the possibility of the bracket loosening and causing oil seepage at the gasket.

The air compressor runs continuously while the engine is running. While the compressor is running, actual compression of air is controlled by the compressor governor which acts in conjunction with the unloading mechanism in the compressor cylinder block. The governor starts and stops the compression of air by loading or unloading the compressor when the air pressure in the system reaches the desired minimum or maximum pressure.

During the down stroke of each piston, a partial vacuum is created above the piston which unseats the inlet valve and then allows air drawn from the air box in the engine cylinder block or through an intake

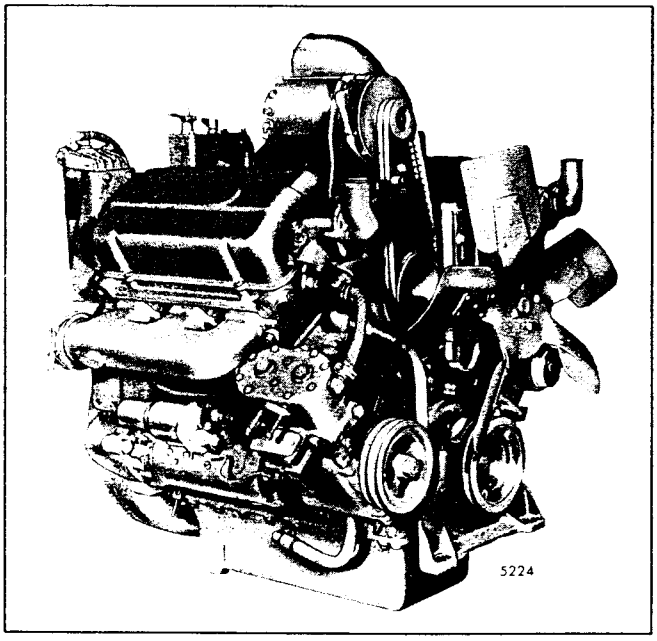


Fig. 1 - Air Compressor Mounting

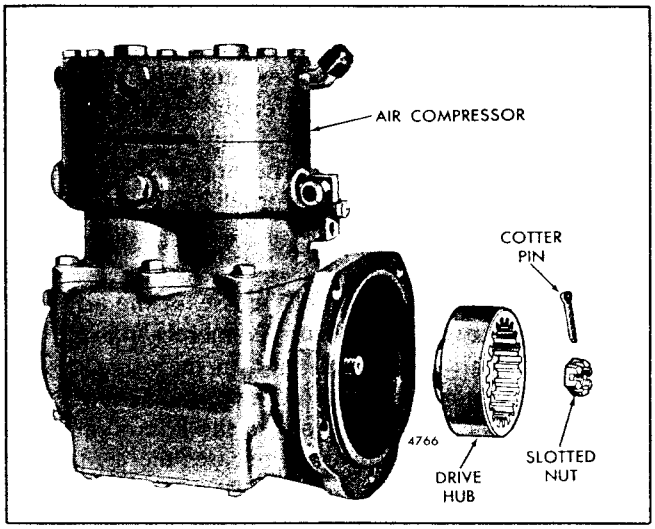


Fig. 2 - Typical Air Compressor With Drive Hub

strainer to enter the cylinder above the piston. As the piston starts the upward stroke, the air pressure on top of the inlet valves, plus the inlet valve return spring force, closes the inlet valve. The air above the piston is further compressed until the pressure lifts the discharge valve and the compressed air is discharged through the discharge line into the reservoir.

As each piston starts its downstroke, the discharge

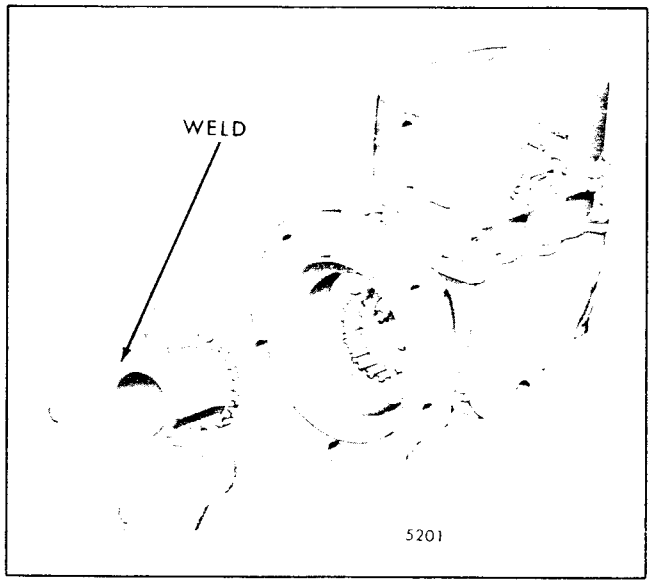


Fig. 3 - Fixture For Holding Drive While Installing or Removing Slotted Nut

valve above it returns to its seat, preventing the compressed air from returning to the cylinder and the same cycle is repeated.

When the air pressure in the reservoir reaches the maximum setting of the governor, compressed air from the reservoir passes through the governor into the cavity below the unloading pistons in the compressor cylinder block. The air pressure lifts the unloading pistons which in turn lifts the inlet valves off their seats.

With the inlet valves held off their seats, the air during each upstroke of the piston is merely passed back through the air inlet cavity and to the other cylinder where the piston is on the downstroke. When the air pressure in the reservoir drops to the minimum setting of the governor, the governor releases the air pressure beneath the unloading pistons. The unloading piston return spring then forces the piston down and the inlet valve springs return the inlet valves to their seats and compression is resumed.

Service Note

When installing a pulley or a drive hub on a flange mounted air compressor (Fig. 2), it is important the 3/4 "-10 drive shaft slotted nut be tightened to 100 lb-ft torque minimum before installing the 3/32 "x1-1/4 " cotter pin.

The air compressor drive shaft will turn during the torquing operation unless some provision is made to hold it. One way this can be done is to weld a modified drive coupling to a support or base which in turn can be anchored to the mounting flange of the compressor. An old flywheel housing cover that matches the flange of the compressor makes an ideal base for the modified coupling. With the exterior splines of the coupling in mesh with the internal splines of the drive hub and the entire assembly secured to the compressor housing, the hub and shaft are kept from rotating when the torque is applied. That part of the base within the inner diameter of the coupling must be removed to permit placement of the wrench socket on the nut. Two bolts will secure the base to the compressor during the torquing operation (Fig. 3).

COLD WEATHER STARTING

When starting an internal combustion engine in cold weather, a large part of the energy of combustion is absorbed by the pistons, cylinder walls, coolant and in overcoming friction.

Under extremely low outside temperatures, the cold oil in the bearings and between the pistons and cylinder walls creates very high friction and the effort required to crank the engine is much greater than when the engine is warm.

In a diesel engine, the normal means of igniting the fuel sprayed into the combustion chamber is by the heat of the air compressed in the cylinder. This temperature is high enough under ordinary conditions, but at extremely low outside temperatures may not be sufficiently high enough to ignite the fuel injected.

To assist in starting an engine under low temperature conditions, cold weather starting devices are available.

NOTE: Starting aids are not intended to correct deficiencies such as low battery, heavy oil, etc. They are for use when other conditions are normal but the air temperature is too low for the heat of compression to ignite the fuel-air mixture.

PRESSURIZED CYLINDER STARTING AID

Operation

Start the engine during cold weather, using the "Quick Start" starting aid system (Fig. 1) as follows:

1. Press the engine starter button.

2. Pull out the "Quick Start" knob for one or two seconds, then release it.

3. Repeat the procedure if the engine does not start on the first attempt.

CAUTION: Do not crank the engine more than 30 seconds at a time when using an electric starting motor. Always allow one minute intervals between cranking attempts to allow the starting motor to cool.

Service

Periodically perform the following service items to assure good performance:

1. Remove the fluid cylinder and lubricate the valve around the pusher pin under the gasket with a few drops of oil.

2. Lubricate the actuator cable.

3. Actuate the valve with the cable to distribute the oil on the cable and allow the oil to run down through the valve.

4. Remove any dirt from the orifice by removing the air inlet housing fitting, the orifice block and the screen. Then blow air through the orifice end only.

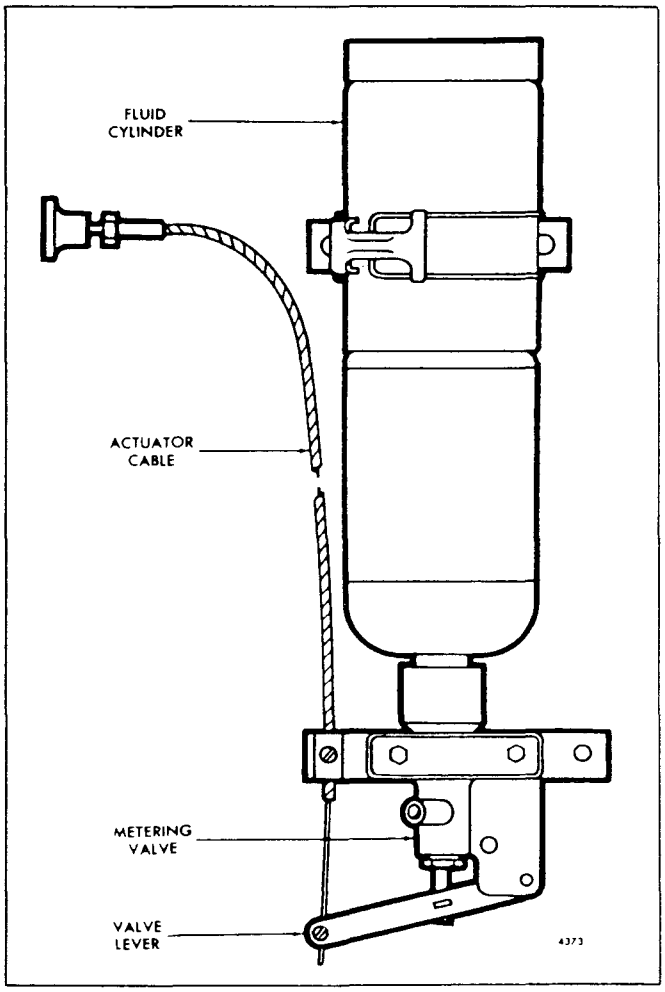


Fig. 1 - "Quick Start" Assembly

5. Assemble and tighten the air inlet housing fitting to the actuator valve and tube.

6. Check for leakage of fluid (fogging) on the outside of the engine air inlet housing by actuating the starting aid while the engine is stopped. If fogging occurs, disassemble and retighten the air inlet housing fitting to the housing.

CAUTION: Do not actuate the starting aid more than once with the engine stopped. *Over-loading the engine air box with this high volatile fluid could result in a minor explosion.*

7. Check the fluid cylinder for hand tightness.

FLUID STARTING AID

The fluid starting aid is designed to inject a highly volatile fluid into the air intake system to assist ignition of the fuel at low ambient temperatures. It consists essentially of a pump and nozzle for injecting the fluid into the air intake and a suitable container for the fluid (Fig. 2). The fluid is contained in suitable capsules to facilitate handling.

This starting aid consists of a cylindrical capsule container fitted with a screw cap. Inside the container is a sliding plunger-like piercing shaft. From the capsule container, a tube leads from the container to a hand-operated pump and another tube leads from the pump to an atomizing nozzle threaded into a tapped hole in the air inlet housing.

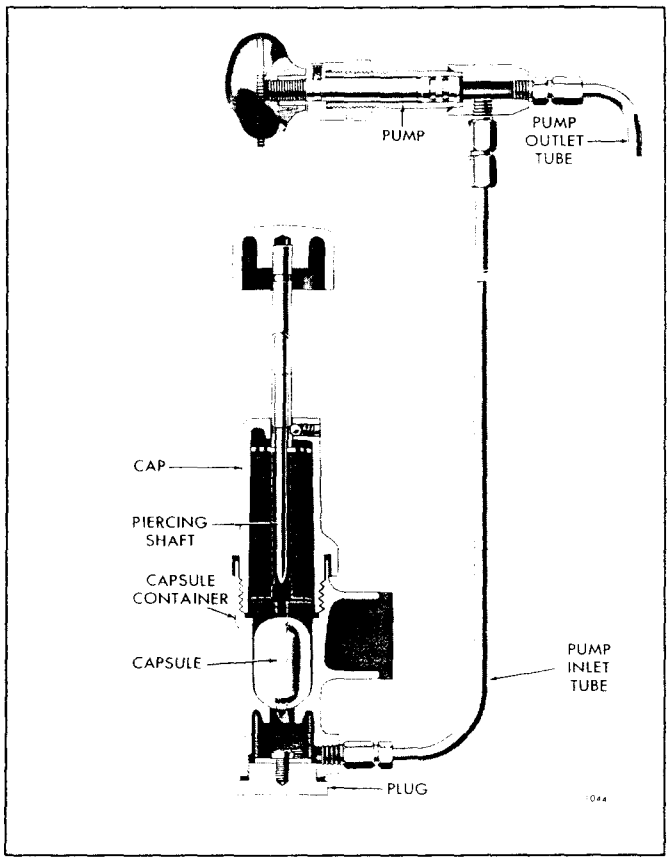


Fig. 2 - Fluid Starting Aid

Installation

The pump may be mounted on the instrument panel or in some other convenient location. The capsule container must be mounted in a vertical position away from such high heat areas as the exhaust manifold, muffler, etc. and should not be located under a hood or in a cab. The atomizing nozzle is screwed into a tapped hole in the air inlet housing. The tank-to-pump tube should be 3/16 " O.D. copper tubing and the pump-to-nozzle tube 1/8 " O.D.

Operation

1. Refer to Fig. 2 and remove the cap from the capsule container. Insert a fluid capsule in the container.

CAUTION: Mount the capsule in an upright position within the container. Use care when handling, since the starting fluid is both toxic and inflammable.

2. Pull the piercing shaft all the way out and thread the cap tight on the container.

3. Push the piercing shaft down until it bottoms. This will break the capsule and fill the container with starting fluid vapor.

4. Move the engine throttle to the full-fuel position.

5. Engage the starter and simultaneously pull the pump plunger all the way out. Then push the plunger in *slowly*, forcing the starting fluid through the atomizing nozzle and into the air intake. Continue to push the pump plunger in until the engine starts. If the plunger is not all the way in when the engine starts, push it in *very slowly* until it locks in the *in* position.

6. Unscrew the cap and remove the used capsule. *Do not leave the empty capsule in the container.*

7. Reinstall the cap tightly on the container body.

NOTE: When not in use, the piercing shaft should be all the way down.

Starting Aid Pump

The principal parts of the starting aid pump are the body, plunger and the spring-loaded ball type inlet and outlet check valves (Fig. 2). The pump body is threaded externally at one end for mounting purposes. One end of the plunger is threaded into the operating knob. Two seal rings of oil resistant material are located in grooves at the other end of the plunger. The inlet check valve, which opens on the suction stroke of the plunger and seats under pressure, is located in the side opening of the pump body. The outlet check valve, which seats under suction and opens under pressure, is installed in the end opening of the pump body. The check valves are identified by the number "1/2" stamped on the inlet valve and the number "30" on the outlet valve. An arrow indicating the direction of flow is also stamped on each check valve.

Remove Pump

Remove the starting aid pump from the mounting panel as follows:

1. Disconnect the starting fluid inlet and outlet tubes from the pump.

2. Unscrew the plunger nut from the pump body and withdraw the plunger assembly.

3. Loosen the pump body jam nut behind the mounting panel.

4. Remove the pump body from the rear of the panel.

5. Remove the jam nut from the pump body.

Disassemble Pump

When the pump was removed from its mounting panel, the plunger assembly was removed from the pump body. If further disassembly is required, proceed as follows:

1. Unscrew the knob from the plunger assembly.

2. Slide the plunger nut from the plunger.

3. The plunger lock ball and spring may be removed by tapping the plunger nut to dislodge them. It is not necessary to remove the plug.

4. Remove the inlet and outlet check valves.

Inspection

Clean the parts with fuel oil and dry them with compressed air. Examine the seal rings for wear or cracks. Replace the seal rings if necessary. The check valves cannot be disassembled. However, they may be cleaned by forcing fuel oil through them with any suitable pump. Inoperative valves must be replaced.

If excessive resistance was encountered during operation of the pump, the nozzle in the air inlet housing may be plugged. Remove and clean the nozzle.

Assemble Pump

1. Install new seal rings on the plunger.

2. Install the lock spring in the plunger nut. Then place the steel ball on top of the spring.

3. Depress the lock ball and slide the plunger nut -- hex end first -- over the threaded end of the plunger.

4. Thread the knob on the plunger.

5. Install the outlet check valve (marked "30") in the end opening of the pump body. The arrow must point away from the pump body.

6. Install the inlet check valve (marked "1/2") in the side opening of the pump body. The arrow must point toward the pump body.

Install Pump

1. Thread the jam nut on the pump body.

2. Insert the thread end of the pump body through the mounting panel (from the rear of the panel).

3. Lubricate the seal rings and carefully slide the plunger assembly into the pump body. Thread the plunger nut on the end of the pump body and tighten it.

4. Install the starting fluid inlet and outlet tubes.

5. If removed, install the nozzle in the air inlet housing.

HYDROSTARTER SYSTEM

The Hydrostarter system illustrated in Figs. 1 and 2 is a complete hydraulic system for cranking internal combustion engines. The system is automatically recharged after each engine start, and can be manually recharged in an emergency. The starting potential does not deteriorate during long periods of inactivity and continuous exposure to hot or cold climates has no detrimental effect upon the Hydrostarter system. Also, the Hydrostarter torque for a given pressure remains substantially the same regardless of the ambient temperature.

The Hydrostarter system consists of a reservoir, an engine-driven charging pump, a manually operated pump, a piston type accumulator, a starting motor and connecting hoses and fittings.

Operation

Hydraulic fluid flows by gravity or slight vacuum from the reservoir to either the engine-driven pump inlet or hand pump inlet. The hand pump is used to supply the initial charge or to recharge the system after servicing or overhaul. Fluid discharging from either pump outlet at high pressure flows into the accumulator and is stored at 3250 psi under the pressure of compressed nitrogen gas. When the starter is engaged with the engine flywheel ring gear and the control valve is opened, high pressure fluid is forced out of the accumulator, by the expanding nitrogen gas, and flows into the starting motor which rapidly accelerates the engine to a high cranking speed. The used fluid returns from the starter directly to the reservoir (Fig. 1).

The engine-driven Hydrostarter charging pump runs continuously during engine operation, recharging the accumulator with fluid. When the proper amount of fluid has been returned to the accumulator, a pressure-operated unloading valve in the engine-driven pump opens and returns the pump discharge directly to the reservoir.

System Components

RESERVOIR

The reservoir is a cylindrical steel tank with a fine mesh screen at the outlet. The filler cap contains a filter to prevent dust and dirt from entering the reservoir.

ENGINE-DRIVEN CHARGING PUMP

The engine-driven charging pump is a single piston, positive displacement type and should run at approximately engine speed. It contains ball check valves and an unloading valve operated by the

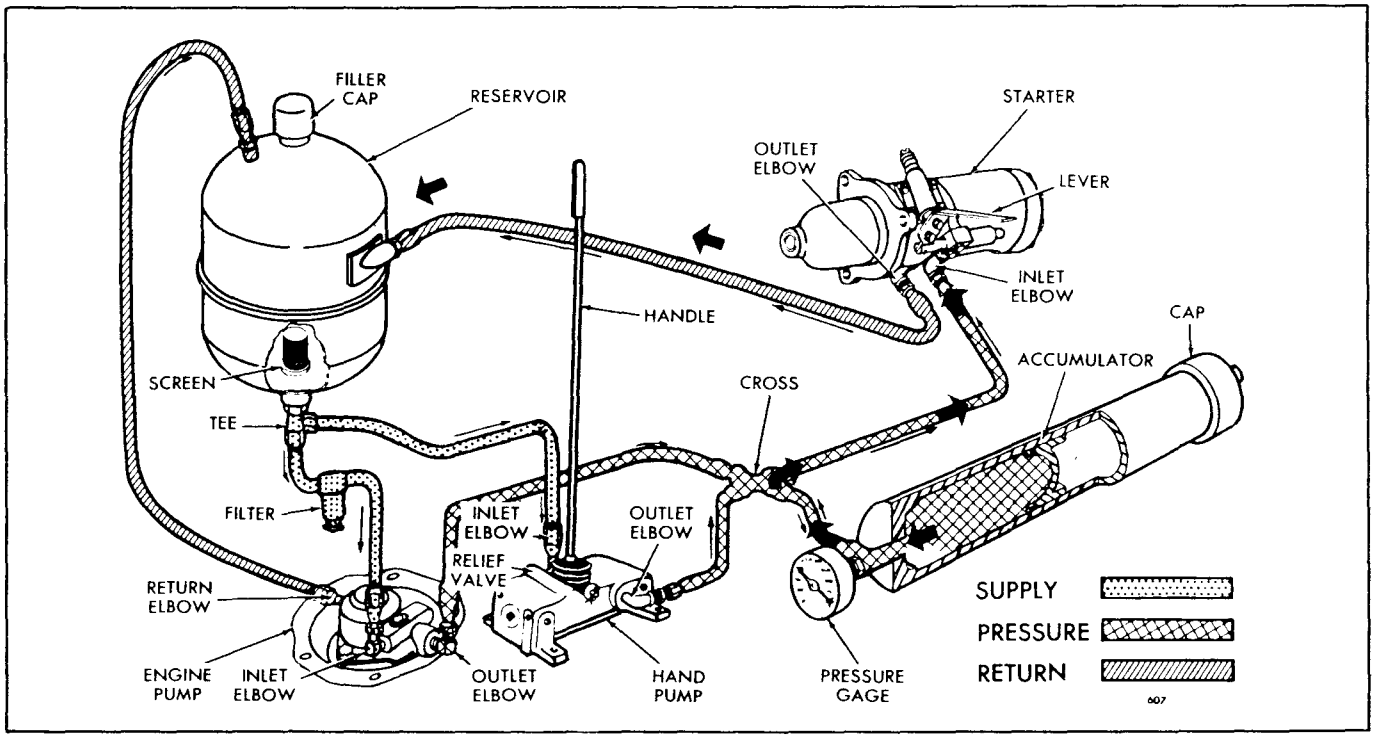


Fig. 1 - Schematic Diagram of Hydrostarter System Showing Oil Flows

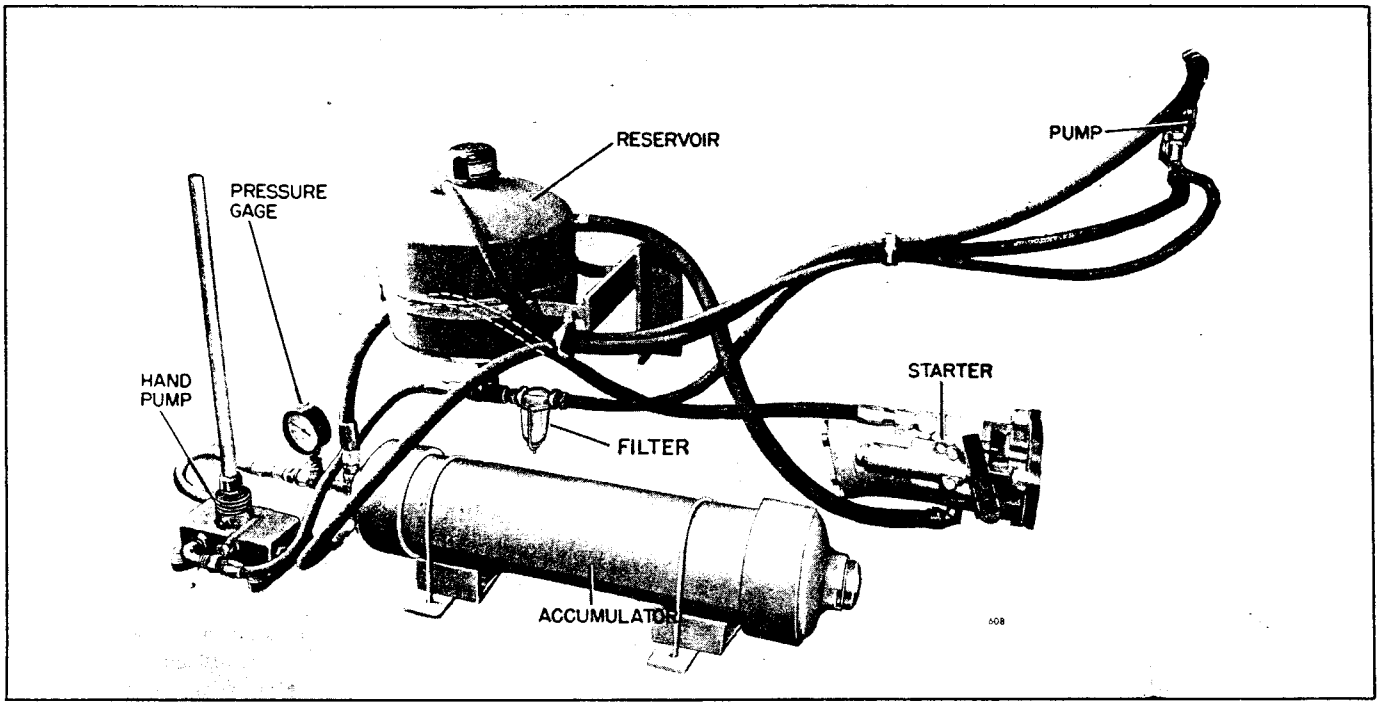


Fig. 2 - Typical Hydrostarter System Mounting

accumulator pressure. Its operation is entirely automatic and will operate in either direction of rotation.

HAND PUMP

The hand pump is a single piston, double-acting, positive displacement type. Flow through the pump is controlled by ball check valves. A manually operated relief valve is provided in this pump so that the accumulator pressure may be relieved when servicing of any components is required.

ACCUMULATOR

The piston-type accumulator is precharged with nitrogen through a small valve. A seal ring between the piston and the shell prevents the loss of gas into the hydraulic system. The accumulator is supplied with the proper precharge.

STARTER

The starter mounts on the flywheel housing and has a pinion gear with an overrunning clutch for engaging the flywheel ring gear. Movement of the starter control lever engages the pinion and opens the control valve in the proper sequence. The motor is a multi-piston, swash plate type. Provision is made so that if pinion tooth abutment occurs, the motor rotates slowly until the pinion snaps into full engagement. When the control lever is released, the pinion is disengaged and the valve is closed by spring action.

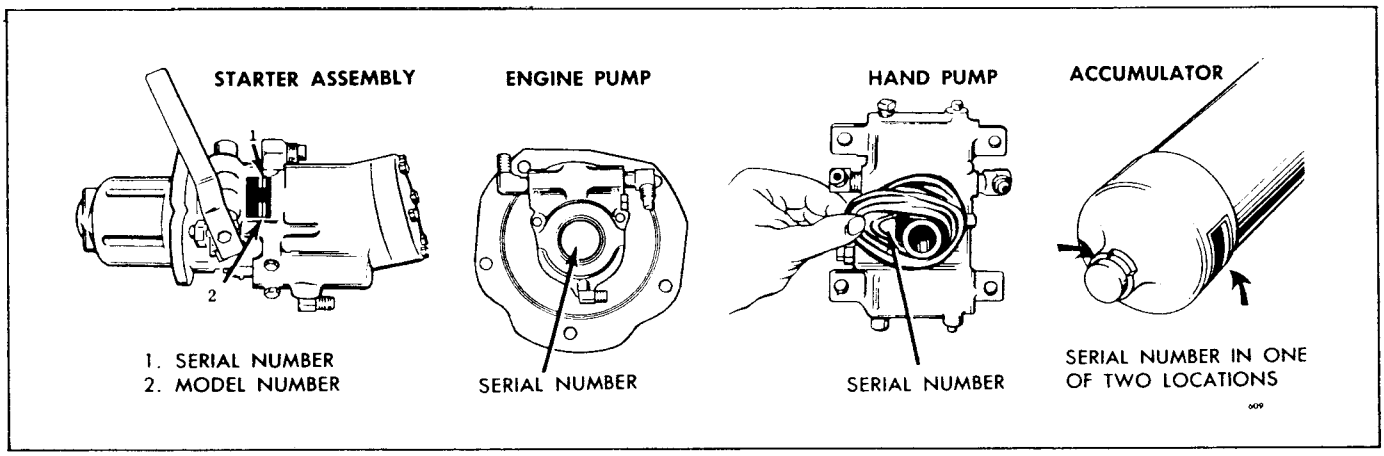


Fig. 3 - Hydrostarter Component Serial Number Locations

Ordering Parts

When ordering replacement parts, always specify the information located by the arrows on each component as shown in Fig. 3. Also include the engine model and serial number to ensure obtaining the correct parts.

FILLING, PURGING AND STARTING

Fill Hydrostarter System

Remove the filler cap from the reservoir and add a sufficient quantity of recommended hydraulic fluid (a mixture of 75% diesel fuel and 25% SAE 10 or 30 lubricating oil) to fill the system.

The required amount of hydraulic fluid will vary depending upon the size of the reservoir, length of the hydraulic hoses and the size and number of accumulators. The reservoir is available in 10, 12 and 23 quart capacities. In a 10 quart capacity reservoir, add approximately 8 quarts of hydraulic fluid; add approximately 10 or 21 quarts of hydraulic fluid to the 12 and 23 quart capacity reservoirs respectively.

NOTE: When the accumulator is charged to 3000 psi and all hoses are filled, there should be enough hydraulic fluid remaining in the reservoir to completely cover the screen in the bottom of the reservoir.

Purge Hydraulic Remote Control System, Hand Pump and Starter of Air

On units equipped with a hydraulic remote control starting system (Fig. 25) consisting of a foot pedal, master cylinder and connecting hose and fittings, purge that portion of the Hydrostarter system as follows: Fill the master cylinder reservoir with diesel fuel oil. Loosen the hose swivel fitting at the back of the starter control valve body and actuate the master cylinder pedal to allow the air to escape from the hydraulic remote starting system. Replenish the fluid in the master cylinder reservoir as required during the purging operation. Then tighten the hose swivel fitting.

Remove the pressure hose (Fig. 1) on the side of the hand pump and pump a few strokes to prime the pump. Priming is complete when a full stream of oil is discharged at each end of the pumping stroke. Then reconnect the pressure hose.

Move the starter control lever (Fig. 4) to engage the starter pinion with the flywheel ring gear and to open the control valve. While holding the lever in this position, operate the hand pump until the starter has turned several revolutions. Then release the starter control lever.

Check Accumulator Precharge Pressure Prior to Initial Engine Start

The precharge pressure of the accumulator is the pressure of the nitrogen gas with which the accumulator is initially charged. This pressure should be checked before the system pressure is raised for the initial engine start. To check the precharge pressure, open the relief valve (Fig. 1) on the side of the hand pump, approximately 1/2 turn, allowing the pressure gage to return to zero. Close the relief valve and pump several strokes on the hand pump. The gage should show a rapid pressure rise from zero to the nitrogen precharge pressure, where it will remain without change for several additional strokes of the pump.

Initial Engine Start

Use the hand pump (Fig. 1) to raise the accumulator pressure until the gage reads as indicated in the following chart.

Ambient Temperature	Pressure Gage Reading
Above 40°F.	1500 psi
+40°F. to 0°F.	2500 psi
Below 0°F.	3300 psi

NOTE: Use the priming pump (Fig. 24) to make sure the fuel filter, fuel lines and injectors are full of fuel before attempting to start the engine.

For ambient temperatures below 45 F., use a fluid starting aid.

NOTE: Add starting fluid just prior to moving the Hydrostarter lever and during the cranking cycle as required. Do not wait to add the starting fluid after the engine is turning over because the accumulator charge may be used up before the engine starts. In this case, the accumulator charge must be replaced with the hand pump.

With the engine controls set for start (throttle at least half-open), push the control lever (Fig. 4) to

simultaneously engage the starter pinion with the flywheel ring gear and to open the control valve. Close the valve quickly when the engine fires to conserve the oil pressure in the accumulator and to prevent excessive overrunning of the starter drive clutch assembly.

Three different basic types of flywheel ring gears are used -- no chamfer, Bendix chamfer and Dyer chamfer on the gear teeth. Some difficulty may be encountered in engaging the starter pinion with the Dyer chamfered ring gears. When this happens, it is necessary to disengage and re-engage until the starter pinion is cammed in the opposite direction enough to allow the teeth to mesh.

Purge Engine-Driven Pump of Air

With the engine running at 1500 rpm or above, loosen the hose connection at the discharge side of the engine-driven pump until a full stream of oil is discharged from the pump. Connect the hose to the pump and alternately loosen and tighten the swivel fitting on the discharge hose until the oil leaking out when the fitting is loose appears free of air bubbles. Tighten the fitting securely and observe the pressure gage. The pressure should rise rapidly to the accumulator precharge pressure (1250 psi at 70°F.) then increase slowly to 2900 to 3300 psi in 6 to 10 minutes, depending upon the size of the particular accumulator.

If the accumulator pressure does not rise, make certain the relief valve (Fig. 1) is closed after the pressure is released and repeat the above purging procedure.

Engine-Driven Pump By-Pass Check

The engine-driven pump should by-pass oil to the reservoir when the pressure reaches 2900 to 3300 psi. Check to determine that the pump is by-passing by removing the reservoir filler cap and disconnecting the pump by-pass hose at the reservoir and holding the hose over the open reservoir filler spout. An occasional spurt of oil may emit from the hose prior to by-passing. When the pump by-passes, a full and continuous stream of oil will flow from the hose. Reconnect the hose at the reservoir and install the filler cap.

HYDROSTARTER MOTOR

The Hydrostarter (starting) motor is mounted on the flywheel housing in the same manner as a conventional starting motor. This starting motor has an inherently high rate of acceleration; therefore, the engine is cranked faster than is possible with other starting systems. Right and left-hand starters are achieved by assembling the motor housing (Fig. 4) to the valve plate in one of two positions 180° apart and by changing the drive clutch assembly. The drive housing can be adjusted in 12 different positions to accommodate various flywheel housing configurations.

The control lever may be attached in any one of four positions where it is most accessible.

Positive starting motor engagement is assured because movement of the control lever mechanically pushes the starter pinion into engagement with the engine flywheel ring gear before the control valve is fully opened. When a tooth abutment is encountered, the valve permits a small flow of oil to turn the pinion slowly until it snaps into full engagement. Spring action disengages the pinion and closes the control valve when the lever is released. An overrunning clutch protects the starting motor at all times from being driven at high speeds by the engine before disengagement of the pinion.

Remove Hydrostarter Motor

1. Release the oil pressure in the hoses and the accumulator by opening the relief valve (Fig. 1) on the side of the hand pump.

> **CAUTION:** The oil pressure in the system must be released prior to servicing the Hydrostarter motor or other parts to prevent possible injury to personnel or equipment.

2. Clean all of the exterior dirt from the Hydrostarter and the hydraulic hoses.

3. Disconnect the remote control hose or linkage, if used.

4. Disconnect the two hydraulic hoses from the starting motor. Cover the open ends of the hoses with masking tape to prevent the entry of dirt.

5. Remove the three bolts and lock washers and lift the starting motor away from the flywheel housing.

Disassemble Hydrostarter Motor

With the exterior of the Hydrostarter motor cleaned, scribe marks on the drive housing, clutch housing,

valve plate and motor housing prior to disassembly to ensure their correct reassembly. Refer to Figs. 4 and 6 and proceed as follows:

1. Remove the two bolts and lock washers and lift the control valve assembly from the valve plate. Remove the body seal ring from the valve plate.

2. Withdraw the control valve from the valve body.

3. Remove the control valve plug only if the control valve body seals are to be replaced. If necessary, remove the valve seal rings from the valve body, being careful not to scratch or damage the valve body.

4. Remove the four bolts and lock washers and slide the drive housing off the shaft. Remove the plug and the oil wick from the drive housing.

5. Remove the four bolts and lock washers and separate the clutch housing and the clutch assembly from the valve plate by sliding them off the shaft. Rotate the control shaft and disengage the overrunning clutch from the fork.

6. Lift the clutch yoke from the drive clutch assembly. Remove the fork from the control shaft.

7. Remove the torsion spring from the control shaft and pull the shaft from the clutch housing. Remove the seal rings from the control shaft. Remove the control lever only if broken or if its position on the control shaft is to be changed.

8. On the Hydrostarter motors equipped with the former control valve assembly, shown in the inset in Fig. 4, remove the drive shaft oil seal washer from the starter shaft.

