MODEL 567D3A

ENGINE MAINTENANCE MANUAL

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ENGINE MAINTENANCE MANUAL

for 567D3A ENGINES (Turbocharged)

SERVICE DEPARTMENT
ELECTRO-MOTIVE DIVISION
GENERAL MOTORS CORPORATION
LA GRANGE, ILLINOIS, U.S.A.

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FOREWORD

This manual covers the 16-cylinder Model 567D3A engine and attached accessories. Minor differences between engines and the manual may be encountered, due to slight refinements in specifications after the manual was sent to press. However, we feel it impractical to make revisions to manuals already distributed, except when changes to current production engines are recommended for engines in service.

Each section of the manual contains the Description, Maintenance, and Service Data as applicable to the engine components covered in the specific section.

Service Data, consisting of the specifications regarding clearance and dimensional limits and a list of the service equipment required, is presented only at the end of each section. The concentration of this information will facilitate maintaining and servicing the engine. In addition, it will provide an expeditious means of revising the manual when only specifications are changed.

Wear limits are often given as diametric clearance. This means the total clearance on the diameter. Most diametric clearances can be measured by placing a feeler gauge on only one side of the object being checked. Other items may have to be checked by measuring the outside diameter of the shaft, using a micrometer, and subtracting this figure from the inside diameter of the bearing in which the shaft turns. A ball micrometer for measuring wall thickness of bearings, and a dial indicator for measuring diametric and longitudinal clearances will be found necessary. For measuring clearances such as piston to cylinder head, or oil pump gears to housing, the use of lead ribbon is recommended. The lead ribbon is inserted between the parts, removed, and measured to obtain the clearance.

Radial clearance is specified when the nature of the part is such that diametric clearance cannot be measured. The radial clearance is always one-half of the diametric clearance.

Longitudinal or thrust clearances are listed throughout the manual with all of the clearances removed at one end of the part being measured. Where it is not convenient to take out all of the thrust at one end, the thrust at each end should be measured and added, to give the total longitudinal clearance.

Clearance and dimensional limits used in this manual are defined as follows:

1. New limits are those to which new parts are manufactured. (Drawing tolerances.)
2. Rebuild limits are dimensions which should not be exceeded at the time of rebuild, in order to ensure satisfactory service until the time of the next scheduled overhaul. Unless specified otherwise, the limits given in the manual are rebuild limits.

FACTORY REBUILD SERVICE

Factory Rebuild Service for engines and engine components can be handled in two ways, either Rebuild and Return or Unit Exchange. In Rebuild and Return service, the same parts sent in by the customer are remanufactured and returned to the customer. In general, any item supplied by Electro-Motive can be rebuilt under this service. Unit Exchange involves Electro-Motive Branch shipment of a fully rebuilt assembly in exchange for the one returned by the customer. In either service, the customer is ensured of being provided with the best service and qualified factory recommended parts.

For full particulars regarding either service see your Factory Rebuild Service catalog. In addition to outlining specific conditions relative to the remanufacture of various parts, it also indicates the Factory Branch or Branch Warehouse nearest you which provides the service you may want.

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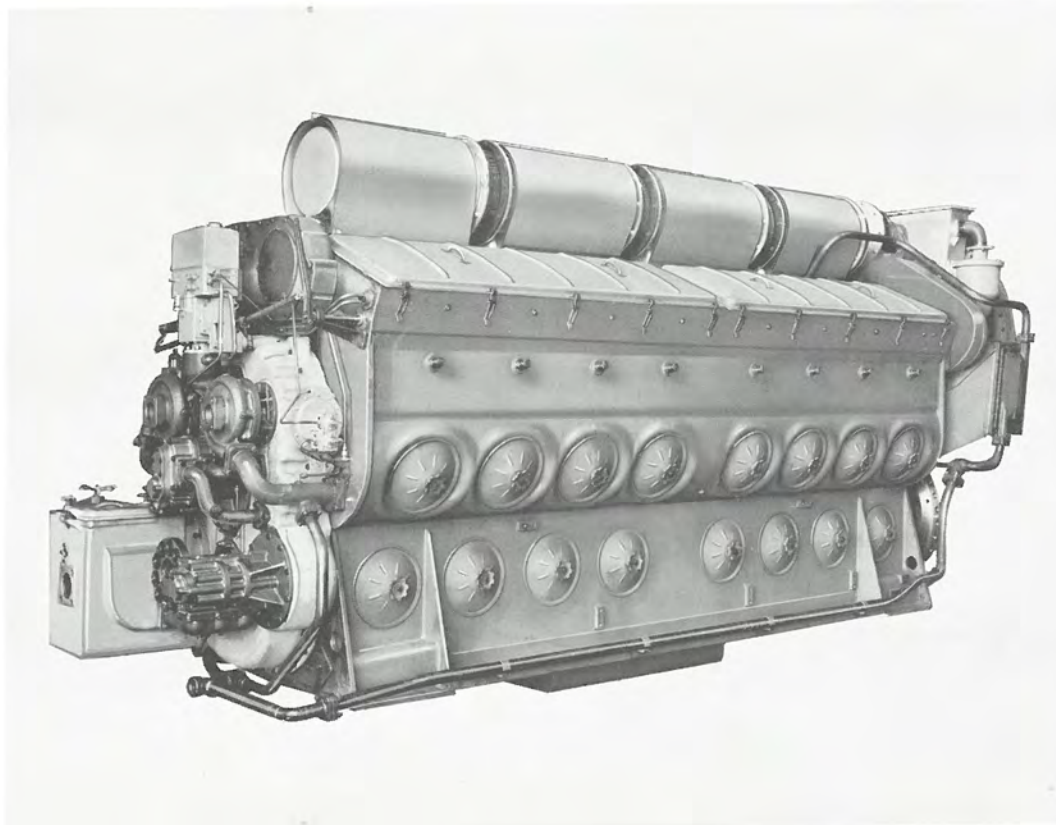

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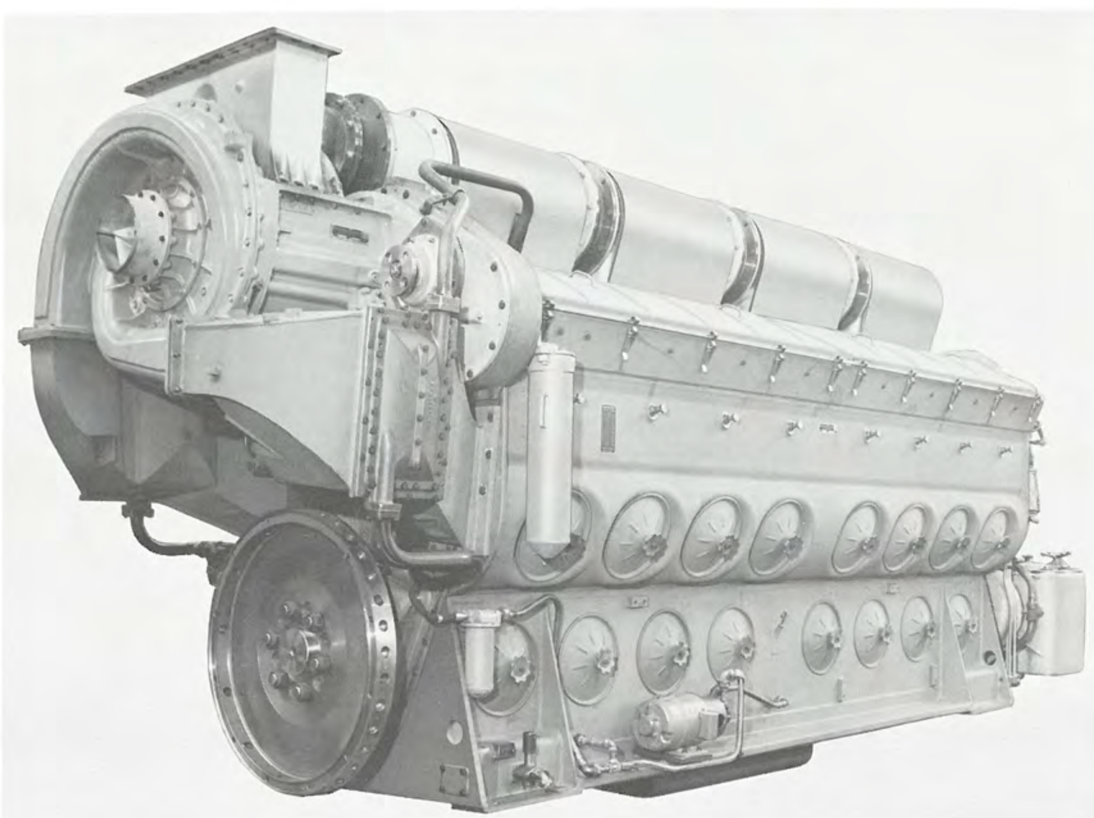
Front Three-Quarter View Model 16-567D3A Engine



