SECTION 9

LUBRICATING OIL SYSTEM

CONTENTS

ELECTRO-MOTIVE

ENGINE MAINTENANCE MANUAL

SECTION 9

LUBRICATING OIL SYSTEM

DESCRIPTION

The complete engine lubricating oil system is a combination of three separate systems. These are the main lubricating system, the piston cooling system and the scavenging oil system. Each system has its own oil pump. The main lube oil pump and piston cooling oil pump, although individual pumps, are both contained in one housing and driven from a common drive shaft. The scavenging oil pump is a separate pump. All the pumps are driven from the accessory gear train at the front of the engine. Parts of the complete oil system and a schematic arrangement of oil circulation are shown in Fig. 9-1.

MAIN LUBRICATING OIL SYSTEM

The main lubricating oil system supplies oil under pressure to most of the moving parts of the engine. The main lube oil pump takes oil from the strainer housing at the right front of the engine. Oil from the pump goes into the main oil manifold which is located above the crankshaft, and extends the length of the engine. Maximum oil pressure is limited by a relief valve in the passage between the pump and the main oil manifold

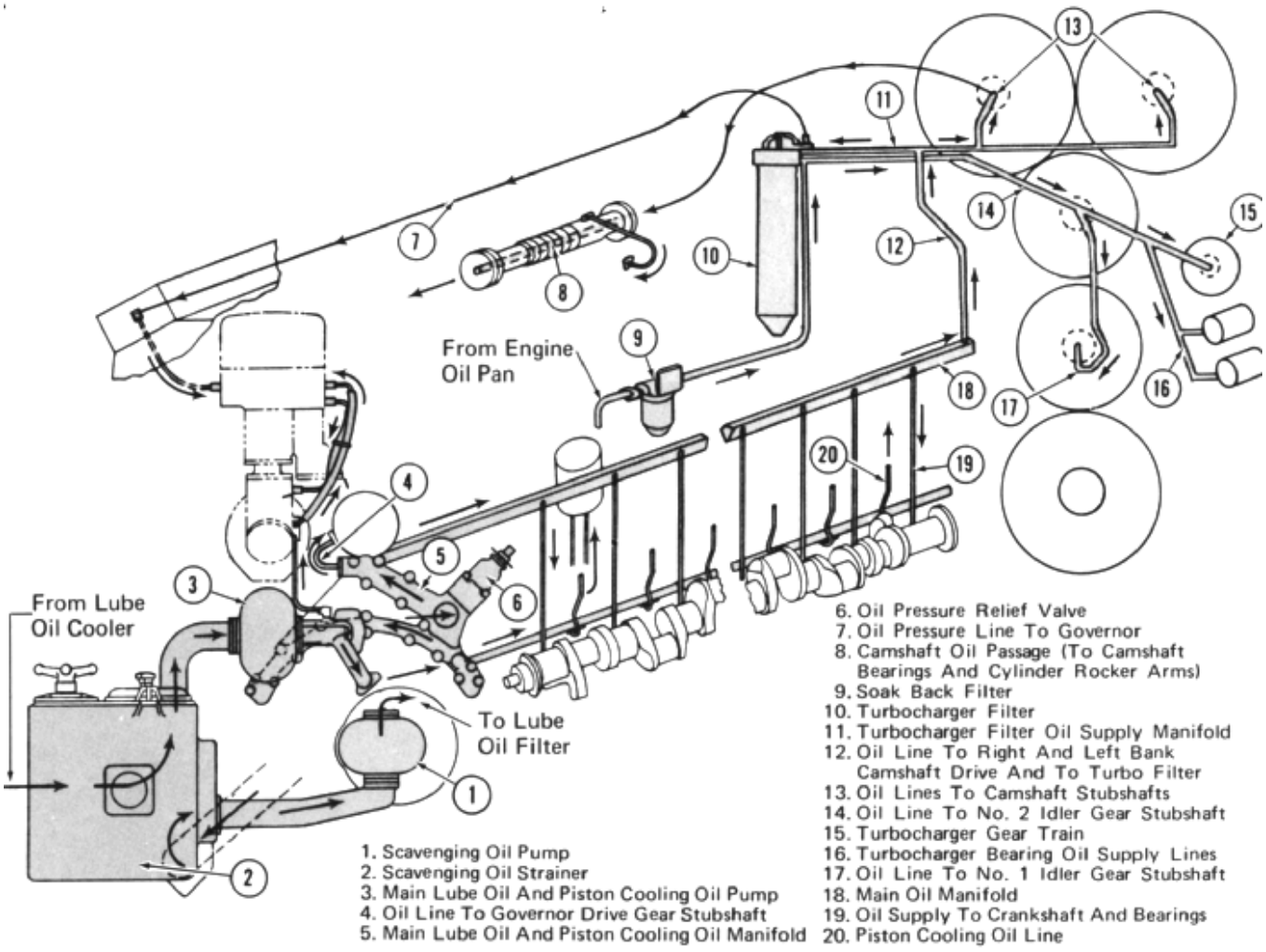


Fig. 9-1 - Lubricating Oil System

Oil tubes at the center of each main bearing "A" frame conduct oil from the main manifold to the upper half of the main crankshaft bearings. Drilled passages in the crankshaft supply oil to the connecting rod bearings, damper, and accessory drive gear at the front of the crankshaft. Leak-off oil from the adjacent main bearings lubricates the crankshaft thrust bearings.

Oil from the main lube oil manifold enters the gear train at the rear of the engine, at the idler gear stubshaft bracket. Oil passages in the stubshaft bracket distribute the oil. One passage conducts oil to both the right and left bank camshaft drive gear stubshaft brackets and to a manifold connected to the turbocharger oil filter. After passing through the filter, the oil enters the return line in the manifold and flows back to the idler gear stubshaft. A passage in the idler gear stubshaft bracket directs lube oil to the upper and lower stubshaft bearings. Filtered oil enters the turbocharger oil system from the upper idler gear stubshaft.

An oil passage in the turbocharger filter head, parallel to the filter output line, is connected to a passage in the turbocharger oil manifold. An oil pressure line is connected between the manifold passage and the low oil pressure device in the governor.

Oil enters the hollow bore camshafts from the camshaft drive stubshafts. Radial holes in the camshaft conduct oil to each camshaft bearing. An oil line from one camshaft bearing at each cylinder supplies oil to the rocker arm shaft, rocker arm cam follower assemblies, hydraulic lash adjusters, and the injector rocker arm button. Leak-off oil returns to the oil pan through passages between the top deck and the oil pan.

Passages in the turbocharger conduct oil to the turbocharger bearings, idler gear, planet gear assembly, and auxiliary drive bore.

Considerable heat will remain in the metal parts of the turbine when the engine is shut down, and if the oil supply to the turbocharger was shut off suddenly, this heat would penetrate the turbocharger bearing area. To prevent possible overheating of the turbocharger, oil is automatically supplied to the turbocharger after stopping the engine.

Protection is provided against a hot oil condition by a thermostatic valve. Descriptive information is contained in Section 13, Protective Devices.

PISTON COOLING OIL SYSTEM

The piston cooling oil system pump receives oil from a common suction with the main lube oil pump and delivers oil to the two piston cooling oil manifolds extending the length of the engine, one on each side. A piston cooling oil pipe at each cylinder directs a stream of oil through the carrier to cool the underside of the piston crown and the ring belt. Some of this oil enters the oil grooves in the piston pin bearing and the remainder drains out through holes in the carrier crown to the sump.

SCAVENGING OIL SYSTEM

The scavenging oil system pump, Fig. 9-I, takes oil through the scavenging oil strainer from the oil pan sump or reservoir. The pump then forces the oil through the oil filters and oil cooler which are located near the engine. Oil then returns to the strainer housing to supply the main lube oil pump and piston cooling oil pump with cooled and filtered oil. Excess oils spills over a dam in the strainer housing and returns to the oil pan.

OIL GAUGE

An oil level gauge, Fig. 9-2, extends from the side of the oil pan into the oil pan sump. The oil level should be maintained between the low and full marks on the gauge, with the reading taken when the engine is at idle speed and the oil is hot.

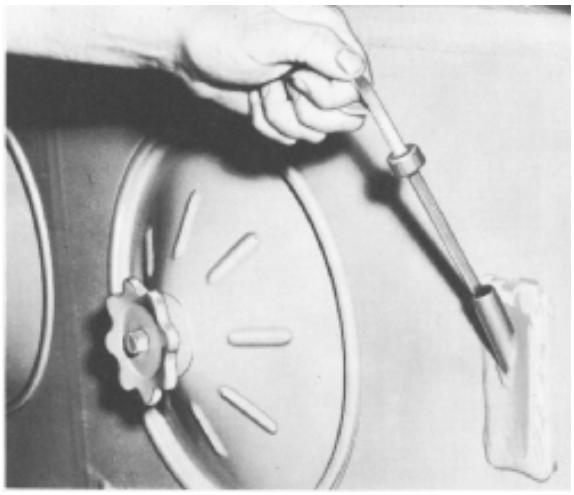


Fig. 9-2 - Oil Level Gauge

MAINTENANCE

MAIN LUBRICATING OIL PRESSURE

Adequate lubricating oil pressure must be maintained at all times when the engine is running.