9. Withdraw the motor housing and needle bearing assembly together with the end cover and bearing as

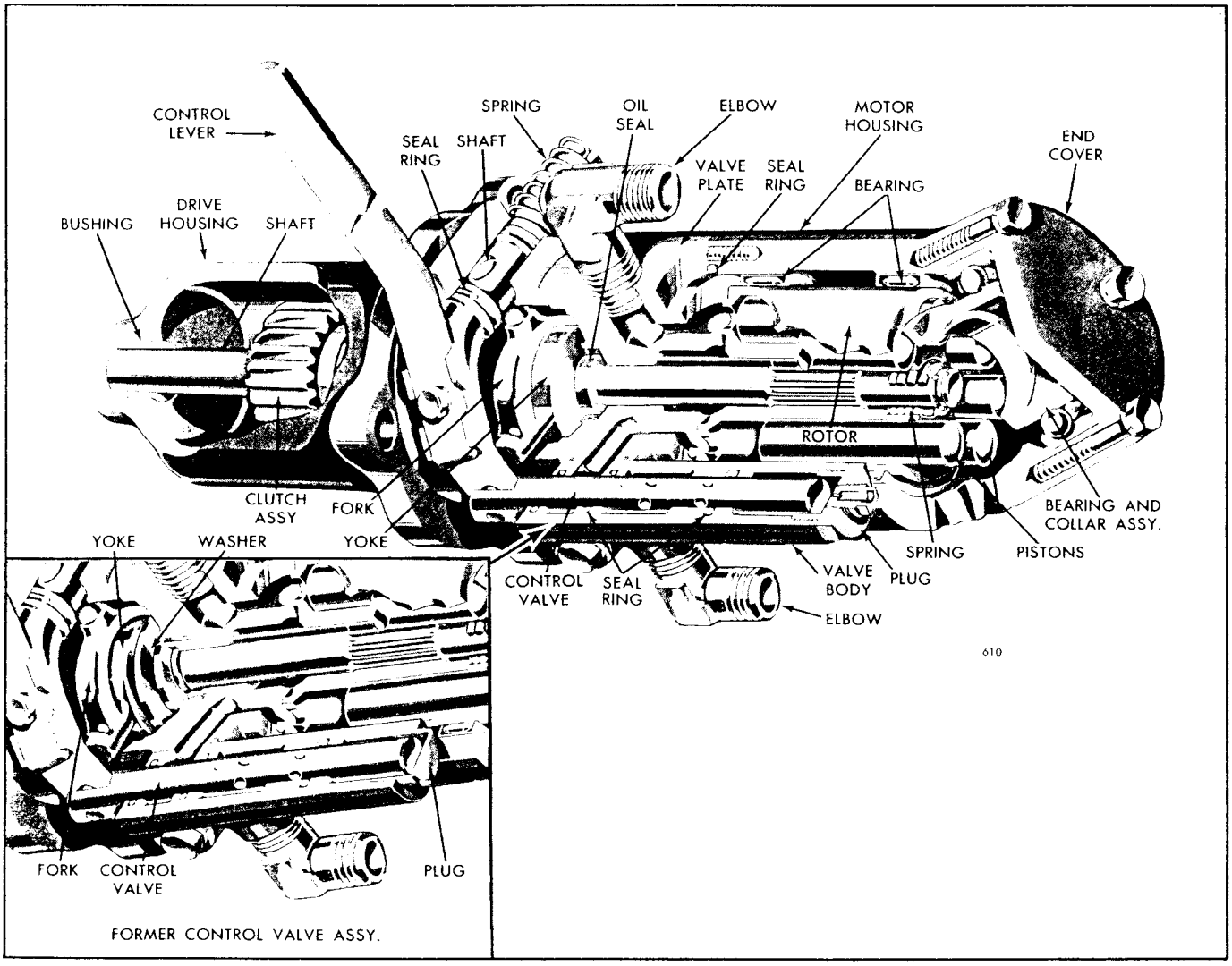


Fig. 4 - Cutaway View of Hydrostarter

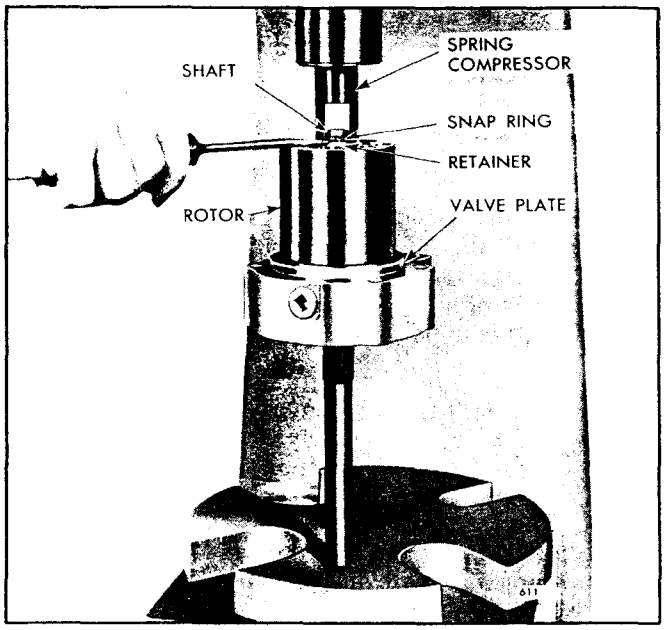


Fig. 5 - Removing Snap Ring from Starter Shaft

an assembly from the valve plate, being careful not to drop the pistons from the rotor.

10. Remove the pistons from the rotor.

11. Locate the shaft in an arbor press and, using spring compressor J 7187, press on the edge of the retainer to compress the spring as shown in Fig. 5. Then remove the snap ring.

12. Remove the retainer and compression spring from the starter shaft. Then slide the rotor and the valve plate assembly off of the starter shaft.

13. Remove the starter shaft compression spring shims from the spring bore in the rotor, if used.

14. Remove the starter shaft oil seal from the valve plate only if it is leaking.

15. Remove the seal ring from the motor housing.

16. Remove the bolts and lock washers and separate the end cover, bearing and gasket as an assembly from the motor housing.

17. Lift the bearing and collar assembly from the end cover.

Inspect Hydrostarter Motor Parts

Wash all of the parts in clean fuel oil and dry them with compressed air, with the exception of the drive clutch assembly.

Examine the teeth and internal splines of the drive clutch assembly for excessive wear and replace if necessary.

If the overrunning clutch slips, preventing positive pinion engagement, replace it unless the slippage is due to extremely cold weather which would cause the grease to set up and prevent the clutch from operating. Then wash it thoroughly in clean fuel oil to free the rollers in the clutch shell and lubricate with SAE 5W oil. Attach a tag to the starter, noting the lubricant used in the clutch assembly.

NOTE: When replacing the drive clutch assembly, only the Delco Remy drive clutch assemblies are available for service and, if the unit did not incorporate a Delco Remy drive clutch before, it will be necessary to replace the drive housing also.

Check the rotor and pistons for scoring or other damage.

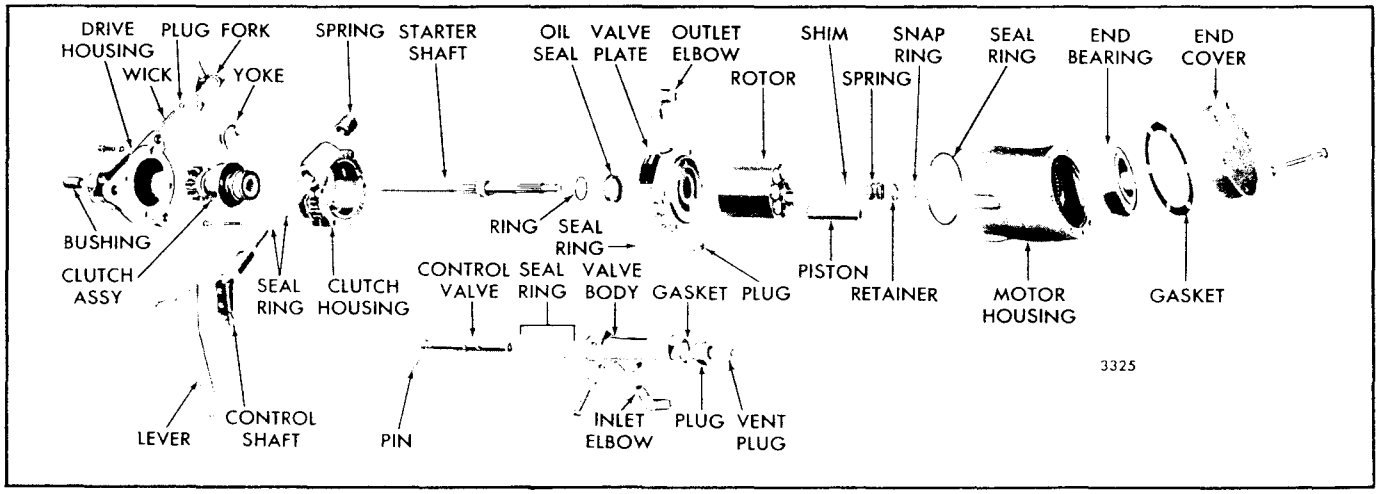


Fig. 6 - Hydrostarter Motor Details and Relative Location of Parts

Replace the yoke if it is cracked or worn on the faces near slots.

Replace the clutch fork if the trunnions or machined shank of the fork is bent, or are worn out of alignment.

Replace the starter shaft oil seal if the lip is rough or hard.

The rotor bearings (Fig. 4) should not require replacement; however, if they are worn excessively, a new motor housing and bearing assembly must be installed.

Apply light engine oil to the end bearing. Then hold the inner race and revolve the outer race slowly by hand to check for rough spots.

Replace the control shaft torsion spring or compression spring if either is broken or damaged in any way.

A square section split ring was used with the compression spring retainer on early Hydrostarter motors. The current type retainer is used with a round section snap ring. The drive shaft was revised accordingly. When an early type shaft is replaced, a new spring retainer and snap ring are required.

The current Hydrostarter motor incorporates a new design control valve assembly that may be identified by the threaded plug in the end of the valve housing. A tapped hole in the plug is provided for attachment of a flexible hose when a remote control is used, otherwise, a 1/8" - 27 vent plug is installed. A cup plug was pressed in the former valve housing.

NOTE: The washer between the shaft seal and the clutch yoke (see inset in Fig. 4) is used ONLY in the early Hydrostarter motors with the former type control valve. If the Hydrostarter motor is overhauled and a new control valve assembly is installed, remove the washer. However, if the control valve assembly is replaced and the motor is not disassembled, the washer may be left in the motor.

Assemble Hydrostarter Motor

Refer to Figs. 4 and 6 and assemble the Hydrostarter motor as follows:

NOTE: Do not reassemble a R.H. starter for L.H. rotation. The drive clutch for a R.H. starter will not drive at all if assembled on a L.H. starter. Similarly, the drive clutch for a L.H. starter will not drive if assembled on a R.H. starter. In both of these cases, the clutch will run free and will transmit no torque. The clutch will be forced to run at excessive speeds with a full accumulator and no driving load.

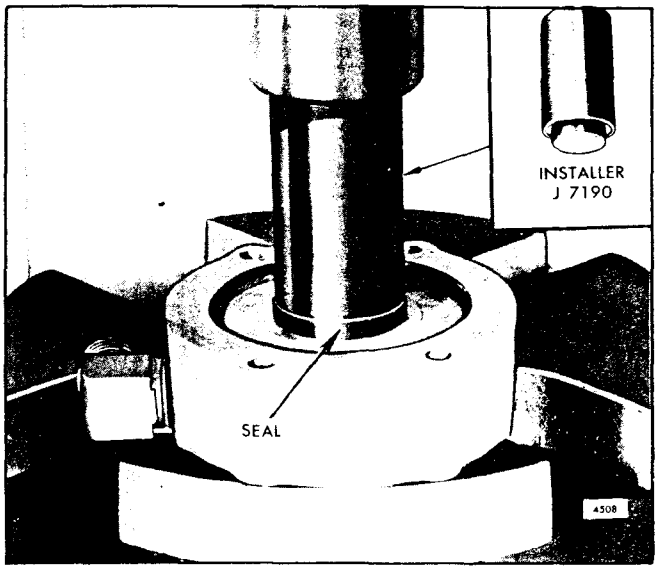


Fig. 7 - Installing Hydrostarter Shaft Seal in Valve Plate

1. Place the bearing and collar assembly in the end cover, thrust collar side up, and attach the end cover to the motor housing with bolts and lock washers. Use a new gasket between the cover and the housing.

2. If the shaft oil seal was removed, install a new seal in the valve plate with the lip of the seal facing in, using installer J 7190 (Fig. 7). The seal is properly positioned when the installer bottoms in the valve plate. Install the oil seal retaining ring in the ring groove in the valve plate.

On the former valve plate that does not incorporate the shaft oil seal retaining ring groove, stake the seal in place in at least six places.

3. Apply a thin coat of grease on the forward face of the starter shaft collar, then place the valve plate, seal side first, over the forward splined end of the starter shaft, followed by the rotor, shims (if used), compression spring and the spring retainer.

4. With the assembly in an arbor press and using spring compressor J 7187 as shown in Fig. 5, install the snap ring in the shaft ring groove.

On the current Hydrostarter motors, a .031" shim(s) is used on the starter shaft back of the compression spring as shown in Fig. 8, to limit the starter shaft travel and prevent the collar on the shaft from moving past the lip of the oil seal and damaging the seal when the shaft returns to its normal position. When reassembling a Hydrostarter motor, the starter shaft

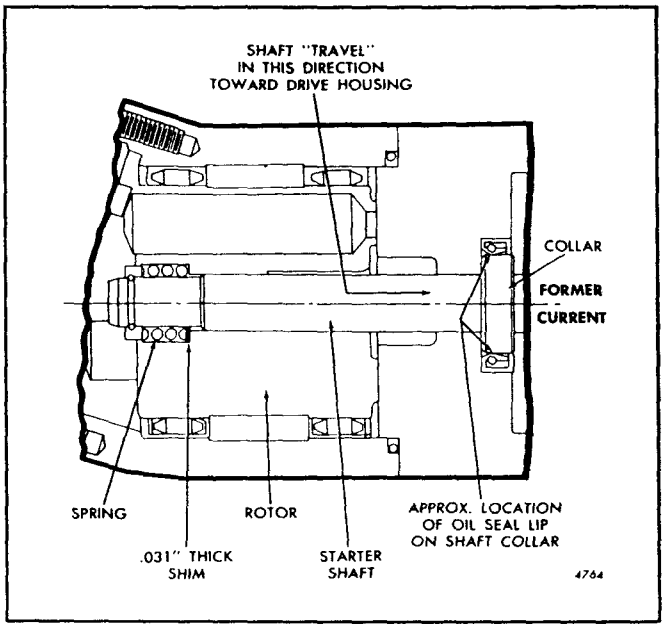


Fig. 8 - Location of Starter Shaft Compression Spring Shim(s)

should be checked as shown in Fig. 9. If the starter shaft travel is more than .100", a .031" shim(s) must be placed back of the compression spring to limit the shaft travel.

5. Insert the pistons, open end first, in the rotor.

6. Install the seal ring on the valve plate. Then assemble the motor housing to the valve plate, noting the scribe marks previously made on the housing and the valve plate.

7. Lubricate and install new seal rings on the control shaft and guide the shaft into the clutch housing gently so as not to damage the seal rings.

8. Install the torsion spring on the end of the control shaft. Apply grease to the fingers of the clutch fork and insert the shank of the fork into the control shaft.

9. Apply grease to the slots of the yoke and to the spool of the drive clutch assembly. Then set the yoke in the collar of the drive clutch assembly.

10. Grease the internal splines in the drive clutch assembly and the external splines on the starter shaft. Rotate the control shaft and insert the clutch fork trunnions into the slots of the yoke. Slide the oil seal washer, if used, onto the shaft. Then slide the assembly, yoke end first, over the starter shaft and engage the clutch and the shaft splines.

NOTE: The starter shaft oil seal washer, mentioned in Step 10, is only used on Hydrostarter motor assemblies using the former control valve assembly shown in the inset in Fig. 4.

11. Align the scribe marks and the bolt holes of the motor housing, valve plate and clutch housing and install the attaching bolts and lock washers.

12. Dip the oil wick in engine oil and insert the wick in the drive housing and secure it with the pipe plug.

13. Align the scribe marks on the drive housing and the clutch housing, then secure the drive housing with bolts and lock washers.

14. If removed, install new seal rings in the seal ring grooves inside the control valve body, then install the control valve body plug in the valve body and the vent plug in the body plug.

NOTE: On a former control valve body, shown in the inset in Fig. 4, press the cup plug against the shoulder in the control valve body.

15. Lubricate the control valve with engine oil, then start the control valve, slotted end out, straight in the control valve body and push it through the three seal rings in the body.

16. Place a new seal ring in the counterbore of the valve plate, engage the roll pin in the slot of the control shaft and attach the control valve assembly to the valve plate with bolts and lock washers.

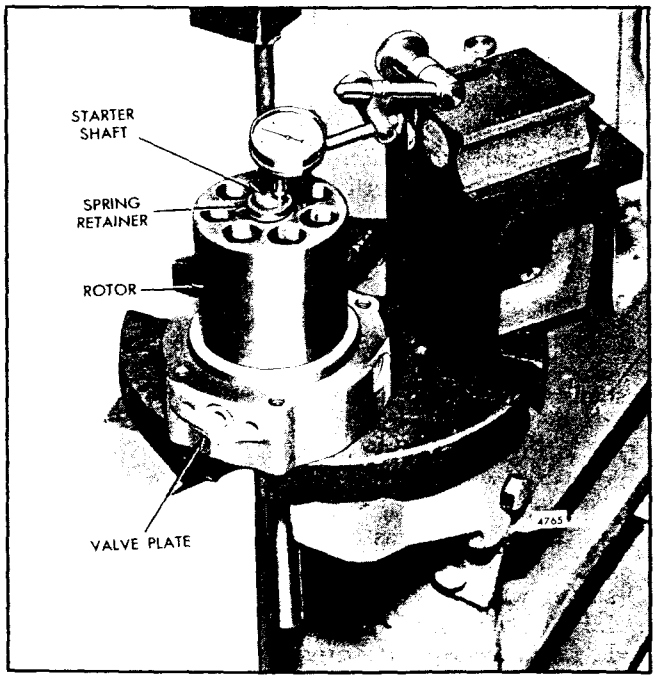


Fig. 9 - Checking Starter Shaft Travel

17. If removed, attach the control lever to the control shaft with bolts and lock washers.

Install Hydrostarter Motor

1. Attach the Hydrostarter motor securely to the flywheel housing with three bolts and lock washers.

2. Connect the two hydraulic hoses to the starter.

3. Connect the remote control hose or linkage, if used.

NOTE: Make sure the hoses and fittings are clean before any connections are made.

ENGINE-DRIVEN HYDROSTARTER CHARGING PUMPS

Depending upon the engine application, either a direct engine-driven charging pump or a belt-driven pump is included in the Hydrostarter system to maintain the proper operating pressure.

The charging pump runs continuously to maintain a pressure of approximately 2900-3300 psi in the accumulator. However, the pump must not be driven at a constant speed exceeding 2500 rpm. An unloading valve, contained within the pump body, by-passes the pump discharge to the reservoir after the operating pressure is attained and, thereafter, permits the pump to operate at less load.

The pump, which will operate in either direction of rotation, will maintain the Hydrostarter system pressure, without appreciable loss, for long periods of time after the engine is shut down.

A sediment bowl is installed in the suction hose to provide the necessary finer degree of filtration required to protect the engine-driven pump mechanism. The sediment bowl encloses a stacked disc type element that may be cleaned and reused.

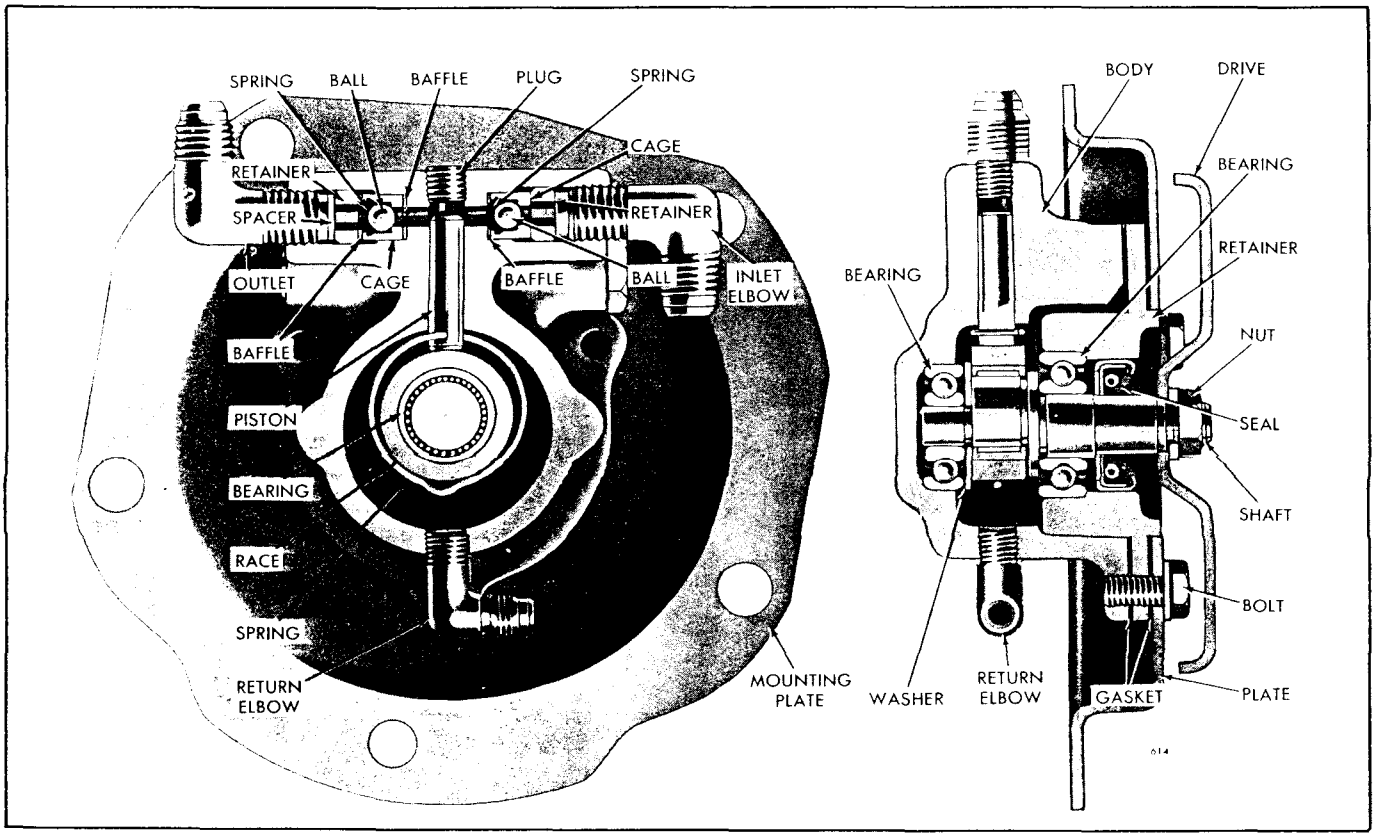


Fig. 10 - Direct Engine-Driven Hydrostarter Charging Pump

DIRECT ENGINE-DRIVEN CHARGING PUMP

The direct engine-driven charging pump is a single-piston positive displacement type. The ball check valves are automatically controlled by the accumulator pressure. The pump shaft is supported on ball

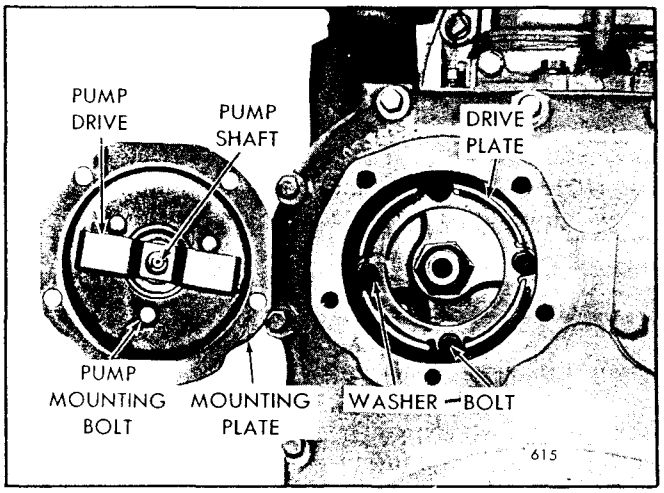


Fig. 11 - Pump Drive Plate Mounting

bearings and a seal, pressed into the pump bearing retainer, prevents leakage. The pump is attached to the flywheel housing and is driven by a drive plate bolted to the camshaft or balance shaft gear (Fig. 11).

Remove Pump

If required, remove the pump as follows:

1. Release the oil pressure in the system by opening the relief valve (Fig. 1) on the side of the hand pump about 1/2 turn.

CAUTION: The oil pressure in the system must be released prior to servicing the pump or other parts to prevent possible injury to personnel or equipment.

2. Clean all of the exterior dirt from the pump and the hydraulic hoses.

3. Disconnect the hydraulic hoses from the charging pump. Then cover the open ends of the hoses to prevent the entry of dirt.

4. Remove the five bolts and lock washers securing the charging pump and mounting plate assembly to the flywheel housing (Fig. 11). Then remove the pump and mounting plate assembly. Remove the mounting plate gasket.

Disassemble Pump

With the pump removed from the engine, refer to Figs. 10 and 12 and proceed as follows:

1. Remove the nut and lock washer and withdraw the pump drive from the shaft.

2. Scribe marks on the mounting plate and the pump body prior to disassembly to ensure their correct reassembly.

3. Remove the three bolts and lock washers and separate the mounting plate from the pump. Remove and discard the gasket. Withdraw the bearing retainer from the pump body. Remove and discard the second gasket.

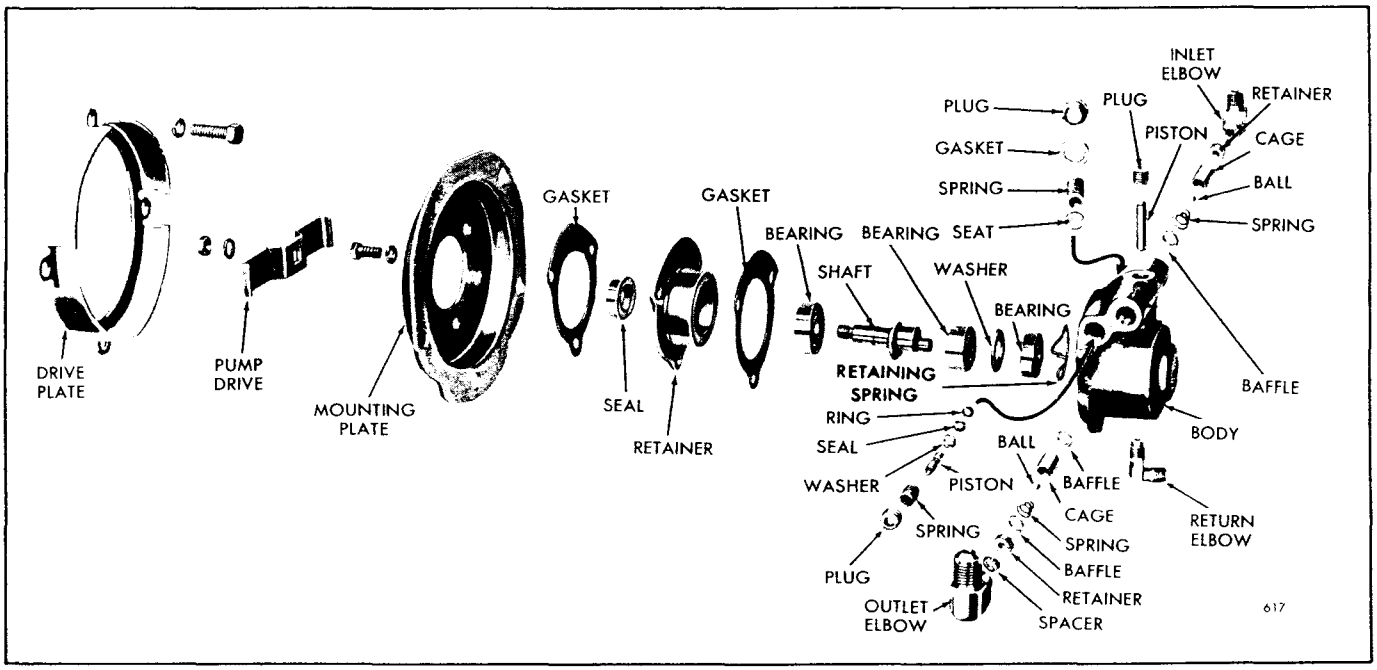


Fig. 12 - Direct Engine-Driven Charging Pump Details and Relative Location of Parts

4. Remove the shaft, bearings and fiber washer as an assembly from the pump body.

5. If inspection reveals the bearings and fiber washer are worn excessively, remove them from the pump shaft for replacement by new parts.

6. Remove the pump piston and the retaining spring from the pump body.

7. Remove the pressure relief spring retaining plug, gasket, spring and spring seat.

8. Remove the compression spring retaining plug, compression spring, pressure relief piston, washer, seal ring and back-up ring.

9. Remove the pump outlet elbow, spacer, retainer and baffle.

The helical spring, ball and cage may then be removed as an assembly. Remove the baffle. DO NOT separate the helical spring and ball from the cage. If the check valve on either side of the pump is defective, replace the complete check valve assembly.

10. Remove the pump inlet elbow and the check valve retainer. Then remove the cage, ball and spring as an assembly. Remove the baffle. DO NOT separate the spring and ball from the cage.

11. The pump-to-reservoir return elbow and plug may be removed, if necessary, to clean the pump body.

12. Remove the oil seal from the bearing retainer if the seal is worn or damaged.

Assemble Pump

After cleaning, inspecting and replacing the necessary parts, refer to Figs. 10 and 12 and proceed as follows:

1. Insert the spring seat and pressure relief spring in the pump body and lock them in place with a gasket and plug.

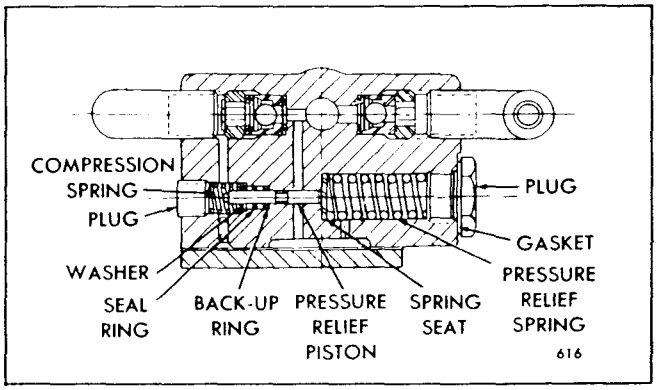


Fig. 13 - Engine-Driven Hydrostarter Charging Pump Pressure Relief Piston Assembly

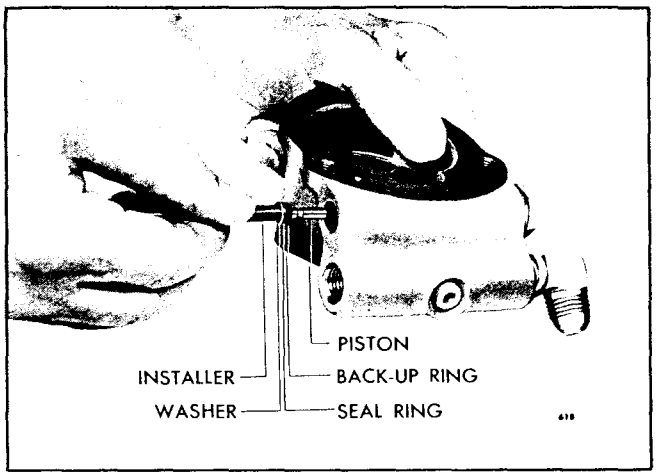


Fig. 14 - Installing Pressure Relief Piston, Back-Up Ring, Seal Ring and Washer in Pump Body with Installer J 7192

2. Slide a new back-up ring, new seal ring and washer onto the end of the pressure relief piston, opposite the flat end. DO NOT slide the seal across the groove in the piston.

3. Coat the back-up ring and seal ring liberally with hydraulic fluid. Then insert the relief piston assembly into the pump body, the flat end of the piston first, using installer J 7192. Apply manual force to the installer in order to gradually work the back-up ring and seal ring into the counterbore around the pressure relief piston. Care must be taken to avoid cutting the seal ring as it is worked into place. Refer to Figs. 13 and 14.

4. Remove the washer and inspect the work to make certain the seal ring is completely in the counterbored hole and that the pressure relief piston is down solidly against the spring seat.

5. Reassemble the washer over the pressure relief piston and insert the compression spring and secure it in place with the plug. Use sealant (Permatex No. 2, or equivalent) sparingly on the threads of the plug.

6. Insert the baffle, check valve assembly (with the spring end facing out) and the baffle into the pump body. Screw the check valve retainer into the body, against the baffle, and tighten it to 120-140 **in-lb** torque.

7. Place the spacer in the body on top of the check valve retainer and install the pump outlet elbow, using sealant (Permatex No. 2, or equivalent) on the threads. DO NOT apply sealant on the last thread nearest the open end of the elbow.

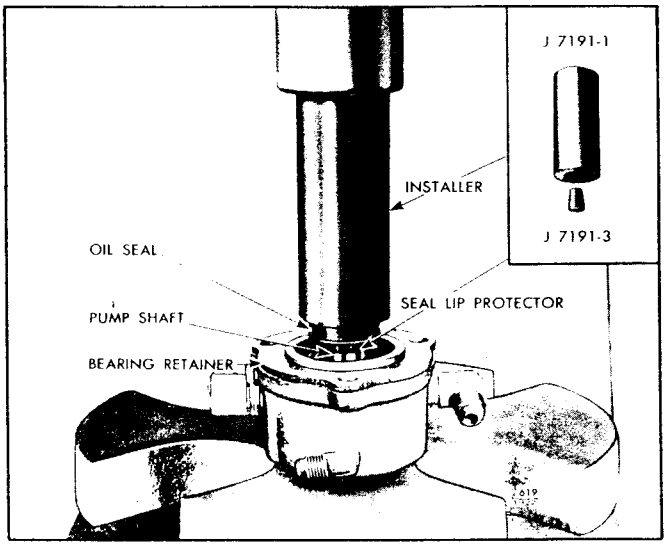


Fig. 15 - Installing Pump Shaft Oil Seal in Bearing Retainer

8. Insert the baffle and check valve assembly (with the spring end of the assembly in first) into the pump body. Screw the check valve retainer into the pump body against the check valve cage and tighten it to 120-140 **in-lb** torque. Install the pump inlet elbow, using sealant (Permatex No. 2, or equivalent) on all of the threads except the last one nearest the open end of the elbow.

9. If the pump-to-reservoir return elbow and plug were removed, apply sealant to all except the first thread on the elbow and plug and reinstall them.

10. Assemble the pump piston and retaining spring in the pump body.

11. Install the bearing and shaft assembly in the pump body. Work the retaining spring up on the bearing.

12. Affix a new gasket to the pump body and press the bearing retainer by hand into the pump body.

13. Install a new oil seal in the bearing retainer as follows:

a. Apply a thin coat of sealing compound to the outside diameter of the oil seal casing.

b. Place the seal lip protector J 7191-3 over the shaft, lubricate the lip of the seal and slide the seal, lip side first, over the seal lip protector and down to the bearing retainer.

c. Place the seal installer J 7191-1 over the seal lip protector J 7191-3, covering the threaded end of the shaft. Then press the seal in flush with the retainer surface. Refer to Figs. 10 and 15.

14. Place a second gasket on the bearing retainer. Align the three bolt holes of the mounting plate, bearing retainer, pump body and both gaskets and secure the parts together with bolts and lock washers. Make sure the scribe marks previously made on the mounting plate and the pump body are aligned to ensure proper position of the pump when it is installed on the engine.

15. Secure the pump drive on the shaft with a nut and lock washer.

Install Pump

Refer to Figs. 2 and 11 and install the pump as follows:

1. Affix a new gasket to the flywheel housing using a non-hardening gasket cement on the flywheel housing side only.

2. Align the tangs on the pump drive with the slots in the drive plate. Attach the pump and mounting plate securely to the engine with bolts and lock washers.

CAUTION: Do not force the pump into place. Use of force, or tightening the bolts when the mounting flange is not against the flywheel housing, will force the drive arm against the pump body and result in damage to the pump when the engine is started.

3. Connect the hydraulic hoses to the pump.

BELT-DRIVEN CHARGING PUMP

The belt-driven charging pump (Fig. 16) is similar in design and operation to the direct engine-driven pump, but has a longer shaft to accommodate a drive pulley.

Disassemble Pump

With the pump removed from the engine, refer to Figs. 16 and 17 and proceed as follows:

1. After removing the pulley retaining nut and lock washer, remove the pulley from the shaft, using a suitable puller.

2. Scribe marks on the bearing retainer and pump body prior to disassembly to ensure their correct reassembly.

3. Remove the three retaining bolts and lock washers. Separate the bearing retainer and pump shaft.

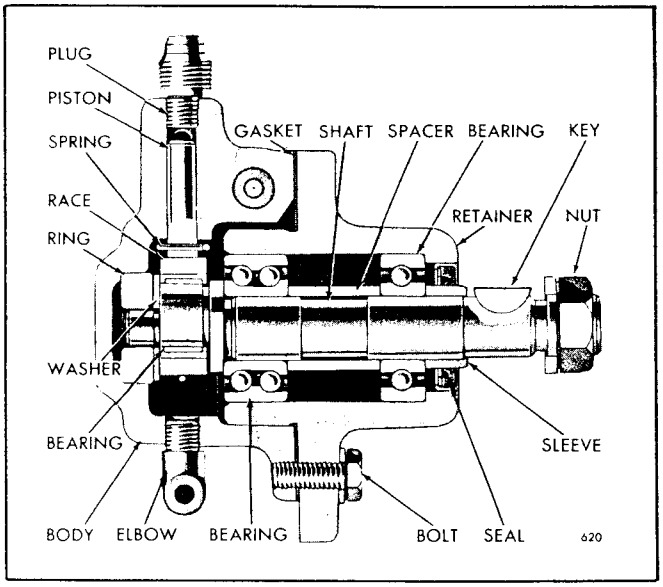


Fig. 16 - Belt-Driven Hydrostarter Charging Pump

including the shaft bearings, as an assembly from the pump body. Remove and discard the pump body gasket.