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Rear Three-Quarter View Model 16-567D3A Engine

GENERAL ENGINE INFORMATION

OPERATING DESCRIPTION

In a two cycle engine each cylinder completes a power cycle in one revolution of the crankshaft. The piston does not function as an air pump during one crankshaft revolution as is the case in a four cycle engine which requires two revolutions of the crankshaft to complete one power stroke in each cylinder. A separate means is provided in a two cycle engine to supply the needed air and to purge the combustion gases from the cylinder.

The engine is equipped with a turbocharger, shown schematically in Fig. 0-1, to efficiently provide the air needed for combustion and scavenging. The turbocharger provides an air supply greater than that provided by the positive displacement blowers used on other model engines.

During engine operation the turbocharger utilizes heat energy in the exhaust from the engine as well as power from the camshaft gear train to drive the turbine. However, when exhaust heat energy is sufficient to drive the turbine alone, the gear drive is disengaged by an overrunning clutch. The turbine then drives a centrifugal blower which furnishes air to the engine.

The air from the centrifugal blower is raised to a higher pressure and likewise to a higher temperature. It is desirable to reduce the air temperature to increase its density before it enters the air box surrounding the cylinders. The air temperature is reduced by passing it through the aftercoolers as shown in Fig. 0-1. Thus cooled air of greater comparable weight and having more oxygen is available to the engine.

Referring to Fig. 0-1, and assuming that the piston is at the bottom of its stroke and just starting up, the air intake ports and the exhaust valves will be open. Air under pressure enters the cylinder through the liner ports, pushes the exhaust gases left from the previous power stroke out

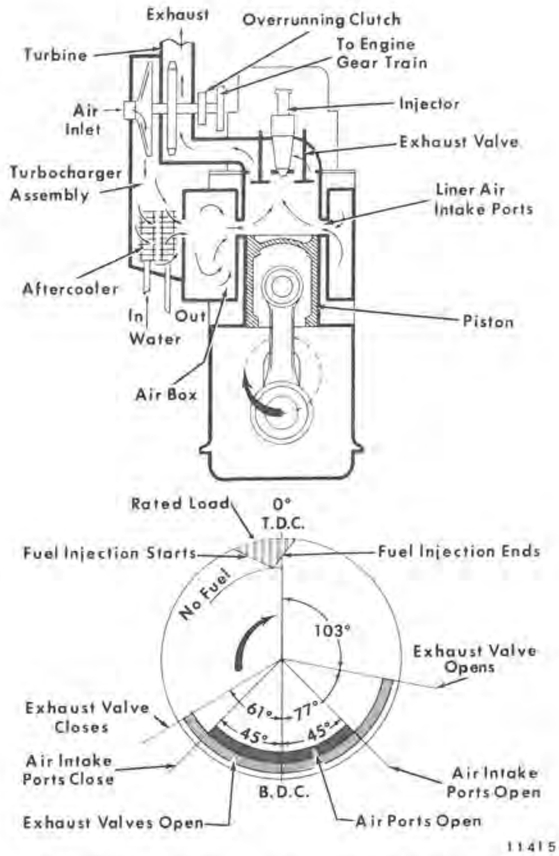


Fig. 0-1 — Schematic Illustration Of 567D3A Engine Operation

through the exhaust valves and fills the cylinder with a fresh supply of air. When the piston is 45° past bottom dead center, the air intake ports will be closed by the piston as indicated on the timing diagram. Shortly after the air intake ports are closed the exhaust valves will also be closed, and the fresh air will be trapped in the cylinder. Closing the exhaust valves after the intake air ports provides for the greatest efficiency in cylinder scavenging of combustion gases.

As the piston continues upward, it compresses the trapped air into a very small volume. Just before the piston reaches top dead center, the fuel injector sprays fuel into the cylinder. Ignition of the fuel is practically instantaneous, due to the temperature of the compressed air trapped in the top of the cylinder. The fuel burns rapidly as the piston is forced down on the power stroke of the piston. As shown in the timing diagram, the piston continues downward in the power stroke until the exhaust valves open.

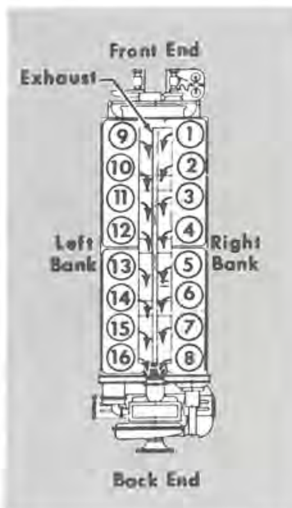
The exhaust valves are opened ahead of the air intake ports to permit most of the combustion gases to escape and reduce the pressure in the cylinder. When the air intake ports are uncovered by the piston at 45° B.B.D.C. as it continues downward, air from the air box under pressure can immediately enter the cylinder, scavenging the remaining combustion gases from the cylinder and providing fresh air for combustion. The piston is again at the original starting point of the description and the cycle of events is repeated.

GENERAL DESCRIPTION AND DATA

DESCRIPTION

This model diesel engine is a "V" type, two cycle engine, incorporating the advantages of low weight per horsepower, positive scavenging air system, solid unit injection and high compression.

The accompanying sketch serves to identify the cylinder locations, ends and banks of the engine as referred to in this manual. The governor, water pumps and lube oil pumps are mounted at the "Front End." The turbocharger and generator are at the "Back End."



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DATA

Bore	8-1/2"
Stroke	10"
Compression Ratio	14.5:1
Full Speed	900 RPM
Idling Speed	315 RPM
Starting Speed	75-100 RPM
Rotation (Facing Back End)	Counter-Clockwise
Angle Between Banks	45°
Weight (Approx.)	34,425 lbs.
(Large Oil Pan)	34,975 lbs.
Firing Order	1-8-9-16-3-6-11-14-4-5-12-13-2-7-10-15
Displacement per Cyl.	567 cubic inches
No. of Exhaust Valves (per Cyl.)	4
Crankpin Diameter - Nominal	6-1/2"
Crankshaft Journal Diameter - Nominal	7-1/2"
Number of Main Bearings	10
Thrust Bearings	2
Fuel Injector	Unit injector with needle valve
Governor	Woodward Electro-Hydraulic Pressure-Rebalancer Model
Cooling System	Atmosphere vented
Water Pumps	Centrifugal type
Lubricating Oil System	Full pressure
Oil Pumps	Helical gear type
Main oil pump and piston cooling pump	Two pumps in one housing, siamesed inlet, double discharge
Scavenging oil pump	Multiple gear

TORQUE VALUES (ft-lbs)