Upon starting and idling the engine, it should be noted that the oil pressure builds up almost immediately. In the event of cold oil, the pressure may rise to the relief valve setting of approximately 862 kPa (125 psi).

Lubricating oil pressure is not adjustable. The operating pressure range is determined by such things as manufacturing tolerances, oil temperature, oil dilution, wear, and engine speed. The pipe plug can be removed from the opening in the pump discharge elbow and a gauge installed to determine the pressure.

The minimum oil pressure is approximately 55-83 kPa (8-12 psi) at idle and 172-200 kPa (25-29 psi) at full speed. In the event of insufficient oil pressure, a shutdown feature built into the governor will automatically protect the engine by shutting it down. Maximum pressure is determined by the relief valve setting.

PISTON COOLING OIL PRESSURE

Pressure of the piston cooling oil will be governed by oil viscosity, speed of engine, temperature of oil, and wear of pump parts. The pipe plug can be removed from the opening in the pump discharge elbow and a gauge installed to determine the pressure.

MAIN LOBE OIL AND PISTON COOLING OIL MANIFOLD

DESCRIPTION

The main lube oil and piston cooling oil manifold, Fig. 9-3, is a one piece casting with cored passages. The manifold is mounted and doweled in the front end plate, under the accessory drive cover.

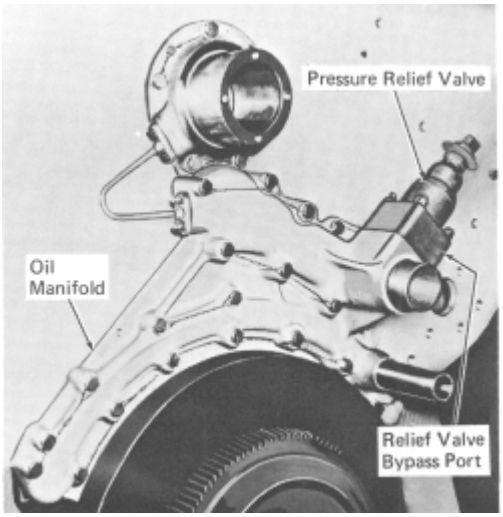


Fig. 9-3 - Lube Oil Manifold And Relief Valve

Connecting tubes passing through the accessory drive cover, protected against leakage by seal rings, connect the manifold to the discharge side of the main lube oil piston cooling oil pumps.

The purpose of the manifold is to transfer the oil supplied by the pumps to the main bearing oil header in the center of the engine. The manifold also transfers oil to the piston cooling oil header pipes on each side of the crankcase, just inside the oil pan mounting flange.

LUBE OIL PRESSURE RELIEF VALVE

DESCRIPTION

The lube oil pressure relief valve, Fig. 9-4, is installed on the lube oil manifold, inside the accessory gear train housing on the left side of the engine, Fig. 9-1. A cover plate provides access to the valve for inspection and adjustment.

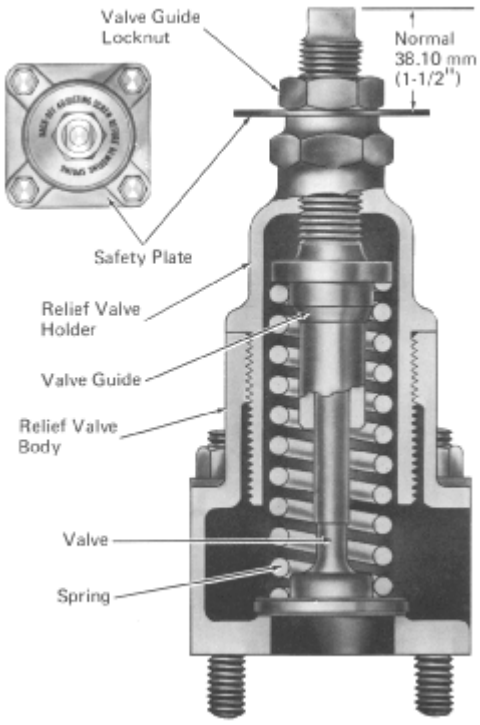


Fig. 9-4 - Lube Oil Pressure Relief Valve

The purpose of the valve is to limit the maximum pressure of the lube oil entering the engine oil system. When the lube oil pump pressure exceeds the spring tension on the valve, the valve will be lifted off its seat and relieve the excess pressure. This oil drains into the accessory housing and then into the oil pan.

MAINTENANCE

The oil pressure relief valve should be removed and the parts inspected at intervals specified in the Scheduled Maintenance Program.

Disassemble the valve and wash all the parts thoroughly. As stated on the safety plate on the valve, back off on the valve guide all the way before removing the valve holder and spring.

Inspect the parts as follows to determine their condition for reuse.

VALVE SPRING

Check the valve spring for any nicks which could cause subsequent spring failure.

Test the valve spring by applying a load of 141 kg (310 lbs). Under this load the spring length should not be less than 114.30 mm (4-1/2").

VALVE GUIDE

Using a telescoping gauge, check the valve guide inside diameter.

If the inside diameter is rough or lightly scuffed, clean up the bore but do not exceed the maximum diameter.

VALVE

Examine the valve stem for roughness and light scuffing. The stem may be handstoned and buffed to remove high spots. Replace the valve if the stem is badly galled.

Check that the outside diameter of the valve stem is not less than the minimum limit.

Also, check for a possible bent valve or distorted face by checking the squareness of the valve face to the stem, measuring from the outer edge of the valve face. Total indicator reading should be as specified.

INSTALLATION

When installing relief valve on engine, make sure that the bypass port is positioned in the downward direction, Fig. 9-3.

SETTING OIL PRESSURE RELIEF VALVE

The setting of the oil pressure relief valve connected to the lube oil manifold determines the maximum oil pressure at the main lube oil pump. It is not set by pressure gauges, but by a specific dimension from the top of the valve guide to the top of the valve holder. To set valve, loosen the locknut, Fig. 9-4, and position the valve guide so that it extends 38.10 mm (1-1/2") above the safety plate.

This setting will permit a maximum oil pressure of about 862 kPa (125 psi) under cold oil conditions, and allow an adequate pressure for normal operation and hot oil.

Lubricating oil manifold pressure or pressure at the valve can be determined by applying a pressure gauge at the main lube oil pump discharge elbow.

PISTON COOLING OIL PIPE

DESCRIPTION

The piston cooling oil pipe is bolted at one end to a flange on the piston cooling oil manifold, and at the other end to the bottom of the cylinder liner. A pipe is located at each cylinder to direct a stream of oil through the piston carrier to the undercrown of the piston. Alignment of the piston cooling oil pipe is very important.

MAINTENANCE

The alignment of the piston cooling oil pipe to the inlet hole in the piston carrier is checked with an alignment gauge as shown in Fig. 9-5. The small end of the gauge fits into the nozzle of the pipe and by bringing the piston to bottom center the gauge should enter the inlet hole in the piston carrier and turn freely in this position. This gauge is not to be used for bending the pipe in case of misalignment. If the gauge will not freely enter the carrier hole, the pipe should be removed and replaced with a new or correctly aligned one.

In addition to the alignment check, the piston cooling pipe nozzle should be examined for ragged edges which might cause the oil to spray out instead of shoot out in a stream.

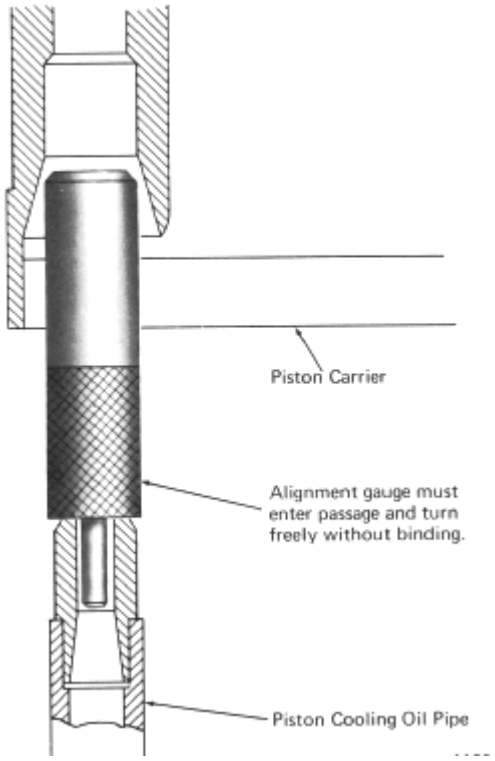


Fig. 9-5 - Piston Cooling Oil Pipe Alignment

CHECKING OIL VISCOSITY

Oil viscosity should be checked at intervals as specified in the Scheduled Maintenance Program. By comparing the viscosity at different intervals, taken at the same temperature, excessive fuel dilution may be detected by an unusual drop in viscosity. Excessive oxidation of the oil may be detected by an unusual rise in viscosity within the recommended oil drain periods. The viscosity limits are directly related to the type of oil being used and the type of viscosity measurements being made. The oil suppliers will furnish these values, which should correspond to a maximum of 5% fuel dilution and a 35% viscosity rise.