4. Press the pump shaft assembly from the bearing retainer using an arbor press or by tapping on the threaded end of the shaft with a plastic hammer.

5. If inspection reveals the pump shaft bearings and oil seal sleeve are worn excessively, remove them from the pump shaft for replacement by new parts.

6. Remove the needle bearing and outer race, fiber washer, retaining spring, piston and thrust ring from the pump body.

7. Remove the oil seal from the bearing retainer if the seal is worn or damaged.

8. Remove the pressure relief spring retaining plug, gasket, spring and spring seat.

9. Remove the compression spring retaining plug, compression spring, pressure relief piston, washer, seal ring and back-up ring.

10. Remove the pump outlet elbow, spacer, retainer and baffle. The helical spring, ball and cage may then be removed as an assembly. Remove the baffle. DO NOT separate the helical spring and ball from the cage. If the check valve on either side of the pump is defective, replace the complete check valve assembly.

11. Remove the pump inlet elbow and the check valve retainer. Then remove the cage, ball and spring as an assembly. Remove the baffle. DO NOT separate the spring and ball from the cage.

12. The pump-to-reservoir return elbow and plug may be removed, if necessary, to clean the pump body.

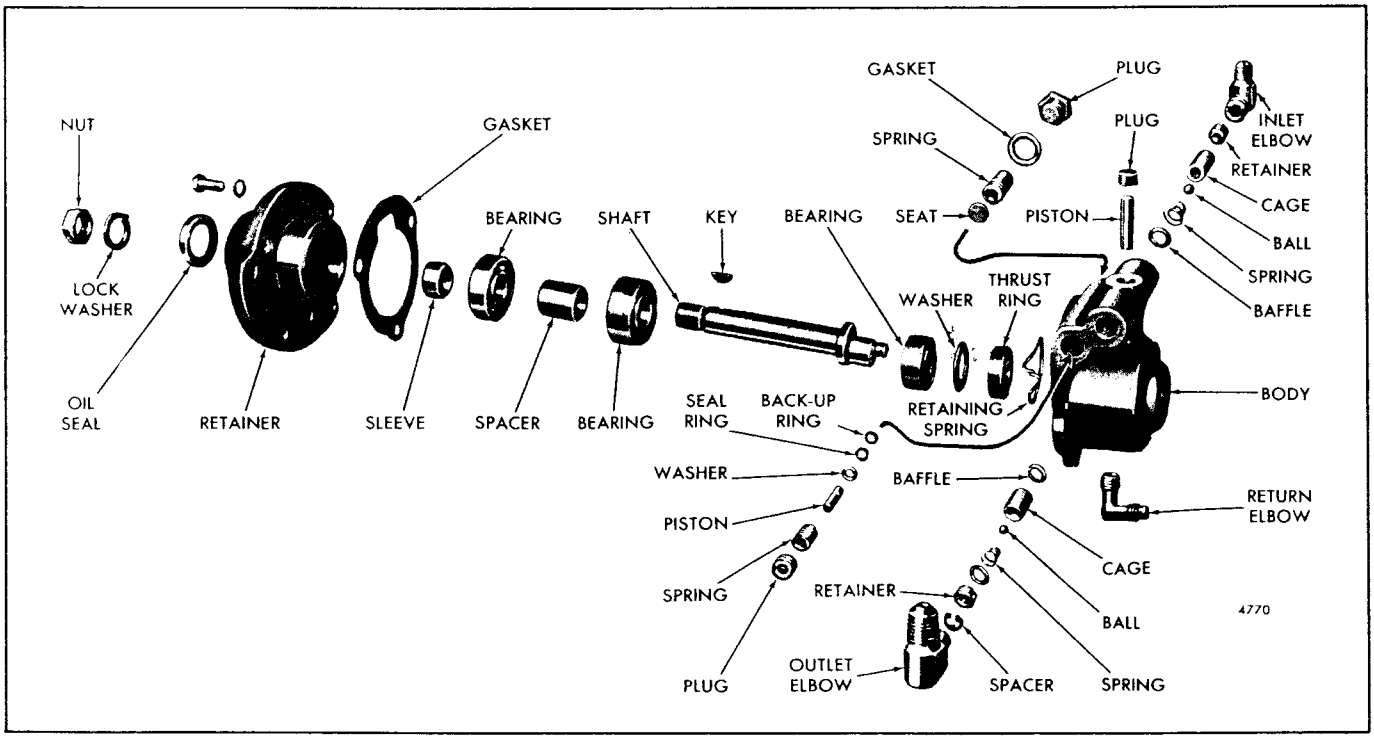


Fig. 17 - Belt-Driven Charging Pump Details and Relative Location of Parts

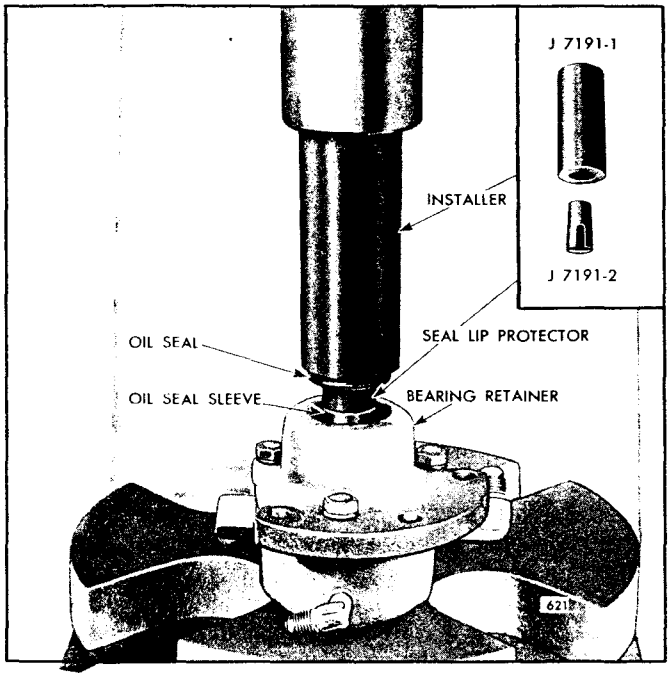


Fig. 18 - Installing Pump Shaft Oil Seal in Bearing Retainer

Assemble Pump

After cleaning, inspection and replacing the necessary parts, refer to Figs. 16 and 17 and proceed as follows:

1. Insert the spring seat and pressure relief spring in the pump body and lock them in place with a gasket and plug.

2. Slide a new back-up ring, new seal ring and washer onto the end of the pressure relief piston, opposite the flat end. DO NOT slide the seal across the groove in the piston.

3. Coat the back-up ring and seal ring liberally with hydraulic fluid. Then insert the relief piston assembly into the pump body, the flat end of the piston first, using installer J 7192. Apply manual force to the installer in order to gradually work the back-up ring and seal ring into the counterbore around the pressure relief piston. Care must be taken to avoid cutting the seal ring as it is worked into place. Refer to Figs. 13 and 14.

4. Remove the washer and inspect the work to make certain the seal ring is completely in the counterbored hole and that the pressure relief piston is down solidly against the spring seat.

5. Reassemble the washer over the pressure relief piston and insert the compression spring and secure it in place with the plug. Use sealant (Permatex No. 2, or equivalent) sparingly on the threads of the plug.

6. Insert the baffle, check valve assembly (with the spring end facing out) and baffle into the pump body. Screw the check valve retainer into the body, against the baffle, and tighten it to 120-140 **in-lb** torque.

7. Place the spacer in the pump body on top of the retainer and install the pump outlet elbow, using sealant (Permatex No. 2, or equivalent) on the threads. DO NOT apply sealant on the last thread nearest the open end of the elbow.

8. Insert the baffle and check valve assembly (with the spring end of the assembly in first) into the pump body. Screw the check valve retainer into the pump body against the check valve cage and tighten it to 120-140 **in-lb** torque. Install the pump inlet elbow, using sealant (Permatex No. 2 or equivalent) on all of the threads except the last one nearest the open end of the elbow.

9. If the pump-to-reservoir return elbow and the plug were removed, apply sealant to all except the first thread on the elbow and plug and reinstall them.

10. Install the thrust ring in the counterbore of the pump body. Lay the fiber washer on the thrust ring.

11. Assemble the pump piston and the retaining spring in the pump body.

12. Install the needle bearing with its outer race in the retaining spring.

> **NOTE:** The current belt-driven pumps incorporate a 5/8" diameter shaft. Former pumps used on 11/16" diameter shaft. When an old pump assembly or shaft is replaced by a current pump or shaft, a new pulley with a 5/8" bore must also be provided. The diameter of the pulley must be such that the pump will not exceed a constant speed of 2500 rpm.

13. Slide the end of the pump shaft assembly through the needle bearing, and the fiber washer into the thrust ring.

14. Affix a new gasket to the pump body. Assemble the bearing retainer to the pump body. Align the scribe marks previously made on the retainer and pump body and install the retaining bolts and lock washers.

15. Install a new oil seal in the bearing retainer as follows:

a. Apply a thin coat of sealing compound to the outside diameter of the oil seal casing.

b. Place the oil seal lip protector J 7191-2 over the shaft, lubricate the lip of the seal and slide the

seal, lip side first, over the oil seal lip protector and down to the bearing retainer.

c. Place the oil seal installer J 7191-1 over the seal lip protector J 7191-2, covering the threaded end of the shaft. Then press the seal in flush with the outer face of the retainer. Refer to Figs. 16 and 18.

16. Install the pulley on the shaft.

17. Install the charging pump on the engine and connect the hydraulic hoses to the pump.

HAND PUMP

The hand pump (Fig. 19), is a single piston double-acting positive displacement type. It is mounted in such a manner that the pumping action is never in a vertical direction and the handle clears all obstructions throughout its complete stroke. The handle may be removed and stored when the pump is not in use.

The hand pump is used to provide the initial hydraulic pressure for a new Hydrostarter installation or to build-up the pressure in the Hydrostarter system if it has been released for any reason.

Flow through the pump is controlled by ball check valves. A manually operated relief valve is provided in the hand pump to release the pressure when servicing of any of the components in the Hydrostarter system is required.

Remove Hand Pump

Remove the hand pump as follows:

1. Release the pressure in the Hydrostarter system by opening the relief valve (Fig. 19) on the side of the pump approximately 1/2 turn.

CAUTION: The oil pressure in the system must be released prior to servicing the hand pump or any other components of the system to prevent possible injury to personnel or equipment.

2. Clean all of the exterior dirt from the hand pump and the hydraulic hoses.

3. Disconnect the hydraulic hoses at the pump.

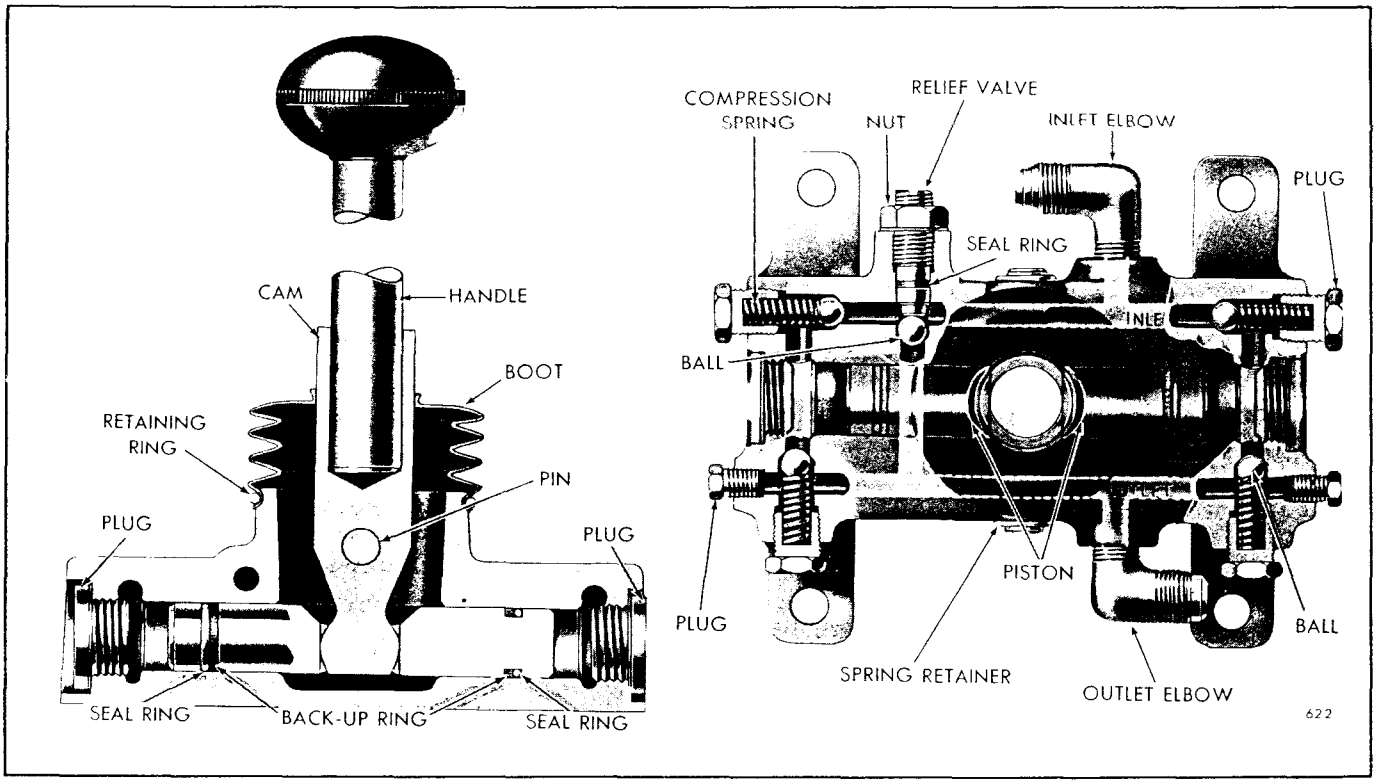


Fig. 19 - Cross Sections of Hydrostarter Hand Pump

4. Remove the attaching bolts and lock washers and lift the pump from its mounting.

Disassemble Hand Pump

1. Withdraw the handle from the pump cam. Release the rubber boot from the pump body by removing the retaining ring.

2. Remove the two spring retainers and withdraw the pin.

3. Withdraw the cam and boot from the pump body.

4. Remove the four plugs, compression springs and check valve balls.

5. Remove the two plugs and metal gaskets and withdraw the piston, with the back-up rings and seal rings, from the pump body.

6. Remove the relief valve and ball. The pump inlet and outlet elbows and remaining plugs may be removed, if necessary, in order to clean or inspect the pump body.

7. Remove the seal rings and the seal back-up rings from the piston.

Assemble Hand Pump

After an initial cleaning, inspect the pump parts. Stone the check valve ball seats in the pump body, if necessary. Then thoroughly clean the pump parts and reseat the balls in the pump body, using a non-hardened steel rod. Assemble the pump as follows:

1. Thoroughly soak new back-up rings in warm oil prior to installation. Slide the back-up rings and new seal rings on the piston.

2. Insert the piston in the pump body, notched side up, and secure it in place with plugs and new metal gaskets.

3. Clean and install the four check valve balls and springs. Install the retaining plugs.

4. If the pump inlet and outlet elbows and plugs were removed, reinstall them in the pump body. Use Permatex No. 2, or equivalent, on all male threads except the thread nearest to the open end.

5. Assemble a new seal ring on the relief valve, then insert the ball in place and secure it with the relief valve and lock nut.

6. Install the cam and insert the pin through the pump body and cam. Install the spring retainers on the pin. Install the rubber boot and secure it with a retaining ring.

7. Slide the handle into the cam.

Install Hand Pump

1. Secure the pump to its mounting with the attaching bolts and lock washers.

2. Refer to Fig. 1 and connect the two hydraulic hoses to the pump.

NOTE: Make sure the hoses and fittings are clean before any connections are made.

ACCUMULATOR

Three different types of accumulators (Fig. 20) have been used with the Hydrostarter system. The accumulator consists of a heavy duty shell assembly and piston designed to hold the nitrogen pressure for an extended period of time.

The accumulator is preloaded with nitrogen through a small valve and sealed at the time of manufacture. A seal ring is assembled in the groove of the piston, between two teflon (formerly leather) back-up rings, to prevent the nitrogen from entering the hydraulic system. The nitrogen is stored in the air valve end of the accumulator and the fluid is discharged at the opposite end.

A rubber seal ring and a teflon (formerly leather) back-up ring are used at each cap to prevent the escape of fluid and nitrogen from the shell. Nitrogen is used because it is an inert gas that will not rust or corrode the piston or the accumulator. Also, it is inexpensive, non-toxic, non-explosive and readily available.

Oil enters the accumulator under pressure from either the engine-driven pump or the hand pump and forces the piston back, compressing the nitrogen gas and storing the energy to operate the system.

The accumulator is available in either 1-1/2 or 2-1/4 gallon capacity.

If a longer cranking period is desired, two or more accumulators may be connected in parallel, provided that a reservoir of sufficient capacity is used.

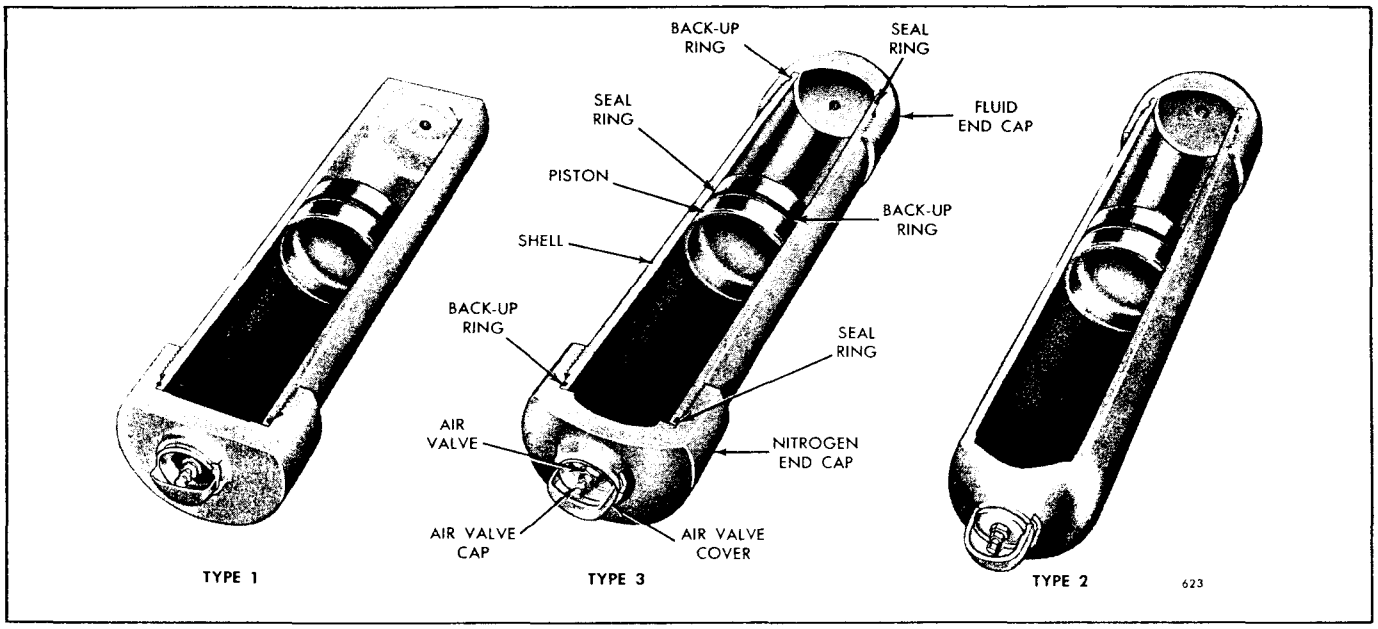


Fig. 20 - Cross Section of Typical Accumulators

Service replacement accumulators are supplied with a precharge of nitrogen (1250 ± 50 psi).

Remove Accumulator

1. Release the oil pressure in the hoses and the accumulator by opening the relief valve (Fig. 1) on the side of the hand pump.

CAUTION: The oil pressure in the Hydrostarter system must be released prior to servicing the accumulator or other components to prevent possible injury to personnel or equipment.

2. Clean all of the exterior dirt from the accumulator and the hydraulic hoses.

3. Disconnect the hydraulic hose at the accumulator.

4. Remove the pressure gage and the fittings from the fluid end cap of the accumulator.

5. Remove the attaching U bolts and lift the accumulator from its mounting.

Disassemble Accumulator

Normally, no maintenance of the accumulator is required other than painting to resist external corrosion. However, if there is a loss of the nitrogen precharge pressure due to a leaky air valve, indicated by bubbles in a soap solution applied around the valve, or due to leakage past the piston, indicated by bubbles and foaming in the reservoir, replace either the air valve or the piston seal rings as required. Seal rings between the end cap and the shell will rarely require replacement, unless the accumulator is disassembled.

1. If a defective air valve was the cause of leakage, remove the air valve cover (Fig. 20) from the accumulator cap and the air valve cap from the air valve. Loosen the 5/8" hex swivel nut on the air valve stem approximately 1-1/2 turns and then depress the valve core to release any remaining nitrogen pressure before removing the air valve. Remove the valve and replace it with a new part.

However, if damaged piston and cap seal rings are surmised, continue with the disassembly.

2. Remove the accumulator caps from the shell with a strap wrench, then push the piston out of the shell by hand.

On the former accumulator (TYPE 1 or 2), remove the cap from the shell with a strap wrench, then insert a rod through the tapped hole in the fluid end or air valve end of the shell and push the piston out of the shell. Do not damage the threads in the accumulator with the rod.

3. Remove and discard the seal ring and the back-up rings from the piston.

4. Remove and discard the seal rings and the back-up rings from the shell.

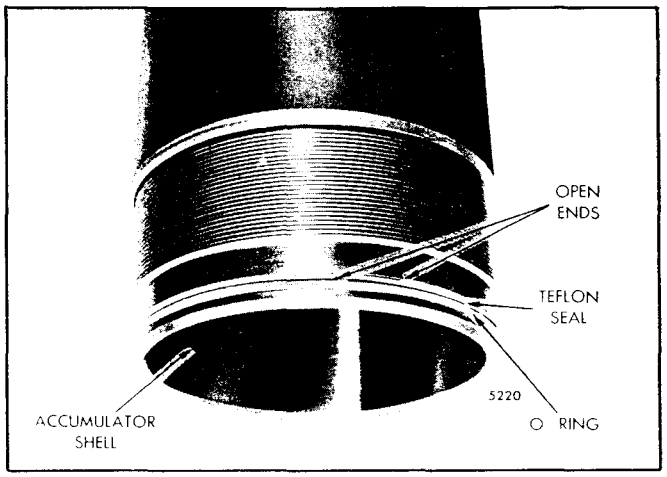


Fig. 21 - Proper Installation of Teflon Back-up Ring

Assemble Accumulator

After cleaning the shell, piston and cap thoroughly, assemble the accumulator as follows:

1. Install new teflon back-up rings (Fig. 20) and new seal rings ("O" rings) in the grooves of the shell, with the seal ring nearest the open end of the shell (Fig. 21).

> **NOTE:** It is important that the teflon seal be installed in the ring groove of the shell so that the open ends do not catch on the threads of the steel cap when it is threaded into the end of the shell. Lubricate the seal ring and the sealing surface of the end cap with engine oil before installing the cap. Reverse positioning of the open ends of the back-up ring can cause contact between the ends and the cap itself. This can cause the back-up ring to buckle and result in an improper seal ring seal when the cap is threaded on the shell.

2. On the current TYPE 3 accumulator, install the fluid end cap on the shell, being careful not to damage the seal ring.

3. Assemble a new seal ring between the two new teflon back-up rings in the piston ring groove. To insure correct positioning of the seal ring ("O" ring) and the two teflon back-up rings, it is recommended that a suitable ring compressor with a diameter capacity of 3-1/2" to 7" and a 3-1/2" high compression band be used.

4. Install the ring compressor on the piston and rings and place the entire assembly on the open end of the shell (Fig. 22). Lubricate the inner surface of the ring compressor and the beginning inner region of the shell with engine oil to reduce friction between the piston and the shell.

5. Carefully drive the piston into the shell with a hammer and block of wood, tapping gently to slowly move the seal ring and back-up rings across the chamfered edge of the shell.

a. On TYPE 1 and 3 accumulators, slide the piston, crown side first, into the shell.

   On a TYPE 2 accumulator, slide the piston, crown side facing out, into the shell.

b. On TYPE 1 and 3 accumulators, install the nitrogen end cap on the shell.

   On a TYPE 2 accumulator, install the fluid end cap on the shell.

6. Install the fittings and pressure gage in the fluid end cap. Use sealant (Permatex No. 2, or equivalent) on all male threads except the thread nearest the open end.

Install Accumulator

1. Secure the accumulator to its mounting with the U bolts.

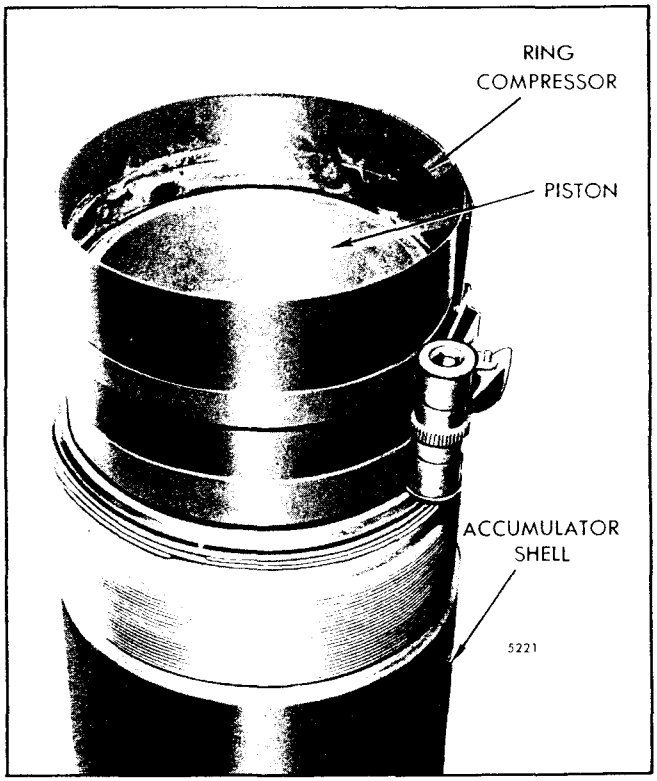


Fig. 22 - Installing Piston in Accumulator Shell

2. Connect the hydraulic hoses to the accumulator.

NOTE: Make sure the hoses and fittings are clean before any connections are made.

Charge Accumulator

Use the following procedure in precharging an accumulator with commercial nitrogen.

1. Attach the gage end of charging kit J 6714-02 to the nitrogen tank (Fig. 23).

2. Remove the air valve cover (Fig. 20) from the accumulator cap and the cap from the air valve.

3. Install the air valve stem extension on the air valve.

4. Completely back-off the shaft pin in the air check valve connector on the charging kit hose and install the connector on the air valve stem extension. Draw the swivel nut up tight.

5. Loosen the 5/8" hex lock nut on the accumulator air valve stem by turning it counterclockwise. Do not turn the lock nut more than one and one-half turns.

6. Turn the shaft pin in the air check valve connector clockwise until the valve core in the air valve is depressed.

7. Charge the accumulator by opening the valve on the nitrogen tank and allow a small flow of nitrogen to enter the accumulator until the charging kit gage registers 1300 psi. Close the nitrogen tank valve.

To check the precharge pressure during charging, simply shut off the valve to the nitrogen tank, allow a small increment of time for the pressure to stabilize

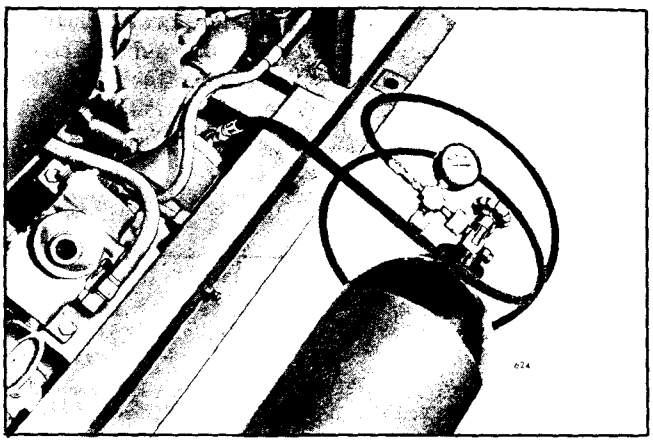


Fig. 23 - Charging Accumulator with Charging Kit J 6714-02

and the pressure indicated on the gage is the accumulator precharge pressure.

8. Back-off the shaft pin in the air check valve and tighten the 5/8" hex lock nut on the accumulator valve stem. This isolates the pressure in the charging kit hose.

9. Depress the bleed-off valve on the pressure gage to reduce the pressure in the hose to zero.

10. Repeat Steps 5 and 6 to check for a precharge pressure of 1250 psi.

11. Disconnect the accumulator charging kit from the accumulator and from the nitrogen tank.

12. Check for gas leakage by applying a soap solution to the accumulator valve stem.

13. Replace the cap on the air valve and install the air valve cover on the accumulator cap.

14. Make sure a caution decal is on the accumulator. The decal states: *This vessel pre-charged to 1250 psi with dry nitrogen.*

RESERVOIR

The reservoir consists of a cylindrical steel tank of sufficient capacity to hold the entire oil supply for the Hydrostarter system. A filler cap and breather assembly, with a dry-type filter, is located at the top of the reservoir. A fine mesh screen at the reservoir outlet filters all of the fluid flowing to the suction side of the pump.

Reservoirs are available in two basic shapes to fit various installations. There are three sizes of reservoirs: 10, 12, or 23 quart capacity. The size of the reservoir used depends upon the requirements of the particular Hydrostarter installation.

The supply hoses (Fig. 1) leading to the engine-driven pump and the hand pump are connected to the screen at the bottom of the reservoir. A return hose from the engine-driven pump connects to the top of the reservoir, while a drain hose from the Hydrostarter motor is connected to the fitting at the side of the reservoir.

The reservoir must be mounted (with the filler cap at the top) so that the outlet at the bottom of the tank is not more than 36" below nor 12" above the inlet of the engine-driven pump.

The reservoir requires very little attention other than periodically draining and flushing the old fluid out and cleaning the screen. After cleaning, fill the reservoir with new clean fluid. Make certain that the oil level is sufficient to completely cover the screen at the bottom of the reservoir. This check is made after the accumulator is charged and the engine-driven pump is by-passing oil to the reservoir.

FUEL SYSTEM PRIMING PUMP

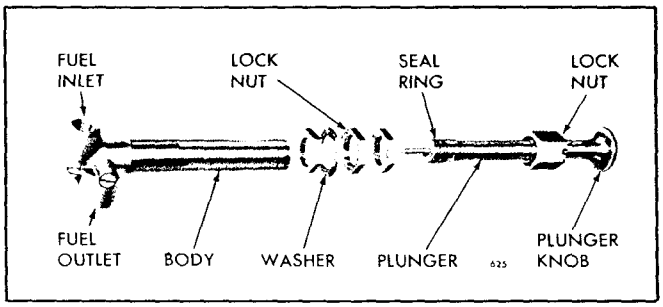


Fig. 24 - Fuel System Priming Pump and Relative Location of Parts

The small compact priming pump (Fig. 24) is used to permit the operator to prime the injectors. Before starting the engine, the operator must make sure ample fuel is present in the injectors, fuel lines, fuel filters and fuel manifolds.

The priming pump requires very little service other than an occasional cleaning of the ball check valves in the inlet and outlet passages of the pump or replacement of the seal rings. To clean the ball check valves, remove the plugs, springs and ball check valves. Clean the parts with fuel oil and reinstall them in the pump.

To replace the seal rings, loosen the lock nut and withdraw the plunger. Discard the oil seal rings. Install new seal rings and insert the plunger carefully in the pump body. Tighten the lock nut.

HYDRAULIC REMOTE CONTROL SYSTEM

The hydraulic remote control system consists of a master cylinder, a pedal, a lever arm, two springs and a flexible hose. It is an independent hydraulic system using diesel fuel oil as the hydraulic fluid to actuate the Hydrostarter control valve by means of the manually operated master cylinder.

The master cylinder (Figs. 25 and 26) is a single piston, positive displacement type of mechanism and is connected to the control valve on the Hydrostarter by a flexible hose. The fluid displaced by the piston is ported to the rear of the control valve.

Hydraulic pressure opens the control valve and engages the starter pinion with the engine flywheel ring gear in the proper sequence.

The master cylinder may be located at any desired location. However, for distances greater than 15 feet, 1/4" O.D. steel or copper tubing must be used between the flexible hose and the master cylinder. The flexible hose is always connected to the Hydrostarter control valve housing.

Current Hydrostarter motors are equipped with a control valve that incorporates a threaded valve housing plug with a 1/8" - 27 tapped hole in the center for installation of the flexible hose. A 1/8" - 27 vent plug is installed when the remote control system is not used. A cup plug was used in the valve housing on former Hydrostarter motors.

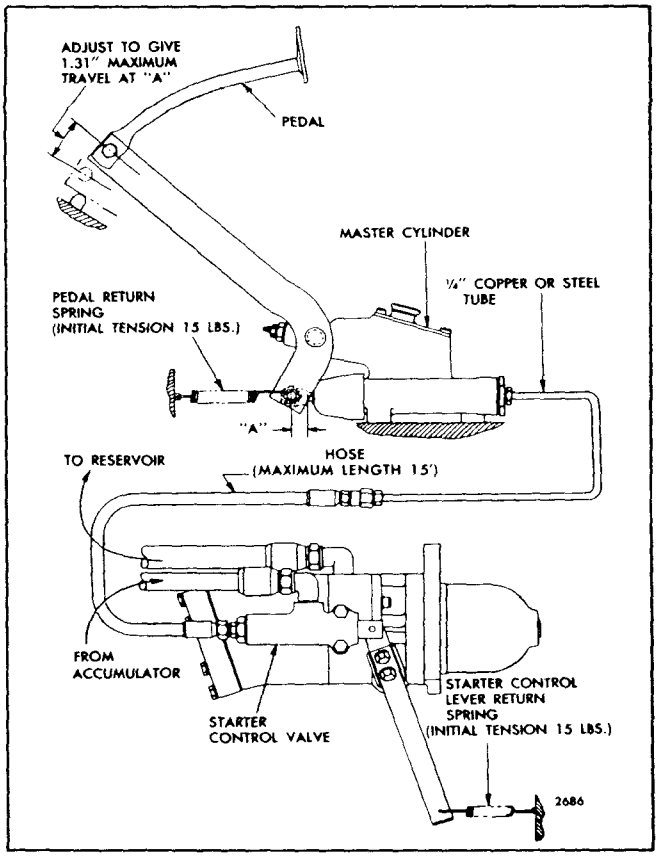


Fig. 25 - Hydraulic Remote Control System for Hydrostarter

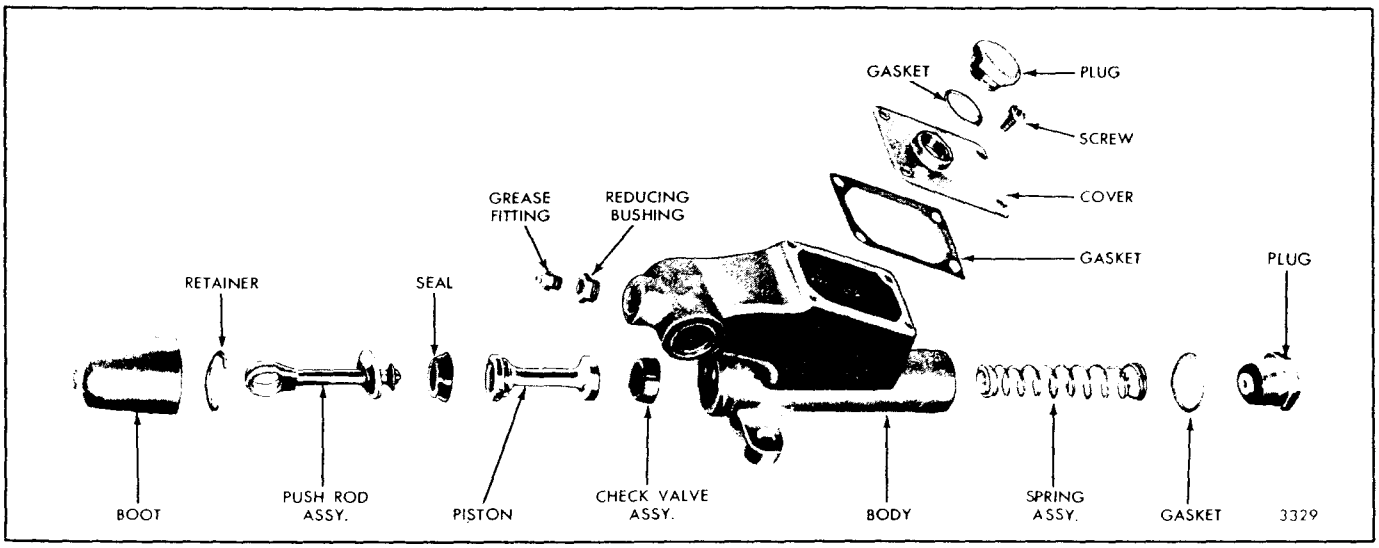


Fig. 26 - Hydraulic Starter Remote Control Master Cylinder Details and Relative Location of Parts

Springs are used to return the master cylinder piston and the Hydrostarter control lever to the off position. The springs have an initial tension of 15 lbs (Fig. 25).