Cylinder Head Nuts	200
Liner Stud Application (Min.)	50
Fork Rod Basket Bolts (at serrations)	190-200
Split Basket Bottom Bolts (1/2"-20)	75
Main Bearing Nuts	500-800
Crab Stud Nuts	1800
Engine Flywheel Mounting Bolts	1500
Flywheel Coupling Bolts (3/4"-16)	295
Injector Crab Nuts	50
Oil Pan To Crankcase Mounting Bolts	450

TORQUE VALUES (ft-lbs) Cont'd

Front and Rear 1/2" Mounting Bolts	
Hardened (with mark on head)	85
Not Hardened (no mark on head)	65
Turbocharger Assembly	
3/4" Mounting Bolts	175
Cylinder Head Frame Bolts	30
Rocker Arm Shaft Nuts	300
Injector Fuel Lines	40
Camshaft and Injector Shaft Bolts	20-25
Fuel Manifold Blocks	25
Exhaust Connection to Turbocharger	
Stainless Steel (1/2"-20)	45
Exhaust Manifold Bolts (5/8"-18)	130
Exhaust Manifold Connecting Clamp Bolt	70 in-lbs
Swirl Type Exhaust Manifold Bolts (1/2"-20)	80
Harmonic Balancer Bolts (Mounting)	400
Accessory Drive Gear Bolts (Mounting)	250
Accessory Drive Flange Retaining Bolt	500
Cylinder Head Elbow (3/8"-16 socket head)	30
Water Pump Impeller (5/8"-18)	80
Water Pump Gear (1"-14)	265
Stationary Bushing	6
Water Manifold Strap Nuts	15
Liner Water Inlet Tube Bolts (in liner)	30
Piston Cooling Oil Pipe Bolts	20
Engine Hold Down Bolts	450
Camshaft Stubshaft Bracket (1/2" socket head)	75
Camshaft Bearing Blocks (3/8"-24)	27

NOTE: All single values given may vary plus or minus five percent.

SERIAL NUMBERS

Major components of the engine are identified by serial numbers for historical record. When reference is made regarding a part having a serial number, the serial number should be included in the information as well as other identification used concerning the part. Following are major engine items identified with a serial number, and its location on the part.

ENGINE - serial number is shown on the engine nameplate located at the right bank of the engine, and stamped at the upper left corner of the crankcase below the cover frame base.

CRANKCASE - serial number is on the right side of the main bearing caps, at each end "A" frame and at the center of both top decks under each camshaft.

OIL PAN - serial number is located on the left side of the oil pan near the crankcase support base at the front or rear.

CRANKSHAFT - serial numbers are located on the last crank pin throw and also at the front throw of the front half, in 1/2" high numerals with the EMD symbol.

CYLINDER HEAD - serial number is located at top face outside diameter opposite exhaust side.

CYLINDER LINER - serial number is located above the air inlet ports above the water inlet connection.

PISTON - serial number is located at the bottom inside diameter at the taper below the oil control ring.

PISTON CARRIER - serial number is located below the thrust washer platform on the outside diameter.

PISTON PIN - serial number is located at end of pin on same end as small identification hole.

FORK CONNECTING ROD - serial numbers are located in three different locations as the fork rod assembly consists of two basket halves and the rod. On basket half with dowel, number is located above basket-to-rod bolt hole. On other half, it is located below basket-to-basket bolt holes. On the rod, number is located to the left of center above serrations on the dowel side of rod.

BLADE ROD - serial number is located at end of slipper opposite the long toe.

CAMSHAFT ASSEMBLY - serial number of the assembly is located at the end of the accessory end stubshaft.

ENGINE GEARS - serial number is located on the rim of the gear.

GOVERNOR - serial numbers are provided on the governor nameplate.

WATER PUMP - serial number is located on the housing flange rim and is preceded by an "R" or "L" to show pump installation, at the right or left bank.

LUBRICATING OIL PUMP - serial number is located at the front end cover and is preceded by the letter "L" to identify it as a lubricating pump.

SCAVENGING OIL PUMP - serial number is located at end cover and is preceded by the letter "S" to identify it as the scavenging pump.

FUEL INJECTORS - serial number is located on same side as the injector rack, and is provided by injector manufacturer.

TURBOCHARGER - serial number is located on the nameplate attached to the turbocharger at the right side.

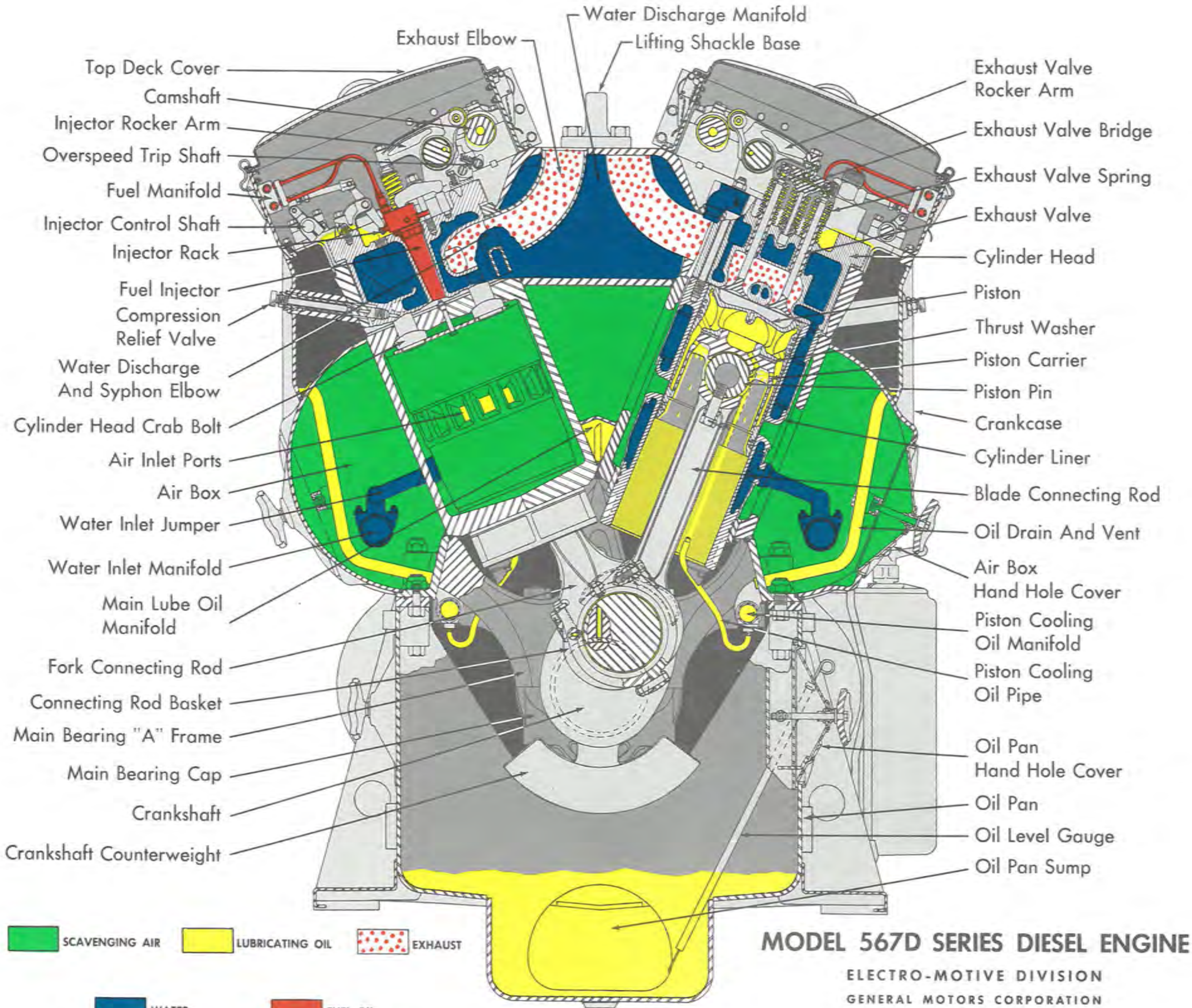
AFTERCOOLER - serial number is located at the center bolt surface at the water inlet side. (Core serial number located on nameplate on core.)