Operating an engine with badly oxidized oil or poor oil filtration will result in oil cooler core plugging, carbon buildup on piston undercrowns, ring grooves, oil rings, and piston pin bearing grooves. and limitation of oil flow to the main and connecting rod bearings with subsequent engine damage.

To provide protection to the engine, the oil and system components should be carefully observed for proper functioning and corrective measures taken where necessary. Oil and filter change periods should be followed closely since the oil is not only oxidizing, but contaminants are corning into the engine from fuel combustion, as well as the normal air-borne contaminants which are not caught by the air filters. It is therefore beneficial to drain the oil and eliminate these contaminants as specified in the Scheduled Maintenance Program.

CHANGING OIL

Engine lube oil should be drained. filters replaced. and strainers and screens cleaned at intervals outlined in the Scheduled Maintenance Program. Before the oil is drained, its viscosity should be checked for any indication of fuel dilution. If fuel leakage is indicated, the leak should be corrected before charging the engine with new oil.

GENERAL PROCEDURE

1. Shut down the engine.
2. Open drain valve in the oil strainer housing to drain oil into the engine oil pan sump.
3. Provide a container or oil runoff line for drained oil.
4. Remove pipe plug from oil drain valve and open valve to drain all the oil from the engine oil pan sump.
5. Remove pump strainers from strainer housing, and remove the oil filters from the filter housing.
6. Clean the strainers using a suitable cleaner, and rinse thoroughly.
7. Wash down top deck, oil pan, and filter housings using fuel oil or kerosene. Drain off cleaning fluid and wipe areas free of excess fluid. using bound edge absorbent towels.
8. Replace pipe plugs in drain lines, where required, and close valve. Where necessary, renew gaskets.
9. Install clean strainers and screens. Install new elements in filter containers. Prepare system to receive new oil.

10. Recharge engine with new lubricating oil qualified for use. Add oil through square filler opening in strainer housing.

CAUTION: Ensure that strainer housing internal drain valves are closed and oil strainer is filled to overflow before starting engine.

Sufficient oil will be retained in the housing to supply main lube and piston cooling oil pumps on starting. Engine oil level is shown on the oil gauge. Pour a liberal quantity of oil over cylinder heads and top deck components before starting.

11. Inspect engine prior to starting, then start engine. Check oil level with engine at idle speed. If oil level is not to "full" mark on gauge, add oil to bring level to "full" mark, with engine at idle speed and with hot oil.

NOTE: Under some conditions the oil level may be above the bottom of the oil pan handles so care must be taken when the oil pan handhole covers are removed.

OIL STRAINER HOUSING

DESCRIPTION

The oil strainer housing. Fig. 9-6, is a large box-shaped cast aluminum housing which is mounted on the right front side of the engine on the accessory drive cover. It contains independent strainers for the main oil pump supply and scavenging oil pump. There are two strainers for the main lube pump oil and one strainer screen for scavenging pump oil. with a separate oil inlet and discharge for each of the systems.

The two main lube oil pump strainers. Fig. 9-7, each consists of a replaceable element of a pleated perforated metal core covered with mesh screening, and a metal cylinder which encloses the element. The cylinder prevents collapse of the element in the event of a high pressure drop. The element is attached to the cylinder by a through bolt in the cylinder which runs through the base of the element and is secured with a locknut. The unperforated outer cylinder provides a constant head of oil since suction is from the bottom only and not through the entire length of the screen.

The flow of oil is from the bottom of the strainer between the cylinder and the mesh screen, through the mesh screen and the perforated metal core into the center of the element, then out the top of the strainer.

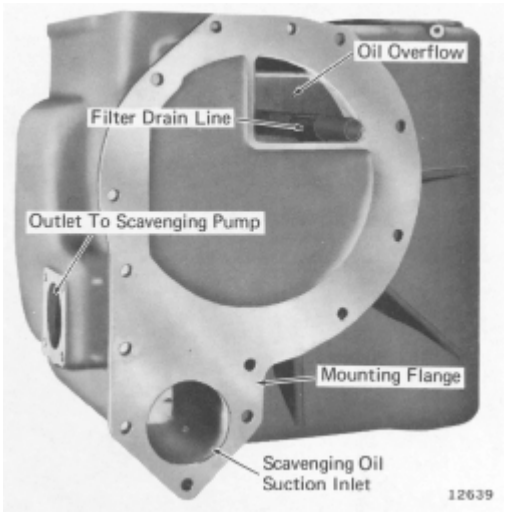


Fig. 9-6 - Oil Strainer Housing

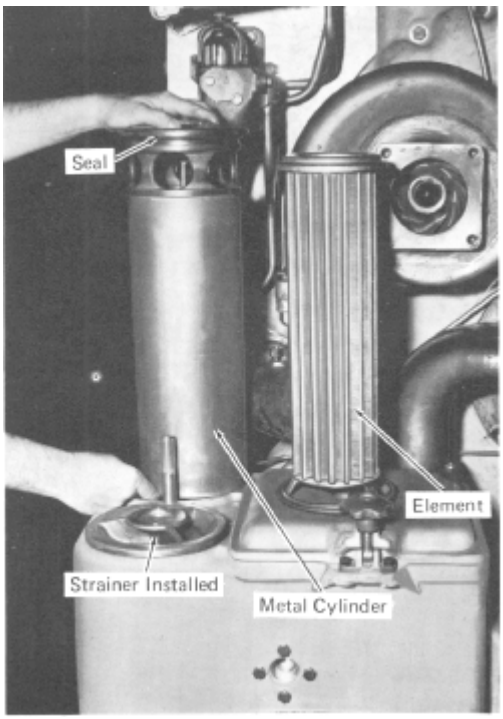


Fig. 9-7 - Main And Piston Cooling Oil Pump Strainers

When in place, they are held by a crab and handwheel on the stud between the holes. Each strainer is sealed at the top by a seal ring. Also, oil under pump pressure is admitted to a groove around each strainer, just below the seal, to prevent air

entry in event of a leaky seal. A partition adjacent to the strainers, open at the bottom, separates them from the oil inlet area of the housing. Oil enters the strainers at the partition bottom and is taken up by thy pump through a cast passage in the housing.

The scavenging oil pump strainer, Fig. 9-8, has a rigid perforated metal screen which retains its shape and is easily cleaned. When the strainer is installed in the housing, it is held in position with three nuts. Two handwheels on swivel bolts secure a cover over the strainer and drain valves. The scavenging oil strainer inlet and outlet openings are shown in Fig. 9-6.

An oil level is maintained in the strainer housing up to the bottom of the overflow opening, Fig. 9-6. Excess oil returns to the oil pan sump. A spring-loaded valve, Fig. 9-9, is provided to drain the oil from the strainer housing into the oil pan sump, at the time of an oil change. An additional valve, Fig. 9-9, is used to drain the oil filter housing. Both valves are located under the filler cover and must be kept closed at all times except for the period of draining.