The master cylinder lever arm must be adjusted to give the piston push rod a maximum travel of 1.31" (Fig. 25). The Hydrostarter control valve must be free to open to a minimum of 1-1/16".

The Hydrostarter remote control system may be purged of air as follows:

1. Fill the master cylinder with fuel oil.

2. Loosen the hose fitting at the Hydrostarter control valve.

3. Actuate the master cylinder pedal until all of the air is discharged from the system and a solid stream of fuel oil is being discharged with each stroke.

NOTE: Replenish the fluid in the master cylinder as required during the purging operation.

4. Tighten the hose fitting and check for leaks.

LUBRICATION AND PREVENTIVE MAINTENANCE

Inspect the system periodically for leaks. Primarily, examine the high pressure hoses, connections, fittings and the control valve on the starter. Make certain that the oil level in the reservoir is sufficient to completely cover the screen at the bottom of the tank. Make this check after the accumulator is charged and the engine-driven pump is by-passing oil to the reservoir.

Every 2000 hours, or as conditions warrant, drain the reservoir and remove the screen. Flush out the reservoir and clean the screen and filler cap. Then reinstall the screen.

Remove the bowl and element from the filter in the engine-driven pump supply hose (Fig. 1). Wash the bowl and element in clean fuel oil and reassemble the filter.

Release the pressure and drain the remaining hydraulic fluid from the system by disconnecting the hoses from the Hydrostarter components. Then reconnect all of the hydraulic hoses.

CAUTION: The oil pressure in the system must be released prior to servicing the Hydrostarter motor or other components to prevent possible injury to personnel or equipment.

NOTE: Make sure all hoses and fittings are clean before any connections are made.

Fill the Hydrostarter system with new clean fluid as recommended.

Lubrication

Remove the Hydrostarter from the engine every 2000 hours for lubrication. Before removing the Hydrostarter, release the pressure in the system by means of the relief valve in the hand pump. Then remove the three bolts that retain the starting motor to the flywheel housing. Remove the starting motor without disconnecting the hydraulic hoses. This will prevent dirt and air from entering the hydraulic system.

Apply a good quality, lightweight grease on the drive clutch pinion to make sure the clutch will slide freely while compressing the spring. Also apply grease to the fingers of the clutch fork and on the spool of the clutch yoke engaged by the fork. This lubrication period may be reduced or lengthened according to the severity of service.

Remove the pipe plug from the starting motor drive housing and saturate the shaft oil wick with engine oil. Then reinstall the plug.

After lubricating, install the starting motor on the flywheel housing and recharge the accumulator with the hand pump.

On units equipped with a hydraulic remote control system, lubricate the shaft in the master cylinder through the pressure grease fitting every 2000 hours.

Cold Weather Operation

Occasionally, when an engine is operated in regions of very low temperatures, the starter drive clutch assembly may slip when the starter is engaged. If the clutch slips, proceed as follows:

1. Release the oil pressure in the system by opening the relief valve in the hand pump.

> **CAUTION:** The oil pressure in the system must be released prior to servicing the Hydrostarter motor or other components to prevent possible injury to personnel or equipment.

2. Disconnect the hydraulic hoses from the starting motor.

3. Remove the three retaining bolts and lock washers and withdraw the starting motor from the flywheel housing.

4. Disassemble the starting motor.

5. Wash the Hydrostarter drive clutch assembly in clean fuel oil to remove the old lubricant.

6. When the clutch is free, apply SAE 5W lubricating oil.

7. Reassemble the starting motor and reinstall it on the engine. Then attach a tag to the starter noting the lubricant used in the clutch.

8. Recharge the accumulator with the hand pump.

Marine Application

In addition to the normal Hydrostarter lubrication and maintenance instructions, the following special precautions must be taken for marine installations or other cases where equipment is subject to salt spray and air, or other corrosive atmospheres:

1. Clean all exposed surfaces and apply a coat of zinc-chromate primer, followed by a coat of suitable paint.

2. Apply a liberal coating of Lubriplate, type 130-AA, or equivalent, to the following surfaces.

   a. The exposed end of the starter control valve and around the control shaft where it passes through the clutch housing (Fig. 4).

   b. The exposed ends of the hand pump cam pin (Fig. 19).

3. Operate all of the moving parts and check the protective paint and lubrication every week.

Trouble Shooting

The ability of the Hydrostarter system to provide positive starts under all conditions, with little service over a long period of time, depends primarily on proper maintenance.

Certain abnormal conditions that may interfere with the satisfactory performance of the Hydrostarter system, together with the methods of determining the cause of such conditions, are covered in the Trouble Shooting Charts in Section 12.0.

Service

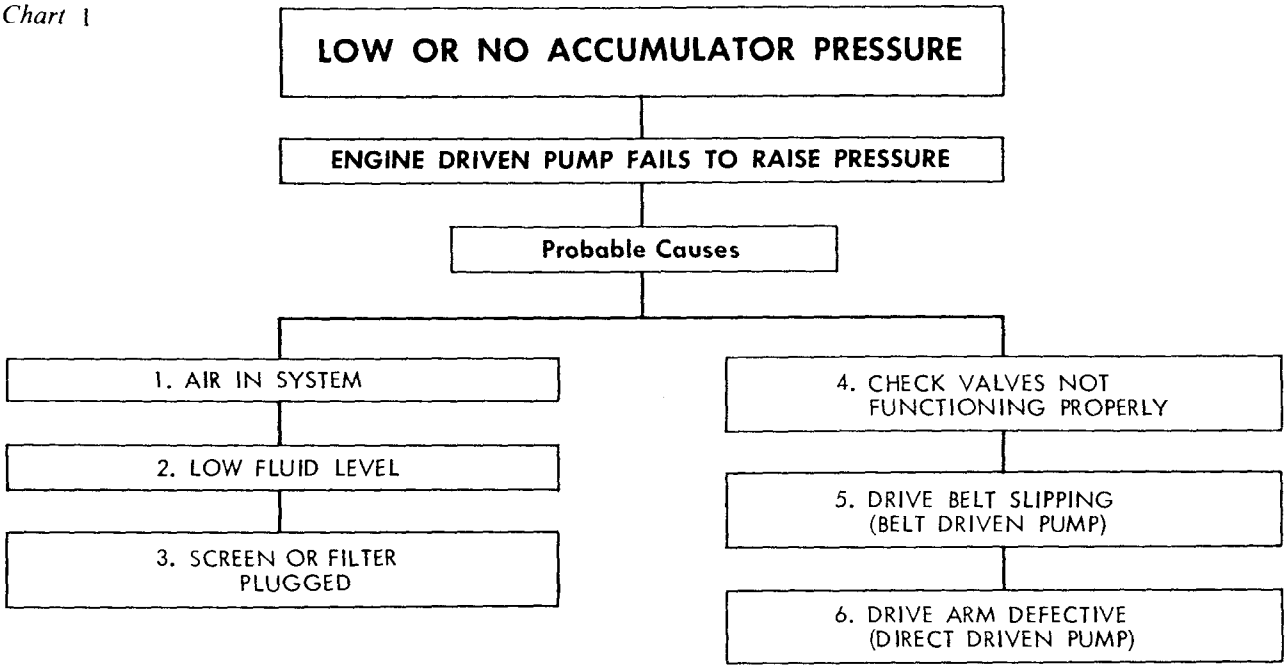
Before any work is performed, the oil pressure in the Hydrostarter system must be released to prevent possible injury to personnel or equipment.

Remove all of the exterior dirt before any portion of the hydraulic system is opened. Dust, dirt or other foreign material must never be allowed to enter the system.

TROUBLE SHOOTING - SPECIFICATIONS - SERVICE TOOLS

TROUBLE SHOOTING (Hydrostarter)

Chart 1



SUGGESTED REMEDY

1. To purge the engine driven pump of air:

a. Operate the engine at maximum no-load engine speed.

b. Break the hose connection at the discharge side of the engine-driven pump until a full stream of oil is discharged from the pump.

c Connect the hose to the pump and alternately loosen and tighten the swivel fitting on the discharge hose until oil leaking out, when the fitting is loose, appears free of air bubbles.

d. Tighten the fitting securely and observe the pressure gage. The pressure must rise rapidly to the accumulator precharge pressure (1250 psi at 70°F.) then increase slowly to 2900 to 3300 psi in 6 to 10 minutes, depending upon the size of the particular accumulator. If the accumulator pressure does not rise, make certain that the hand pump relief valve is closed after the pressure is released and repeat the above purging procedure.

2. The fluid level in the reservoir must be sufficient to completely cover the screen at the bottom of the tank after the accumulator is charged and the engine-driven pump is by-passing a full stream of fluid to the reservoir.

3. Remove and clean the reservoir screen and flush out the reservoir tank. Also clean the filter located in the supply hose between the reservoir and the engine driven pump.

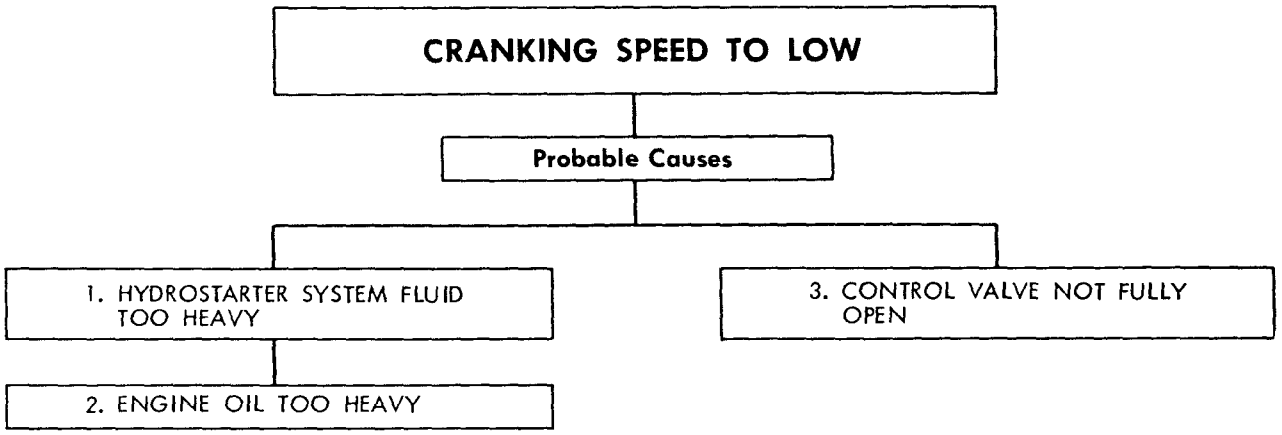
4. Open the relief valve on the side of the hand pump, while the engine is running, to permit the engine-driven pump to wash the check valves free from particles.

If the accumulator can be charged with the hand pump but not with the engine-driven pump, then a check valve in the engine pump is defective. Replace the faulty check valve assembly.

5. Adjust or replace the drive belt if necessary.

6. Replace the pump drive arm.

Chart 2



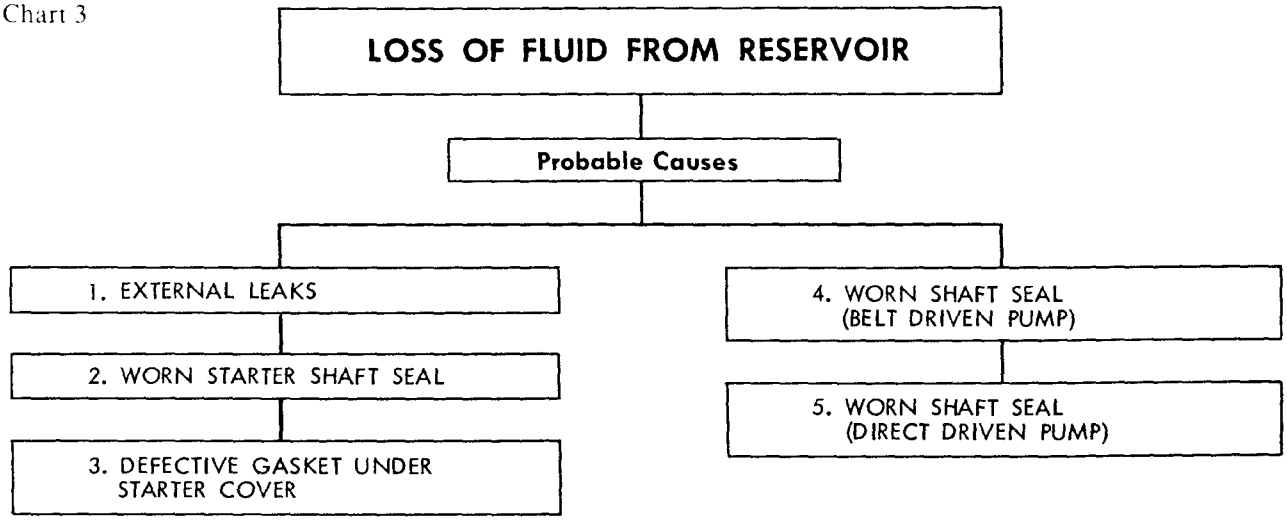
SUGGESTED REMEDY

1. Check the mixture of fluid in the system. Use fluid consisting of 75% diesel fuel and 25% SAE 10 or 30 lubricating oil.

2. Replace the oil with the proper viscosity grade. Refer to the *Engine Lubricating Oil Specifications* in Section 13.3.

3. Check the travel of the control valve located on the side of the starter. Minimum travel is 1-1/16". Remove any obstruction preventing sufficient control valve or control lever handle travel.

Chart 3



SUGGESTED REMEDY

1. With pressure in the system, check all hoses and fittings for leaks. Tighten or replace the fittings and any defective parts.

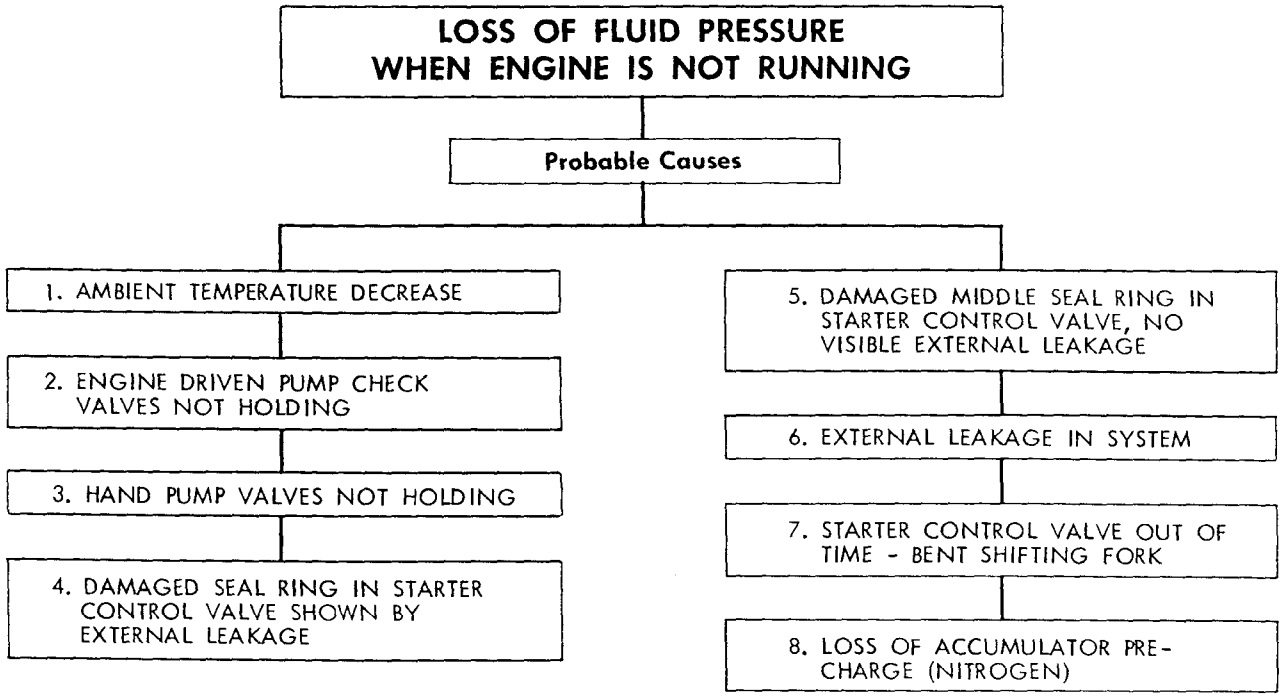
2. Remove the starter after releasing the system pressure and observe the inside of the clutch housing. If evidence of system fluid is found, replace the shaft seal.

3. Operate the starter. During the cranking cycle, watch closely for fluid leaking around the cover or any of the retaining bolts.

4. While the pump is by-passing at full system pressure, examine the shaft for evidence of leaks. Replace the seal if necessary.

5. After the pump has been by-passing at full system pressure, remove the pump from the flywheel housing and examine the back of the mounting plate near the seal for evidence of leaks. Replace the shaft seal if necessary.

Chart 4



SUGGESTED REMEDY

1. A drop in temperature will decrease the nitrogen pressure. Adjust the pressure as needed for cranking requirements by use of the hand pump.

2. Disconnect the return hose and inlet hose from the engine-driven pump. Leakage from the inlet fitting means that both check valves are defective. Leakage at the return fitting only means that the outlet check valve is defective. Replace the defective check valve assembly(s).

3. Disconnect the inlet hose from the hand pump. Leakage from the inlet fitting means that either the relief valve alone or both the inlet and outlet check valves are defective. Stone and clean the ball seats in the pump body and replace the balls and springs if necessary.

4. Remove the control valve from the starter and replace the seal ring.

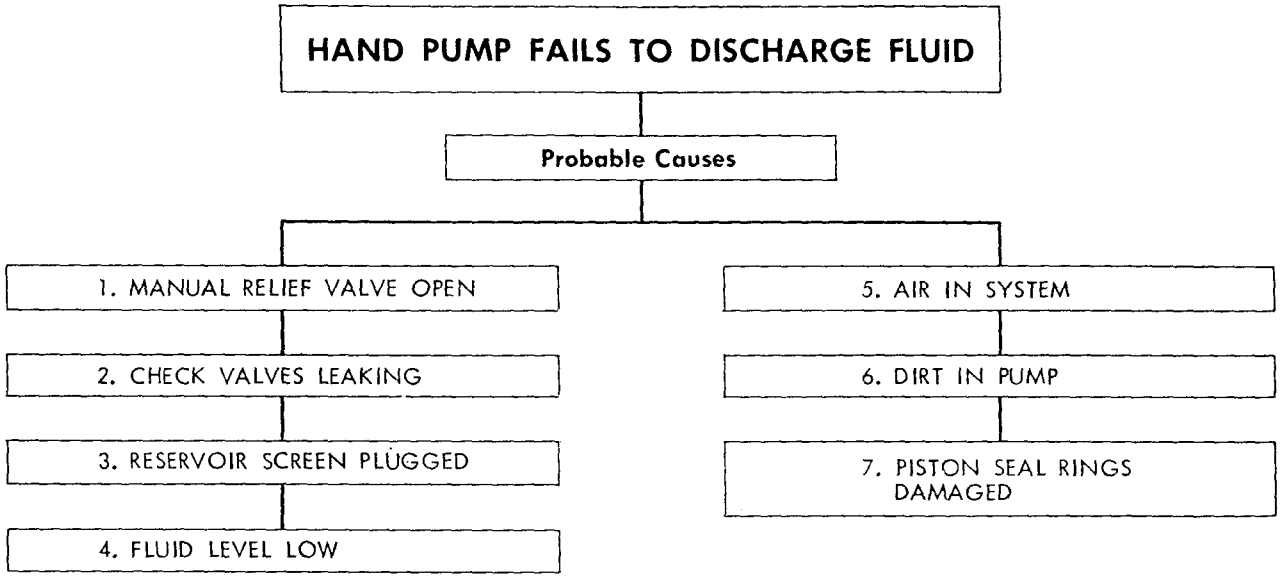
5. Disconnect the return hose from the starter. Use the hand pump to raise the pressure if necessary. If fluid leaks from the return fitting when the control valve is closed, the middle seal ring is damaged. Remove the control valve and replace the seal ring.

6. Examine all hoses and fittings for leaks. Tighten or replace the fittings and any defective parts.

7. With the control valve closed, check the length of the piston protruding beyond the valve body. The correct length is 7/8" ± 1/32". If the length is incorrect, the shifting fork may be bent or the nylon yoke between the fork and the clutch collar may be damaged. Replace the faulty parts.

8. See Chart 7.

Chart 5



SUGGESTED REMEDY

1. Close the relief valve.

2. If caused by dirt, open the relief valve and operate the hand pump slowly for a few minutes to wash the particles out of the check valves. If this is unsuccessful, stone and clean the ball seats in the pump body and replace the balls and springs if necessary.

3. Remove and clean the reservoir screen, flush the reservoir tank and reassemble.

4. See Chart 1. Item 2.

5. To purge the hand pump of air:

   a. Relieve any system pressure, then disconnect the outlet hose from the hand pump.

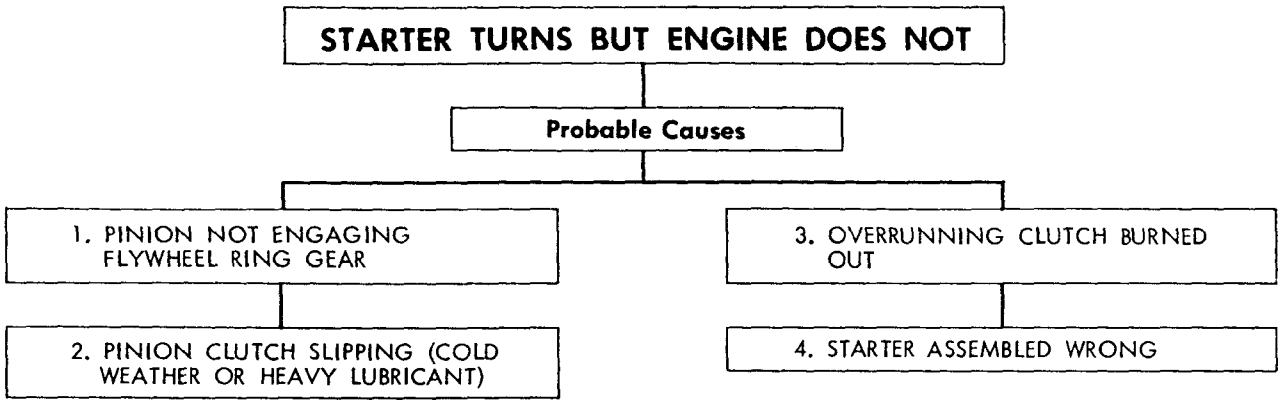
   b. Close the manual relief valve and operate the pump until fluid is discharged when stroking in both directions.

   c. Reconnect the outlet hose.

6. See Item 2.

7. Replace the seal rings.

Chart 6



SUGGESTED REMEDY

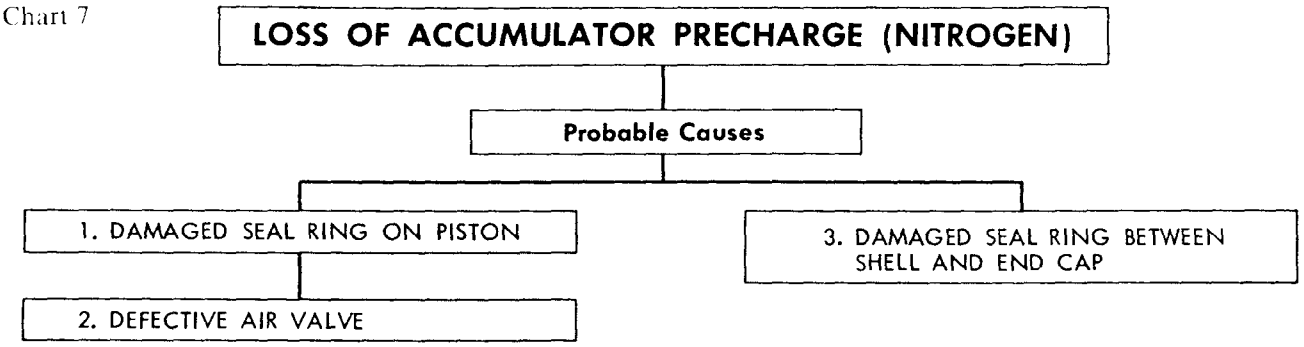
1. Check the shifting fork. If the fork is bent, replace it.

2. Wash out the heavy lubricating oil and replace it with SAE 5W or SAE 10 oil.

3. Replace the clutch. If a mechanical linkage is attached to the control lever, add sufficient spring force to assure that the clutch is withdrawn from engagement, and that the control valve is returned to the shut-off position. If no mechanical linkage is used, disengage the starter as soon as the engine starts. Prolonging the period during which the clutch overruns will reduce clutch life.

4. The starter may be assembled for L.H. rotation but with a R.H. overrunning clutch. Remove the starter and assemble it correctly.

Chart 7



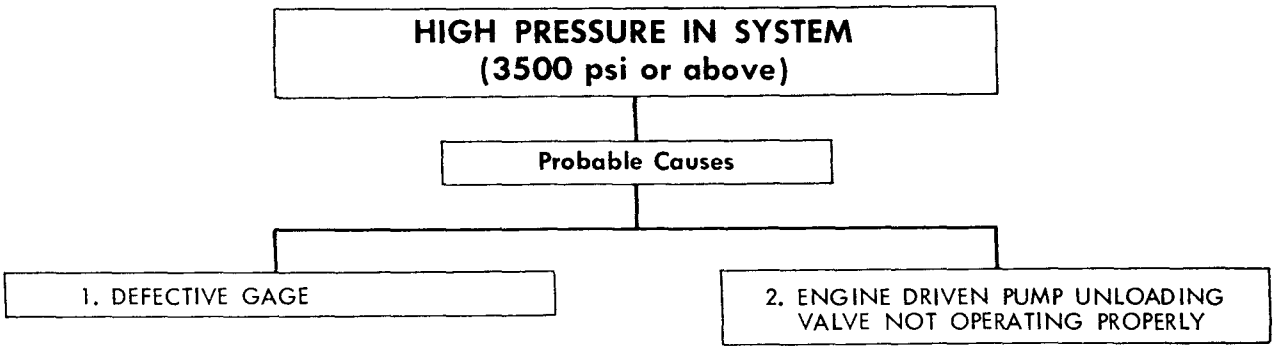
SUGGESTED REMEDY

1. With some nitrogen precharge but no fluid pressure in the system, bubbles and foaming in the reservoir indicate that the nitrogen is leaking past the seal ring on the accumulator piston. Overhaul the accumulator.

2. Release the pressure in the system by opening the relief valve on the side of the hand pump. Then, loosen the hex lock nut on the nitrogen valve approximately 3/4 turn to release the remaining precharge before attempting to remove the valve from the accumulator. Replace the air valve.

3. Apply light oil on the threaded end of the accumulator at the end of the cap. Bubbling of the oil indicates a leak past the end cap seal. Release the nitrogen precharge before removing the cap to replace the seals.

Chart 8

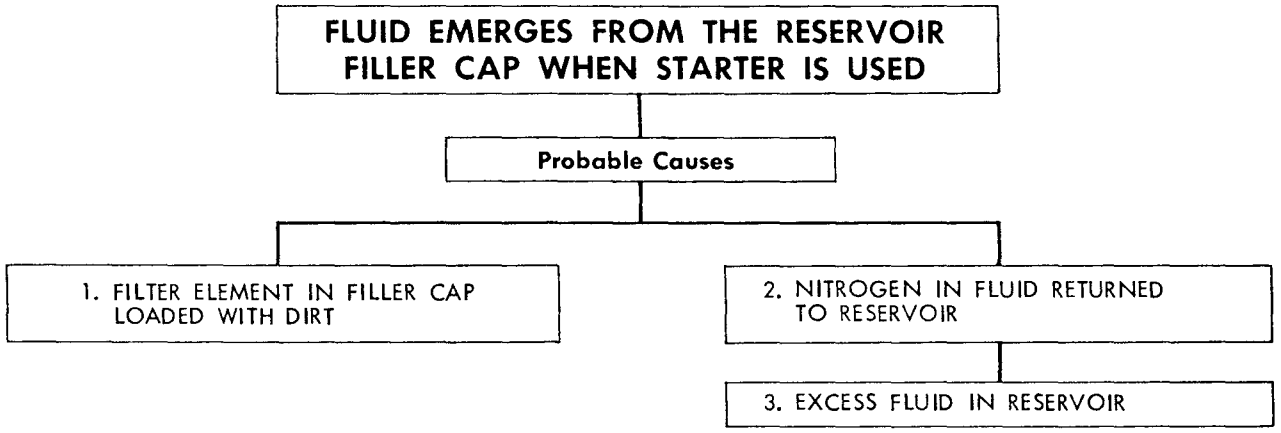


SUGGESTED REMEDY

1. Replace the gage.

2. Overhaul the pump.

Chart 9



SUGGESTED REMEDY

1. Rinse the filler cap thoroughly in fuel oil and dry it with compressed air.

2. Overhaul the accumulator. See Chart 7. Item 1.

3. Check the fluid level after the accumulator is charged and the engine-driven pump is by-passing a full stream of oil to the reservoir. The fluid level must be sufficient to completely cover the screen in the bottom of the tank.

Chart 10

FLUID EMERGES AROUND RUBBER BOOT ON HAND PUMP

Probable Causes

1. DAMAGED PISTON SEAL RINGS

SUGGESTED REMEDY

1. Replace the seal rings and leather back-up rings on the pump piston.

Chart 11

FLUID EMERGES FROM ENDS OF STARTER CONTROL VALVE WHEN STARTER IS OPERATED

Probable Causes

1. DAMAGED FRONT CONTROL VALVE SEAL RING

2. BENT SHIFTING FORK CAUSING END OF CONTROL VALVE TO MOVE PAST THE REAR SEAL RING

SUGGESTED REMEDY

1. Operate the starter. If fluid emerges around the front end of the control valve, the seal ring is damaged.

2. See Chart 4, Item 7. Also operate the starter. If fluid emerges from the cap on the rear of the control valve, the fork is bent and the seal ring may be damaged.

HYDROSTARTER SPECIFICATIONS

Hydrostarter Motor

Type	Swash plate
Number of pistons	Seven
Displacement per revolution *20 Series*	2 cu. in.
Displacement per revolution *35 Series*	3.5 cu. in.
Maximum torque at 3000 psi *20 Series*	80 lb-ft
Maximum torque at 3000 psi *35 Series*	140 lb-ft
Drive	Overrunning clutch
Inlet port *20 and 35 Series*	No. 8 elbow (J1C 37° flare)
Return port *20 Series*	No. 10 elbow (SAE 45°flare)
Return port *35 Series*	No. 12 elbow (SAE 45° flare)

Engine-Driven Pump

Type	Positive displacement
Number of pistons	One
Displacement per revolution	0.0208 cu. in.
Inlet port	No. 6 elbow (SAE 45° flare)
Outlet port	No. 6 elbow (J1C 37° flare)
By-pass port	No. 4 elbow (SAE 45° flare)
Maximum discharge pressure	3250 psi
Maximum continuous speed	2500 rpm

Manual Pump

Type	Positive displacement
Number of pistons	One
Displacement per stroke	0.773 cu. in.
Inlet port	No. 6 elbow (SAE 45° flare)
Outlet port	No. 6 elbow (J1C 37° flare)

Accumulator

Type	Piston
Capacity	200 or 300 cu. in.
Precharge (nitrogen)	1250 psi
Operating pressure	2900-3000 psi
Port	3/8 NPTF

Reservoir

Capacity	10, 12, 16 or 23 qt.
Outlet port	1/4 NPT
Pump return port	1/8 NPT
Starter return port	1/2 NPT
Drain (plug) port	1/8 NPT

Remote Control Master Cylinder

Type	Positive displacement
Number of pistons	One
Displacement per stroke	1.2 cu. in.
Outlet port	7/16-24 inverted flare tap

Filter

Type	Sediment bowl-stacked disc
Degree of filtration	50 microns
Inlet port	1/8 NPTF
Outlet port	1/8 NPTF

STANDARD BOLT AND NUT TORQUE SPECIFICATIONS

THREAD SIZE	TORQUE (lb-ft)	THREAD SIZE	TORQUE (lb-ft)
1/4 -20	7-9	9/16-12	90-100
1/4 -28	8-10	9/16-18	107-117
5/16-18	13-17	5/8 -11	137-147
5/16-24	15-19	5/8 -18	168-178
3/8 -16	30-35	3/4 -10	240-250
3/8 -24	35-39	3/4 -16	290-300
7/16-14	46-50	7/8 - 9	410-420
7/16-20	57-61	7/8 -14	475-485
1/2 -13	71-75	1 - 8	580-590
1/2 -20	83-93	1 -14	685-695

SERVICE TOOLS

TOOL NAME	TOOL NO.
Accumulator charging kit	J 6714-02
Oil seal installer	J 7190
Oil seal installer set	J 7191
Seal installer	J 7191-1
Seal lip protector	J 7191-2
Seal lip protector	J 7191-3
Piston, back-up and seal ring, washer installer	J 7192
Spring compressor	J 7187

SECTION 13

OPERATING INSTRUCTIONS

CONTENTS

ENGINE OPERATING INSTRUCTIONS

PREPARATION FOR STARTING ENGINE FIRST TIME

Before starting an engine for the first time, carefully read and follow the instructions in Sections 13 and 14 of this manual. Attempting to run the engine before studying these instructions may result in serious damage to the engine.

NOTE: When preparing to start a new or overhauled engine or an engine which has been in storage, perform all of the operations listed below. Before a routine start (at each shift), see *Daily Operations* in the *Lubrication and Preventive Maintenance Chart*, Section 15.1.

Cooling System

Install all of the drain cocks or plugs in the cooling system (drain cocks are removed for shipping).

Open the cooling system vents, if the engine is so equipped.

Loosen the water return line near the top of the turbocharger (if used).

Remove the filler cap and fill the cooling system with clean, soft water or a protective solution consisting of high boiling point type antifreeze, if the engine will be exposed to freezing temperatures (refer to *Engine Coolant* in Section 13.3). Keep the liquid level about two inches below the filler neck to allow for fluid expansion.

Use a quality rust inhibitor if only water is used in the cooling system.

Close the vents, if used, after filling the cooling system.

Tighten the turbocharger water return line.

On marine installations, prime the raw water cooling system and open any sea cocks in the raw water pump intake line. Prime the raw water pump by removing the pipe plug or electrode provided in the pump outlet elbow and pour water in the pump.

CAUTION: Failure to prime the raw water pump may result in damage to the pump impeller.

Lubrication System

The lubricating oil film on the rotating parts and bearings of a new or overhauled engine, or one which has been in storage, may be insufficient for proper lubrication when the engine is started for the first time.

It is recommended that the engine lubricating system be charged with a pressure prelubricator, set to supply a minimum of 25 psi oil pressure, to ensure an immediate flow of oil to all bearings at the initial engine start-up. The oil supply line should be attached to the engine so that oil under pressure is supplied to the main oil gallery.

With the oil pan dry, use the prelubricator to prime the engine with sufficient oil to reach all bearing surfaces. Use *heavy-duty* lubricating oil as specified under *Lubricating Oil Specifications* in Section 13.3. Then remove the dipstick, wipe it with a clean cloth, insert and remove it again to check the oil level in the oil pan. Add sufficient oil, if necessary, to bring it to the full mark on the dipstick. Do not overfill.

If a pressure prelubricator is not available, fill the crankcase to the proper level with *heavy-duty* lubricating oil as specified under *Lubricating Oil Specifications* in Section 13.3. Then pre-lubricate the upper engine parts by removing the valve rocker cover(s) and pouring lubricating oil, of the same grade and viscosity as used in the crankcase, over the rocker arms.

Turbocharger

Disconnect the turbocharger oil inlet line and pour approximately one pint of clean engine oil in the line, thus making sure the bearings are lubricated for the initial start. Reconnect the oil line.

Air Cleaner

If the engine is equipped with oil bath air cleaners, fill the air cleaner oil cups to the proper level with clean engine oil. *Do not overfill.*

Transmission

Fill the transmission case, marine gear or torque converter supply tank to the proper level with the lubricant specified under *Lubrication and Preventive Maintenance* in Section 15.1.

Fuel System

Fill the fuel tank with the fuel specified under *Diesel Fuel Oil Specifications* in Section 13.3.

If the unit is equipped with a fuel valve, it must be opened.

To ensure prompt starting, fill the fuel system between the pump and the fuel return manifold with fuel. If the engine has been out of service for a considerable length of time, prime the filter between the fuel pump and the injectors. The filter may be primed by removing the plug in the top of the filter cover and slowly filling the filter with fuel.

In addition to the above, on an engine equipped with a Hydrostarter, use a priming pump to make sure the fuel lines and the injectors are full of fuel before attempting to start the engine.

NOTE: The fuel system is filled with fuel before leaving the factory. If the fuel is still in the system when preparing to start the engine, priming should be unnecessary.

Lubrication Fittings

Fill all grease cups and lubricate at all fittings with an all purpose grease. Apply lubricating oil to the throttle linkage and other moving parts and fill the hinged cap oilers with a hand oiler.

Drive Belts

Adjust all drive belts as recommended under *Lubrication and Preventive Maintenance* in Section 15.1.

Storage Battery

Check the battery. The top should be clean and dry, the terminals tight and protected with a coat of petroleum jelly and the electrolyte must be at the proper level.