ENGINE PAINTING

If an engine is to be removed from service and completely overhauled and the interior repainted, the parts to be painted must be cleaned in a vat of caustic solution to remove old paint, grease and oil from the pores of the metal. The caustic solution must be thoroughly removed by washing the parts in clean hot water, and air dried with an air hose. (Aluminum parts must not be washed in the caustic solution.) If caustic cleaning is not done before painting, the paint will peel off the interior of the engine and contaminate the lube oil lines. Mask off parts which are not to be painted.

Use crankcase primer paint (5 gal. 8187782, 1 gal. 8187781) on the following: interior of crankcase, oil pan, air duct, top deck, cylinder head cover frames (except on seal surface), accessory and camshaft drive housings. Do not paint machined surfaces, liners, heads or seal surfaces.

To refinish the engine exterior, remove grease and oil with alkaline cleaner. Mask off water, fuel and oil fittings. If required, apply coat of primer. Then apply a finish coat of Suede Gray (5 gal. 8133054, 1 gal. 8122047). Larger containers of paint are available.



MODEL 567D SERIES DIESEL ENGINE

ELECTRO-MOTIVE DIVISION
GENERAL MOTORS CORPORATION
LA GRANGE, ILLINOIS, U.S.A.

PRINTED IN U.S.A.

PLATE 10366 - A

CRANKCASE AND OIL PAN

CRANKCASE

DESCRIPTION

The crankcase, Fig. 1-1, is the main structural part of the engine. It is a steel fabrication forming a rigid self-supporting assembly to accommodate the cylinder power assemblies, crankshaft, and engine mounted accessories.

The crankcase is primarily constructed around two cylinder banks. Each bank is formed by joining two channels into a long rectangular box-like structure. An upper and lower bore is provided in this structure for each cylinder liner; and a cylinder head retainer, Fig. 1-1, is located at the top of each cylinder bore. Openings are provided in each side at each cylinder for inspection, and scavenging air circulation.

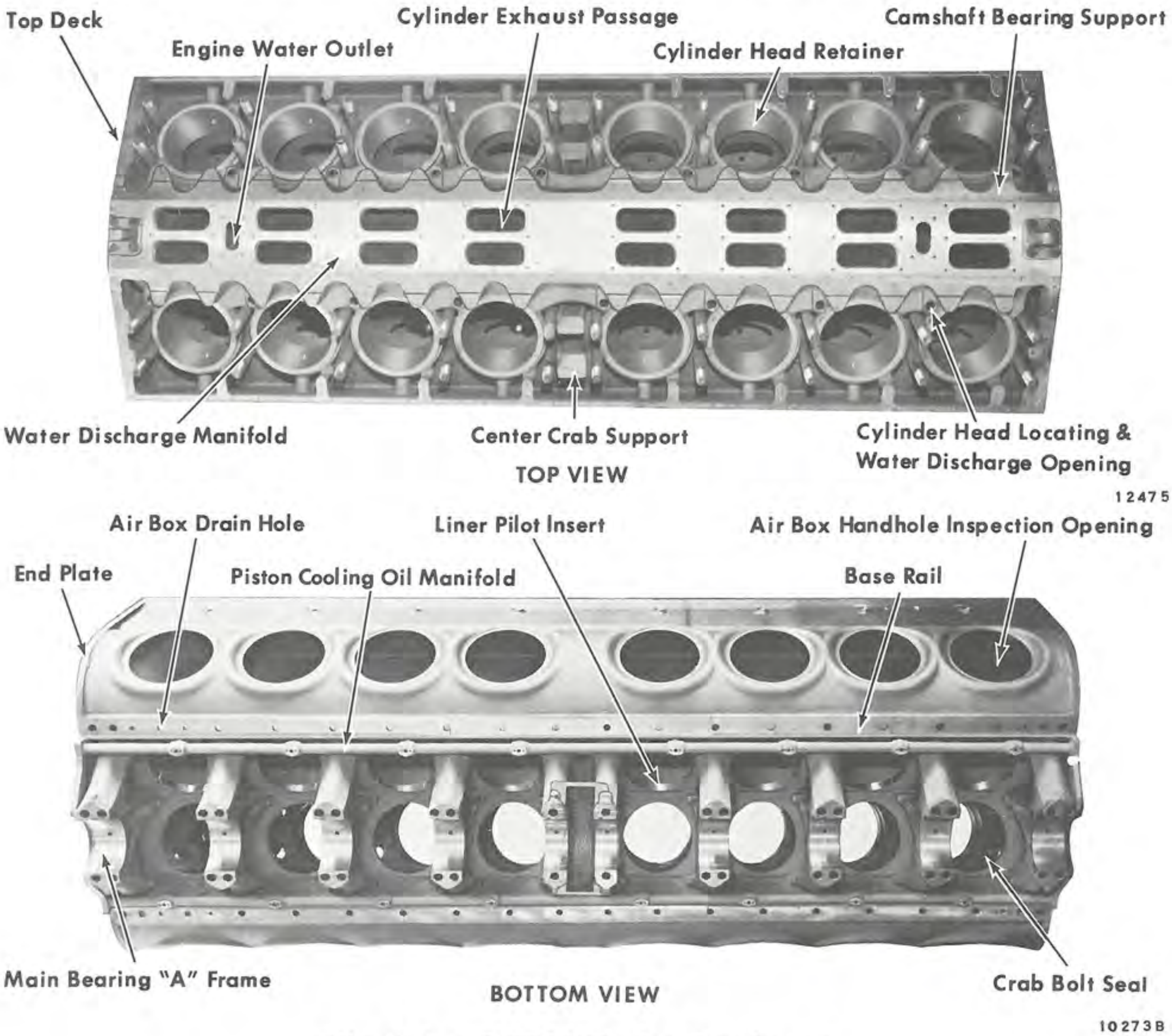


Fig. 1-1 — 567D3A Engine Crankcase

The cylinder banks are positioned at 45° to each other in the crankcase, forming a "V." The top of the "V" is closed by the water discharge manifold which extends the length of the engine. The sides of the manifold are closed by the camshaft bearing support wing plate and seal plates which join the cylinder head retainers. A water discharge opening is located at each cylinder location to receive the water discharge pipe from each cylinder head. This opening also serves to locate the power assembly properly in the crankcase. From each cylinder head retainer an exhaust passage extends through and to the top of the water discharge manifold. The bottom of the "V" is spanned by a plate to form the main lubricating oil manifold, which extends the length of the engine terminating at openings in each end plate. The cylinder banks are joined and the front and back of the crankcase closed by the end plates. Air admission openings are provided in the rear end plate, and both end plates are drilled and tapped to accept the engine mounted accessories.

The sides of the crankcase are closed by side sheets having inspection openings which are normally closed with gasketed covers. The side sheets, end plates, and top and bottom plates form the air box or air reservoir which surrounds the cylinder liners. Plates extending above the side sheets between each end plate are provided with top bars to serve as a base for the cylinder head cover frame. These plates also create an oil channel along the outboard side of the cylinder head retainers. Combination drain and ventilating pipes extend from this channel, through the air box to the oil pan. At each cylinder, a tube extends from the outside of the top plate into the retainer pocket to accommodate the cylinder relief valve.

Base rails provided with mounting holes extend the length of the crankcase on each side and serve to support the crankcase on the oil pan. Separate drain holes in the base rails at the rear ends allow any liquid accumulation in the air box to drain into pipes and air box drain tanks built into the oil pan. The piston cooling oil manifolds paralleling the base rails on the inside, have a flange at each cylinder location for the application of the piston cooling pipe.