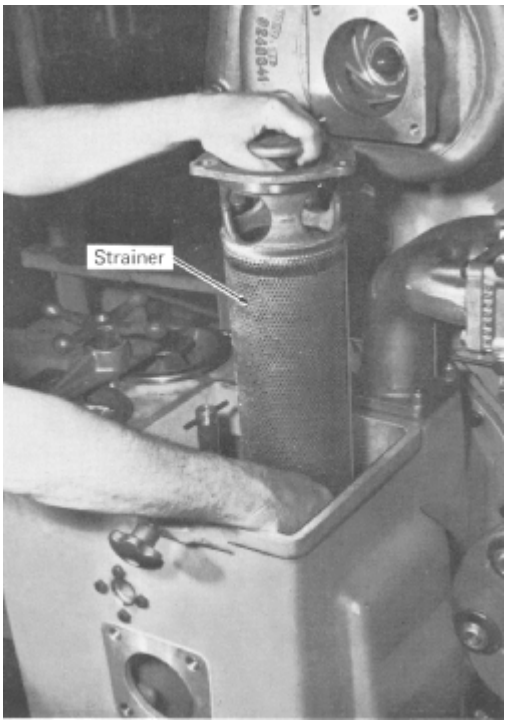


Fig. 9-8 - Scavenging Oil Pump Strainer

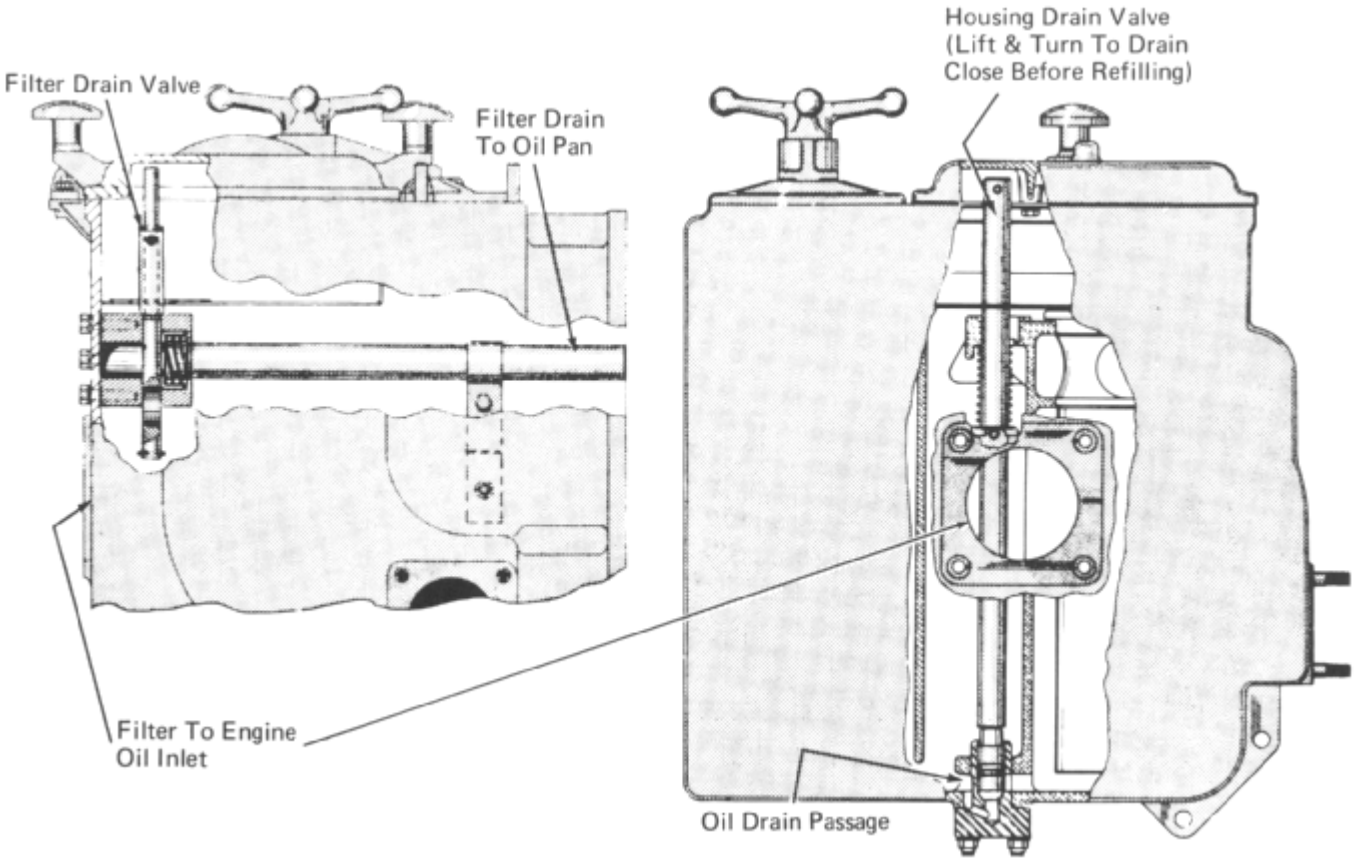


Fig. 9-9 - Strainer Housing Drain Valves

MAINTENANCE

Lube oil strainers should be removed at each oil change and strainers and housing thoroughly cleaned, using a petroleum solvent.

As previously described, the engine lube oil strainers have a seal of oil under pressure in addition to the seal rings. The oil under pressure will leak out under the strainer flanges if the seal rings are not seated properly or are damaged. When strainers are replaced, care should be taken to see that the sealing surfaces are free from nicks and scratches and seal rings are in good condition. Also, that the oil passages to the seals are open and clear.

The pressure oil seal may be checked, with the engine at idle speed, by loosening the large handwheel until the seal ring of the furthest strainer from the engine is free of the housing. Oil should leak out around the strainer flange. If no oil appears, the engine should be shut down and the oil supply passages inspected and cleaned. Any air which might enter system at this location will be discharged with the lubricating oil and may cause damage, even though normal oil pressure is indicated.

When replacing the scavenging strainer, be sure the strainer is seated properly or the scavenging pump will lose suction causing a loss of lube oil pressure.

LUBE OIL SEPARATOR

DESCRIPTION

The oil separator is an elbow-shaped cylindrical housing containing a wire mesh screen element. It is mounted on the turbocharger housing. An elbow assembly connects the oil separator to the eductor tube assembly in the exhaust stack, Fig. 9-10. The exhaust gases in the stack create a suction in the eductor tube, which draws up oily vapors from the engine through the separator element. The oil collects on the element and drains back into the engine. The gaseous vapors going through the element are discharged into the exhaust stack and vented to atmosphere.

MAINTENANCE

The screen should be removed from the oil separator and cleaned at intervals specified in the Scheduled Maintenance Program.

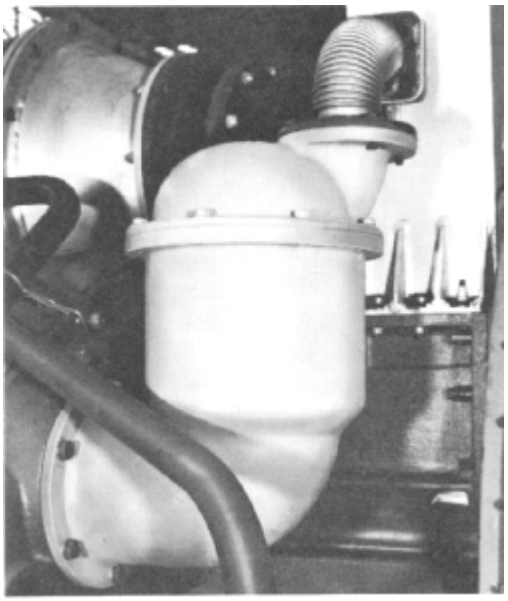


Fig. 9-10 - Lube Oil Separator

1. Shut down the engine.
2. Remove bolts from the separator cover.
3. Disconnect the flexible exhaust tube assembly from the eductor tubes and remove the housing cover and exhaust tube elbow as an assembly.
4. Remove eductor assembly tubes from stack.
5. Separate inner eductor tube from outer tube by inserting screwdriver at the top of the eductor flanges.
6. Clean carbon deposits from inside and outside of both eductor tubes.
7. Remove screen clement from separator cover and wash in petroleum solvent. Rinse clement in hot water and blow dry with compressed air.
8. Insert inner tube into outer tube with hole in inner tube flange aligned with pin in outer tube flange.
9. Place eductor assembly into stack with the word TOP, stamped on the inner tube flange, facing upward.
10. Install screen element into cover and mount cover to separator with mounting bolt.
11. Attach exhaust elbow and eductor assembly to exhaust stack with four mounting bolts.

MAIN LUBE OIL AND PISTON COOLING OIL PUMPS

DESCRIPTION

The main lube oil and piston cooling oil pumps, Fig. 9-11, are contained in one housing. The two pumps are separated by a spacer plate between the sections of the pump body. Each has its individual oil inlet and discharge opening. The piston cooling pump gears at the end are narrower than the lube oil pump gears. The lube oil and piston cooling oil pump assembly is mounted in the center of the accessory drive housing and is driven by the accessory drive gear.

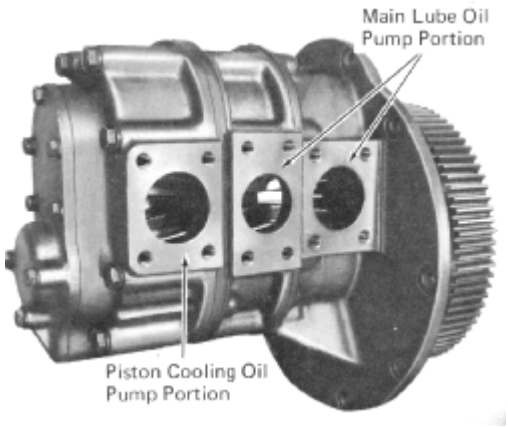


Fig. 9-11 - Main Lube Oil And Piston Cooling Oil Pumps (16-Cyl.)

MAINTENANCE

NOTE: In the following "Disassembly" and "Assembly" procedures, disregard references to "center body" for 8 and 12cylinder engines. Also disregard "center gear" for 8 and 12-cylinder engines.