NOTE: When necessary, check the battery with a hydrometer; the reading should be 1.265 or higher. However, hydrometer readings should always be corrected for the temperature of the electrolyte.

Generator Set

Where applicable, fill the generator end bearing housing with the same lubricating oil as used in the engine.

A generator set should be connected and grounded in accordance with the applicable local electrical codes.

CAUTION: The base of a generator set must be grounded.

Clutch

Disengage the clutch, if the unit is so equipped.

STARTING

Before starting the engine for the first time, perform the operations listed under *Preparation For Starting Engine First Time.*

Before a routine start, see *Daily Operations* in the *Lubrication and Preventive Maintenance Chart*, Section 15.1.

If a manual or an automatic shut-down system is incorporated in the unit, the control must be set in the open position before starting the engine. The blower will be seriously damaged if operated with the air shut-off valve in the closed position.

Starting at air temperatures below 40 ° F. requires the use of a cold weather starting aid. See *Cold Weather Starting*, Section 12.6.

The instructions for the use of a cold weather fluid starting aid will vary dependent on the type being used. Reference should be made to these instructions before attempting a cold weather start.

CAUTION: Starting fluid used in capsules is highly inflammable, toxic and possesses anesthetic properties.

Initial Engine Start (Electric)

Start an engine equipped with an electric starting motor as follows: Set the speed control lever at part throttle, then bring it back to the desired no-load speed. In addition, on mechanical governors, make sure the stop lever on the governor cover is in the *run* position; on hydraulic governors, make sure the stop knob is pushed all the way in. Then press the starting

motor switch firmly. If the engine fails to start within 30 seconds, release the starting switch and allow the starting motor to cool a few minutes before trying again. If the engine fails to start after four attempts, an inspection should be made to determine the cause.

CAUTION: To prevent serious damage to the starter, if the engine does not start, do not press the starting switch again while the starting motor is running.

Initial Engine Start (Hydrostarter)

Start an engine equipped with a Hydrostarter as follows:

Use the priming pump to make sure the fuel filter, fuel lines and injectors are full of fuel before attempting to start the engine.

Raise the Hydrostarter accumulator pressure with the hand pump until the gage reads as indicated in the chart.

Ambient Temperature	Pressure Gage Reading
Above 40°F.	1500 psi
40°F. to 0°F.	2500 psi
Below 0°F.	3300 psi

Set the engine controls for starting with the throttle at least half open.

NOTE: During cold weather, add starting fluid at the same time the Hydrostarter motor lever is moved. Do not wait to add the fluid after the engine is turning over.

Push the Hydrostarter control lever to simultaneously engage the starter pinion with the flywheel ring gear and to open the control valve . Close the valve as soon as the engine starts to conserve the accumulator pressure and to avoid excessive over-running of the starter drive clutch assembly.

RUNNING

Oil Pressure

Observe the oil pressure gage immediately after starting the engine. If there is no pressure indicated within 10 to 15 seconds, stop the engine and check the lubricating oil system. Refer to the *Trouble Shooting Charts* in Section 15.2.

Warm-Up

Run the engine at part throttle and no-load for approximately five minutes, allowing it to warm-up before applying a load.

If the unit is operating in a closed room, start the room ventilating fan or open the windows, as weather conditions permit, so ample air is available for the engine.

Inspection

While the engine is running at operating temperature, check for coolant, fuel or lubricating oil leaks. Tighten the line connections where necessary to stop leaks.

Engine Temperature

Normal engine coolant temperature is 160 F. to 185 F.

Crankcase

If the engine crankcase was refilled, stop the engine after normal operating temperature has been reached, allow the oil to drain (approximately 10 minutes) back into the crankcase and check the oil level. Add oil, if necessary, to bring it to the proper level on the dipstick.

Use only the *heavy duty* lubricating oil specified under *Lubricating Oil Specifications* in Section 13.3.

Cooling System

Remove the radiator or heat exchanger tank cap *slowly* after the engine has reached normal operating temperature and check the engine coolant level. The coolant level should be near the top of the opening. If necessary, add clean soft water or a high boiling point type antifreeze.

Transmission

Check and, if necessary, replenish the oil supply in the transmission.

Turbocharger

Make a visual inspection of the turbocharger for leaks and excessive vibration. Stop the engine immediately if there is an unusual noise in the turbocharger.

Avoid Unnecessary Engine Idling

During long engine idling periods, the engine coolant temperature will fall below the normal operating range. The incomplete combustion of fuel in a cold engine will cause crankcase dilution, formation of lacquer or gummy deposits on the valves, pistons and rings and rapid accumulation of sludge in the engine.

NOTE: When prolonged engine idling is necessary, maintain at least 800 rpm.

STOPPING

Normal Stopping

1. Release the load and decrease the engine speed. Put all shift levers in the *neutral* position.

2. Allow the engine to run at half speed or slower with no load for a short time, then move the stop lever to the *stop* position to shut down the engine.

Emergency Stopping

If the engine does not stop after using the normal stopping procedure, pull the "Emergency Stop" knob all the way out. This control cuts off the air to the engine. Do not try to restart again until the cause for the malfunction has been found and corrected.

CAUTION: The emergency shut-down system should never be used except in an emergency. Use of the emergency shut-down can cause oil to be sucked past the oil seals and into the blower housing.

The air shut-off valve, located on the blower air inlet housing, must be reset by hand and the "Emergency Stop" knob pushed in before the engine is ready to start again.

Fuel System

If the unit is equipped with a fuel valve, close it. Fill the fuel tank; a full tank minimizes condensation.

Exhaust System

Drain the condensation from the exhaust line or silencer.

Cooling System

Drain the cooling system if it is not protected with antifreeze and freezing temperatures are expected. Leave the drains open. Open the raw water drains of a heat exchanger cooling system.

Crankcase

Check the oil level in the crankcase. Add oil, if necessary, to bring it to the proper level on the dipstick.

Transmission

Check and, if necessary, replenish the oil supply in the transmission.

Clean Engine

Clean and check the engine thoroughly to make certain it will be ready for the next run.

Refer to *Lubrication and Preventive Maintenance* and perform all of the daily maintenance operations. Also perform the operations required for the number of hours or miles the engine has been in operation.

Make the necessary adjustments and minor repairs to correct difficulties which became apparent to the operator during the last run.

ALTERNATING CURRENT POWER GENERATOR SET OPERATING INSTRUCTIONS

These instructions cover the fundamental procedures for operating an alternating current power generator set (Fig. 1). The operator should read these instructions before attempting to operate the generator set.

Never operate a generator set for a short (15 minute) interval - the engine will not reach normal operating temperature in so short a period.

Avoid operating the set for extended periods at no-load.

Ideally, operate the set for one hour with at least 40% load (generator rating).

When a test must be made with a line load of less than 40% of the generator rating, add a supplementary load.

Connect the supplementary load to the load terminals of the control cabinet circuit breaker so that the generator can be "loaded" whenever the breaker is closed.

Make certain that the supplementary load is such that it can be controlled to permit a reduction in the load should a normal load increase occur while the set is operating. Locate the supplementary load outside the engine room, if desirable, to provide adequate cooling.

Loading the generator set to 40% of the generator rating and operating it for one-hour intervals will bring the engine and generator to normal operating temperatures and circulate the lubricants properly. Abnormal amounts of moisture, carbon and sludge are due primarily to low internal operating temperatures which are much less likely to occur when the set is tested properly.

PREPARATION FOR STARTING

Before attempting to start a new or an overhauled engine or an engine which has been in storage, perform all of the operations listed under *Preparation for Starting Engine First Time* in Section 13.1. Before a routine start, see *Daily Operations* in the *Lubrication and Preventive Maintenance Chart* in Section 15.1.

In addition to the *Engine Operating Instructions*, the following instructions also apply when operating an alternating current power generator set.

1. Before the first start, check the generator main

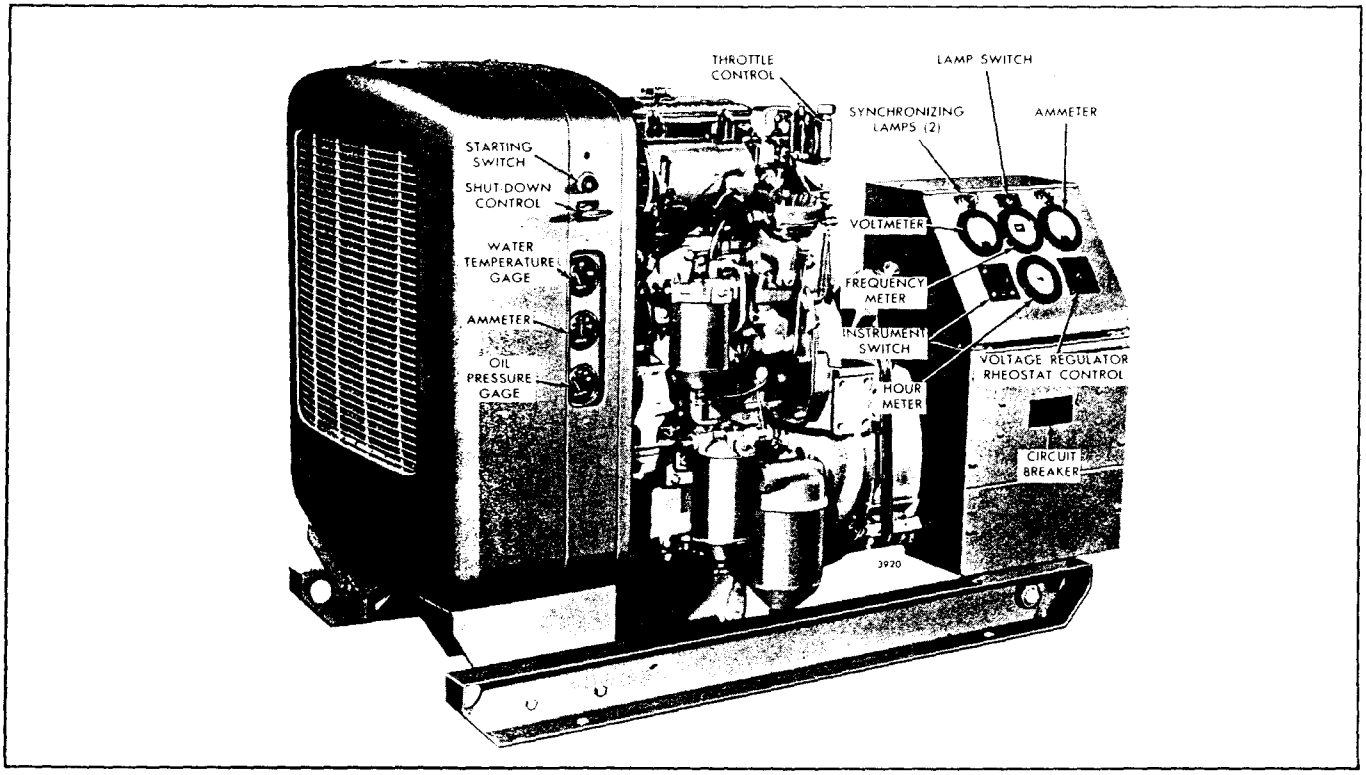


Fig. 1 - Location of Controls on Power Generator Set

bearing oil reservoir. If necessary, add sufficient lubricating oil, of the same grade as used in the engine crankcase, to bring it to the proper level on the sight gage.

2. Check the interior of the generator for dust or moisture. Blow out dust with low pressure air (25 psi maximum). If there is moisture on the interior of the generator, it must be dried before the set is started. Refer to the appropriate Delco Products Maintenance bulletin.

3. The air shut-off valve located in the air inlet housing must be in the open or reset position.

4. Refer to Fig. 1 and place the circuit breaker in the **off** position.

5. If the generator set is equipped with synchronizing lamps, place the lamp switch in the **off** position.

6. Turn the voltage regulator rheostat knob counterclockwise to its lower limit.

7. Make sure the power generator set has been cleared of all tools or other objects which might interfere with its operation.

STARTING

If the generator set is located in a closed space, start the ventilating fan or open the doors and windows, as weather permits, to supply ample air to the engine.

The engine may require the use of a cold weather starting aid if the ambient temperature is below 40°F. Refer to *Cold Weather Starting Aids* in Section 12.6.

Press the throttle button and turn the throttle control (Fig. 1) counterclockwise to a position midway between **run** and **stop**. Then press the starting switch firmly.

If the engine fails to start within 30 seconds, release the starting switch and allow the starting motor to cool a few minutes before trying again. If the engine fails to start after four attempts, an inspection should be made to determine the cause.

> **CAUTION:** To prevent serious damage to the starter, if the engine does not start, do not press the starting switch again while the starting motor is rotating.

RUNNING

Observe the engine oil pressure gage immediately after starting the engine. If there is no oil pressure indicated within 10 to 15 seconds, stop the engine and check the engine lubricating system.

If the oil pressure is observed to be normal, increase the throttle setting to cause the engine to run at its synchronous speed.

PREPARING GENERATOR FOR LOAD

After the engine is warmed up (or the oil pressure has stabilized), prepare the generator set for load as follows:

1. Bring the engine up to the rated speed.

2. Turn the instrument switch to the desired position.

3. Turn the voltage regulator rheostat knob slowly in a clockwise direction to raise the voltage, while watching the voltmeter, until the desired voltage is attained.

4. If the generator set is equipped with a frequency meter, adjust the engine speed with the vernier throttle knob until the desired frequency is indicated on the meter.

5. Make sure all power lines are clear of personnel, then place the circuit breaker control in the **on** position.

> **NOTE:** Perform Step 5 only if the generator set is not being paralleled with an existing power source. If it is being paralleled with a power source already on the line, read and follow the instructions under *Paralleling* before turning the circuit breaker control to the **on** position.

PARALLELING

If the load conditions require an additional unit to be placed on the line, the following instructions will apply to power generator sets of equal capacity, with one generator set in operation on the line.

1. Prepare the generator set to be paralleled as outlined under *Preparation For Starting, Starting Running* and items 1 through 4 under *Preparing Generator for Load.*

2. Check the voltmeter (Fig. 1); the voltage must be the same as the line voltage. Adjust the voltage regulator rheostat control if the voltages are not the same.

3. Place the synchronizing lamp switch, of the generator set to be paralleled, in the **on** position.

4. Turn the vernier throttle knob until both units are operating at approximately the same frequency as

indicated by the slow change in the brilliancy of the synchronizing lamps.

5. When the synchronizing lamps glow and then go out at a very slow rate, time the dark interval. Then, in the middle of this interval, turn the circuit breaker control to the **on** position. This places the incoming generator set on the line, with no load. The proper share of the existing load must now be placed on this generator.

6. The division of the kilowatt load between the alternating current generators operating in parallel depends on the power supplied by the engines to the generators as controlled by the engine governors and is practically independent of the generator excitation. Divide the kilowatt load between the generators by turning the vernier throttle knob counterclockwise on the incoming generator and clockwise on the generator that has been carrying the load (to keep the frequency of the generators constant) until both ammeters read the same, indicating that each generator is carrying its proper percentage of the total K.W. load.

7. The division of the reactive KVA load depends on the generator excitation as controlled by the voltage regulator. Divide the reactive load between the generators by turning the voltage regulator rheostat control on the incoming generator (generally clockwise to raise the voltage) until the ammeters read the same on both generator sets and the sum of the readings is minimum.

NOTE: The generator sets are equipped with a resistor and current transformer connected in series with the voltage coil of the regulator (cross-current compensation) which equalizes most but not all of the reactive KVA load between the generators.

8. When the load is 80 per cent power factor lagging (motor and a few lights only), turn the vernier throttle knob on the incoming generator until the ammeter on that unit reads approximately 40 per cent of the total current load.

9. Rotate the voltage regulator rheostat control on the incoming generator clockwise to raise the voltage until the ammeters read the same on both units.

NOTE: If a load was not added during paralleling, the total of the two ammeter readings should be the same as the reading before paralleling. Readjust the voltage regulator rheostat on the incoming generator, if necessary.

10. To reset the load voltage, turn the voltage regulator rheostat controls slowly on each unit. It is necessary to turn the controls the same amount and in the same direction to keep the reactive current equally divided.

Power generator sets with different capacities can also be paralleled by dividing the load proportionately to their capacity.

STOPPING

The procedure for stopping a power generator set or taking it out of parallel is as follows:

1. Turn off all of the load on the generator when stopping a single engine unit.

2. Shift the load from the generator when taking it out of parallel operation by turning the vernier throttle knob until the ammeter reads approximately zero.

3. Place the circuit breaker control in the **off** position.

4. Turn the voltage regulator rheostat control in a counterclockwise direction to the limit of its travel.

5. Press the throttle button and turn the throttle control to **stop** to shut-down the engine.

NOTE: When performing a tune-up on a generator set that will be operated in parallel with another unit, adjust the speed droop as specified in *Engine Tune-Up*.

OPERATING INSTRUCTIONS FOR SERIES 2-53 POWER GENERATOR UNITS IN RAILROAD REFRIGERATION CARS

Before Starting Each Trip

1. Check the engine oil level in the crankcase with the dipstick which is attached to a pipe cap with an integral bar grip and is located at the front of the engine below the radiator. The crankcase oil level should be at, or near, the *full* mark on the dipstick. The large capacity of the oil pan permits extended operation without frequently replenishing the oil supply. However, never let the oil level fall below the *add* mark on the dipstick. When adding oil between drain periods, add only sufficient oil to complete the trip or to get the unit to the next railroad service station. Use only the *heavy-duty* lubricating oils as specified under *Lubricating Oil Specifications* in Section 13.3.

2. Check the engine hour meter, if the unit is so equipped, or log book to determine whether the engine lubricating oil should be changed. Change oil every 750 to 1000 hours.

3. Check the coolant level in the radiator. Fill with a solution of high boiling point type antifreeze and water as specified by the railroad operating division. Coolant drains located at the bottom of the radiator, side of the engine cylinder block and bottom of the oil cooler must be closed.

4. Fill the fuel tanks with clean fuel oil. Select the proper grade of fuel in accordance with the *Fuel Oil Specifications* in Section 13.3.

5. Check the condition of the storage battery as recommended by the battery manufacturer. Check electrical connections for tightness.

6. Check the power plug to make sure that it is in position and that the clamp ring is tight.

7. Drain the water and sediment from the fuel oil strainer and the fuel oil filter by opening the drain cock at the bottom of each. Drain off 1/4 pint, or more if necessary, to remove accumulated water and sediment. Close the drain cocks.

8. Check the sump tank located under the car between the main fuel tanks for water and sediment. Drain off 1/4 pint, or more if necessary, to remove accumulated water and sediment. On some cars, the sump is formed as part of the main fuel tanks.

9. Service the engine air cleaner. Refer to Section 3.1 for oil bath air cleaners.

On units equipped with dry type air cleaners, proceed as follows:

a. Loosen the wing nuts on the filter fasteners and swing the retaining bolts away from the cleaner.

b. Lift the cleaner away from the housing and inspect it. Clean out any accumulated foreign material.

c. Withdraw the paper filter element and discard it.

d. Inspect the inside of the air cleaner housing to be sure it is free of foreign material.

e. Install the cleaner and secure it in place with the fasteners.

10. Check the oil level indicator, if the unit is so equipped, located on the end of the alternator. Add engine oil if the oil level is low.

Starting the Diesel Engine

For a normal start, pull the starting control rod located near the starter button. This opens the air inlet valve. While holding the starting control rod out, press the starter button. Do not release the starting control rod the instant the engine starts but hold it out for approximately 30 seconds to allow the oil pressure to build up and set the Fail-Safe protective device. The starting control knob may then be released.

If the engine does not start after cranking for 30 seconds, allow the cranking motor to rest for a minute and then repeat the cranking attempt. If the engine does not start after three or four cranking periods, investigate for the cause of trouble (refer to *Trouble Shooting Chart 2* in Section 15.2).

To assist in starting the engine during low ambient temperatures, a "Fluid Starting Aid" is used. This device consists of a pump and nozzle for injecting engine starting fluid into the air intake, and a tube container for holding the capsule containing the fluid. The pump (knob marked AIR HEATER) and the capsule container are mounted at the front of the engine.

Running Check

After the engine has started, check the engine speed and voltage.

First check the engine speed with a hand tachometer. Engines operating at 1800 rpm full load should run 1850 rpm no load. Engines operating at 1200 rpm full load should run at 1240 rpm no load.

Then check the voltage at the terminals with a voltmeter. The voltage should be 208-220 volts at full load and should not exceed 240 volts at no load.

On some units equipped with brushless power generators, the voltage may be adjusted by moving the regulator voltage adjusting screw. Turning the screw clockwise raises the voltage and turning the screw counterclockwise lowers the voltage.

1. The coolant temperature gage should read about 170 °F. when the engine has warmed up and the thermostat has started to open. Temperatures will vary between 165 °F. and 185 °F., depending upon the load and the ambient air temperature.

2. Since the shut-down control prevents operating without adequate oil pressure, some units are not equipped with oil pressure gages. On these units, the oil pressure may be checked at the valve which is located above the shut-down bellows on the blower side of the engine. The oil pressure should be about 40 to 50 psi at 1800 rpm or 28 to 40 psi at 1200 rpm when the coolant temperature is normal. If the oil pressure is below 30 psi at 1800 rpm or 28 psi at 1200 rpm, check for the cause and make the necessary corrections.

3. No battery-charging ammeter is provided. However, the charging rate may be easily determined by connecting an ammeter in series with the wire leading to the BATT terminal of the generator voltage regulator. After completing the test, securely tighten the screw attaching the wire to the BATT terminal. For additional information on the electrical system, refer to Section 7 in this manual.

4. Leaks--Check the unit carefully for fuel, lubricating oil and coolant leaks. Make any necessary repairs.

5. Clean radiator--Check the condition of the radiator core to make sure it is clean and free of dirt.

Stopping the Diesel Engine

Pull the knob, marked "PULL TO STOP", which is located at the front of the engine. Hold the knob in the out position until the engine comes to a complete stop. Return the knob to its original position.

ENGINE OPERATING CONDITIONS

The engine operating charts are included as an aid for engine operation and trouble shooting. Any variations from the conditions as listed may indicate an abnormal situation in need of correction. Make sure that the readings represent true values, and that instruments are accurate, before attempting to make corrections to the engine.

2, 3 and 4-53 ENGINES

(2-Valve Cylinder Head)

	1200 rpm	1800 rpm	2000 rpm	2200 rpm
Lubrication System				
Lubricating oil pressure (psi):				
Normal	30-50	40-60	40-60	40-60
Minimum for safe operation	18.0	30.0	30.0	30.0
*Lubricating oil temperature (degr. F.) - max.:				
Normal (2-53)	190-230	190-220	190-225	
Normal (3-53 and 4-53)		200-235	200-235	200-235
Air System				
Air box pressure (inches mercury) - min. at full load:				
At zero exhaust back pressure (2-53)	2.0	4.1	5.2	
At zero exhaust back pressure (3, 4-53)		3.8	4.9	6.2
At max. full load exh. back press. (2-53)	3.0	5.7	7.2	
At max. full load exh. back press. (3, 4-53)		5.5	6.9	8.6
Air inlet restriction (inches water) - full load max.:				
Dirty air cleaner - oil bath or dry type (2-53)	6.8	13.4	16.0	
Dirty air cleaner - oil bath or dry type (3, 4-53)	6.8	13.4		18.8
Clean air cleaner:				
2-53 oil bath type	4.5	9.5	10.8	
3, 4-53 oil bath type	4.5	9.5	10.8	12.0
2-53 dry type with precleaner	4.5	6.8	10.8	
3, 4-53 dry type with precleaner	4.5	6.8	10.8	12.0
2-53 dry type less precleaner	3.0	5.5	6.5	
3, 4-53 dry type less precleaner	3.0	5.5	6.5	7.4
Crankcase pressure (inches water) - max.	0.5	0.5	0.5	0.5
Exhaust back pressure (inches mercury) - max.:				
Full load	1.3	2.1	2.5	3.0
§Full load (fork lift truck)	4.2	9.7	12.1	
No load	0.6	1.3	1.7	2.1
§No load (fork lift truck)	2.5	6.0	7.5	
Fuel System				
Fuel pressure at inlet manifold (psi):				
Normal with .070 " restriction	45-60	45-70	45-70	45-70
Minimum	35	35	35	35
Fuel spill (gpm) - minimum at no-load:				
.070 " restriction	0.6	0.6	0.6	0.6
Fuel pump suction at pump inlet (inches mercury) - max.:				
Clean system	6.0	6.0	6.0	6.0
Dirty system	12.0	12.0	12.0	12.0

	1200 rpm #	1800 rpm	2000 rpm	2200 rpm
Cooling System				
Coolant temperature (degr. F.) - normal	160-185	160-185	160-185	160-185
Raw water pump:				
Inlet restriction (inches mercury) - max.		8.0†	8.0†	8.0
Outlet pressure (psi) - max.		10.0†	10.0†	10.0
Keel cooler pressure drop (psi)				
Maximum through system		6.0†	6.0†	6.0
Compression				
Compression pressure (psi at sea level):				
Average - new engine - at 600 rpm 525				
Minimum - at 600 rpm 475				

3, 4-53 IN-LINE, 6V, 8V-53 AND 53N ENGINES

(4-Valve Cylinder Head)

	2200 rpm	2500 rpm	2800 rpm
Lubrication System			
Lubricating oil pressure (psi):			
Normal	40-60	40-60	40-60
Minimum for safe operation	30.0	32.0	32.0
*Lubricating oil temperature (degr. F.) - max.	200-235	200-235	200-235
Air System			
Air box pressure (inches mercury) - min. at full load:			
At zero exhaust back pressure	3.7	4.8	6.1
At maximum exhaust back pressure	5.4	8.0	9.3
Air inlet restriction (inches water) - full load max.:			
Dirty air cleaner - oil bath or dry type	18.8	23.0	25.0
Clean air cleaner - oil bath or dry type with precleaner	12.0	14.0	16.0
Clean air cleaner - dry type without precleaner	7.4	8.7	10.0
Crankcase pressure (inches water) - max.	0.8	0.9	1.0
Exhaust back pressure (inches mercury) - max.:			
Full load	3.0	4.0†	4.0+
§Full load (fork lift truck)	6.5	8.4	10.5
No load	2.1	2.7†	2.7++
§No load (fork lift truck)	4.2	5.5	7.0
Fuel System			
Fuel pressure at inlet manifold (psi):			
Normal with .070" restriction	45-70	45-70	45-70
Minimum	35	35	35
Fuel spill (gpm) - minimum at no-load:			
.070" restriction	0.6	0.6	0.6
Fuel pump suction at pump inlet (inches mercury) - max.:			
Clean system	6.0	6.0	6.0
Dirty system	12.0	12.0	12.0

	2200 rpm	2500 rpm	2800 rpm
Cooling System			
Coolant temperature (degr. F.) - normal	160-185	160-185	160-185
Raw water pump:			
Inlet restriction (inches mercury) - max.	5.0†	5.0†	5.0
Outlet pressure (psi) - max.	10.0†	10.0†	10.0
Keel cooler pressure drop (psi)			
Maximum through system	6.0†	6.0†	6.0
Compression			
Compression pressure (psi at sea level):			
Average - new engine - at 600 rpm	480		
Average - new "N" engine - at 600 rpm	590		
Minimum - at 600 rpm	430		
Minimum-"N" engine - at 600 rpm	540		

*The lubricating oil temperature range is based on the temperature measurement in the oil pan at the oil pump inlet. When measuring the oil temperature at the cylinder block oil gallery, it will be 10° lower than the oil pan temperature.

+ Marine engines only 5.5 inches mercury at 2800 rpm.

+ + Marine engines only 3.8 inches mercury at 2800 rpm.

†Maximum when this is the full-load engine speed.

§Fork lift trucks only when performance required is less than rated for injector used as power loss may be as high as 9-12%—@ maximum rpm.

#2-53 reefer car engines only.

4-53 TURBOCHARGED ENGINES

4-53 TURBOCHARGED ENGINES	2500 rpm
Lubrication System	
Lubricating oil pressure (psi):	
Normal	40-60
Minimum for safe operation	32.0
*Lubricating oil temperature (degr. F.) - max.	205-240
Air System	
Air box pressure (inches mercury) - N70 injectors - full load:	
Minimum exhaust back pressure (clean ports)	31.5-38.5
Maximum exhaust back pressure	29.6-36.6
Air inlet restriction (inches water) - full load max.:	
Air silencer	20.0
Crankcase pressure (inches water) - maximum	1.0
Exhaust back pressure (inches mercury) - maximum:	
Full load	2.5
No load	1.8
Fuel System	
Fuel pressure at inlet manifold (psi):	
Normal with .070 " restriction	45-70
Minimum	35.0
Fuel spill (gpm) - minimum at no-load:	
.070 " restriction	0.6
Cooling System	
Coolant temperature (degr. F.) - normal	160-185
Compression	
Compression pressure (psi at sea level):	
Average - new engine - at 600 rpm	480
Minimum - at 600 rpm	430

*The lubricating oil temperature range is based on the temperature measurement in the oil pan at the oil pump inlet. When measuring the oil temperature at the cylinder block oil gallery, it will be 10° lower than the oil pan temperature.

ENGINE RUN-IN INSTRUCTIONS

Following a complete overhaul or any major repair job involving the installation of piston rings, pistons, cylinder liners or bearings, the engine should be "run-in" on a dynamometer prior to release for service.

The dynamometer is a device for applying specific loads to an engine. It permits the serviceman to physically and visually inspect and check the engine while it is operating. It is an excellent method of detecting improper tune-up, misfiring injectors, low compression and other malfunctions, and may save an engine from damage at a later date.

The operating temperature within the engine affects the operating clearances between the various moving parts of the engine and determines to a degree how the parts will wear. Normal coolant temperature (160° - 185°F.) should be maintained throughout the run-in.

The rate of water circulation through the engine on a dynamometer should be sufficient to avoid having the engine outlet water temperature more than 10°F. higher than the water inlet temperature. Though a 10° rise across an engine is recommended, it has been found that a 15° temperature rise maximum can be permitted.

Thermostats are used in the engine to control the coolant flow; therefore, be sure they are in place and fully operative or the engine will overheat during the run-in. However, if the dynamometer has a water stand-pipe with a temperature control regulator, such as a Taylor valve or equivalent, the engine should be tested without thermostats.

The *Basic Run-In Horsepower Schedule* is shown in the Table. The horsepower shown in the table is at SAE conditions: dry air density .0705 lb/cu. ft., air temperature of 85°F., and 500 ft. elevation.

DYNAMOMETER TEST AND RUN-IN PROCEDURES

The Basic Engine

The great number of engine applications make any attempt to establish comparisons for each individual model impractical. For this reason, each model has a basic engine rating for comparison purposes.

A basic engine includes only those items actually required to run the engine. The addition of any engine driven accessories will result in a brake horsepower figure less than the values shown in the *Basic Engine Run-In Schedule*. The following items are included on the basic engine: blower, fuel pump, fresh water pump and governor. The fan and battery-charging generator typify accessories not considered on the basic engine.

In situations where other than basic engine equipment is used during the test, proper record of this fact should be made on the *Engine Test Report*. The effects of this additional equipment on engine performance should then be considered when evaluating test results.

Dynamometer

The function of the dynamometer is to absorb and measure the engine output. Its basic components are a frame, engine mounts, the absorption unit, a heat exchanger, and a torque loading and measuring device.

The engine is connected through a universal coupling to the absorption unit. The load on the engine may be varied from zero to maximum by decreasing or increasing the resistance in the unit. The amount of

BASIC RUN-IN HORSEPOWER SCHEDULE*

RPM	Time	2-Valve Head			4-Valve Head				
		2-53	3-53	4-53	3-53	4-53	4-53T**	6V-53	8V-53
1800	10 Min.	10	15	20	15	20	20	30	40
1800	1/2 Hr.	30							
2000	1/2 Hr.	40							
2200	1/2 Hr.		64	87	64	87	89	130	175
2200	1/2 Hr.		68	92					
2500	1/2 Hr.						133		
2500	1/2 Hr.						150		
2800	1/2 Hr.					85	115	171	228

Final run-in (within 5% of Rated BHP) should be for 1 1/2 hours at 2000 rpm for 2-53 engine, 2200 rpm for all 2-Valve cylinder head engines, 2500 rpm for 4-53 turbocharged engines (4-Valve) and 2800 rpm for all other 4-Valve) cylinder head engines.

*S45 and N45 Injectors Only

**Prior to starting the engine, remove the turbocharger oil supply line at the turbocharger and add CLEAN engine oil to the turbocharger oil inlet to insure pre-lubrication of the unit. Reconnect the oil line and idle the engine for at least one minute after starting and before increasing the engine speed to 1200 rpm.

power absorbed in a water brake type dynamometer, as an example, is governed by the volume of fluid within the working system. The fluid offers resistance to a rotating motion. By controlling the volume of water in the absorption unit, the load may be increased or decreased as required.

The power absorbed is generally measured in torque (lb-ft) on a suitable scale. This value for a given engine speed will show the brake horsepower developed in the engine by the following formula:

$$BHP = (T \times RPM)/5250$$

Where:

BHP = brake horsepower
T = torque in lb-ft
RPM = revolutions per minute

Some dynamometers indicate direct brake horsepower readings. Therefore, the use of the formula is not required when using these units.

During the actual operation, all data taken should be recorded immediately on an *Engine Test Report* (see sample on page 4).

Instrumentation

Certain instrumentation is necessary so that data required to complete the *Engine Test Report* may be obtained. The following list contains both the minimum amount of instructions and the proper location of the fittings on the engine so that the readings represent a true evaluation of engine conditions.

a. Oil pressure gage installed in one of the engine main oil galleries.

b. Oil temperature gage installed in the oil pan, or thermometer installed in the dipstick hole in the oil pan.

c. Adaptor for connecting a pressure gage or mercury manometer to the engine air box.

d. Water temperature gage installed in the thermostat housing.

e. Adaptor for connecting a pressure gage or water manometer to the crankcase.

f. Adaptor for connecting a pressure gage or mercury manometer to the exhaust manifold at the flange.

g. Adaptor for connecting a vacuum gage or water manometer to the blower inlet.

h. Adaptor for connecting a fuel pressure gage to the fuel manifold inlet passage.

i. Adaptor for connecting a pressure gage or mercury manometer to the turbocharger.

In some cases, gages reading in pounds per square inch are used for determining pressures while standard characteristics are given in inches of mercury or inches of water. It is extremely important that the scale of such a gage be of low range and finely divided if accuracy is desired. This is especially true of a gage reading in psi, the reading of which is to be converted to inches of water. The following conversion factors may be helpful.

Inches of water = psi x 27.7"
Inches of mercury = psi x 2.04"

NOTE: Before starting the Run-In or starting the engine for any reason following an overhaul, it is of extreme importance to observe the instructions on *Preparation for Starting Engine First Time* in Section 13.1.

Run-In Procedure

The procedure outlined below will follow the order of the sample *Engine Test Report.*

A. PRE-STARTING

1. Fill the lubrication system as outlined under *Lubricating System -- Preparation for Starting Engine First Time* in Section 13.1.

2. Prime the fuel system as outlined under *Fuel System -- Preparation for Starting Engine First Time* in Section 13.1.

3. A preliminary valve clearance adjustment must be made before the engine is started. See *Valve Clearance Adjustment* in Section 14.1.

4. A preliminary injector timing check must be made before starting the engine. See *Timing Injector* in Section 14.2.

5. Preliminary governor adjustments must be made as outlined in Section 14.

6. Preliminary injector rack adjustment must be made -- see Section 14.

B. BASIC ENGINE RUN-IN

The operator should be observant at all times, so that any malfunction which may develop will be detected. Since the engine has just been reconditioned, this run-in will be a test of the workmanship of the serviceman who performed the overhaul. Minor difficulties should be detected and corrected so that a major problem will not develop.

After performing the preliminary steps, be sure all water valves, fuel valves, etc are open. Also inspect the exhaust system, being sure that it is properly connected to the engine. Always start the engine with minimum dynamometer resistance.

After the engine starts, if using a water brake type dynamometer, allow sufficient water, by means of the control loading valves, into the dynamometer absorption unit to show a reading of approximately 5 lb-ft on the torque gage (or 10-15 HP on a horsepower gage). This is necessary, on some units, to lubricate the absorption unit seals and to protect them from damage.

Set the engine throttle at idle speed, check the lubricating oil pressure and check all connections to be sure there are no leaks.

Refer to the *Engine Test Report* sample which establishes the sequence of events for the test and run-in, and to the *Basic Run-In Horsepower Schedule* which indicates the speed (rpm), length of time and the brake horsepower required for each phase of the test. Also, refer to the *Operating Conditions* in Section 13.2 which presents the engine operating characteristics. These characteristics will be a guide for tracing faulty operation or lack of power.

Engine governors in most cases must be reset at the maximum full-load speed designated for the run-in. If a governor is encountered which cannot be adjusted to this speed, a stock governor should be installed for the run-in.

After checking the engine performance at idle speed and being certain the engine and dynamometer are operating properly, increase the engine speed to half speed and apply the load indicated on the *Basic Run-In Horsepower Schedule.*

The engine should be run at this speed and load for 10 minutes to allow sufficient time for the coolant temperature to reach the normal operating range. Record length of time, speed, brake horsepower, coolant temperature and lubricating oil pressure on the *Engine Test Report.*

Run the engine at each speed and rating for the length of time indicated in the *Basic Run-In Horsepower Schedule.* This is the Basic Run-In. During this time engine performance will improve as new parts begin to "seat in". Record all of the required data.