As shown in Fig. 1-1, the main bearing "A" frames are located at each end of the crankcase and in between each cylinder location. The "A" frames are welded to the base rails and at the juncture of the cylinder banks to strengthen the bottom of the crankcase and support the crankshaft. A main bearing cap is attached at a serrated joint to each "A" frame, and held by four main bearing bolts, except the two center "A" frames, which have two bolts. The "A" frames and caps are line bored to accommodate the main bearings which support the crankshaft. A drilled passage extends from the top of each main bearing "A" frame bore into the main lubricating oil manifold. Oil tubes are inserted into these passages with their ends extending above the bottom of the manifold. The entire crankshaft and bearing oil supply is provided through these tubes.

MAINTENANCE

CLEANING CRANKCASE

The crankcase should be cleaned, to remove foreign material, after any work has been done on the interior of the engine, or if damage has occurred in the engine. This can be done by using a spray gun and solvent. The equipment near the engine should be protected against the spray. After spraying the top deck, wipe with towels saturated with solvent. Wipe all solvent trapped in corners and pockets. Use only lintless, bound-edge towels.

Cleaning of the air box with a spray gun while liners are in place is not recommended practice, due to possibility of dirt entering liners at the ports.

At any time cleaning is done on the crankcase, protection should be given to oil passages, bearing surfaces, gears, etc., to prevent gritty material from being trapped. Cleaning procedures should be in accord with accepted practice or as recommended by the supplier of cleaning material.

CRANKCASE INSPECTION

Serious crankcase failures can be avoided and longer crankcase life obtained by careful periodic crankcase inspection. Inspection may disclose small discrepancies which, if allowed to progress, might result in major failure, loss of service, or loss of the crankcase. Inspection and early trouble detection and repair are most important, since major repair generally cannot be done in the field. In instances where major repair is involved requiring extensive welding, it is essential that the crankcase be stress relieved and remachined where necessary. This tends to shorten crankcase life, as there is a limit to number of times this can be done.

In addition, when an engine failure occurs due to breakdown of parts, a careful inspection is essential at locations other than the immediate vicinity of the damaged area. (For example, an engine failure in which a connecting rod damages the liner pilot.) A rod may also strike and nick the stress plates. It is most important in this event that the stress plate be inspected in the holes opposite the liner and if any nicks are found, they must be blended out. The stress plates are subject to shock loading and nicks may serve as possible stress concentrators and lead to cracking. It is recommended that a crankcase requiring rebuild or reconditioning be returned to the manufacturer for the work.

LOWER LINER BORE INSERT

DESCRIPTION

A replaceable phosphate treated cast iron insert, Fig. 1-2, is used in each lower liner bore of the crankcase to provide a wear surface at the lower liner pilot. Seals held in grooves in the lower liner pilot, prevent air passage between the insert and the liner. These seals are particularly important in turbocharged engines to prevent loss of air to the cylinders and a positive pressure buildup in the oil pan.

MAINTENANCE

When the inside diameter of the insert, installed in the crankcase, reaches the maximum limit, the insert should be removed and a new one installed.

Replacement of the insert in the lower liner bore of the crankcase requires the use of a sturdily constructed tool to apply and remove the insert safely and efficiently. The lower liner insert application and removal tool, Fig. 1-3, is specifically

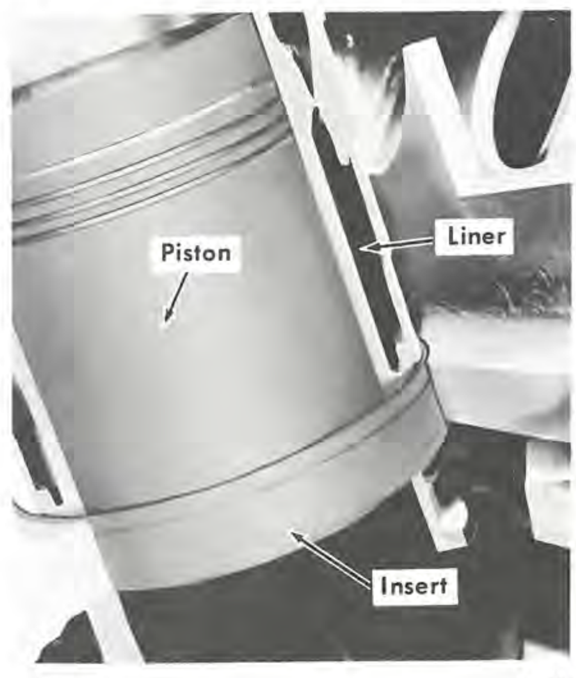


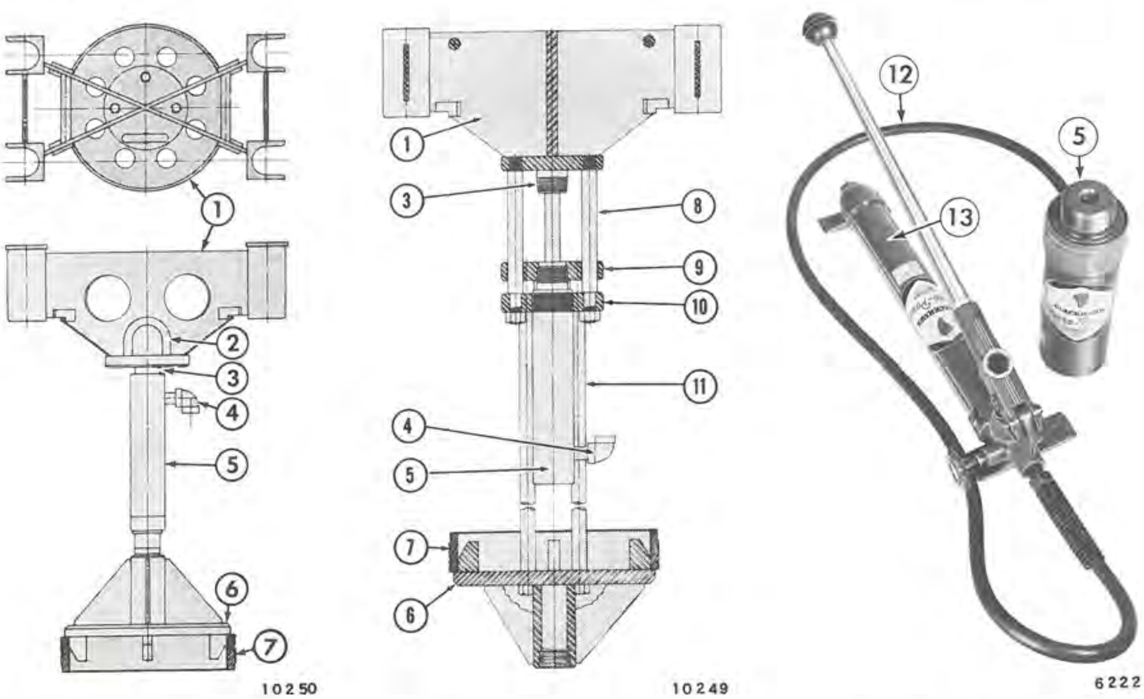
Fig. 1-2 — Lower Liner Bore Insert

designed to do this work. This tool consists of a press and puller assembly and a 10-ton hydraulic jack. The hydraulic jack consists of a 10-ton hydraulic ram, a high pressure hose, and a high pressure hydraulic pump.