DISASSEMBLY

1. CIean the pump externally before disassembly.
2. Hold the pump in a suitable vise.

   As a safety precaution, provide an additional support at the center of the pump until the front body and bushing and piston cooling pump gears are removed.
3. Remove the long bolts holding the front body to the center body, Fig. 9-12

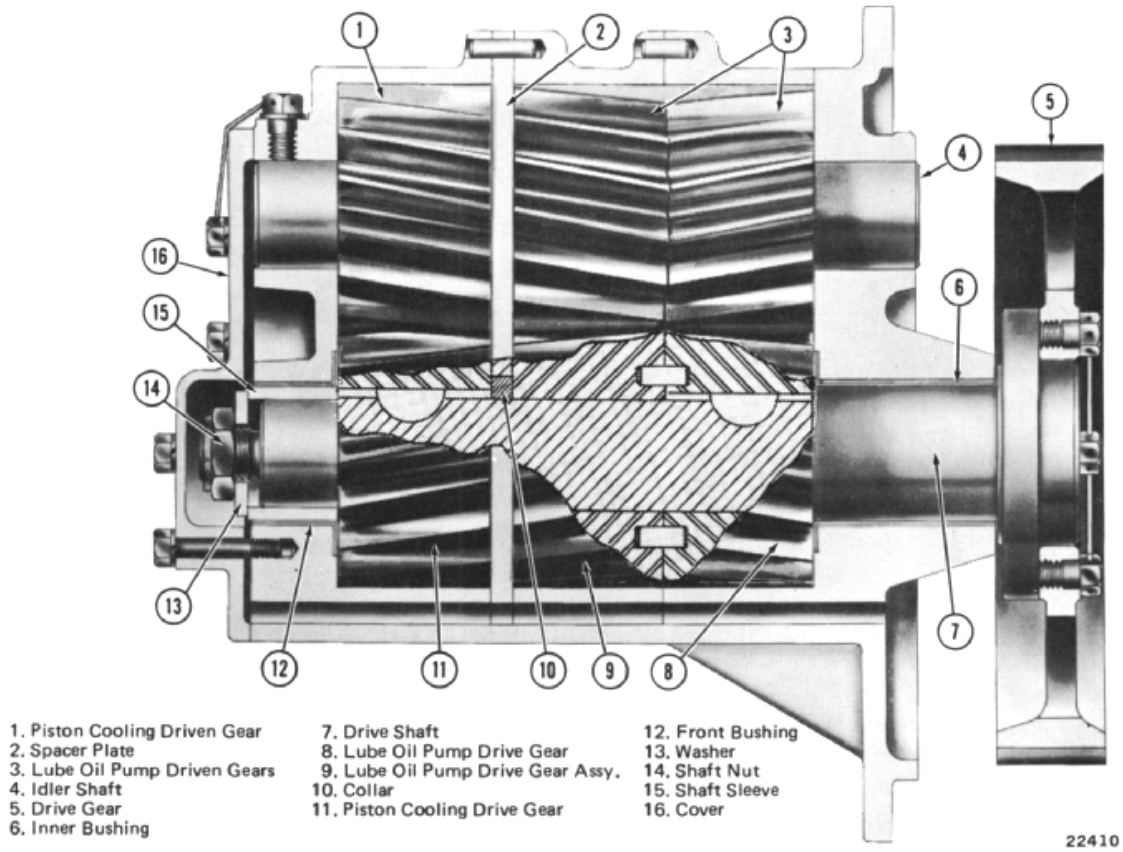


Fig. 9-12 - Main Lube Oil And Piston Cooling Oil Pumps, Cross-Section (16 Cyl.)

4. Using a rawhide mallet, tap the front body at the inlet and outlet openings, to remove -the front body, cover, idler shaft, and outer driven gear as an assembly.

5. Remove the drive shaft nut, and washer.

6. Support pump on its flange, pump drive gear down, so that gear is free to move downward. 7. Apply pressure to shoulder of drive shaft and press the shaft down a maximum of 12.70 mm (1/2").

CAUTION: If shaft is pressed down too far, the piston cooling pump gear key will shear the collar in the spacer plate.

8. Manually raise pump drive gear and drive shaft until a 12.70 mm (1/2") clearance is obtained between the drive shaft sleeve and the piston cooling pump drive gear.

9. Attach a puller to the drive shaft sleeve and remove sleeve from the drive shaft.

10. Remove the piston cooling pump drive gear and its key.

11. Remove the spacer plate and collar.

12. Remove the tube oil pump center driven gear and drive gear assembly.

13. Using a rawhide mallet, remove the center body portion of the pump.

14. Remove the tube oil pump inner driven gear, drive gear, and key.

15. The pump drive gear and shaft assembly is then removed.

16. Keep all parts of the one pump assembly together.

CLEANING

Clean all the individual parts of the pump using a petroleum solvent. After cleaning, dry the parts with compressed air.

INSPECTION PUMP BODIES

1. Check the surface of the pump bodies for nicks, dents or scratches which may have protrusions above the normal surface. Smooth down any evidence of roughness.

2. Inspect the drive shaft bushings for imbedded dirt, metallic particles, flaking and pitting. Bushings with light scratches and small quantities of imbedded dirt may be reused after smoothing up, provided bore sizes are within the maximum limits.

3. Replace the bushings if any other adverse conditions exist. Details of construction and application of bushing installation and removal tools are shown in Fig. 9-13.

4. Using fine abrasive cloth on a smooth surfaced tool, clean off the gasket face of the pump bodies.

SPACER

Inspect the sides of the spacer for smoothness. If necessary, smooth the sides using fine abrasive cloth held flat on a flat surfaced tool.

GEARS

l. Inspect the gear teeth for nicks, pitting, and excessive wear. Light nicks are permissible provided they are blended by filing and stoning.

2. Gears having tooth faces pitted in excess of 30% of tooth contact area should not be reused.

3. Inspect the driven gear bushing inside diameter for wear and possible damage.

4. Driven gear bushing installation and removal tool construction and application is shown in Fig. 9-14.

5. Inspect the keyways in the drive gears for any damage which would interfere with the key application.

6. The drive shaft gear may be magnaflux inspected.

DRIVE SHAFT, KEYS, AND IDLER SHAFT

1. Inspect the shafts for any roughness. Check the drive shaft keyways and key fit. making sure the keys fit snugly in the shaft.

2. Check the drive shaft diameter to determine whether the drive shaft to body bushing clearance is within maximum limits.

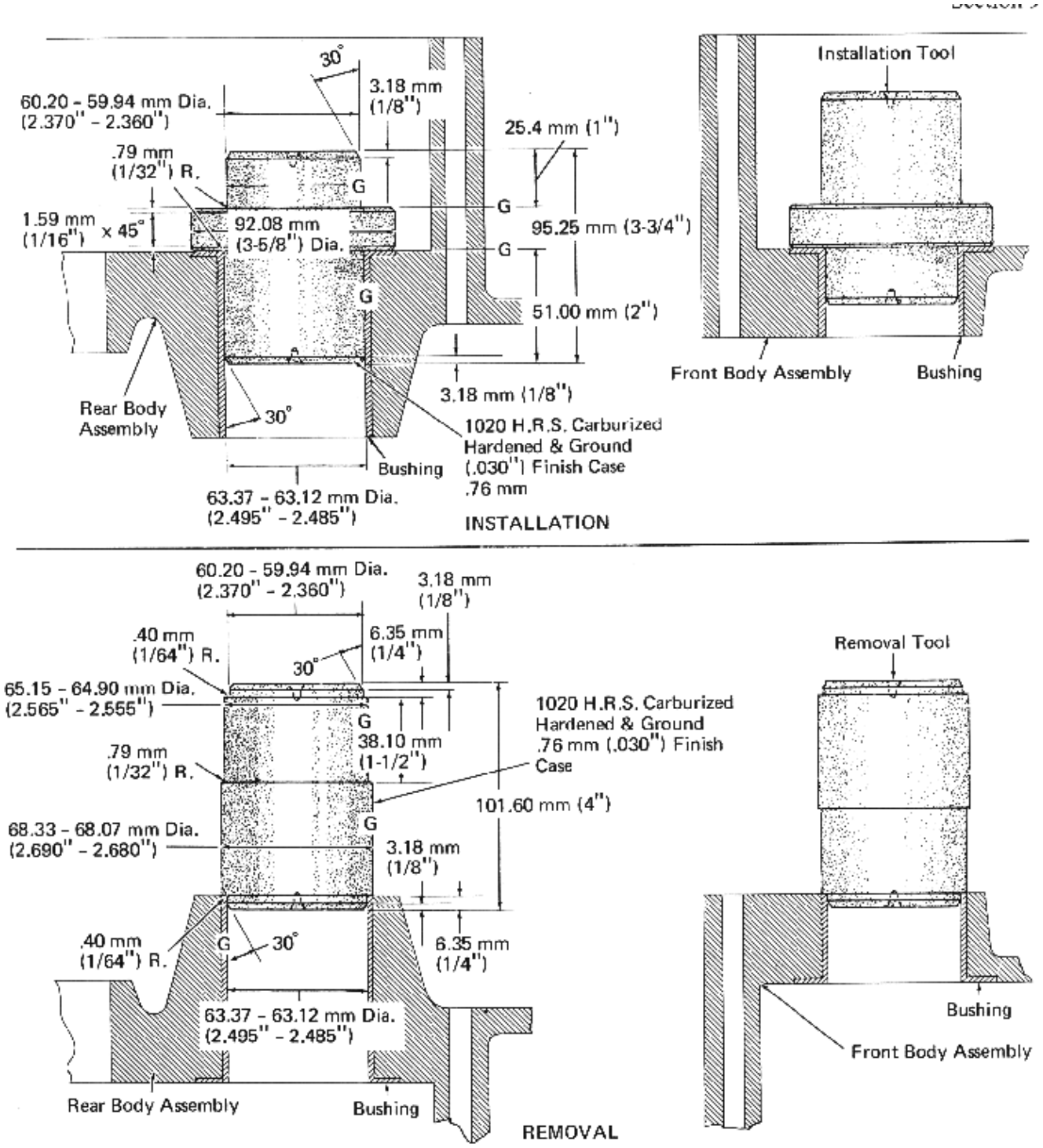


Fig. 9-13 - Oil Pump Body Bushing Tools

3. Also check the idler shaft to make certain that the shaft to bushing clearance is within maximum limits.

ASSEMBLY

1. Place the mounting flange of the cleaned and inspected rear body, Fig. 9-12, in the bench vise with the drive shaft bore facing up.