C. BASIC RUN-IN INSPECTION

While the engine is undergoing the Basic Run-In, check each item indicated in Section "C" of the *Engine Test Report.* Check for fuel oil or water leaks in the rocker arm compartment.

During the final portion of the Basic Run-In, the engine should be inspected for fuel oil, lubricating oil and water leaks.

Upon completion of the Basic Run-In and Inspection, remove the load from the dynamometer and reduce the engine speed gradually to idle and then stop the engine.

D. INSPECTION AFTER BASIC RUN-IN

The primary purpose of this inspection is to provide a fine engine tune-up. First, tighten the cylinder head and rocker arm shaft bolts to the proper torque. Next, complete the applicable tune-up procedure. Refer to Section 14.

E. FINAL RUN-IN

After all of the tests have been made and the *Engine Test Report* is completed through Section "D", the engine is ready for final test. This portion of the test and run-in procedure will assure the engine owner that his engine has been rebuilt to deliver factory rated performance at the same maximum speed and load which will be experienced in the installation.

If the engine has been shut-down for one hour or longer, it will be necessary to have a warm-up period of 10 minutes at the same speed and load used for warm-up in the Basic Run-In. If piston rings, cylinder liners or bearings have been replaced as a result of findings in the Basic Run-In, the entire Basic Run-In must be repeated as though the run-in and test procedure were started anew.

All readings observed during the Final Run-In should fall within the range specified in the *Operating Conditions* in Section 13.2, and should be taken at full load unless otherwise specified. Following is a brief discussion of each condition to be observed.

The engine *water temperature* should be taken during the last portion of the Basic Run-In at full load. It should be recorded and should be within the specified range.

ENGINE TEST REPORT

Date _____ Unit Number _____

Repair Order Number _____ Model Number _____

A	PRE-STARTING				
1. PRIME LUB. OIL SYSTEM	2. PRIME FUEL SYSTEM	3. ADJUST EXHAUST VALVES	4. TIME INJECTORS	5. ADJ. GOV.	6. ADJUST INJ. RACKS

B BASIC ENGINE RUN-IN						
TIME AT SPEED	TIME		RPM	BHP	WATER TEMP.	LUB. OIL PRESS.
	START	STOP				

C BASIC RUN-IN INSPECTION	
1. Check oil at rocker mechanism	
2. Inspect for lubricating oil leaks	
3. Inspect for fuel oil leaks	
4. Inspect for water leaks	
5. Check and tighten all external bolts	
6.	

D INSPECTION AFTER BASIC RUN-IN			
1. Tighten Cylinder Head & Rocker Shaft Bolts		4. Adjust Governor Gap	
2. Adjust Valves (Hot)		5. Adjust Injector Racks	
3. Time Injectors		6.	

E FINAL RUN-IN							
TIME		TOP RPM		BHP	AIR BOX PRESSURE FULL LOAD	EXHAUST BACK PRESSURE F/L	CRANKCASE PRESSURE F/L
START	STOP	NO-LOAD	FULL LOAD				

BLOWER INTAKE RES. - F/L	FUEL OIL PRESSURE RET. MAN. F/L	WATER TEMP. FULL LOAD	LUB. OIL TEMP. F/L	LUB. OIL PRESSURE		IDLE SPEED
				FULL LOAD	IDLE	

F INSPECTION AFTER FINAL RUN			
1. Inspect Air Box, Pistons, Liners, Rings		6. Replace Lubricating Oil Filter Elements	
2. Inspect Blower		7. Tighten Flywheel Bolts	
3. Check Generator Charging Rate		8. Rust Proof Cooling System	
4. Wash Oil Pan, Check Gasket		9.	
5. Clean Oil Pump Screen, Remove Cloth		10.	

REMARKS:

Final Run OK'd _____ Dynamometer _____ Date _____

NOTE: Operator must initial each check and sign this report.

The *lubricating oil temperature* reading must be taken while the engine is operating at full load and after it has been operating long enough for the temperature to stabilize. This temperature should be recorded and should be within the specified range.

The *lubricating oil pressure* should be recorded in psi after being taken at engine speeds indicated in the *Operating Conditions*, Section 13.2.

The *fuel oil pressure* at the fuel manifold inlet passage should be recorded and should fall within the specified range. Fuel pressure should be recorded at maximum engine rpm during the Final Run-In.

Check the *air box pressure* while the engine is operating at maximum speed and load. This check may be made by attaching a suitable gage (0-15 psi) or manometer (15-0-15) to an air box drain or to a hand hole plate prepared for this purpose. If an air box drain is used as a source for this check, it must be clean. The air box pressure should be recorded in inches of mercury.

Check the *crankcase pressure* while the engine is operating at maximum run-in speed. Attach a manometer, calibrated to read in inches of water, to the oil level dipstick opening. Normally, crankcase pressure should decrease during the run-in indicating that new rings are beginning to "seat-in".

Check the *air inlet restriction* with a water manometer connected to a fitting in the air inlet ducting located 2" above the air inlet housing. When practicability prevents the insertion of a fitting at this point, the manometer may be connected to a fitting installed in the 1/4" pipe tapped hole in the engine air inlet housing. If a hole is not provided, a stock housing should be drilled, tapped and kept on hand for future use.

The restriction at this point should be checked at a specific engine speed. Then, the air cleaner and ducting should be removed from the air inlet housing and the engine again operated at the same speed while noting the manometer reading. The difference between the two readings, with and without the air cleaner and ducting, is the actual restriction caused by the air cleaner and ducting.

Check the normal air intake vacuum at various speeds (at no-load) and compare the results with the *Engine Operating Conditions* in section 13.2. Record these readings on the *Engine Test Report*.

Check the *exhaust back pressure* at the exhaust manifold companion flange or within one inch of this location. This check should be made with a mercury manometer through a tube adaptor installed at the tapped hole. If the exhaust manifold does not provide a 1/8" pipe tapped hole, such a hole can be incorporated by reworking the exhaust manifold.

Install a fitting for a pressure gage or manometer in this hole. Care should be exercised so that the fitting does not protrude into the stack. The manometer check should produce a reading in inches that is below the *Maximum Exhaust Back Pressure* for the engine (refer to Section 13.2).

Turbocharger compressor outlet pressure and turbine inlet pressures are taken at full-load and no-load speeds.

Refer to the *Basic Run-In Horsepower Schedule* and determine the maximum rated brake horsepower and the full-load speed to be used during the Final Run-In. Apply the load thus determined to the dynamometer. If a hydraulic governor is used, the droop may be adjusted at this time by following the prescribed procedure. The engine should be run at this speed and load for 1/2 hour. While making the Final Run-In, the engine should develop, within 5%, the maximum rated brake horsepower indicated for the speed at which it is operating. If this brake horsepower is not developed, the cause should be determined and corrections made.

When the above conditions have been met, adjust the maximum no-load speed to conform with that specified for the particular engine. This speed may be either higher or lower than the maximum speed used during the Basic Run-In. This will ordinarily require a governor adjustment.

All information required in Section "E", Final Run-In, of the *Engine Test Report* should be determined and filled in. After the prescribed time for the Final Run-In has elapsed, remove the load from the dynamometer and reduce the engine speed gradually to idle speed and then stop the engine. The Final Run-In is complete.

F. INSPECTION AFTER FINAL RUN-IN

After the Final Run-In and before the *Engine Test Report* is completed, a final inspection must be made. This inspection will provide final assurance that the engine is in proper working order. During this inspection the engine is also made ready for any brief delay in delivery or installation which may occur. This is accomplished by rust-proofing the fuel system as outlined in Section 15.3. Also, a rust inhibitor should be introduced into the cooling system (refer to Section 13.3).

DIESEL FUEL OIL SPECIFICATIONS

The quality of the fuel oil used for high-speed diesel engine operation is a major factor in satisfactory engine performance and life. The fuel oils selected must be clean, completely distilled, stable, and non-corrosive. Enlist the aid of your supplier in obtaining proper fuel oil. The responsibility for clean fuel lies with the fuel supplier as well as with the operator.

DISTILLATION RANGE, CETANE NUMBER, AND SULFUR CONTENT are three of the most important properties in the selection of diesel fuels for optimum combustion and minimum wear. Engine speed, load, and atmospheric temperature influence the selection of the fuels with respect to distillation range and cetane number. THE SULFUR CONTENT OF THE FUEL MUST BE AS LOW AS POSSIBLE, to avoid excessive deposit formation and premature wear.

Diesel fuels are generally marketed according to ASTM DESIGNATION D975 and only distillate fuels No. 1D and 2D are considered satisfactory for Detroit Diesel engines. Residual fuels and furnace oils, generally, are not considered satisfactory for Detroit Diesel engines. In some regions, however, fuel suppliers may distribute only one fuel that is marketed as either diesel fuel (ASTM D-975) or domestic heating fuel (ASTM D-396). In this case, the fuel should be investigated to determine whether the physical properties conform with those shown in the Fuel Oil Selection Chart.

As a guide to the selection of the proper fuel oil for various applications refer to the ASTM Classification Chart and the Fuel Oil Selection Chart.

ASTM Classification of Diesel Fuel Oils

	No. 1-D	No. 2-D
Flash Pt.; °F Min.	100	125
Carbon Residue; %	0.15	0.35
Water and Sediment; (% by Volume) Max.	Trace	0.10
Ash; % by Wt.; Max.	0.01	0.02
Distillation, °F 90% Pt.; Max.	550	640
Min.	-	540
Viscosity at 100°F; centistokes Min.	1.4	2.0
Max.	2.5	4.3
Sulfur; % Max.	0.5	0.5
Cetane No; Min.	40	40

Engine operation at altitudes above 5000 feet requires use of next lighter class of fuel oil than would normally be used.

During cold weather engine operation, the "cloud point" (the temperature at which wax crystals begin to form in the fuel oil) should be 10°F. below the lowest expected fuel temperature to prevent clogging of the fuel filters by wax crystals.

At temperatures below -20°F. consult an authorized Detroit Diesel Service Outlet, since particular attention must be given the cooling system, lubricating system, fuel system, electrical system, and cold weather starting aids for efficient engine operation.

FUEL OIL SELECTION CHART

Type of Engine Service	Typical Application	General Fuel Classification	Final Boiling Point (Max.)	Cetane Number (Min.)	Sulfur Content (Max.)
Light load and speed with considerable idling.	City Buses	No. 1-D	550°F	45	0.30%
Light load and speed.	Generator Sets, Industrial and Automotive Equipment in city and suburban operation.	Winter No. 1-D	550°F	45	0.30%
		Summer No. 1-D	600°F	40	0.50%
Medium load and speed.	Marine Pleasure Craft, Tractors, Industrial Equipment.	Winter No. 1-D	600°F	45	0.50%
		Summer No. 2-D*	675°F	40	0.50%
Heavy load and high speed with idling.	Highway Trucks	Winter No. 2-D*	675°F	45	0.50%
		Summer No. 2-D*	675°F	40	0.50%
Heavy load and high speed.	Heavy Duty Off-the-Road Equipment, Trucks, Tractors	No. 2-D*	675°F	45	0.50%

*NOTE: For most satisfactory engine life, use only those No. 2-D diesel fuel oils containing 0.50% or less sulfur. Where minimum exhaust smoke is required or where long periods of idling or cold weather conditions below 32°F. are encountered, the more volatile or light distillate fuels are recommended.

BREAK-IN OILS AND ADDITIVES MARKETED FOR FUELS AND LUBRICANTS

The use of proprietary blends of supplementary additive or concentrates such as engine oil supplements, break-in oils, tune-up compounds and friction reducing compounds is not recommended in lubricating oils used in Detroit Diesel engines unless given official Detroit Diesel part numbers and made available for use in appropriate service applications. This also applies to the use of metal containing diesel fuel additives.

DIESEL LUBRICATING OIL SPECIFICATIONS

OIL QUALITY

There are hundreds of commercial crankcase oils marketed today. Lubricants marketed for heavy duty diesel service consist of refined crude oil to which has been added additives compounded to meet the desired engine performance levels. Oil additive selection is based on evaluations conducted by the oil supplier; therefore, satisfactory OIL QUALITY is the responsibility of the oil supplier. (The term oil supplier is applicable to refiners, blenders and rebranders of petroleum products, and does not include distributors of such products.) Experience has shown that oil performance in commercial heavy duty diesel service applications varies from brand to brand.

Obviously engine manufacturers or users cannot completely evaluate the hundreds of commercial oils; therefore, the selection of a suitable lubricant in consultation with a reliable oil supplier, strict observance of his oil change recommendations (used oil sample analysis can be of value), and proper filter maintenance will provide your best assurance of satisfactory oil performance.

Detroit Diesel lubricant recommendations are based on general experience with current lubricants of various types and give consideration to the commercial lubricants presently available.

RECOMMENDATION

MIL-L-2104B Lubricants

Detroit Diesel engines have given optimum performance, and experienced the longest service life with MIL-L-2104B, SAE 30 oils. However, the additive concentration of some MIL-L-2104B oils has been substantially increased in order to meet 1968-1969 MS performance requirements. Some of these 1968-1969 MS/MIL-L-2104B oils have given unsatisfactory performance because of excessive exhaust valve and ring-belt ash deposits. For these reasons our primary lubricant recommendations are MIL-L-2104B and Supplement 1 oils with the following limitations:

1. Zinc, as zinc diorganodithiophosphate, between a minimum of 0.07 and a maximum of 0.10 percent by weight.

2. Sulfated ash (ASTM D-874) of 1.00 percent maximum by weight, except lubricants that contain only barium detergent - dispersants where 1.50 percent by weight is allowed.

Contact a reliable oil supplier and obtain his assurance that his product has been tested and given good performance in Detroit Diesel engines. An SAE 30 oil is recommended for year-round use. The use of lower viscosity oils or multigrade products will usually result in less than normal engine life.

MIL-L-45199B (Series 3) Lubricants

The use of Low Ash Series 3 oils (sulphated ash less than 1.65 percent by weight - ASTM designation D-874) may be necessary if the continued use of high sulfur fuel (sulfur greater than 0.5 percent by weight - ASTM D-129) is unavoidable. Consult a reliable oil supplier, obtain assurance that his products have been tested in Detroit Diesel engines, and select the best performer for optimum engine life.

Low ash Series 3 oils do NOT have to meet any specific military low temperature performance requirements; therefore, they may NOT perform as well as MIL-L-2104B lubricants in cold climates.

The older high ash Series 3 oils should NOT be used in Detroit Diesel engines as they tend to deposit heavy ash on valve faces and head inserts resulting in channelling, guttering, and short engine life.

Supplement 1 Lubricating Oils

See MIL-L-2104B limitations under Recommendation.

Multigrade Lubricating Oils

Multigrade oils are NOT recommended. The use of an SAE-30 grade is desirable for year-round use when cold starting can be accomplished. Multigrade oils should be considered only as the "last resort" to facilitate starting when prolonged exposure to temperatures below freezing is unavoidable and adequate starting aids are unavailable.

Experience clearly indicates that multigrade oils are NOT comparable to SAE-30 lubricants for heavy duty diesel service. Cylinder liner scuffing, liner port and ring groove deposit levels are all greater using multigrade lubricants. This results in shortened engine life.

COLD WEATHER OPERATION

Cold weather starting will be facilitated when immersion type electrical coolant heaters can be used. Other practical considerations, such as the use of batteries, cables and connectors of adequate size, generators or alternators of ample capacity, proper setting of voltage regulators, ether starting aids, oil and coolant heater systems, and proper fuel selection will accomplish starting with the use of SAE-30 oil. For complete cold weather starting information, consult an Authorized Detroit Diesel Service Outlet.

OIL CHANGES

It is recommended that new engines be started with 100 hour oil change periods. For highway vehicles this corresponds to approximately 3,000 miles, and for "city-service" vehicles approximately 1,000-2,000 miles. The drain interval may then be gradually increased, or decreased with experience on a specific lubricant while also considering the recommendations of the oil supplier (analysis of the drained oil can be helpful here) until the most practical oil change period for the particular service has been established.

Solvents should not be used as flushing oils in running engines. Dilution of the fresh refill oil supply can occur which may be detrimental.

OIL FILTRATION

Heavy sludge deposits found on the oil filter elements at the time of an oil change must be taken as an indication that the detergency of the oil has been exhausted. When this occurs, the oil drain interval should be shortened. Since abrasive dust, metal particles and carbon material accumulate in the lubricating oil during engine operation, the oil filter elements must be replaced each time the oil is changed.

> **NOTE:** The manufacturer's warranty applicable to Detroit Diesel engines provides in part that the provisions of such warranty shall not apply to any engine unit which has been subject to misuse, negligence or accident. Accordingly, malfunctions attributable to neglect or failure to follow the manufacturer's lubricating recommendations indicated above may not be within the coverage of the warranty.

ENGINE COOLANT

Engine coolant is considered as any solution which is circulated through the engine to provide the means for heat transfer from the various engine components. In general, water containing various materials in solution is used for this purpose.

The function of the coolant is basic in the design and the successful operation of the engine and must be carefully selected and properly maintained.

COOLANT REQUIREMENTS

A suitable coolant solution must meet the following five basic requirements:

1. Provide for adequate heat transfer.

2. Provide a corrosion resistant environment within the cooling system.

3. Prevent formation of scale or sludge deposits in the cooling system.

4. Be compatible with the cooling system hose and seal materials.

5. Provide adequate freeze protection during cold weather operation.

Normally requirements 1 through 4 are satisfied by combining a suitable water with reliable inhibitors. When operating conditions dictate the need for freeze protection, a solution of suitable water and an ethylene glycol type antifreeze containing adequate inhibitors will provide a satisfactory coolant.

WATER

Any water, whether of drinking quality or not, will produce a corrosive environment in the cooling system. Also, scale deposits may form on the internal surfaces of the cooling system due to the mineral content of the water. Therefore, water selected as a coolant must be properly treated with inhibitors to control corrosion and scale deposition.

To determine if a particular water is suitable for use as a coolant when properly inhibited, the following characteristics must be considered. The concentration of (1) chlorides, (2) sulfates, (3) total hardness and (4) dissolved solids. These materials are objectionable for a number of reasons: chlorides and/or sulfates will accelerate corrosion, while hardness (percentage of magnesium and calcium present) will cause deposits of scale. Total dissolved solids may cause scale deposits, sludge deposits, corrosion or a combination of these. Chlorides, sulfates, magnesium and calcium are among but not necessarily all the materials which make up dissolved solids. Water, within the limits specified in Tables 1 and 2, Figure A, is satisfactory as an engine coolant when proper inhibitors are added.

CORROSION INHIBITORS

A corrosion inhibitor is a water soluble chemical compound which protects the metallic surfaces of the cooling system against corrosive attack. Some of the more commonly used corrosion inhibitors are chromates, borates, nitrates, nitrites and soluble oil. Depletion of all types of inhibitors occur through normal operation and therefore strength levels must be maintained by the addition of inhibitors at prescribed intervals.

CHROMATES: Sodium chromate and potassium dichromate are two of the best and more commonly used *water* system corrosion inhibitors. Care should be exercised in handling these materials due to their toxic nature.

Chromate inhibitors should *not* be used in ethylene glycol antifreeze solutions. Chromium hydroxide, commonly called "green slime", can result from the use of chromate inhibitors with permanent type antifreeze. This material deposits on the cooling system passages, reducing the heat transfer rate and will result in engine overheating. Engines which have operated with a chromate inhibited water must be chemically cleaned before the addition of ethylene glycol type antifreeze. A commercial heavy duty descaler should be used in accordance with the manufacturer's recommendation for this purpose.

SOLUBLE OIL: Soluble oil has been used as a corrosion inhibitor for many years. It has, however, required very close attention relative to the concentration level due to adverse effects on heat transfer if the concentration exceeds 1% by volume. For example: 1-1/4% of soluble oil in the cooling system increases fire deck temperatures 6% and a 2-1/2% concentration raises fire deck temperature up to 15%. Soluble oil is *not* recommended as a corrosion inhibitor.

NON-CHROMATES: Non-chromate inhibitors (borates, nitrates, nitrites, etc.) provide corrosion protection in the cooling system with the basic

TABLE 1

	PARTS PER MILLION	GRAINS PER GALLON
Chlorides (Maximum)	40	2.5
Sulfates (Maximum)	100	5.8
Total Dissolved Solids (Maximum)	340	20
Total Hardness (Maximum)	170	10

Refer to Table 2 for evaluation of water intended for use in a coolant solution.

TABLE 2

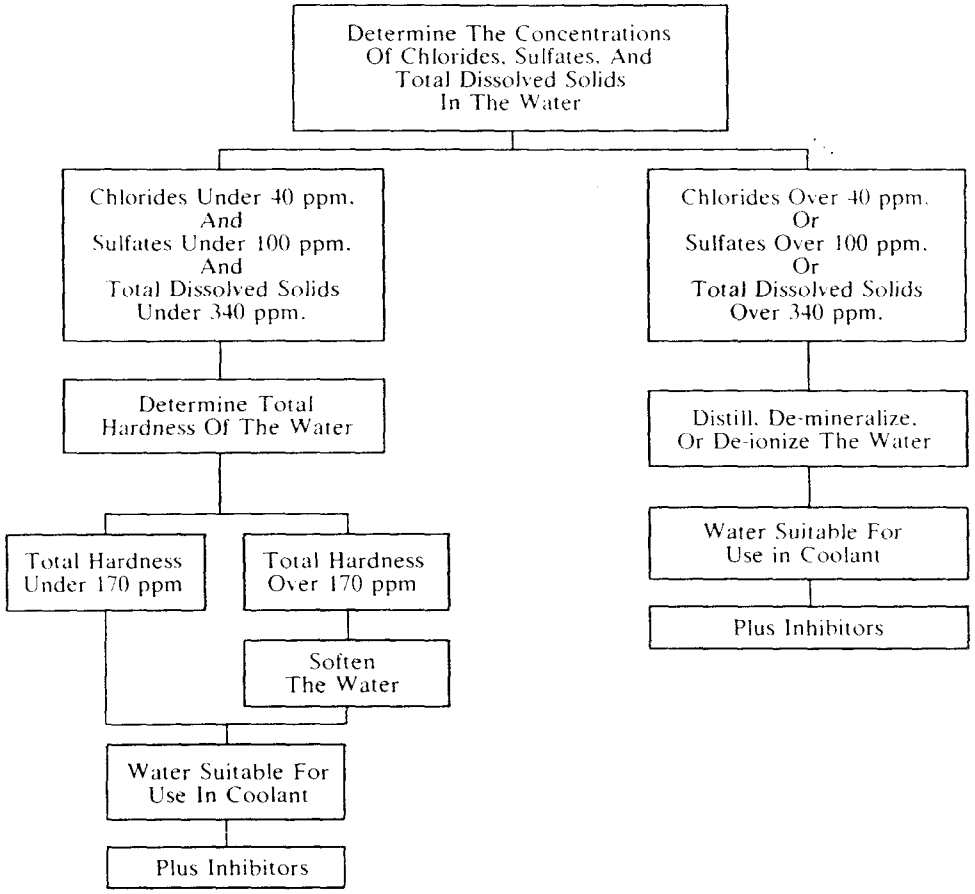


Figure A

advantage that they can be used with either water or a water and ethylene glycol solution.

INHIBITOR SYSTEMS

An inhibitor system is considered as a combination of chemical compounds which provide corrosion protection, pH control and water softening ability. Corrosion protection has been discussed earlier under the section on *Corrosion Inhibitors*. The pH control is used to maintain an acid free solution. The water softening ability deters formation of mineral deposits. Inhibitor systems are available in various forms such as coolant

COOLANT INHIBITOR CHART

Inhibitor or Inhibitor System	Corrosion Inhibitor Type	Complete Inhibitor System	Coolant	
			Water	Ethylene Glycol Solution
Sodium Chromate	Chromate	No	Yes	No
Potassium Dichromate	Chromate	No	Yes	No
Perry Filter Element 5020 (Type O & OS)	Chromate	Yes	Yes	No
Perry Filter Element 5030 (Type O & OS)	Non-Chromate	Yes	Yes	Yes
*Perry Filter Element PAF	Non-Chromate	Yes	No	Yes
Lenroc Filter	Non-Chromate	Yes	Yes	Yes
Nalcool 2000	Non-Chromate	Yes	Yes	Yes

*Discontinued August 1968.

Figure B

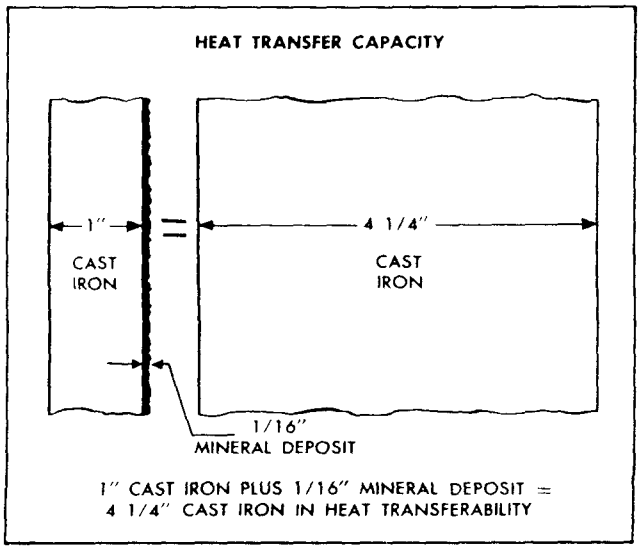


Figure C

filter elements, liquid and dry bulk inhibitor additives and as an integral part of permanent antifreeze.

COOLANT FILTER ELEMENTS: Replaceable elements are available with various chemical inhibitor systems. Care should be used in the selection of elements relative to inhibitor compatibility with coolant solutions shown in Figure B.

Problems have developed from the use of the magnesium lower support plate used by some manufacturers in their coolant filters. The magnesium plate will be attacked by solutions which will not be detrimental to other metals in the cooling system. The dissolved magnesium will be deposited in the hottest zones of the engine where heat transfer is most critical (Figure C). The use of aluminum or zinc in preference to magnesium is recommended to eliminate this type of deposit.

A high chloride coolant will have a detrimental effect on the water softening capabilities of systems using ion-exchange resins. Accumulations of calcium and magnesium ions removed from the coolant and held captive by the zeolite resin can be released into the coolant by a regenerative process caused by high chloride content solutions.

BULK INHIBITOR ADDITIVES: Commercially packaged inhibitor systems are available which can be added directly to the engine coolant or to bulk storage tanks containing coolant solution. Both chromate and non-chromate systems are available and care should be taken regarding inhibitor compatability with other coolant constituents (Figure B).

A non-chromate inhibitor system is recommended for use in Detroit Diesel engines. These systems can be used with either water or ethylene glycol antifreeze solutions and provide corrosion protection, pH control and water softening. One of the approved non-chromate inhibitor systems, Nalcool 2000, offers the additional advantage of a simple on site test to determine protection level and, since this product is added directly to the coolant, it requires no additional hardware or plumbing.

ANTIFREEZE

When freeze protection is required, an ethylene glycol base permanent antifreeze should be used. An inhibitor system is included in this type of antifreeze and no additional inhibitors are required on initial fill if a minimum antifreeze concentration of 30% by volume is used. Solutions of less than 30% concentration do not provide sufficient corrosion protection. Concentrations over 67% adversely affect freeze protection and heat transfer rates (Figure D).

Inhibitor depletion will occur in ethylene glycol base antifreeze through normal service. The inhibitors should be replenished at approximately 500 hour or 20,000 mile intervals with a non-chromate inhibitor system. Commercially available inhibitor systems such as Nalcool 2000 may be used to re-inhibit antifreeze solutions.

Several brands of permanent antifreeze are available with sealer additives. The specific type of sealers vary with the manufacturer. Antifreeze with sealer additives is *not* recommended for use in Detroit Diesel engines due to plugging problems throughout various areas of the cooling system.

COOLANT RECOMMENDATIONS

1. Always use a properly inhibited coolant.

2. If freeze protection is required, always use ethylene glycol antifreeze.

3. Re-inhibit antifreeze with a non-chromate inhibitor system.

4. Always follow the manufacturer's recommendations on inhibitor usage and handling.

5. Do not use soluble oil.

6. Chromate inhibitors should *never* be used with permanent antifreeze.

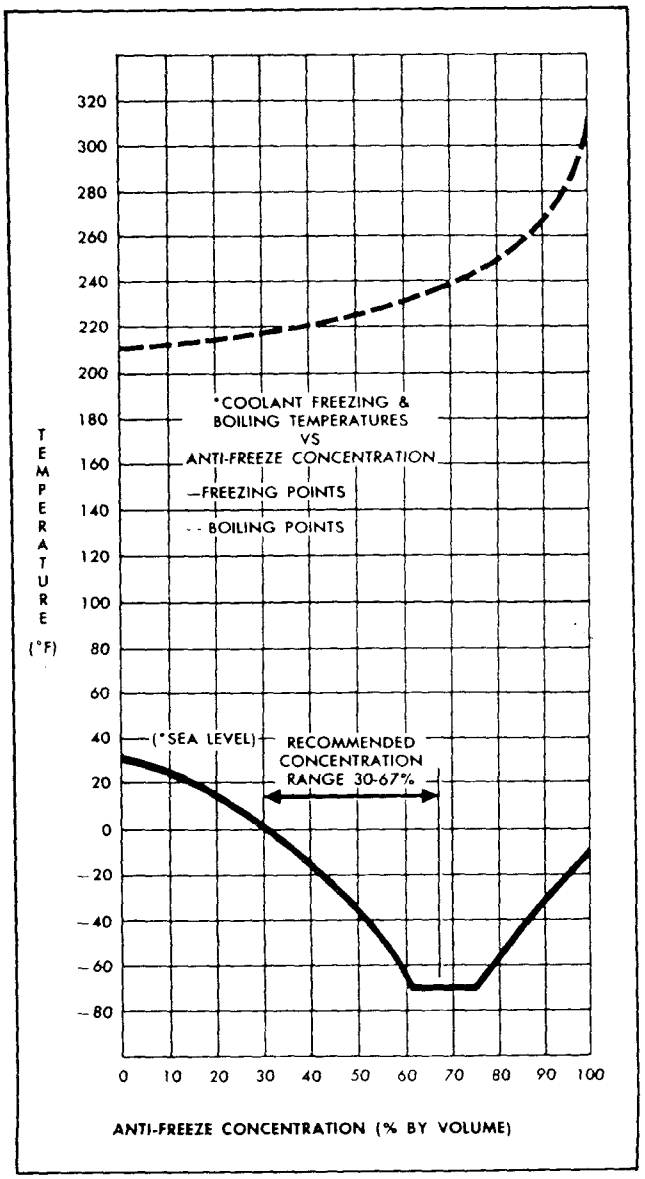


Figure D

7. Sealer type antifreeze should *not* be used.

8. Maintain prescribed inhibitor strength.

SECTION 14

ENGINE TUNE-UP

CONTENTS

ENGINE TUNE-UP PROCEDURES

There is no scheduled interval for performing an engine tune-up. As long as the engine performance is satisfactory, no tune-up should be needed. Minor adjustments in the valve and injector operating mechanisms, governor, etc. should only be required periodically to compensate for normal wear on parts.

Various types of governors are used. Since each governor has different characteristics, the tune-up procedure varies accordingly. The following types of governors are used:

1. Limiting speed mechanical.

2. Variable speed mechanical.

3. Constant speed mechanical.

4. Hydraulic.

The mechanical governors are identified by a name plate attached to the governor housing. The letters D.W.-L.S. stamped on the name plate denote a

double-weight limiting speed governor. A single-weight variable speed governor name plate is stamped S.W.-V.S.

Normally, when performing a tune-up on an engine in service, it is only necessary to check the various adjustments for a possible change in the settings. However, if the cylinder head, governor, or injectors have been replaced or overhauled, then certain preliminary adjustments are required before the engine is started.

The preliminary adjustments consist of the first four items in the tune-up sequence. The procedures are the same except that the valve clearance is greater for a cold engine.

NOTE: If a supplementary governing device, such as a load limit device, is used, it must be disconnected prior to the tune-up. After the governor and injector rack adjustments are completed, the supplementary governing device must be re-connected and adjusted.

To tune-up an engine completely, all of the adjustments are made by following the applicable tune-up sequence given below after the engine has reached the normal operating temperature. Since the adjustments are normally made while the engine is stopped, it may be necessary to run the engine between adjustments to maintain normal operating temperature.

Tune-Up Sequence for Mechanical Governor

1. Adjust the exhaust valve clearance.
2. Time the fuel injectors.
3. Adjust the governor gap.
4. Position the injector rack control levers.
5. Adjust the maximum no-load speed.
6. Adjust the idle speed.
7. Adjust the buffer screw.
8. Adjust the throttle booster spring (variable speed governor only).

NOTE: Use new valve rocker cover gasket(s) after each tune-up.

Tune-up Sequence for Hydraulic Governor

1. Adjust the exhaust valve clearance.
2. Time the fuel injectors.
3. Adjust the fuel rod.
4. Position the injector rack control levers.
5. Adjust the load limit screw.
6. Adjust the speed droop.
7. Adjust the maximum no-load speed.

NOTE: Use new valve rocker cover gasket(s) after each tune-up.

EXHAUST VALVE CLEARANCE ADJUSTMENT

The correct exhaust valve clearance at normal engine operating temperature is important for smooth, efficient operation of the engine.

Insufficient valve clearance can result in loss of compression, misfiring cylinders and, eventually, burned valve seats and valve seat inserts. Excessive valve clearance will result in noisy operation, especially in the low speed range.

Whenever the cylinder head is overhauled, the exhaust valves are reconditioned or replaced, or the valve operating mechanism is replaced or disturbed in any way, the valve clearance must first be adjusted to the cold setting to allow for normal expansion of the engine parts during the engine warm-up period. This will ensure a valve setting that is close enough to the specified clearance to prevent damage to the valves when the engine is started.

ENGINES WITH TWO VALVE CYLINDER HEADS

All of the exhaust valves may be adjusted in firing order sequence during one full revolution of the crankshaft. Refer to the *General Specifications* at the front of the manual for the engine firing order.

Exhaust Valve Clearance Adjustment (Cold Engine)

1. Remove the loose dirt from the valve rocker cover and remove the cover.

2. Place the governor speed control lever in the *idle* speed position. If a stop lever is provided, secure it in the *stop* position.

3. Rotate the crankshaft, manually or with the starting motor, until the injector follower is fully depressed on the particular cylinder to be adjusted.

CAUTION: If a wrench is used on the crankshaft bolt at the front of the engine, do not turn the crankshaft in a left-hand direction of rotation or the bolt may be loosened.

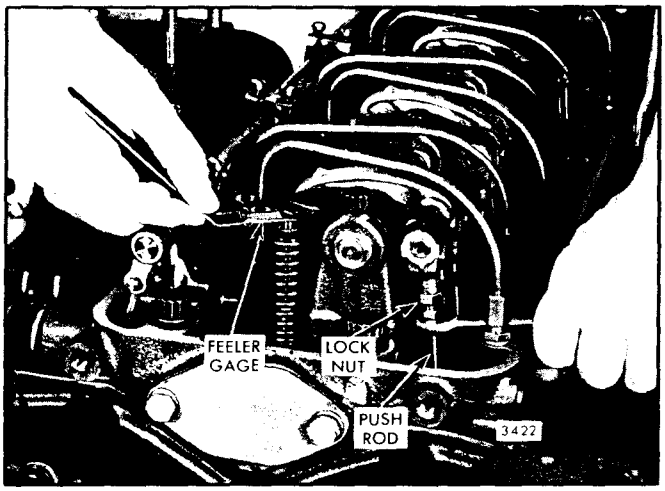


Fig. 1 - Adjusting Valve Clearance (Two Valve Head)

4. Loosen the exhaust valve rocker arm push rod lock nut.

5. Place an .011 " feeler gage, J 9708, between the exhaust valve stem and the rocker arm (Fig. 1). Adjust the push rod to obtain a smooth pull on the feeler gage.

6. Remove the feeler gage. Hold the push rod with a 5/16 " wrench and tighten the lock nut with a 1/2 " wrench.

7. Recheck the clearance. At this time, if the adjustment is correct, the .010 " feeler gage (J 9708) will pass freely between the valve stem and the rocker arm, but the .012 " feeler gage will not pass through. Readjust the push rod, if necessary.

8. Adjust and check the remaining exhaust valves in the same manner as above.

Exhaust Valve Clearance Adjustment (Hot Engine)

Maintaining normal engine operating temperature is particularly important when making the final exhaust valve clearance adjustment. If the engine is allowed to cool before setting any of the valves, the clearance, when running at full load, may become insufficient.

1. With the engine at normal operating temperature (160 °-185 ° F.), recheck the exhaust valve clearance with feeler gage J 9708. At this time, if the valve clearance is correct, the .008 " gage will pass freely between the end of the valve stem and the rocker arm and the .010 " gage will not pass through. Readjust the push rod, if necessary.