INSERT APPLICATION

The arrangement of the tool for insert application is shown in Figs. 1-3a and 3c. The insert is installed as follows:

1. Coat the contact area of the outside diameter of the insert with white lead or similar lubricant.
2. Manually place the insert (7) in place in the lower bore, and position it for the pressing operation by starting it uniformly in the bore.
3. Assemble the tool as shown in Fig. 1-3a, with the ram screwed into the screw plug, and into the boss of the insert plate (6). The ram plunger should be in the retracted position. Disconnect the high pressure hose (12) if it is attached to the ram.
4. Lift the tool at the hoisting ring (2), and place the tool into the cylinder bore resting upon the cylinder retainer. The tool should be positioned so the hose connection is accessible from the stress plate inspection opening. Secure the tool using four crab nuts at the crab stud holding bosses.
5. Attach the high pressure hose (12) to the ram (5) at the ram connection (4), and using the hydraulic pump, extend the plunger to contact and press the bore until the shoulder is seated.



a. Insert Application b. Insert Removal c. Hydraulic Jack

1. Crab Stud Holding Assembly
2. Hoisting Ring
3. Screw Plug
4. High Pressure Hose Connection
5. 10 Ton Ram
6. Insert Plate
7. Insert
8. Holding Studs
9. Upper Plate
10. Ram Plate
11. Pulling Studs
12. High Pressure Hose
13. Hydraulic Pump

Fig. 1-3 — Liner Bore Insert Application And Removal Tool

INSERT REMOVAL

The arrangement of the tool for insert removal is shown in Fig. 1-3b. The insert is removed as follows:

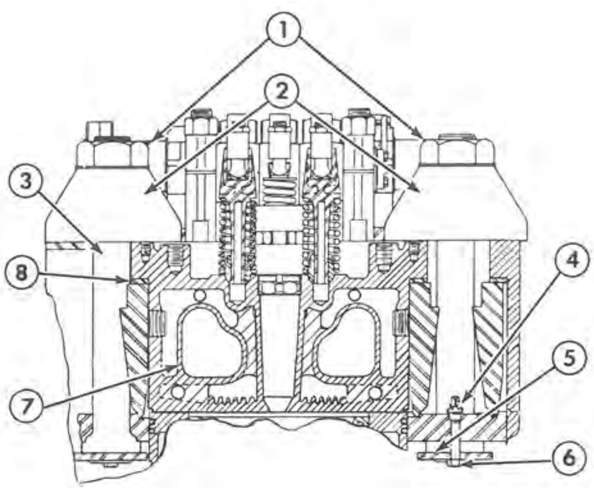
1. Assemble the tool for removal as shown and remove the four nuts holding the insert plate (6) and remove the plate. Also, remove the high pressure hose (12) from the ram (5) if it is connected.
2. Lift the tool using the hoisting ring and place in the cylinder, resting upon the retainer. Position the tool so that the hose fitting may be reached at the outboard side to permit hose application. Apply four crab nuts to secure the tool.
3. Place the ram plunger so that the insert plate bolts extend below the insert to permit insert plate application, as shown in Fig. 1-3b. Apply the insert plate and its holding bolts.
4. Connect the high pressure hose (12) to its fitting (4) on the ram (5) and using the pump (13) remove the insert (7) from the crankcase bore.

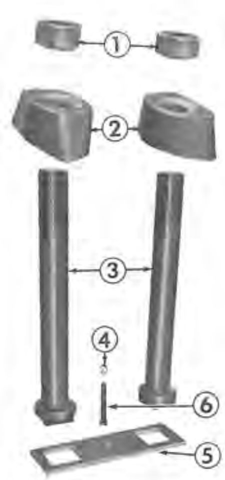
In the event that the insert application and removal tool is not available, the insert may be applied and removed using a mallet and a phenolic or wooden block.

CRAB BOLTS

DESCRIPTION

The cylinder head and liner are bolted together and this assembly is held in the cylinder head retainer by 1-3/4" crab bolts, head crabs, and nuts, Fig. 1-4. The crab bolts extend up through the cylinder bank upper deck plate adjacent to each cylinder retainer. The bolt heads have a spherical seating surface which seats in a like surface, the bolts being held in position by a separate plate and bolt for each pair of bolts. The square bolt heads fit corresponding holes in the plate which prevents their turning when being torqued. Head crabs, each contacting two cylinder heads, except for end or center crabs, hold the power assemblies firmly in place. A spherical surface in the top of the crab receives a crab nut with a mating spherical seat.





1. Crab Nut
2. Crab
3. Crab Bolt
4. Retainer Bolt Nut
5. Retainer Plate
6. Retainer Bolt
7. Cylinder Head
8. Cylinder Head Seat Ring

Fig. 1-4 — Crab Bolt Installation

MAINTENANCE

The crab bolts can be removed through the air box by removing the crab bolt retainer plate bolt and retainer plate. The retainer plate and bolt are easily accessible only after liner has been removed. Crab bolt threads may be cleaned up using a 1-3/4"-12 thread die, and nut threads may be cleaned up using a 1-3/4"-12 tap. Whenever crab bolt threads are exposed, they should be covered with thread protectors.

Torque value of the cylinder head crab nuts is 1800 ft-lbs $\pm$ 90 ft-lbs. A powerench for tightening crab nuts is available through our Parts Department. This is a mechanical advantage wrench used in conjunction with a standard torque wrench.

Before reapplication of the crab nut, examine for burrs, roughness, or galling which would affect the true torque value. Care should be taken to see that the spherical surface is smooth to provide good contact and prevent air leakage from the air box. The crab stud threads should be lubricated at time of assembly, using a lubricant having specifications similar to Texaco Stud Lube 921, or as a second choice, engine lube oil.

Crab bolt nuts should be tightened in two passes, half torque at each pass, tightening the diagonally opposite nuts alternately to form a letter "X." This method applies whether tightening an entire bank or a single cylinder. After final cylinder assembly, bring engine water temperature to 170° F. and retorque crab nuts and liner stud nuts to proper torque. Recheck at intervals specified in the Scheduled Maintenance Program.

NOTE: When liner and crab nuts are being retightened, those that move at less than the specified torque values should be tightened to proper value. Those which DO NOT MOVE, below or up to the proper values, should be checked by pulling up to a value not exceeding 10% more than recommended torque.

MAIN BEARING STUD BOLT APPLICATION

DESCRIPTION

The main bearing stud bolts are shown in Fig. 1-5. Each "A" frame has four 1-1/4" lubrized main bearing studs except the center "A" frames, which have two each. They pass through the "A" frame and main bearing caps with their lower ends 7" below the "A" frame serrations. Lockwire holes are provided at the lower ends of the studs. A 5/16" transverse hole at the upper end of each stud accommodates a 1/4" bolt which passes through the stud and slots in the upper nut. Semicircular or "D" shaped nuts are used at the upper end of the stud. The flats of adjacent nuts are mated to prevent turning. The upper nuts have a spherical seating surface to match a similar surface in the "A" frame. Since the center "A" frames are separated from each other, a retainer assembly is used to prevent the upper nuts from turning. The retainer assembly is held in place over the nuts by the 1/4" bolts which pass through the nuts and studs. The lower main bearing nuts are conventional slotted hexagon nuts using lockwire to aid in securing the nuts.

MAINTENANCE

Thread size at both ends of main bearing stud bolt is 1-1/4"-12. To clean up threads, a 1-1/4"-12 thread die can be used, while a 1-1/4"-12 tap can be used on the stud nuts. To aid in obtaining correct torque values, the threads should be cleaned before parts application.

Upon application, each stud is inserted into its place in the "A" frame and run into its nut until the 5/16" hole in the top of stud lines up with the bolt slot of the nut. The lockwire end of the stud should be 7" from the serrations on the "A" frame when the stud is brought out with the spherical surface of the upper nut contacting the mating surface in the "A" frame. This is to ensure that the lockwire passes through the slots of the lower stud nuts when the bearing cap is applied and the nuts tightened properly. The 1/4" bolt and self locking nut may then be applied to all the upper nut and stud assemblies except the center "A" frames. The upper nut flats contact each other when in place on all "A" frames except the center "A" frames, which are separated from each other. A retainer plate is used on the center "A" frame upper nuts to prevent them from turning. After the stud has been run into the nuts the proper amount, the retainer, which is like a channel, is placed over the nuts. The 1/4" bolts are then applied through the retainer and stud and across the nut slots. The bolt slots in the retainer are of different widths, one slot being larger to secure the bolt head and prevent it from turning when being tightened. The retainers are cut away on one side to provide clearance for a stiffener plate between the center "A" frames.