2. With the pump drive gear applied to the drive shaft, lightly oil the shaft journal and insert the shaft in the rear body bushing.

3. Place the inner drive gear key in the drive shaft and install the inner drive gear on the shaft with the dowel holes in the gear facing toward the front of the pump.

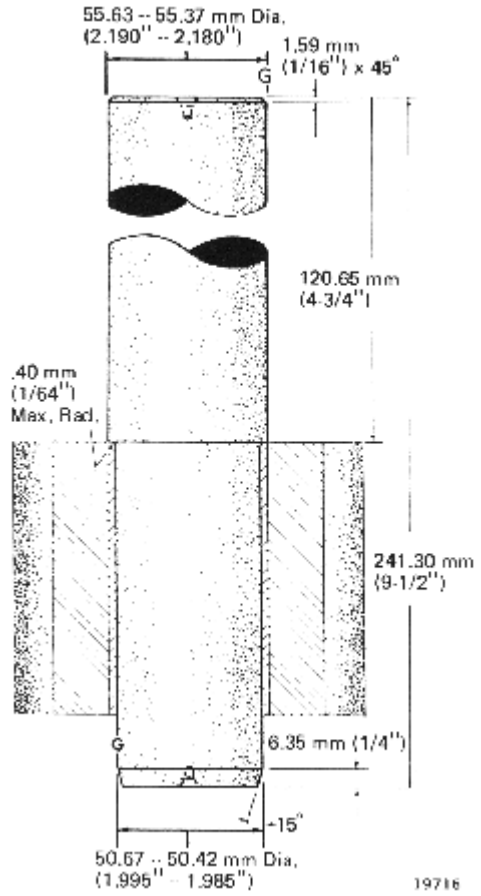


Fig. 9-14 - Oil Pump Driven Gear Bushing Tool

CAUTION: Refer to Service Data for diagram of helix angle position of abutting gears.

4. After oiling the bushing, apply the mating driven gear, meshing it with the drive gear.

5. Oil the pump rear body to center body gasket and apply it to the gasket face of the rear body, being careful to align the bolt and dowel holes.

6. Apply the center body to the rear body.

7. Apply center drive gear assembly to drive shaft with dowels aligned with holes in rear drive gear. Slide center gear toward rear of pump until dowels and dowel holes are fully mated.

8. Install center driven gear to mate with center drive gear assembly.

9. Oil the body gasket and apply to the center body.

10. Apply the spacer plate to the center body and the collar to the drive shaft.

11. Install the piston cooling drive gear key in the drive shaft and apply the drive gear.

NOTE: The use of the cleaner activator and retaining compound, as described in the following Steps, does not apply to 8 and 12-cylinder engines.

12. Make sure that sleeve and drive shaft are free of dirt, oil, and grease. Spray cleaner activator on the I.D. of the sleeve and the O.D. of the shaft, and wipe off.

13. Respray sleeve and shaft and allow to dry for about 10 minutes. Do not wipe off.

14. Coat entire surface of shaft, which is covered by the sleeve, by applying retaining compound in small amounts.

15. Apply sleeve and wipe off excess compound at each end of sleeve. Apply heavy duty washer and nut. Tighten nut to 441-475 N·m (325-350 ft-lbs) torque.

NOTE: Retaining compound sets quickly so that delay in torquing nut could result in improper clamping of gears.

16. Check that all excess compound is removed before proceeding with assembly.

17. Oil the spacer plate gasket and apply to the spacer.

18. Completely coat the bushing in the front body with oil.

19. Apply the piston cooling pump driven gear to the idler shaft which was left assembled to the front pump body and cover, and apply this assembly to the pump. If the front body, cover, and idler shaft were disassembled, apply these parts individually using a new oiled gasket between the cover and the front body.

20. Complete assembly of the pump by installing the long bolts through the cover. Tighten securely.

21. If possible, allow pump to remain unused for approximately 24 hours after torquing to ensure sleeve to shaft retention.

ASSEMBLY INSPECTION

1. After pump assembly, rotate the pump drive gear to check for gear noise or tight assembly.

2. Check the thrust of the drive gears. This may be done by securing an indicator on the pump flange with the indicator button contacting the rim of the pump drive gear, Fig. 9-15. Push the drive gear inward so that all clearance is located at one end, then set the indicator to zero. Pull the drive gear outward to determine the amount of thrust clearance.

3.

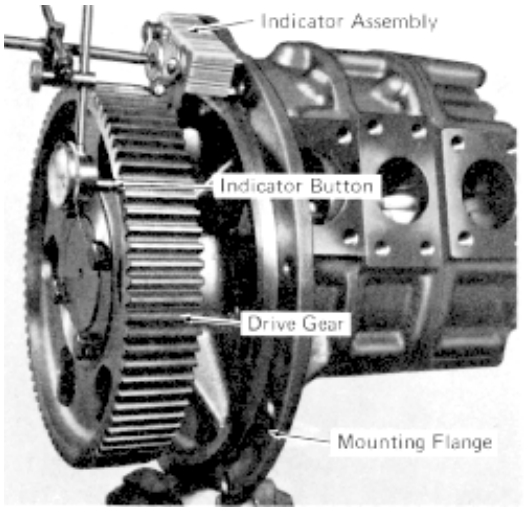


Fig. 9-15 - Checking Pump Drive Gear End Thrust

3. Leaving the indicator button on the outside of the pump drive gear rim, rotate the drive gear to check the gear runout. Drive gear runout should not exceed specified total indicator reading, with thrust in one direction.

4. Check the pump flange runout. Mount the indicator clamp on the drive gear and place the indicator button to contact the pump flange. Set the indicator to zero, and with the thrust held in one direction, rotate the drive gear. The runout of the pump flange face should not exceed specified total indicator reading.

5. Check the pump gears to body radial clearance. Clearance should be within the specified limits.

6. Additional clearances and limits are listed in the "Service Data" at the end of the section. Some of these clearances must be obtained by comparing the individual mating parts, or by assembly and disassembly using lead wire or other suitable means to obtain the part to part clearance.

7. After pump inspection, seal off the pump body openings, and provide protection for the teeth of the pump drive gears.

SCAVENGING OIL PUMP

DESCRIPTION

The scavenging oil pump, Fig. 9-16, is a positive displacement, helical gear type pump. The pump body, split transversely for ease of maintenance, contains sets of mated pumping gears. The driving gears are retained on the pump drive gear shaft by keys. The idler shaft is held stationary in the housing by a set screw, and the driven pump gears rotate on this shaft on bushings pressed into the gear bores. The drive shaft turns in bushings pressed into the pump body. These bushings are made with thrust collars which protrude slightly above the pump body and absorb the thrust of the drive gears. The scavenging pump is mounted on the accessory housing in line with and to the left of the crankshaft, and is driven by the accessory drive gear.

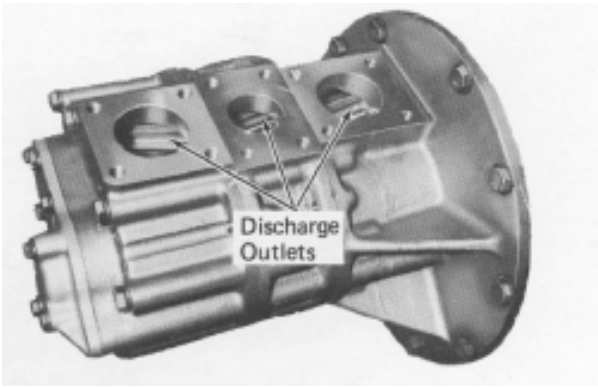


Fig. 9-16 - Scavenging Oil Pump (16 & 20-Cyl.)

MAINTENANCE

NOTE: In the following "Disassembly" and "Assembly" procedure, disregard references to "center body" for 8 and 12-cylinder engines. Also disregard "center gear" for 8 and 12-cylinder engines.

Construction and maintenance of the scavenging oil pump is similar to the main lube oil and piston cooling oil pump, except for the use of the spacer in the main lube oil pump.

DISASSEMBLY

1. Clean the external surfaces of the pump before disassembly.

2. Hold the pump in a suitable vise. As a safety precaution, provide additional support until the rear body is removed.

3. Remove the long bolts holding the pump bodies together.

4. Using a rawhide mallet, tap the front body at the oil inlet and outlet openings to remove the front body, idler shaft, and cover as an assembly.