2. After the exhaust valve clearance has been adjusted, check the fuel injector timing (Section 14.2).

ENGINES WITH FOUR VALVE CYLINDER HEADS

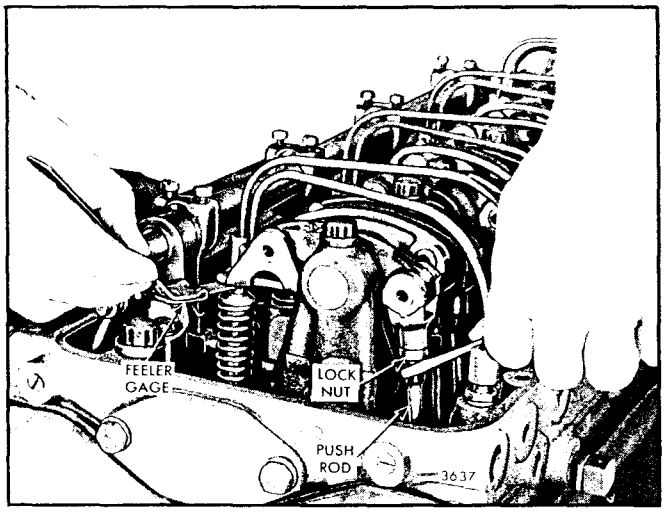


Fig. 2 - Adjusting Valve Clearance (Four Valve Head)

All of the exhaust valves may be adjusted in firing order sequence during one full revolution of the crankshaft. Refer to the *General Specifications* at the front of the manual for the engine firing order.

Exhaust Valve Clearance Adjustment (Cold Engine)

1. Remove the loose dirt from the valve rocker cover and remove the cover.

2. Place the governor speed control lever in the *idle* speed position. If a stop lever is provided, secure it in the *stop* position.

3. Rotate the crankshaft, manually or with the starting motor, until the injector follower is fully depressed on the particular cylinder to be adjusted.

CAUTION: If a wrench is used on the crankshaft bolt at the front of the engine, do not turn the crankshaft in a left-hand direction of rotation or the bolt may be loosened.

4. Loosen the exhaust valve rocker arm push rod lock nut.

5. Place a .027 " feeler gage, J 9708, between the end of one exhaust valve stem and the rocker arm bridge (Fig. 2). Adjust the push rod to obtain a smooth pull on the feeler gage.

6. Remove the feeler gage. Hold the push rod with a 5/16 " wrench and tighten the lock nut with a 1/2 " wrench.

7. Recheck the clearance. At this time, if the adjustment is correct, the .025 " gage will pass freely between the end of one valve stem and the rocker arm bridge and the .027 " gage will not pass through. Readjust the push rod, if necessary.

8. Adjust and check the remaining exhaust valves in the same manner as above.

Exhaust Valve Clearance Adjustment (Hot Engine)

Maintaining normal engine operating temperature is particularly important when making the final exhaust valve clearance adjustment. If the engine is allowed to cool before setting any of the valves, the clearance, when running at full load, may become insufficient.

1. With the engine at normal operating temperature (160 °-185 ° F.), recheck the exhaust valve clearance with feeler gage J 9708. At this time, if the valve clearance is correct, the .023 " gage will pass freely between the end of one valve stem and the rocker arm bridge and the .025 " feeler gage will not pass through. Readjust the push rod, if necessary.

2. After the exhaust valve clearance has been adjusted, check the fuel injector timing (Section 14.2).

FUEL INJECTOR TIMING

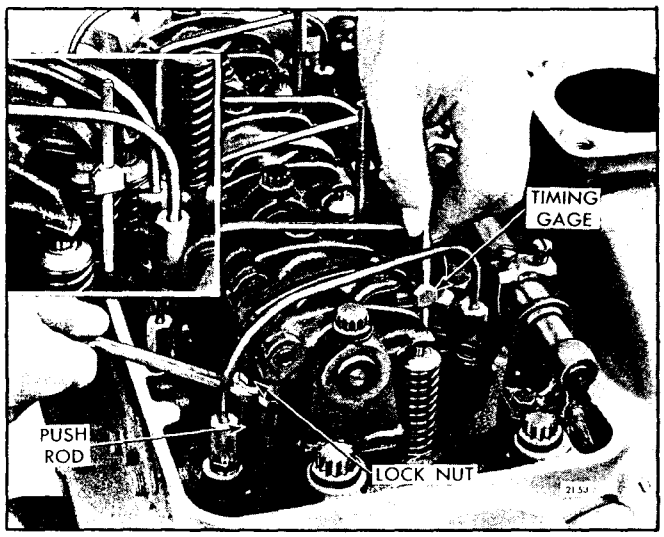


Fig. 1 - Timing Fuel Injector

Injector	Timing Dimension	Timing Gag
35 (Reefer Car)	1.508	J 8909
35	1.484	J 1242
40	1.484	J 1242
45	1.484	J 1242
S40	1.460	J 1853
S45	1.460	J 1853
S50	1.460	J 1853
L40	1.460	J 1853
N40	1.460	J 1853
N45	1.460	J 1853
N50	1.460	J 1853
*C40	1.460	J 1853
*C45	1.460	J 1853
*C50	1.460	J 1853

*With 1973 on-highway vehicle engines.

INJECTOR TIMING GAGE CHART

To time an injector properly, the injector follower must be adjusted to a definite height in relation to the injector body.

All of the injectors can be timed in firing order sequence during one full revolution of the crankshaft. Refer to the *General Specifications* at the front of the manual for the engine firing order.

Time Fuel Injector

After the exhaust valve clearance has been adjusted (Section 14.1), time the fuel injectors as follows:

1. Place the governor speed control lever in the *idle* speed position. If a stop lever is provided, secure it in the *stop* position.

2. Rotate the crankshaft, manually or with the starting motor, until the exhaust valves are fully depressed on the particular cylinder to be timed.

CAUTION: If a wrench is used on the crankshaft bolt at the front of the engine, do not turn the crankshaft in a left-hand direction of rotation or the bolt may be loosened.

3. Place the small end of the injector timing gage (refer to the chart for the correct timing gage) in the hole provided in the top of the injector body, with the flat of the gage toward the injector follower (Fig. 1).

4. Loosen the injector rocker arm push rod lock nut.

5. Turn the push rod and adjust the injector rocker arm until the extended part of the gage will just pass over the top of the injector follower.

6. Hold the push rod and tighten the lock nut. Check the adjustment and, if necessary, readjust the push rod.

7. Time the remaining injectors in the same manner as outlined above.

8. If no further engine tune-up is required, install the valve rocker cover, using a new gasket.

LIMITING SPEED MECHANICAL GOVERNOR AND INJECTOR RACK CONTROL ADJUSTMENT

IN-LINE ENGINE

After adjusting the exhaust valves and timing the fuel injectors, adjust the governor and position the injector rack control levers.

NOTE: Loosen the load limit lever for the load limiting device, if the engine is so equipped, before proceeding with the governor adjustment.

Adjust Governor Gap

With the engine stopped and at operating temperature, adjust the governor gap as follows:

1. Remove the high speed spring retainer cover.

2. Back out the buffer screw until it extends 5/8" beyond the governor housing.

3. Clean and remove the valve rocker cover.

4. Start the engine and adjust the idle speed screw (Fig. 5) to obtain an idle speed of 500-600 rpm.

NOTE: The recommended idle speed is 500-600 rpm, but may vary with special engine applications.

5. Stop the engine and remove the governor cover.

6. Start the engine and control the speed manually by operating the injector control tube lever. The engine speed should be between 800 and 1000 rpm.

CAUTION: Do not overspeed the engine.

7. Check the gap between the low speed spring cap and the high speed spring plunger with a .0015" feeler gage. If the gap setting is incorrect, reset the gap adjusting screw (Fig. 1). If the setting is correct, the .0015" movement can be seen by placing a few drops of oil into the governor gap and pressing a screw driver against the gap adjusting screw. Movement of the cap toward the plunger will force the oil from the gap in the form of a small bead.

8. Hold the gap adjusting screw and tighten the lock nut.

9. Recheck the gap and readjust if necessary.

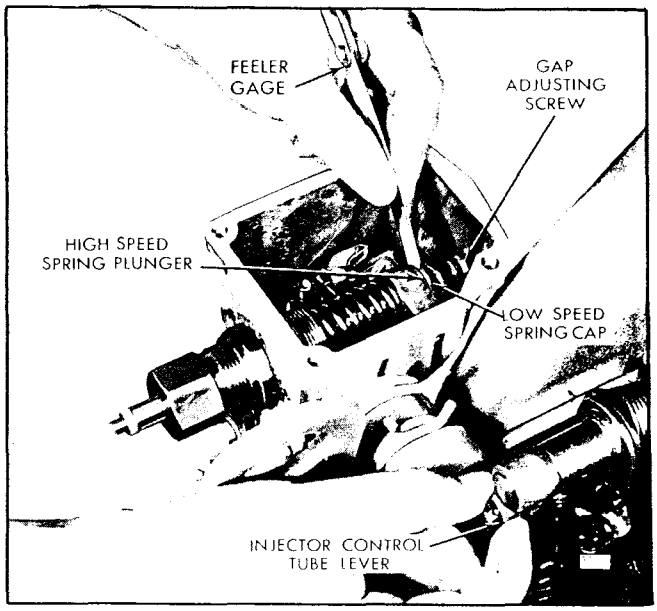


Fig. 1 - Adjusting Governor Gap

10. Install the governor cover. The governor cover should be placed on the housing with the pin of the speed control lever projecting into the slot of the differential lever.

11. Install the screws and lock washers finger tight. Pull the cover away from the engine and tighten the screws. This step will properly locate the cover on the governor housing.

Position Injector Rack Control Levers

The position of the injector racks must be correctly set in relation to the governor. Their position determines the amount of fuel injected into each cylinder and ensures equal distribution of the load.

Adjust the rear injector rack control lever first to establish a guide for adjusting the remaining injector rack control levers.

1. Disconnect any linkage attached to the speed control lever.

2. Loosen all of the inner and outer injector rack control lever adjusting screws (Fig. 2). Be sure all of the levers are free on the injector control tube.

3. Move the speed control lever to the full-fuel

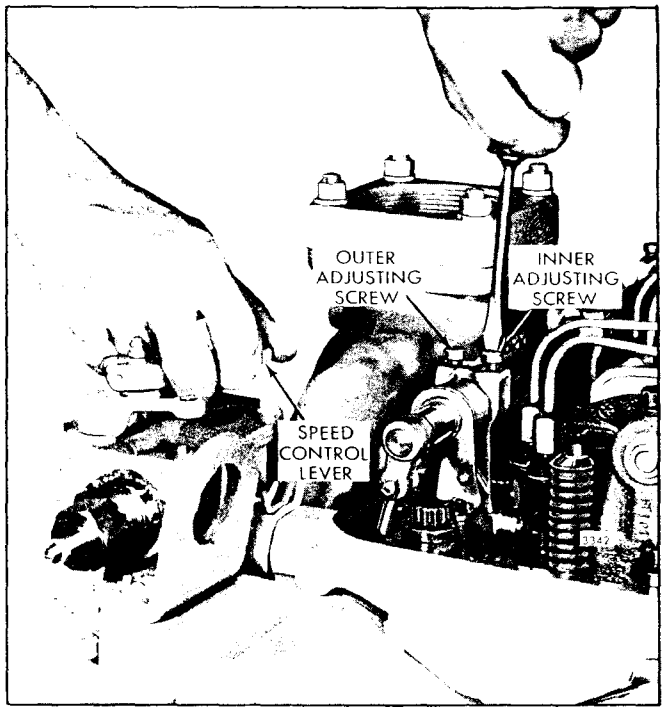


Fig. 2 - Positioning the Rear Injector Rack Control Lever

position. Turn the inner adjusting screw down on the rear injector rack control lever until a step-up in effort is noted. This will place the rear injector rack in the full-fuel position. Turn down the outer adjusting screw until it bottoms lightly on the injector control tube. Then alternately tighten both the inner and outer adjusting screws. This should result in placing the governor linkage and control tube assembly in the same positions that they will attain while the engine is running at full-load.

4. To be sure of proper rack adjustment, hold the speed control lever in the full-fuel position. Press down on the injector rack coupling causing the coupling to rotate.

> **NOTE:** This coupling is on the end of the injector rack and fits around the ball end of the rack control lever.

The setting is sufficiently tight if the coupling returns to its original position. If the coupling does not return to its original position, it is too loose. To correct, back off the outer adjusting screw slightly and tighten the inner adjusting screw.

The coupling is too tight if, when moving the speed control lever from the idle to the maximum speed position, the injector rack coupling becomes tight before the speed control lever reaches the end of its travel (stop under the governor cover). This will result in a step-up in effort to move the speed control lever to its maximum speed position and a deflection in the fuel rod (fuel rod deflection can be seen at the bend). If the coupling is found to be too tight, back off the inner adjusting screw slightly and tighten the outer adjusting screw.

5. Manually hold the rear injector rack control lever in the full-fuel position. Turn down the inner adjusting screw on the injector rack control lever of the adjacent injector until the injector rack has moved into the full-fuel position and the inner adjusting screw is bottomed on the injector control tube. Turn the outer adjusting screw down until it bottoms lightly on the injector control tube. Then alternately tighten both the inner and outer adjusting screws.

> **NOTE:** Overtightening of the injector rack control lever adjusting screws during installation or adjustment can result in damage to the injector control tube. The recommended torque of the adjusting screws is 24-36 **in-lbs.**

6. Recheck the rear injector rack to be sure that it has remained snug on the ball end of the injector rack control lever while adjusting the adjacent injector. If the rack of the rear injector has become loose, back off the inner adjusting screw slightly on the adjacent injector rack control lever. Tighten the outer adjusting screw. When the settings are correct, the racks of both injectors must be snug on the ball end of their respective rack control levers.

7. Position the remaining rack control levers as outlined in Steps 5 and 6.

Adjust Maximum No-Load Engine Speed

All governors are properly adjusted before leaving the factory. However, if the governor has been reconditioned or replaced, and to ensure the engine speed will not exceed the recommended no-load speed as given on the engine name plate, the maximum no-load speed may be set as follows:

TYPE A GOVERNOR SPRINGS (Fig. 4):

1. Loosen the lock nut (Fig. 3) and back off the high speed spring retainer approximately five turns.

2. With the engine at operating temperature and no-load on the engine, place the speed control lever in the full-fuel position. Turn the high speed spring retainer IN until the engine is operating at the recommended no-load speed.

The best method of determining the engine speed is with an accurate tachometer.

3. Hold the high speed spring retainer and tighten the lock nut.

TYPE B GOVERNOR SPRINGS (Fig. 4):

1. Start and warm-up the engine.

2. Place the speed control lever in the full-fuel position and note the engine speed.

3. Stop the engine and, if necessary, adjust the engine to the desired no-load speed as follows:

a. Remove the high speed spring retainer, high speed spring and plunger.

CAUTION: Be careful not to jar the assembly while it is being removed to prevent the low speed spring and cap from dropping into the governor.

b. Remove the high speed spring from the high speed spring plunger and add or remove shims (Fig. 4) as required to establish the desired engine no-load speed.

NOTE: For each .010" shim added, the engine speed will be increased approximately 10 rpm.

c. Install the high speed spring on the high speed spring plunger and assemble the spring assembly into the governor housing. Install the spring retainer in the governor housing and tighten it securely.

d. Start the engine and recheck the engine no-load speed. Repeat the steps above as necessary to establish the no-load speed.

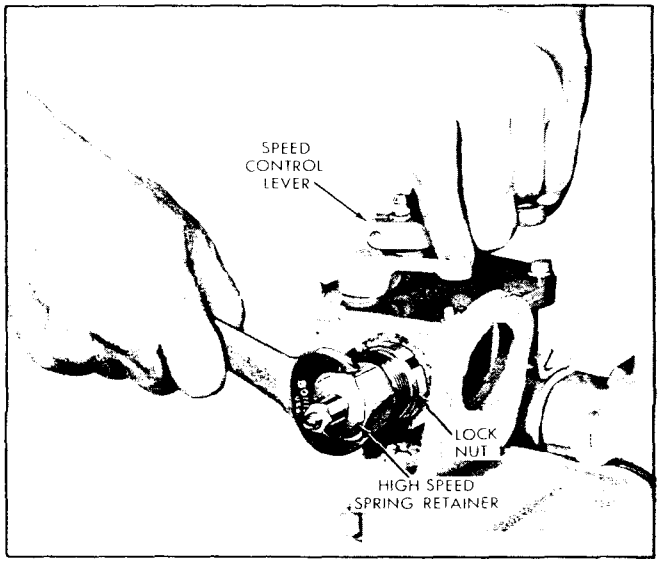


Fig. 3 - Adjusting Maximum No-Load Engine Speed

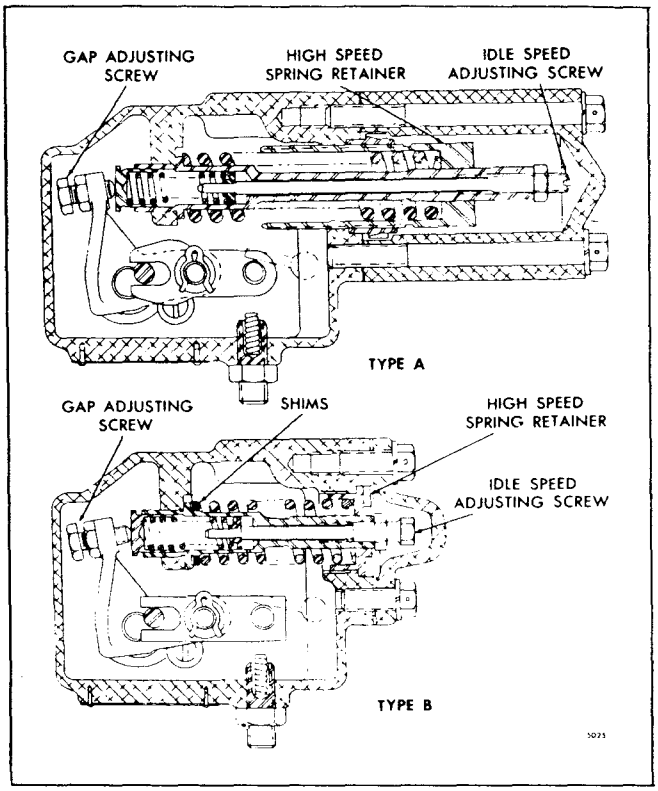


Fig. 4 - Governor Spring Assemblies

Adjust Idle Speed

With the maximum no-load speed properly adjusted, the idle speed may be adjusted as follows:

1. With the engine running at normal operating temperature and with the buffer screw backed out to avoid contact with the differential lever, turn the idle speed adjusting screw (Fig. 5) until the engine idles at the recommended idle speed.

The recommended idle speed is 500-600 rpm, but may vary with the particular engine application.

2. Hold the idle speed adjusting screw and tighten the lock nut.

3. Install the high speed spring cover and tighten the two bolts.

Adjust Buffer Screw

With the idle speed properly set, adjust the buffer screw as follows:

1. With the engine running at normal operating

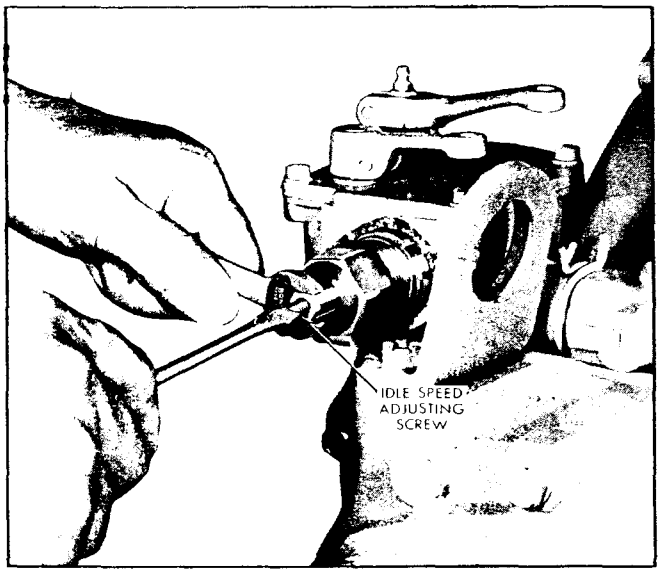


Fig. 5 - Adjusting Engine Idle Speed

temperature, loosen the lock nut and turn the buffer screw in (Fig. 6) so that it contacts the differential lever as lightly as possible and still eliminates engine roll.

NOTE: Do not increase the engine idle speed more than 15 rpm with the buffer screw.

2. Recheck the maximum no-load speed. If it has increased more than 25 rpm from the maximum speed attained in Step 1, back off the buffer screw until the increase is less than 25 rpm.

3. Hold the buffer screw and tighten the lock nut.

If the engine is equipped with a supplementary governing device, refer to Section 14.14 and adjust it at this time.

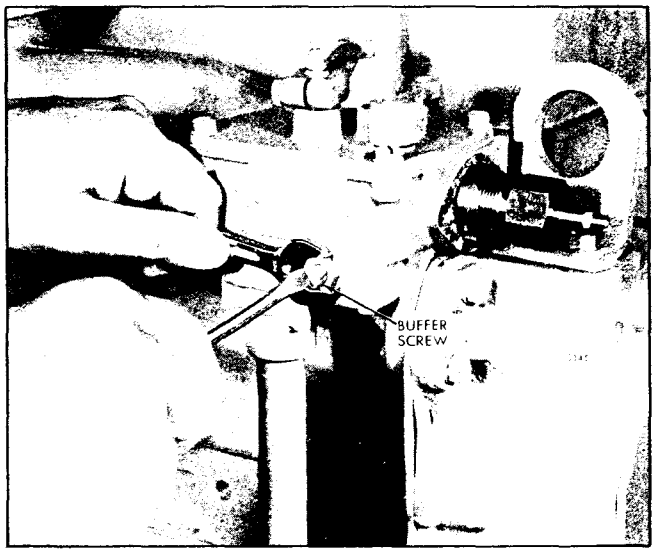


Fig. 6 - Adjusting the Buffer Screw

LIMITING SPEED MECHANICAL GOVERNOR AND INJECTOR RACK CONTROL ADJUSTMENT (V-TYPE ENGINE)

6V-53 ENGINE

The limiting speed mechanical governor is mounted at the rear of the engine, between the flywheel housing and the blower (Fig. 1). The governor is driven by the right blower rotor drive gear. The left blower rotor drive gear is driven by a shaft, that passes through the governor housing, from the engine gear train. There are two types of limiting speed governor assemblies. The difference in the two governors is in the spring mechanism (Fig. 5). One has a long spring mechanism, the other has a short spring mechanism for certain vehicle engine applications.

After adjusting the exhaust valves and timing the fuel injectors, adjust the governor and position the injector rack control levers.

NOTE: Before proceeding with the governor and injector rack adjustments, disconnect any supplementary governing device. After the adjustments are completed, re-connect and adjust the supplementary governing device as outlined in Section 14.14.

Adjust Governor Gap

With the engine stopped and at operating temperature, adjust the governor gap as follows:

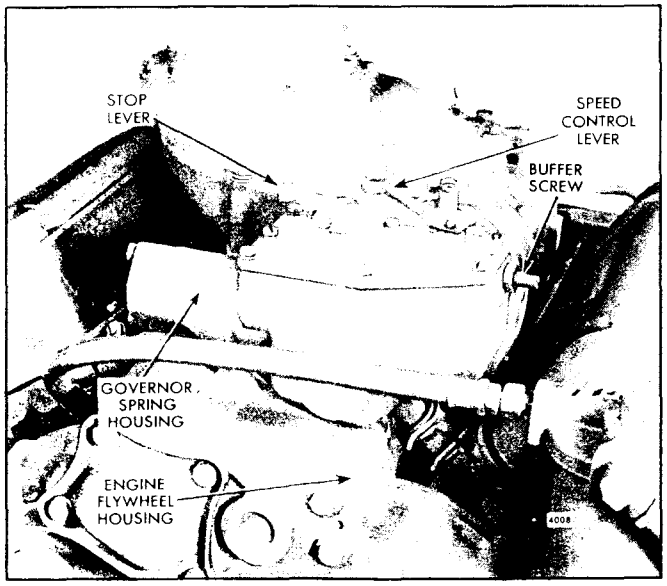


Fig. 1 - Limiting Speed Governor Mounting

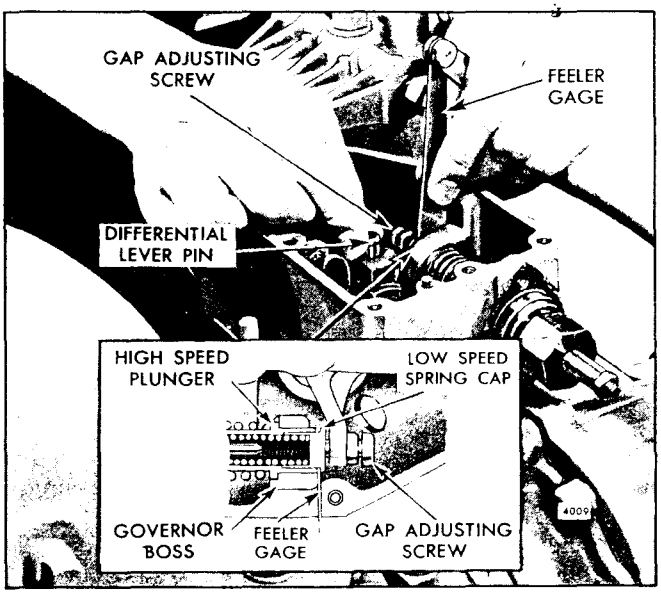


Fig. 2 - Checking Governor Gap

1. Remove the high speed spring retainer cover.

2. Back out the buffer screw until it extends 9/16 " to 5/8 " from the surface of the governor housing.

CAUTION: Do not back the buffer screw out beyond the limits given, or the control link lever may disengage the differential lever.

3. Start the engine and loosen the idle speed adjusting screw lock nut. Then adjust the idle screw (Fig. 6) to obtain the desired engine idle speed.

4. Stop the engine and remove the governor cover and the valve rocker covers. Discard the gaskets.

5. Start and run the engine, between 800 and 1000 rpm, by manual operation of the differential lever.

CAUTION: Do not overspeed the engine.

6. Check the gap between the low speed spring cap and the high speed spring plunger with a .0015 " feeler gage. If the gap setting is incorrect, reset the gap adjusting screw (Fig. 2). If the setting is correct,

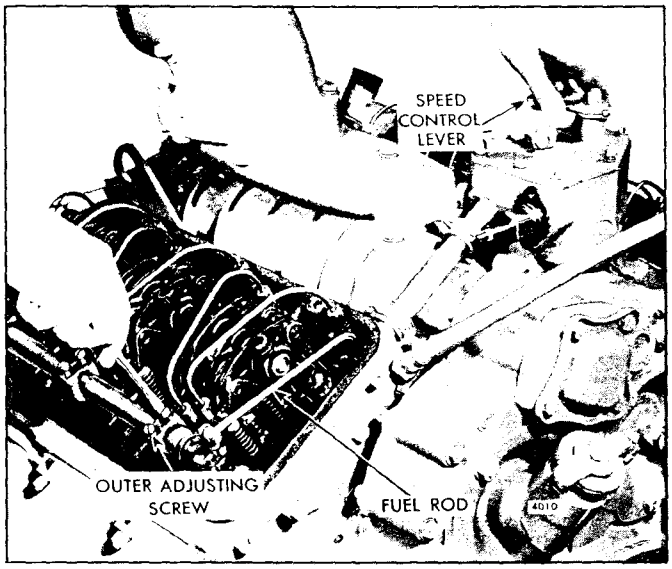


Fig. 3 - Positioning No. 3L Injector Rack Control Lever

the .0015 " movement can be seen by placing a few drops of oil into the governor gap and pressing a screw driver against the gap adjusting screw. Movement of the cap toward the plunger will force the oil from the gap in the form of a small bead.

7. Hold the gap adjusting screw and tighten the lock nut.

8. Recheck the gap and readjust if necessary.

9. Stop the engine and reinstall the governor cover.

Position Injector Rack Control Levers

Properly positioned injector rack control levers with the engine at full load will result in the following:

1. Speed control lever at the maximum speed position.

2. Governor low speed gap closed.

3. High speed spring plunger on the seat in the governor control housing.

4. Injector fuel control racks in the full-fuel position.

The letters R or L indicate the injector location in the right or left cylinder bank, viewed from the rear of the engine. Cylinders are numbered starting at the front of the engine on each cylinder bank. Adjust the No. 3L injector rack control lever first to establish a guide for adjusting the remaining injector rack control levers.

1. Disconnect the linkage attached to the speed control lever.

2. Turn the idle speed adjusting screw so that about 1/2 " of the screw projects from the lock nut.

CAUTION: A false full fuel rack setting may result if the idle speed adjusting screw is not backed out as noted above.

NOTE: This adjustment lowers the tension of the low speed spring so it can be compressed, while closing the low speed gap, without bending the fuel rods.

3. Back out the buffer screw approximately 3/4 " if it has not already been done.

4. Remove the clevis pin from the fuel rod and the right cylinder bank injector control tube lever.

5. Loosen all of the inner and outer injector rack control lever adjusting screws on both injector control tubes. Be sure all of the injector rack control levers are free on the injector control tubes.

6. Move the speed control lever to the maximum speed position; hold it in that position with light finger pressure. Turn the inner adjusting screw on the No. 3L injector rack control lever down as shown in Fig. 3 until a slight movement of the control tube lever is observed or a step-up in effort to turn the screw driver is noted. This will place the No. 3L injector in the full-fuel position. Turn down the outer adjusting screw until it bottoms lightly on the injector control tube. Then alternately tighten both the inner and outer adjusting screws. This should result in placing the governor linkage and control tube asembly in the same positions that they will attain while the engine is running at full load.

NOTE: Overtightening of the injector rack control lever adjusting screws during installation or adjustment can result in damage to the injector control tube. The recommended torque of the adjusting screws is 24-36 **in-lbs.**

7. To be sure of the proper rack adjustment, hold the speed control lever in the maximum speed position and press down on the injector rack with a screw driver or finger tip, causing the rack to rotate.

The setting is sufficiently tight if the rack returns to its original position. If the rack does not return to its original position, it is too loose. To correct this condition, back off the outer adjusting screw slightly and tighten the inner adjusting screw.

The setting is too tight if, when moving the speed

control lever from the idle speed to the maximum speed position the injector rack becomes tight before the speed control lever reaches the end of its travel (stop under the governor cover). This will result in a step-up in effort required to move the speed control lever to its maximum speed position and a deflection in the fuel rod (fuel rod deflection can be seen at the bend). If the rack is too tight, back off the inner adjusting screw slightly and tighten the outer adjusting screw.

8. Remove the clevis pin from the fuel rod and the left bank injector control tube lever.

9. Insert the clevis pin in the fuel rod and the right cylinder bank injector control tube lever and position the No. 3R injector rack control lever as previously outlined in Step 6 for the No. 3L injector rack control lever.

10. Insert the clevis pin in the fuel rod and the left cylinder bank injector control tube lever. Repeat the check on the 3L and 3R injector rack control levers as outlined in Step 7. Check for and eliminate any deflection which may occur at the bend in the fuel rod where it enters the cylinder head.

11. Manually hold the No. 3L injector rack in the full-fuel position, with the lever on the injector control tube, and turn the inner adjusting screw of the No. 2L injector rack control lever down until the injector rack has moved into the full-fuel position. Turn the outer adjusting screw down until it bottoms lightly on the injector control tube. Then alternately tighten both the inner and outer adjusting screws.

12. Recheck the No. 3L injector rack to be sure it has remained snug on the ball end of the rack control lever while positioning the No. 2L injector rack. If the rack of the No. 3L injector has become loose, back off the inner adjusting screw slightly on the No. 2L injector rack control lever and tighten the outer adjusting screw. When the settings are correct, the racks of both injectors must be snug on the ball end of their respective rack control levers.

13. Position the No. 1L injector rack control lever as outlined in Steps 11 and 12.

14. Position the No. 2R and 1R injector racks as outlined above for the left cylinder bank.

15. Turn the idle speed adjusting screw in until it projects 3/16 " from the lock nut to permit starting of the engine.

16. Use new gaskets and replace the valve rocker covers.

Adjust Maximum No-Load Engine Speed

All governors are properly adjusted before leaving the factory. However, if the governor has been reconditioned or replaced, and to ensure the engine speed will not exceed the recommended no-load speed as given on the engine name plate, set the maximum no-load speed as follows:

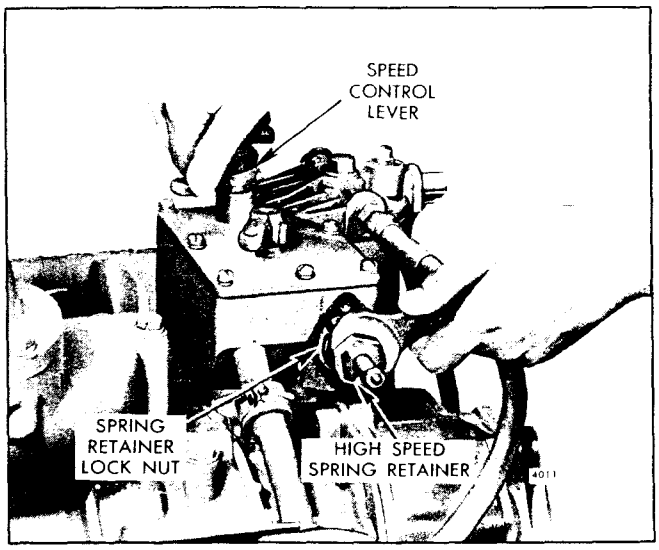


Fig. 4 - Adjusting Maximum No-Load Engine Speed

TYPE A GOVERNOR SPRINGS (Fig. 5):

1. Loosen the lock nut with a spanner wrench and back off the high speed spring retainer several turns. Then start the engine and increase the speed slowly. If the speed exceeds the required no-load speed before the speed control lever reaches the end of its travel, back off the spring retainer a few additional turns.

2. With the engine at operating temperature and no-load on the engine, place the speed control lever in the maximum speed position. Turn the high speed spring retainer in (Fig. 4) until the engine is operating at the recommended no-load speed. Use an accurate hand tachometer to determine the engine speed. The maximum no-load speed varies with the full load operating speed desired as shown in the following table.

Engine Speed Droop

Full Load RPM	Maximum Governor Droop-RPM
0-1200	200
1201-1400	175
1401-1600	150
1601-1800	160
1801-2000	170
2001-2200	180
2201-2400	190
2401-2600	200
2601-2800	210

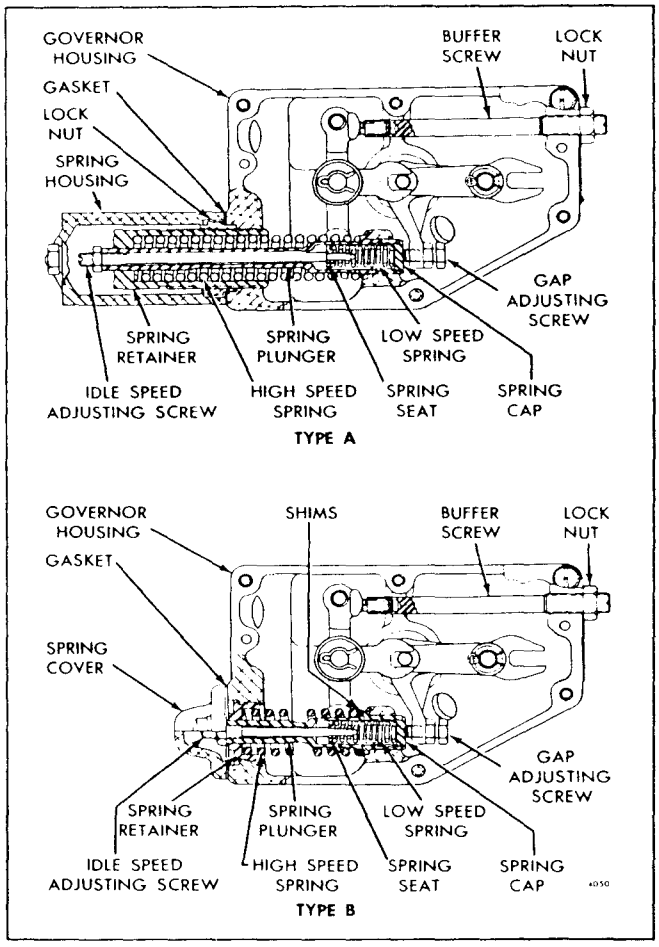


Fig. 5 - Governor Spring Assemblies

EXAMPLE: If the full load speed is to be 2600 rpm, then the no-load speed setting should be 2800 rpm to ensure the governor will move the injector racks into the full-fuel position at the desired full-load speed.

3. Hold the spring retainer and tighten the lock nut.

TYPE B GOVERNOR SPRINGS (Fig. 5):

1. Start the engine and, after it reaches normal operating temperature, remove the load from the engine.

2. Place the speed control lever in the maximum speed position and note the engine speed.

3. Stop the engine and, if necessary, adjust the no-load speed as follows:

a. Remove the high speed spring retainer with tool J 5895 and withdraw the high speed spring and plunger assembly.

CAUTION: To prevent the low speed spring and cap from dropping into the governor, be careful not to jar the assembly while it is being removed.

b. Remove the high speed spring from the high speed spring plunger and add or remove shims as required to establish the desired engine no-load speed.

NOTE: For each .010 " in shims added, the engine speed will be increased approximately 10 rpm.

c. Install the high speed spring on the plunger and install the spring assembly in the governor housing. Tighten the spring retainer securely. The maximum no-load speed varies with the full-load operating speed desired as shown in the following table.

Engine Speed Droop

Full Load RPM	Maximum Governor Droop RPM
2401-2600	150
2601-2800	140

EXAMPLE: If the full-load speed is to be 2800 rpm, then the no-load speed setting should be 2940 rpm to ensure the governor will move the injector racks into the full-fuel position at the desired full-load speed.