Main bearing caps are originally applied to the "A" frame and then are line bored; therefore, they are not interchangeable or available for replacement. They must be reapplied on the same "A" frame in the same original position as removed. Each cap and "A" frame is stamped on the right side with their bearing number, and in addition, all caps and the end "A" frame are stamped with crankcase serial number. Before cap application, check serrations in cap and "A" frame and remove any burrs or foreign material that would prevent a good mating fit.

Torque value of the main bearing nuts is 500 to 800 ft-lbs. For correct assembly, the nuts should be brought up to 500 ft-lbs and then tightened further until lineup of first lockwire hole is reached. This will ensure torque value being within the 500 to 800 ft-lb range.

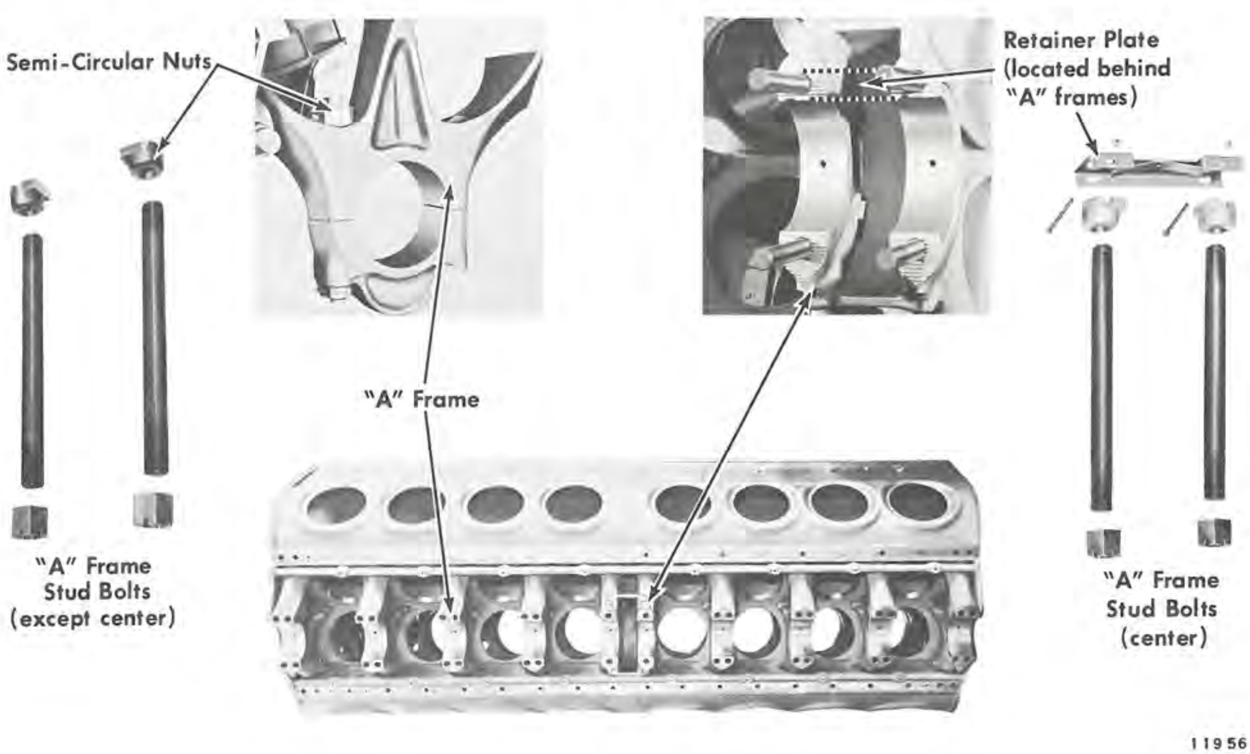


Fig. 1-5 — Main Bearing Stud Bolts

For checking main bearing bore dimensions, a torque value of 650 ft-lbs should be used. With nuts torqued to this amount, check the out-of-round limit of the main bearing bore. Likewise, check that the main bearing bore dimensions are within the minimum and maximum limit. These are the average of six measurements, three taken at each end of the bore. The crankcase main bearing bore measurements must be within these limits to qualify and ensure that the bore is not closed in.

If an overheated bearing makes it necessary to check an "A" frame for "close in" with the crankshaft in the engine, it may be checked using a new upper main bearing. In this check, the "A" frame bore must be able to receive a new upper main bearing shell. Also, check the clearance at each side between the bearing shell and the crankshaft at the split line above the serrations.

A main bearing nut powerench set may be obtained for use on the engine. This wrench, in use, is supported in the oil pan inspection opening. Also, an offset ratchet wrench set is available for running up and loosening main bearing nuts. For complete information on these tools, see the Service Tools Catalog.

OIL PAN

DESCRIPTION

The oil pan, Fig. 1-6, is a steel fabricated assembly. It supports the crankcase and serves as the engine base. The engine oil sump, located centrally in the oil pan, is provided with oil drains.

An oil level bayonet gauge extends from the side of the oil pan into the sump. A scavenging oil pump suction line is built into the oil pan extending from the sump to the front end plate. Openings in each end plate allow oil from the camshaft and accessory end housings to drain into the oil pan. Hand holes at each cylinder location, provided with gasketed covers, allow ac-