5. Remove the drive shaft nut, washer, and sleeve from the drive shaft.

6. Remove the outer drive gear, key and driven gear.

7. Remove the center body.

8. Remove the center drive gear, key, and the mating driven gear.

9. Remove the rear drive gear, key, and driven gear.

10. Remove the pump drive gear and shaft as an assembly from the rear pump body.

11. Keep all parts of the same pump together.

CLEANING

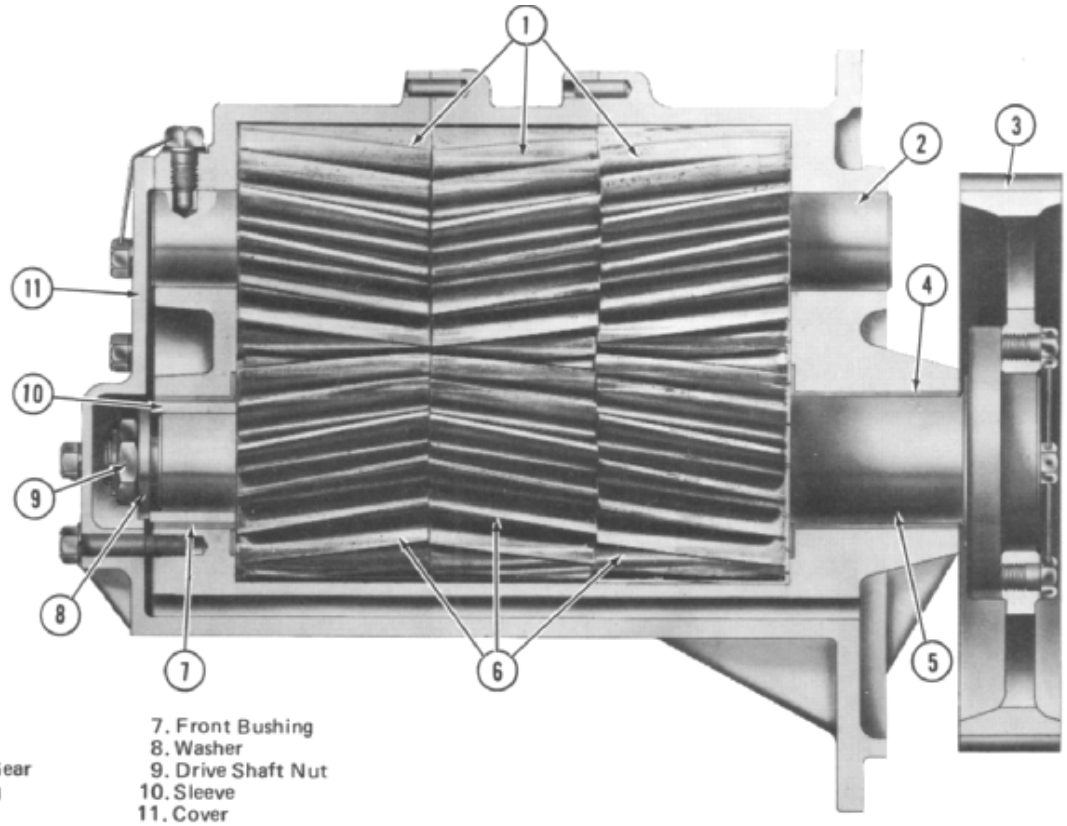
Clean all the individual parts of the pump using a petroleum solvent and rinse in hot water. Dry the parts, using compressed air.

INSPECTION

Refer to the corresponding procedures in the preceding "Main Lube Oil And Piston Cooling Oil Pumps" coverage. Also, refer to "Service Data" at the end of the section.

ASSEMBLY

1. Place the cleaned and inspected rear body, Fig. 9-17, in the vise with the drive shaft bore facing up.



1. Driven Gears
2. Idler Shaft
3. Pump Drive Gear
4. Inner Bushing
5. Drive Shaft
6. Drive Gears
7. Front Bushing
8. Washer
9. Drive Shaft Nut
10. Sleeve
11. Cover

Fig. 9-17 - Scavenging Oil Pump, Cross-Section (16 & 20-Cyl.)

2. Oil the drive shaft journal sparingly, and apply the pump drive gear and shaft as an assembly to the rear body.

3. Apply the drive gear key to the drive shaft and apply the inner drive gear. Apply the mating driven gear.

CAUTION: Refer to Service Data for diagram of helix angle position of abutting gears.

4. Fit the center drive gear key to the shaft.

5. Oil the body gasket and apply it to the rear body.

6. Apply the center body to the rear body.

7. Install the center drive gear to the drive shaft.

8. Place the center driven gear in the body in mesh with drive gear.

9. Apply an oiled gasket to the face of the center body.

10. Apply the outer drive gear key to the drive shaft and install the outer drive gear.

11. Apply the sleeve, heavy duty washer, and drive shaft nut to the shaft. Tighten nut to 441-475 N-m (325-350 ft-lbs).

12. Since the front body, idler shaft, and cover were left as an assembly, these parts may be applied to the pump together. Apply the outer driven gear to the idler shaft and apply this assembly to the pump.

13. Install the long bolts through the cover and tighten securely.

ASSEMBLY INSPECTION

1. After pump assembly, rotate the pump drive gear to check for gear noise or tight assembly.

2. Check the thrust of the pump drive gears. This is done using the same indicator arrangement shown in Fig. 9-15 for the main lube oil pump. Attach the indicator holder to the pump flange with the indicator button contacting the rim of the pump drive gear. Push the drive gear inward to take up all thrust in one direction. Set the indicator button to zero and pull the drive gear outward to determine clearance. Thrust clearance using new parts should be within the specified limits.

3. With the indicator button on the outside of the pump drive gear rim, as when checking thrust clearance, rotate the gear with the thrust held in one direction to check drive gear runout. Drive gear runout should not exceed specified total indicator reading.

4. Check the pump flange runout. Mount the indicator clamp on the drive gear and place the indicator button to contact the pump flange. Set the indicator to zero, and with the thrust held in one direction, rotate the drive gear. The runout of the pump flange face should not exceed specified total indicator reading.

5. Check the pump gears to body radial clearance. Clearance should be within the specified limits.

6. Additional clearances and limits are listed in the "Service Data" at the end of the section. Some of the clearances must be obtained by comparing the individual mating parts, or by assembly and disassembly using lead wire or other suitable means to obtain the part to part clearance.

7. After pump inspection, seal off the pump body openings and provide protection for the drive gear teeth.

TURBOCHARGER OIL FILTER

DESCRIPTION

The turbocharger oil filter, Fig. 9-18, provides additional protection for the high speed bearings and other lubricated areas of the turbocharger, by filtering the oil just before it is admitted to the turbocharger. Oil enters the filter through a cast manifold and, after passing through the filter, returns to the upper idler gear stubshaft and into the turbocharger. The filter element is of pleated paper construction, and is disposable. The filter is mounted on the camshaft drive housing at the right bank of the engine.

The filter head contains two check valves, Fig. 9-18. one to prevent lube oil from the soak back system from going into the turbocharger filter during soak back pump operation and the other to prevent lube oil from the turbocharger filter from entering the soak back system when the engine is running.

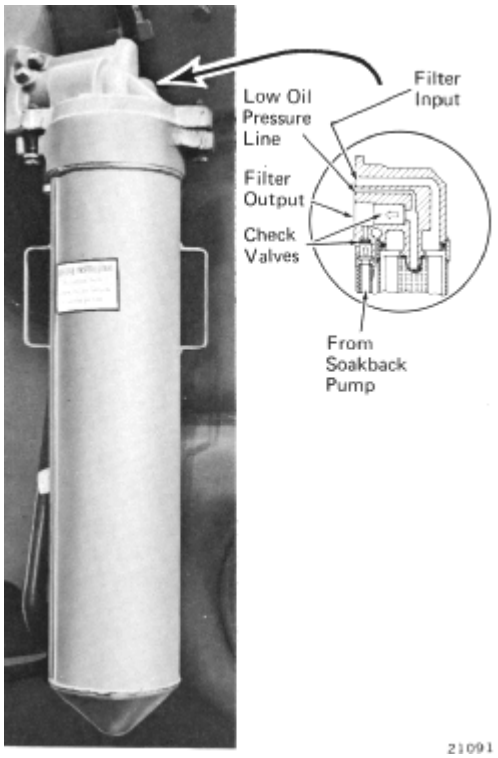


Fig. 9-18 - Turbocharger Oil Filter

MAINTENANCE

The turbocharger filter should be serviced at intervals as specified in the Scheduled Maintenance Program or more frequently if experience indicates it is necessary.

To remove turbocharger filter assembly, loosen the two nuts holding the container to the upper housing until. using the handles on each side of the container, the container can be rotated to disengage from the upper housing. Remove the paper element and dispose of it. Thoroughly clean the container, install a new element, check the seal and replace, it' required. Fill the container with clean oil and reassemble to the upper housing. Do not overtighten attaching bolts as the seal may be damaged.

NOTE: Whenever oil is detected coming from the camshaft bearings with the engine shut down and the soak back pump running. the turbo filter outlet check valve should be inspected.