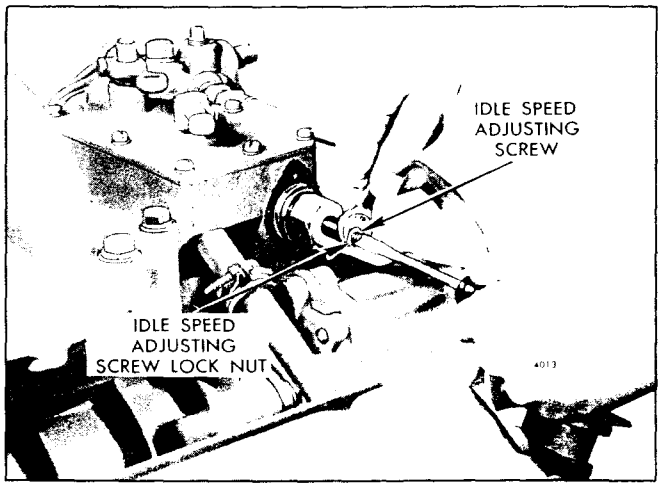


Fig. 6 - Adjusting Engine Idle Speed

d. Start the engine and recheck the no-load speed. Repeat the procedure as necessary to establish the no-load speed required.

Adjust Idle Speed

With the maximum no-load speed properly set, adjust the idle speed as follows:

1. With the engine running at normal operating temperature and with the buffer screw backed out to avoid contact with the differential lever, turn the idle speed adjusting screw (Fig. 6) until the engine idles at the recommended idle speed. The recommended idle speed is 500-600 rpm, but may vary with the engine application.

If the engine has a tendency to stall during deceleration, install a new buffer screw. The current buffer screw uses a heavier spring and restricts the travel of the differential lever to the off (no-fuel) position.

2. Hold the idle screw and tighten the lock nut.

3. Install the high speed spring retainer cover.

Adjust Buffer Screw

With the idle speed properly set, adjust the buffer screw as follows:

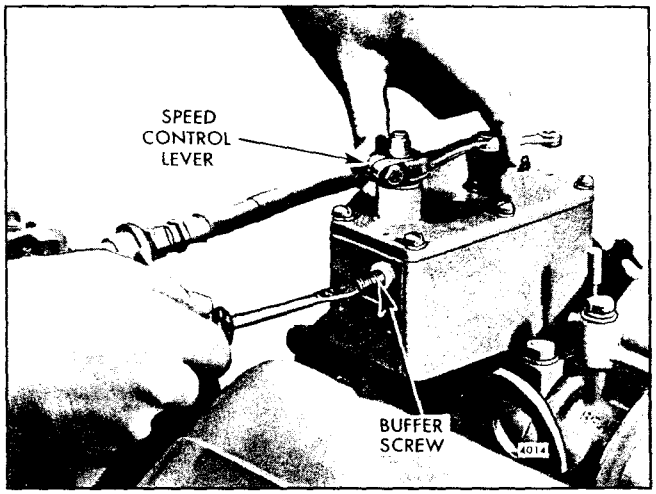


Fig. 7 - Adjusting Buffer Screw

1. With the engine running at normal operating temperature, turn the buffer screw in (Fig. 7) so it contacts the differential lever as lightly as possible and still eliminates the engine roll.

NOTE: Do not increase the engine idle speed more than 15 rpm with the buffer screw.

2. Recheck the maximum no-load speed. If it has increased more than 25 rpm, back off the buffer screw until the increase is less than 25 rpm.

3. Hold the buffer screw and tighten the lock nut.

8V-53 ENGINE

The limiting speed mechanical governor assembly is mounted on the front end of the blower (Fig. 8). The governor weight carrier shaft is attached to and driven by the left-hand helix rotor.

After adjusting the exhaust valves and timing the fuel injectors, adjust the governor and position the injector rack control levers.

NOTE: Before proceeding with the governor and injector rack adjustments, disconnect any supplementary governing device. After the adjustments are completed, re-connect and adjust the supplementary governing device as outlined in Section 14.14.

Adjust Governor Gap

With the engine at operating temperature, set the governor gap as follows:

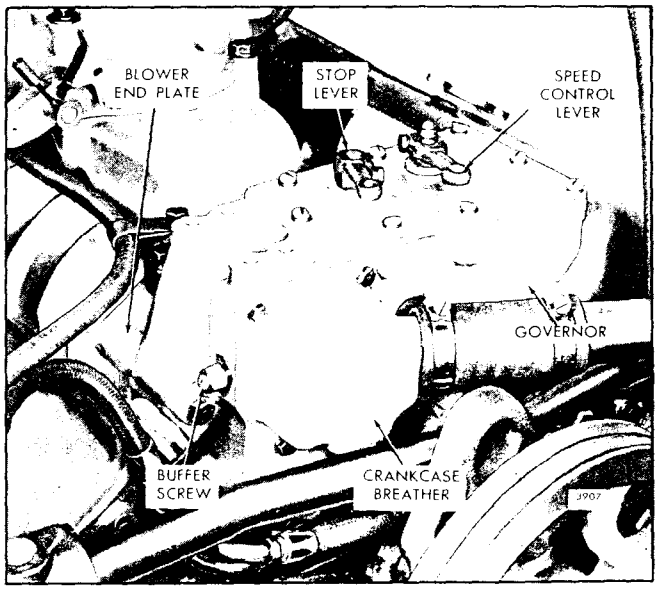


Fig. 8 - Limiting Speed Governor Mounting

1. With the engine stopped, remove the two bolts and

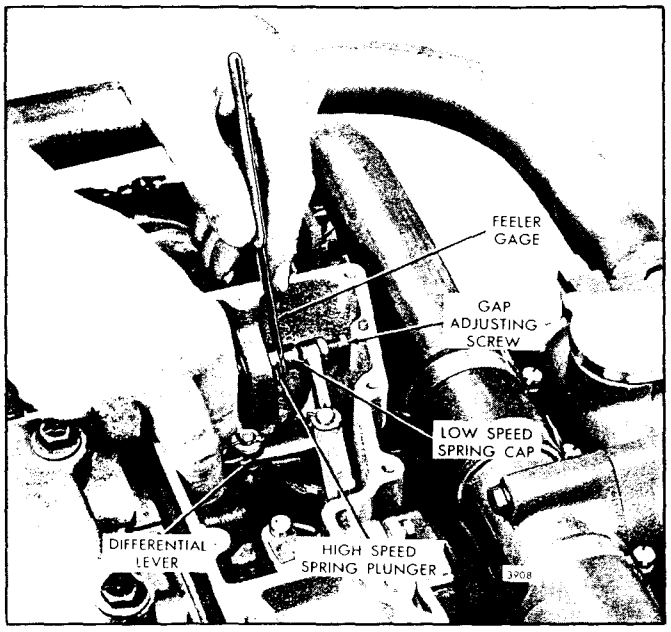


Fig. 9 - Checking Governor Gap

withdraw the governor high speed spring retainer cover.

2. Back out the buffer screw until it extends 9/16 " to 5/8 " from the surface of the governor housing.

CAUTION: Do not back the buffer screw out beyond the limits given, or the control link lever may disengage the differential lever.

3. Start the engine and loosen the idle speed adjusting screw or lock nut, if used. Then adjust the idle screw (Fig. 13) to obtain the desired idle speed.

4. Run the engine until the proper operating temperature is reached, then stop the engine and remove the governor cover and the engine valve rocker covers. Discard the gaskets.

5. Start and run the engine, between 800 and 1000 rpm, by manual operation of the differential lever.

CAUTION: Do not overspeed the engine.

6. Check the gap between the low speed spring cap and the high speed spring plunger with a .0015 " feeler gage. If the gap setting is incorrect, reset the gap adjusting screw (Fig. 9).

If the setting is correct, the .0015 " movement can be seen by placing a few drops of oil into the governor gap adjusting screw. Movement of the cap toward the plunger will force the oil from the gap in the form of a small bead.

7. Hold the gap adjusting screw and tighten the lock nut.

NOTE: Governors which include a starting aid screw threaded into the end of the gap adjusting screw do not require a lock nut as both screws incorporate a nylon patch in lieu of a lock nut.

8. Recheck the gap and readjust if necessary.

9. Stop the engine. Reinstall the governor cover.

10. If a starting aid screw is used, adjust it after the injector rack control levers are positioned.

Position Injector Rack Control Levers

Properly positioned injector rack control levers with the engine at full-load will result in the following:

1. Speed control lever at the maximum speed position.

2. Governor low speed gap closed.

3. High speed spring plunger on the seat in the governor control housing.

4. Injector fuel control racks in the full-fuel position.

The letters R or L indicate the injector location in the right or left cylinder bank, viewed from the rear of the engine. Cylinders are numbered starting at the front of the engine on each cylinder bank. Adjust the No. 1L injector rack control lever first to establish a guide for adjusting the remaining injector rack control levers.

1. Disconnect the linkage attached to the speed control lever.

2. Turn the idle speed adjusting screw until about 1/2 " of the screw projects from the lock nut.

CAUTION: A false full fuel rack setting may result if the idle speed adjusting screw is not backed out as noted above.

NOTE: This adjustment lowers the tension of the low speed spring so it can be compressed, while closing the low speed gap, without bending the fuel rods.

3. If not already done, back out the buffer screw as outlined in Step 2 under *Adjust Governor Gap.*

4. Remove the clevis pin from the fuel rod and the right cylinder bank injector control tube lever.

5. Loosen all of the inner and outer injector rack

control lever adjusting screws on both injector control tubes. Be sure all of the injector rack control levers are free on the injector control tubes.

6. Move the speed control lever to the maximum speed position; hold it in that position with light finger pressure. Turn the inner adjusting screw of the No. 1L injector rack control lever down (Fig. 10) until a slight movement of the control tube lever is observed or a step-up in effort to turn the screw driver is noted. This will place the No. 1L injector in the full-fuel position. Turn down the outer adjusting screw until it bottoms lightly on the injector control tube. Then alternately tighten both the inner and outer adjusting screws. This should result in placing the governor linkage and the control tube assembly in the same positions they will attain while the engine is running at full-load as previously described.

NOTE: Overtightening of the injector rack control lever adjusting screws during installation or adjustment can result in damage to the injector control tube. The recommended torque of the adjusting screws is 24-36 **in-lb.**

7. To be sure the control lever is properly adjusted, hold the speed control lever in the maximum speed position and press down on the injector rack with a screw driver or finger tip, causing the rack to rotate.

The setting is sufficiently tight if the rack returns to its original position. If the rack does not return to its original position, it is too loose. To correct this condition, back off the outer adjusting screw slightly and tighten the inner adjusting screw.

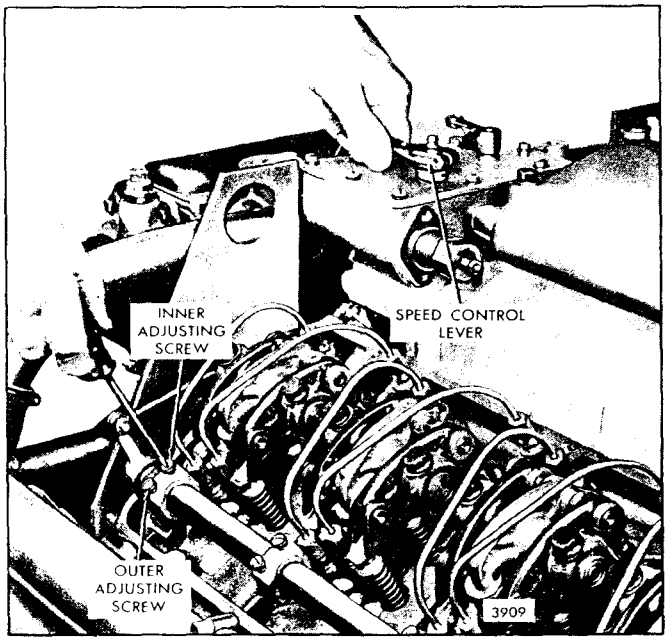


Fig. 10 - Positioning No. 1L Injector Rack Control Lever

The setting is too tight if, when moving the speed control lever from the idle speed to the maximum speed position, the injector rack becomes tight before the speed control lever reaches the end of its travel (stop under the governor cover). This will result in a step-up in effort to move the speed control lever to its maximum speed position and a deflection in the fuel rod (fuel rod deflection can be seen at the bend). If the rack is too tight, back off the inner adjusting screw slightly and tighten the outer adjusting screw.

8. Remove the clevis pin from the fuel rod and the left bank injector control tube lever.

9. Insert the clevis pin in the fuel rod and the right cylinder bank injector control tube lever and position the No. 1R injector rack control lever as previously outlined in Step 6 for the No. 1L injector rack control lever.

10. Insert the clevis pin in the fuel rod and the left cylinder bank injector control tube lever. Repeat the check on the 1L and 1R injector rack control levers as outlined in Step 7. Carefully observe and eliminate any deflection which occurs at the bend in the fuel rod where it enters the cylinder head.

11. Manually hold the No. 1L injector rack in the full-fuel position and turn down the inner adjusting screw of the No. 2L injector rack control lever until the injector rack of the No. 2L injector has moved into the full-fuel position. Turn the outer adjusting screw down until it bottoms lightly on the injector control tube. Then alternately tighten both the inner and outer adjusting screws.

12. Recheck the No. 1L injector rack to be sure it has remained snug on the ball end of the rack control lever while positioning the No. 2L injector rack. If the rack of the No. 1L injector has become loose, back off the inner adjusting screw slightly on the No. 2L injector rack control lever. Tighten the outer adjusting screw. When the settings are correct, the racks of both injectors must be snug on the ball end of their respective rack control levers.

13. Position the No. 3L and 4L injector rack control levers as outlined in Steps 11 and 12.

14. Position the No. 2R, 3R and 4R injector racks as outlined above for the left cylinder bank.

15. Turn the idle speed adjusting screw in until it projects 3/16 " from the lock nut to permit starting of the engine.

16. Use new gaskets and replace the valve rocker covers.

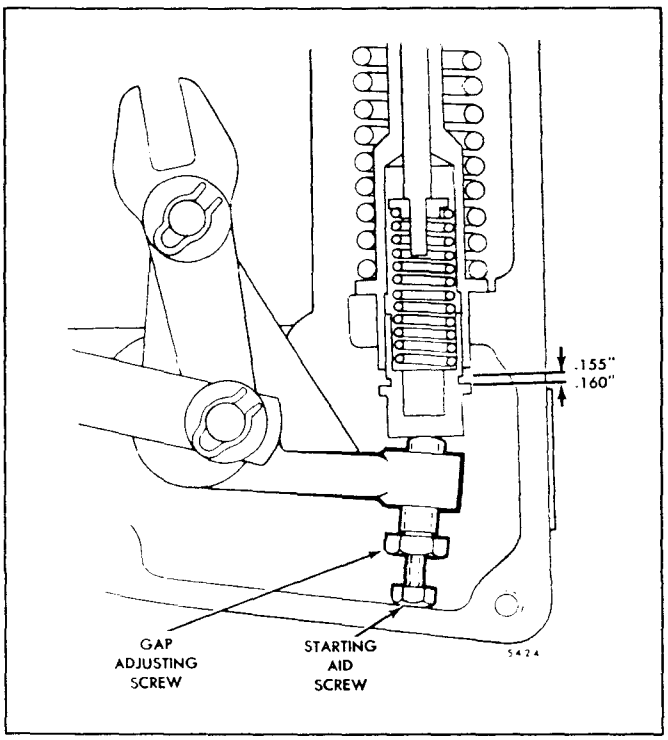


Fig. 11 - Adjust Starting Aid Screw

Adjust Starting Aid Screw

The starting aid screw (Fig. 11) is threaded into the governor gap adjusting screw. This screw is adjusted to position the injector racks at less than full fuel when the governor speed control lever is in the idle position.

The reduced fuel makes starting easier and reduces the amount of smoke on start-up.

CAUTION: The effectiveness of the starting aid screw will be eliminated if the speed control lever is advanced to wide open throttle during starting.

After the normal governor *running* gap of .0015 " has been set and the injector racks positioned, adjust the starting aid screw as follows:

1. With the *engine stopped*, place the governor stop lever in the *run* position and move the speed control lever to the *idle* position.

2. Hold the gap adjusting screw, to keep it from turning, and adjust the starting aid screw to obtain .330" to .360" clearance between the shoulder on the No. 1L injector rack clevis and the injector body, with the head of the starting aid screw against the governor wall.

NOTE: With the *engine stopped*, this adjustment will provide a gap of .155 " to .160 " between the high speed spring plunger and the low speed spring cap (Fig. 11).

3. Move the stop lever to the *stop* position, with the speed control lever still in the *idle* position, and return it to the *run* position.

4. Re-check the injector rack clevis-to-body clearance. Movement of the governor stop lever is to take-up clearances in the governor linkage. The clevis-to-body clearance can be increased by backing out the starting aid screw or reduced by turning it farther into the gap adjusting screw.

5. Start the engine and re-check the *running* gap (.0015 ") and, if necessary, reset it. Then stop the engine.

Adjust Maximum No-Load Engine Speed

All governors are properly adjusted before leaving the factory. However, if the governor has been reconditioned or replaced, and to ensure the engine speed will not exceed the recommended no-load speed as given on the engine name plate, set the maximum no-load speed as outlined below.

1. Loosen the lock nut with a spanner wrench and back off the high speed spring retainer several turns. Then start the engine and increase the speed slowly. If the speed exceeds the required no-load speed before the speed control lever reaches the end of its travel, back off the spring retainer a few additional turns.

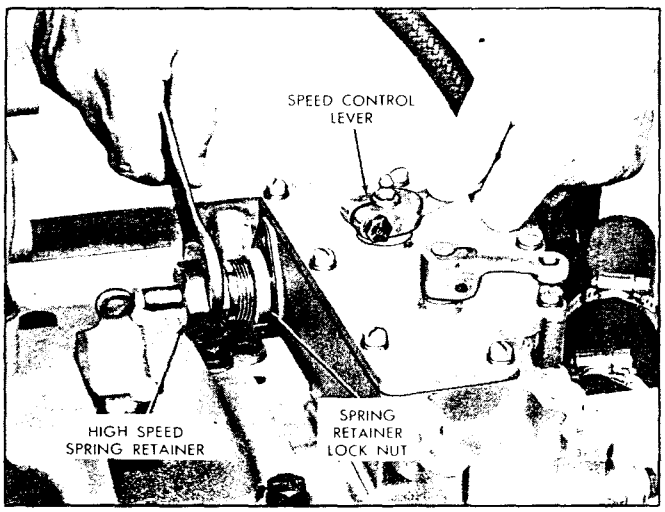


Fig. 12 - Adjusting Maximum No-Load Engine Speed

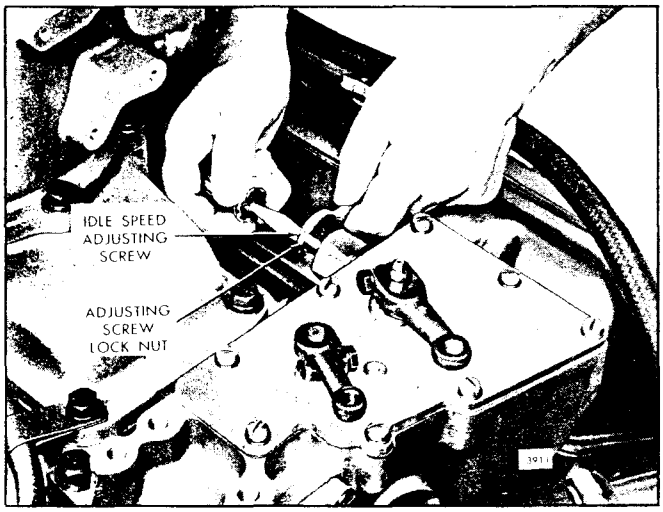


Fig. 13 - Adjusting Engine Idle Speed

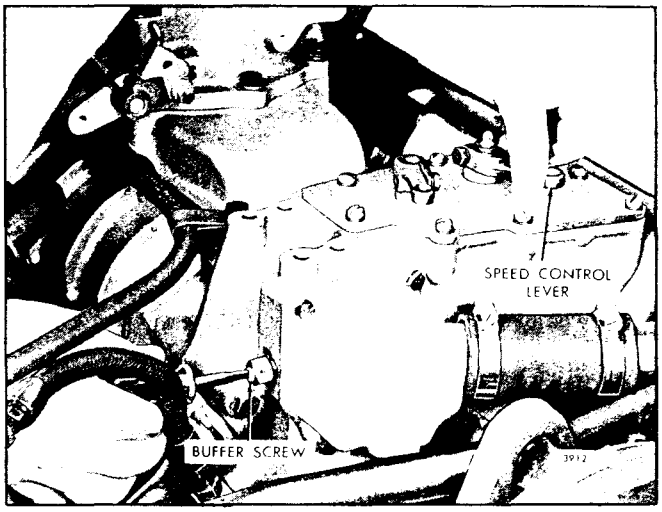


Fig. 14 - Adjusting Buffer Screw

2. With the engine at operating temperature and no-load on the engine, place the speed control lever in the maximum speed position. Turn the high speed spring retainer in (Fig. 12) until the engine is operating at the recommended no-load speed. Use an accurate hand tachometer to determine the engine speed. The recommended speed droop is 150 rpm for governors with a full-load speed range of 2500-2800 rpm.

3. Hold the spring retainer and tighten the lock nut.

Adjust Idle Speed

With the maximum no-load speed properly set, adjust the idle speed as follows:

1. With the engine running at normal operating temperature and with the buffer screw backed out to avoid contact with the differential lever, turn the idle speed adjusting screw (Fig. 13) until the engine idles at the recommended idle speed. The recommended idle speed is 400-600 rpm, but may vary with the engine application.

2. Hold the idle screw and tighten the lock nut.

3. Install the high speed spring retainer cover.

Adjust Buffer Screw

With the idle speed properly adjusted, adjust the buffer screw as follows:

1. With the engine running at normal operating temperature, turn the buffer screw in (Fig. 14) so it contacts the differential lever as lightly as possible and still eliminates engine roll.

NOTE: Do not increase the engine idle speed more than 15 rpm with the buffer screw.

2. Recheck the maximum no-load speed. If it has increased more than 25 rpm, back off the buffer screw until the increase is less than 25 rpm.

3. Hold the buffer screw and tighten the lock nut to retain the adjustment.

After the governor adjustments are completed, adjust any supplementary governing device that may be used as outlined in Section 14.14.

LIMITING SPEED MECHANICAL GOVERNOR ADJUSTMENT

(Variable Low-Speed)

IN-LINE AND 6V-53 ENGINES

The variable low-speed limiting speed mechanical governor used on In-Line and 6V-53 highway vehicle engines is of the double-weight type. It is used where the same engine powers both the vehicle and the auxiliary equipment for unloading bulk products (such as cement, grain or liquids) and a 500 to 1200 rpm idle speed range is desired during auxiliary operation.

During highway operation, the governor functions as a limiting speed governor, controlling the engine idling speed and limiting the maximum operating speed. At the unloading area, the throttle is left in the idle speed position and the remote control knob is turned to obtain the speed required to operate the auxiliary equipment. The governor then functions as a variable speed governor, maintaining a constant speed even when the load is constantly changing, during the unloading operation.

Before resuming highway operation, the remote control knob must be turned all the way back.

Governor identification is provided by a name plate attached to the governor housing. The letters V.L.S.-L.S. stamped on the name plate denote a variable low-speed limiting speed governor.

After adjusting the exhaust valves and timing the injectors, adjust the governor and position the injector rack control levers.

Adjust Governor Gap

With the engine at operating temperature, adjust the governor gap as follows:

1. Stop the engine, remove the two bolts and withdraw the governor spring retainer cover.

2. Back out the buffer screw until it extends approximately 5/8 " from the lock nut.

3. Make a preliminary idle speed (normal highway idle speed) adjustment as follows:

   a. Back out the variable low-speed adjusting shaft until the shoulder on the shaft contacts the shaft retainer (Fig. 1).

   b. Start the engine. Then hold the lock nut and loosen the low-speed adjusting shaft retainer.

   c. Adjust the retainer and shaft assembly to obtain the desired idle speed (500 rpm minimum).

NOTE: It may be necessary to use the buffer screw to eliminate engine roll. Back out the buffer screw, after the idle speed is established, to the previous setting (5/8 "). Then hold the retainer and tighten the lock nut to retain the adjustment.

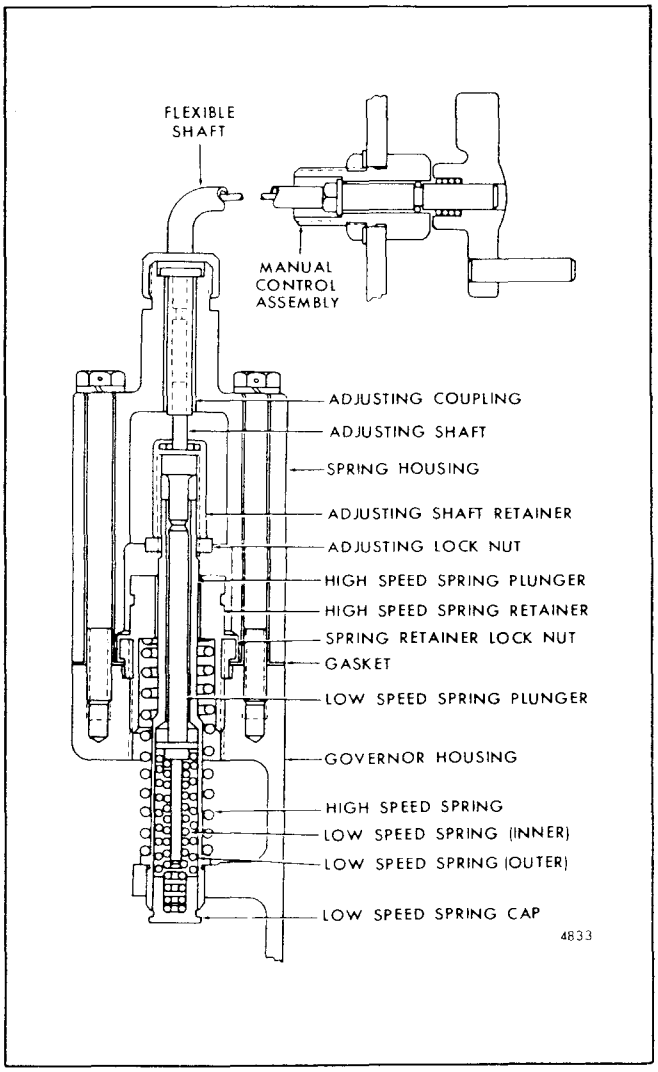


Fig. 1 - Governor Spring Housing and Components

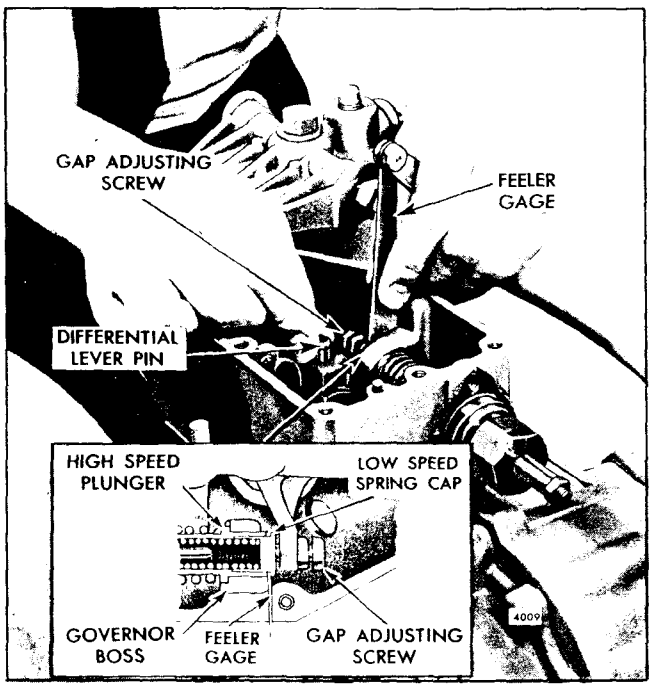


Fig. 2 - Adjusting Governor Gap

4. Stop the engine and remove the governor cover and lever assembly.

5. Start and run the engine between 900 and 1050 rpm by manual operation of the differential lever as shown in Fig. 2. This gap setting range is required because of the lighter low-speed weights and heavier high-speed weights.

CAUTION: Do not overspeed the engine.

6. With the engine operating between 900 and 1050 rpm, set the gap between the low-speed spring cap and the high-speed spring plunger (Fig. 2) at .0015 " by adjusting the gap adjusting screw in the operating shaft lever. If the setting is correct, the .0015 " movement can be seen by placing a drop of oil into the governor gap and pressing a screw driver against the gap adjusting screw. Movement of the cap toward the plunger will force the oil from the gap in the form of a small bead.

7. Hold the gap adjusting screw and tighten the lock nut.

8. Re-install the governor cover and lever assembly.

Position Injector Rack Control Levers

Position the injector rack control levers as outlined in Section 14.3.1 or 14.3.2.

Adjust Idle Speed

Adjust the normal highway idle speed as follows:

1. With the engine running at normal operating temperature and with the buffer screw backed out to avoid contact with the differential lever, hold the lock nut and loosen the variable low-speed adjusting shaft retainer. Adjust the retainer and shaft assembly to obtain a minimum of 500 rpm.

NOTE: It may be necessary to use the buffer screw to eliminate engine roll. Back out the buffer screw, after the idle speed is established, to the previous setting (5/8 ").

Adjust Maximum No-Load Engine Speed

Adjust the maximum no-load engine speed as outlined for the limiting speed mechanical governor in Section 14.3.1 or 14.3.2.

Adjust Buffer Screw

Adjust the buffer screw as outlined in Section 14.3.1 or 14.3.2.

LIMITING SPEED MECHANICAL GOVERNOR

(Fast Idle Cylinder)

6V-53 VEHICLE ENGINE

The limiting speed governor equipped with a fast idle air cylinder is used on vehicle engines where the engine powers both the vehicle and auxiliary equipment.

The fast idle system consists of a fast idle air cylinder installed in place of the buffer screw and a throttle locking air cylinder mounted on a bracket fastened to the governor cover (Fig. 1). An engine shutdown air

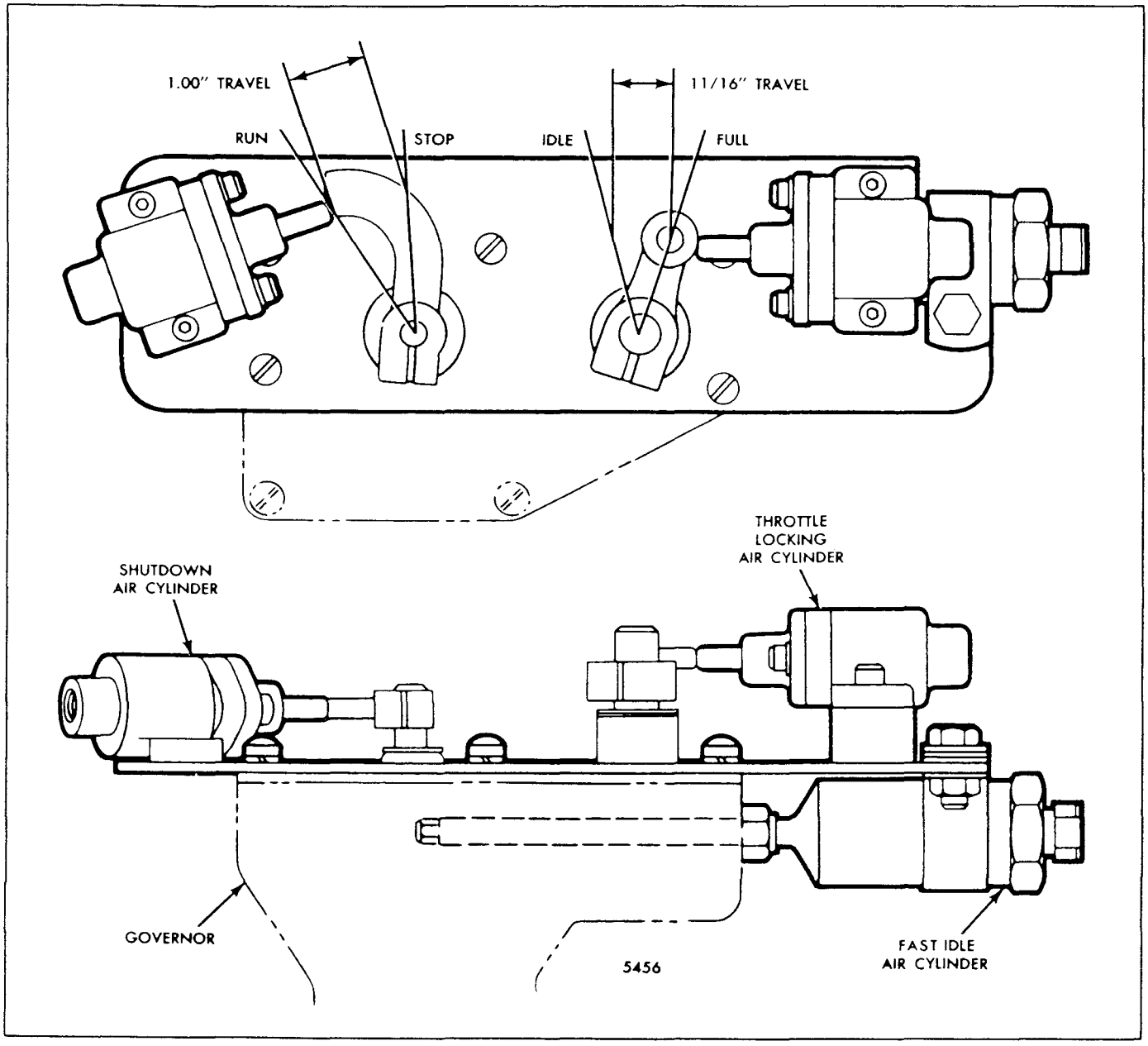


Fig. 1 - Governor with Fast Idle Cylinder

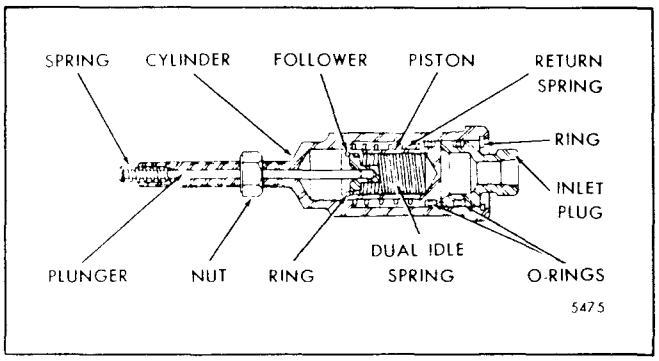


Fig. 2 - Fast Idle Air Cylinder

cylinder, if used, is also mounted on the governor cover.

The fast idle air cylinder and the throttle locking air cylinder are actuated at the same time by air from a common air line. The engine shutdown air cylinder is connected to a separate air line.

The air supply for the fast idle air cylinder is usually controlled by an air valve actuated by an electric solenoid. The fast idle system should be installed so that it will function only when the parking brake system is in operation to make it tamper-proof.

The vehicle accelerator-to-governor throttle linkage is connected to a yield link so the operator cannot overcome the force of the air cylinder holding the speed control lever in the idle position while the engine is operating at the single fixed high idle speed.

Operation

During highway operation, the governor functions as a limiting speed governor.

For operation of auxiliary equipment, the vehicle is stopped and the parking brake set. Then, with the engine running, the low speed switch is placed in the ON position. When the fast idle air cylinder is actuated, the force of the dual idle spring (Fig. 2) is

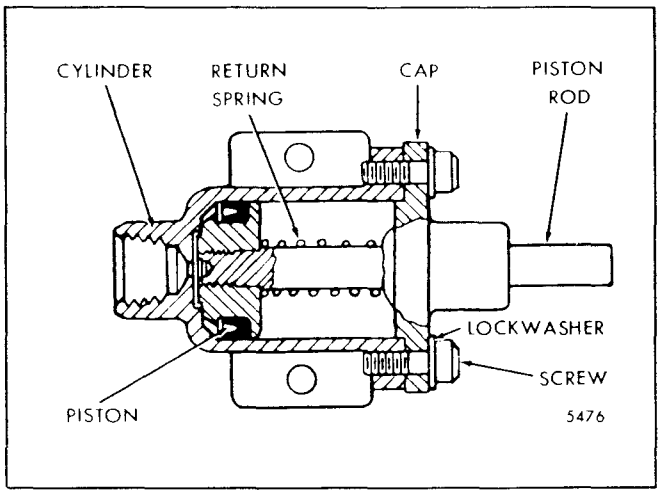


Fig. 3 - Throttle Locking Air Cylinder

added to the force of the governor low speed spring, thus increasing the engine idle speed.

The governor now functions as a constant speed governor at the high idle speed setting, maintaining a near constant engine speed regardless of the load within the capacity of the engine. The fast idle system provides a single fixed high idle speed that is not adjustable, except by disassembling the fast idle air cylinder and changing the dual idle spring. As with all mechanical governors, when load is applied, the engine speed will be determined by the governor droop.

Adjust Governor

Adjust the governor as outlined in Section 14.3.2. However, before adjusting the governor gap, back out the de-energized fast idle air cylinder until it will not interfere with the governor adjustments. After the normal idle speed setting is made, adjust the de-energized fast idle air cylinder in the same manner as outlined for adjustment of the buffer screw.

The throttle locking air cylinder is adjusted on its mounting bracket so it will lock the throttle in the idle position when it is activated, but will not limit the throttle movement when not activated.