SOAK BACK OIL SYSTEM

DESCRIPTION

To ensure lubrication of the turbocharger bearings prior to engine start. and the removal of residual heat from the turbo after engine shutdown, a separate lube oil pressure source is provided. This pressure source is controlled automatically through the engine "start" and "stop" controls.

An electrically driven pump drawing lube oil from the oil pan, pumps the oil through a soak back filter, Fig. 9-19, and the head of the turbocharger oil filter directly into the turbocharger bearing area, Fig. 9-1. The motor driven pump and filter are mounted on the side of the oil pan, Fig. 9-19.

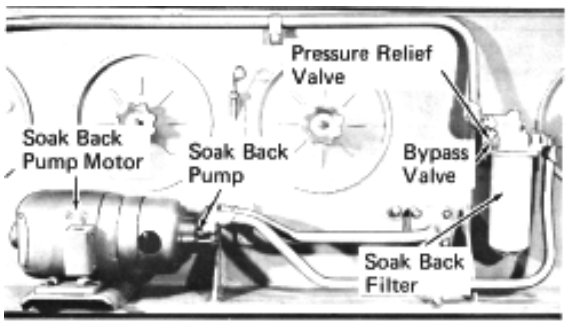


Fig. 9-19 - Soak Back Oil Motor, Pump, And Filter Installation

CAUTION: If the soak back pump should fail to operate when the engine is shut down. restart the engine immediately and allow it to run for 15 minutes at idle speed with no load, to prevent damage to the turbocharger.

If engine is not restarted within two minutes of shutdown, do not restart the engine until soak back pump operation is restored and the engine has been allowed to cool down.

A pressure relief valve, Fig. 9-19, set at 379 kPa (55 psi), is located in the head of the filter. When the engine starts, and the motor driven pump is still running, main lube oil pressure from the engine driven pump becomes greater than the motor driven pump pressure. As there is no outlet for the lower pressure oil. the relief valve will open when the

pressure builds up to 379 kPa (55 psi), and the oil will return to the oil pan through a passage in the filter head mounting flange. Also located in the filter head is a bypass valve, Fig. 9-19, set at 483 kPa (70 psi). This valve will open to permit motor driven pump pressure to bypass a plugged filter element so that lubrication can be supplied to the turbocharger to prevent turbo damage.

MAINTENANCE

The oil filter element should be serviced at the intervals as specified in the applicable Scheduled Maintenance Program, or more frequently if experience indicates it is necessary.

To remove the element from the filter, Fig. 9-19, remove the two bolts from the top of the head and remove the bowl, element and spring from the upper housing.

PRELUBRICATION OF ENGINES

Prelubrication of a new engine, an engine that has been overhauled, or an engine which has been inoperative for more than 48 hours is a necessary and important practice. Prelubrication alleviates loading of unlubricated engine parts during the interval when the lube oil pump is filling the passages with oil. It also offers protection by giving visual evidence that oil distribution in the engine is satisfactory.
Perform prelubrication as follows:

1. Remove the pipe plug at the main lube oil pump discharge elbow, and connect an external source of clean, warm oil at the discharge elbow. Prelube engine at a minimum of 69 kPa (10 psi) for a period of not less than three and not more than five minutes (approximately 57 lpm [15 gpm] using a 1.1 to 1.5 kW [1-1/2 to 2 hp] motor).

2. While oil pressure is being applied, open the cylinder test valves and bar the engine over one complete revolution. Check all bearings at the crankshaft, camshafts, rocker arms, and at the rear gear train for oil flow. Also check for restrictions and excessive oil flow. If fluid discharge is observed from any cylinder test valve, find the cause and make the necessary repairs.

3. On new or overhauled engines remove the pipe plug at the piston cooling oil pump discharge elbow and connect the external oil source at that opening. Check for unrestricted oil flow at each piston cooling tube.
4. Disconnect the external oil source and replace the pipe plugs at the pump discharge elbows. Close the cylinder test valves.

5. Pour a liberal quantity of oil over the cylinder mechanism of each bank.

6. Check oil level in strainer housing and, if required, add oil to strainer housing until it overflows into the oil pan.

7. Replace and securely close all handhole covers and engine top deck covers.

NOTE: When an engine is replaced due to mechanical breakdown, it is important that the entire oil system, such as oil coolers, filters, and strainers, be thoroughly cleaned before a replacement engine or the reconditioned engine is put in service. A recurrence of trouble may be experienced in the clean engine, if other system components have been neglected.

In some cases engines have been removed from service and stored in the "as is" condition by draining the oil and applying anti-rust compound. When these engines are returned to service, care must be taken to see that any loose deposits are flushed out before adding a new oil charge. The entire engine should be sprayed with fuel, to break up any sludge deposits, and then drained, being careful that the drains are not plugged. Fuel should not be sprayed directly on the valve mechanism or bearings, as lubrication will be removed or dirt forced into these areas. The surfaces should then be wiped dry before new oil is added to the engine.

OIL SYSTEM INFORMATION

Additional information on the oil system and components is given in the latest revisions of Maintenance Instruction bulletins. These instructions cover important items such as the Scheduled Maintenance Program, which outlines maintenance intervals, and flushing and cleaning information.

Engine lubricating oil should be qualified for use.

SERVICE DATA
LUBRICATING OIL SYSTEM

SPECIFICATIONS

Clearance and dimensional limits listed below are defined as follows:

1. New limits are those to which new parts are manufactured. (Drawing tolerances.)

2. Minimum, maximum, and tolerance measurements are provided as service limits. At time of rebuild or any time unscheduled maintenance is performed, the service limits should not be exceeded. Engine components within these limits may be reused with the assurance that they will perform satisfactorily until the next scheduled overhaul.

Lube Oil Pressure Relief Valve

Valve guide inside diameter - Max.	12.764 mm (.5025")
Valve stem outside diameter - Min.	12.484 mm (.4915")
Valve face to stem squareness (outer edge of valve face) - T.I.R. Max.	0.05 mm (.002")

Oil Pumps

Drive shaft to rear housing bushing clearance -	
New	0.038-0.114 mm (.0015"-.0045")
Max.	0.18 mm (.007")
Sleeve to bushing clearance -	
New	0.038-0.127 mm (.0015"-.0050")
Max.	0.18 mm (.007")
Idler shaft to gear bushing clearance -	
New	0.038-0.130 mm (.0015"-.0051")
Max.	0.18 mm (.007")
Driven gears - total thrust clearance -	
New	0.41-0.61 mm (.016"-.024")
Max.	0.61 mm (.024")
Thrust face of bushing to body clearance (front and rear) -	
New	0.02-0.18 mm (.001 "-.007")
Min.	0.000 mm (.000")
Drive and driven gear backlash -	
New	0.30-0.41 mm (.012"-.016")
Max.	0.76 mm (.030")
Radial clearance of drive and driven gear to body -	
Min.	0.038 mm (.0015")
Max.	0.25 mm (.010")
*Drive shaft thrust clearance (pump assembled)	0.20-0.56 mm (.008"-.022")
**Drive shaft thrust clearance (pump assembled).	0.13-0.56 mm (.005"-.022")
Pump drive gear face runout - T.I.R. Limit	0.08 mm (.003")
Pump flange face runout - T.I.R. Limit	0.13 mm (.005")
Pump flange pilot concentricity - T.I.R. Limit	0.05 mm (.002")

Pump drive gear to accessory drive gear backlash

New	0.20-0.41 mm (.008"-.016")
Max.	0.64 mm (.025")

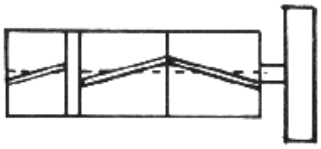
NOTE: *Scavenging pump only

**Lube and piston cooling pump only

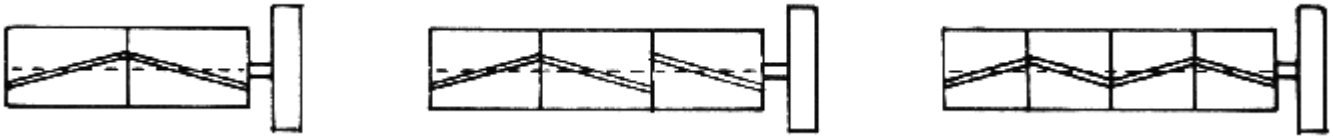
Pump/motor assembly

Parallel coupling alignment - Max.	0.38 mm (.015")
Axial clearance between jaw and spider - Min.	0.76 mm (.030')

HELIX ANGLE POSITION OF OIL PUMP GEARS



MAIN LUBE OIL AND PISTON COOLING PUMPS



SCAVENGING OIL PUMPS

EQUIPMENT LIST

	Part No.
Gauge - piston cooling oil pipe alignment	8071720
Cleaner - piston cooling oil pipe	8087086
Spray gun	8193041
Cleaner activator (170 grams [6 oz]).	8352873
Retaining compound (50 cc)	8366781

Mich. Oil Filter should be changed with 25 psi or above.

LUBE OIL SYSTEM ——TURBOCHARGED ENGINES