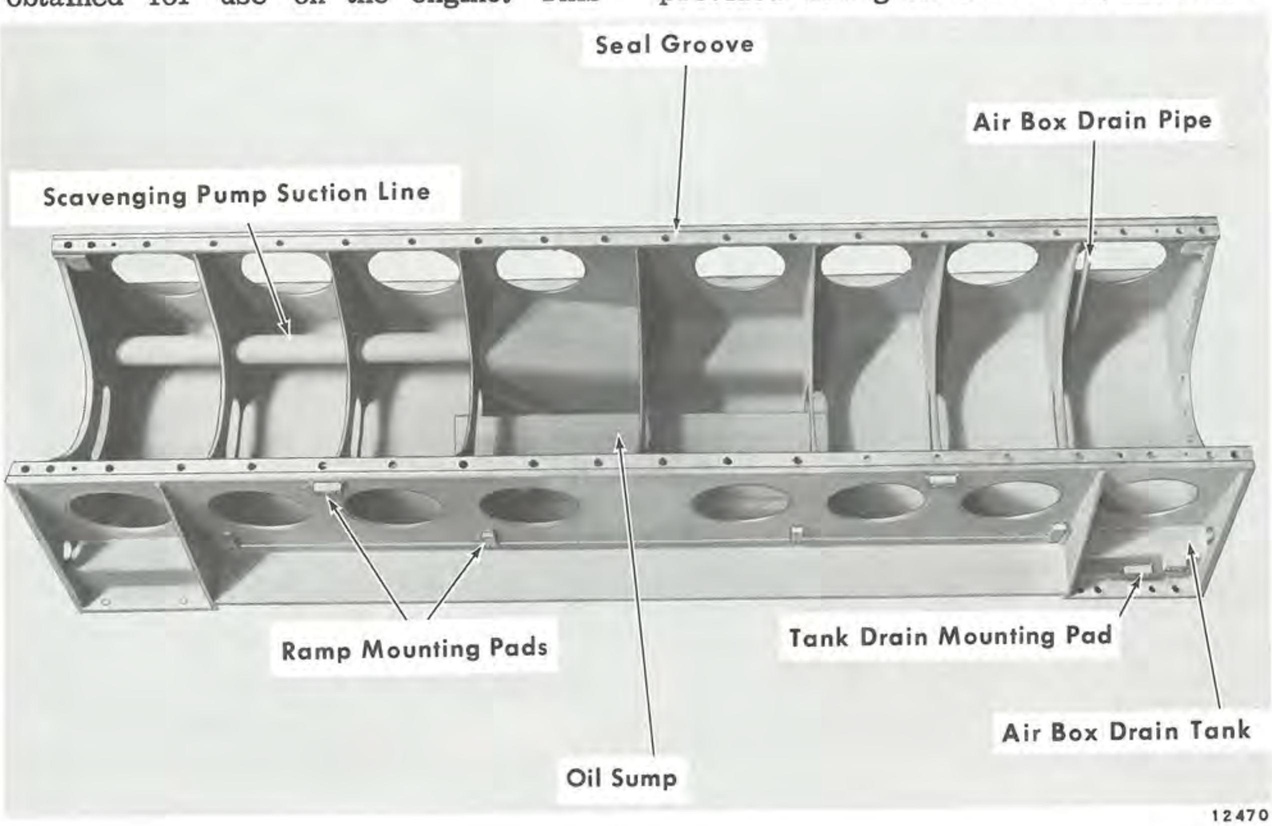


Fig. 1-6 — Basic Oil Pan

cess to enclosed engine parts. Separate air box drain tanks in the oil pan receive any liquid accumulations from the air box through a drain pipe and passage through the oil pan and crankcase mounting rails.

The seal arrangement between the crankcase and oil pan mounting rails consists of a silicone rubber cord placed in a groove outside the bolt line the entire length of each oil pan mounting rail. A small "O" ring seal placed in a counterbore, seals the air box drain opening. Dowels hold the crankcase to oil pan alignment after original assembly and, crankcase to oil pan bolts secure the assembly.

An increased capacity oil pan, Fig. 1-7, although not a part of the basic engine, is available as optional equipment. The larger sump considerably extends the locomotive operating range, regarding the addition of oil.

MAINTENANCE

CLEANING

The oil pan should be thoroughly cleaned at the time of an oil change or any time the engine is damaged. Particular attention should be given the oil lines and air box drain tanks to make certain there is no accumulation of foreign material. Wipe out accumulation from corners and pockets.

INSPECTION

Inspect the interior surfaces of the oil pan for loose or flaking paint.

In addition, inspect the seal grooves, air box drain counterbore, end plates, and handhole cover gasket surfaces for any nicks or roughness which would damage the seals or interfere with proper sealing.

12476A

BASIC

12476B

INCREASED CAPACITY

Fig. 1-7 — Oil Pan Sump Configurations

CRANKCASE TO OIL PAN SEAL

DESCRIPTION

A round silicone seal cord placed in a groove, Fig. 1-6, in the oil pan mounting rail effectively prevents any leakage at the junction of the crankcase and oil pan. Particular attention in manufacture is given to the crankcase and oil pan mating surfaces and the groove in the oil pan to ensure that they are clean, smooth, and free of any burrs or nicks which would injure the seal. The groove depth in the oil pan is also maintained within close tolerances to realize the full effectiveness of the seal cord.

MAINTENANCE

Before seal application, inspect oil pan rails for nicks, burrs, or foreign material of any kind in seal grooves, and remove to provide a clean smooth surface. Any indentation in the seal grooves or base rails that would allow oil seepage must be filled with solder and finished flush with surrounding area.

Along outside edge of oil pan rail surface, apply one coat of Tite Seal #3, approximately 1/2" wide and about .015" thick, or thickness of ordinary playing card.

Install seals in the grooves without twisting or stretching and without lubricant. The individual seals for each model engine are longer than required, but do not cut off seal ends at this time.

Place crankcase over oil pan, and using lineup pin guides in the four corner holes, lower crankcase on oil pan. Apply taper dowel bolts and tighten. Check crankcase to oil pan alignment, using care not to damage seal cord.

CAUTION: Do not pull or stretch the ends of seal cord.

Assemble all crankcase to oil pan bolts with washers and snug four corner bolts to about 100 ft-lbs torque. Starting with the center bolt and alternating between the bolts to the left and right of center, tighten bolts to a torque of 100 ft-lbs. After tightening bolts on both sides of engine to 100 ft-lbs repeat tightening sequence bringing bolts to a final torque of 450 ft-lbs.

After all bolts have been tightened to 450 ft-lbs, cut seal cord ends to provide a seal protrusion from face of end plates of 3/32" ± 1/64". This seal protrusion will seal the three way joint of oil pan, crankcase, and end housing.

All crankcase to oil pan bolts must be tightened at regular intervals, in accordance with the Scheduled Maintenance Program.

AIR BOX DRAINS

DESCRIPTION

Any accumulation of liquids from the engine air box settles in the drain tanks, located on each side of the oil pan at the rear of the engine. A drain valve, Fig. 1-8, is provided to manually drain each tank.

12467

Fig. 1-8 — Air Box Drain Valve

The drain valve is a spring loaded step-on type valve that is fully opened when depressed. When released, the valve returns to its normal position, but is never completely closed. A bypass orifice is an internal part of the valve and permits liquid from the tank to be drained off should the accumulation become excessive between periodic manual drain periods. Every time the valve is depressed, the orifice is cleaned by the spindle, at the top of the closure plug.

MAINTENANCE

The only maintenance required is to drain the air box drain tanks at appropriate intervals noting if there is any excessive accumulation of oil and water in the air box. If a discharge is noted from the drain tank with the air box drain valves in normal position, the source of the air box accumulation should be investigated.

SERVICE DATA

CRANKCASE AND OIL PAN

SPECIFICATIONS

Upper liner pilot bore - New		12.091"
	Limit	12.104"
Lower liner pilot insert bore - New		10.377" - 10.382"
(installed in crankcase)	Limit	10.386"
Lower liner pilot bore in crankcase - New		11.062" - 11.065"
	Limit	11.068"
Main bearing bore with bearing caps installed and torqued to 650 ft-lbs.		
Diameter of bore - Max.		8.252"
	Min.	8.249"
Bore out-of-round - Limit		.005"
Bearing shell to crankshaft clearance (Each side above serrations at split line) - Min.		.015"

EQUIPMENT LIST

	Part No.
Crab stud thread protectors	8034600
Crab nut tap 1-3/4" - 12	8050688
Towels (bound-edge wiping towels)	8052752
Main bearing bolt thread die 1-1/4" - 12	8060349
Main bearing nut tap 1-1/4" - 12	8060387
Crab stud thread die 1-3/4" - 12	8067409
Hydraulic jack 10-ton	8078281
Main bearing nut offset ratchet wrench	8191591
Spray gun (for engine cleaning)	8193041
Main bearing nuts powerench set	8250854
Crab nut powerench set	8250855
Main bearing cap lifter	8252846
Lower insert application and removal tool	8275379
Press and puller assembly	8275380

CYLINDER HEAD AND ACCESSORIES

CYLINDER HEAD

DESCRIPTION

The cylinder head is installed in the engine as shown in Fig. 2-1. Crab bolt nuts and crabs contacting each cylinder head hold it securely to the cylinder head retainer in the crankcase. A cylinder head seat ring, Fig. 2-2, is installed between the cylinder head and retainer to take any wear that may occur. The head is secured to the cylinder liner by eight equally spaced studs and nuts, and the assembly is firmly held in the crankcase, by the crabs.

Correct positioning of the cylinder head is ensured by alignment of the water discharge elbow, Fig. 2-3, and its mating hole in the crankcase. A long siphon tube elbow is used on the last right bank and first left bank cylinder head to siphon the water from the water discharge manifold when the engine water is drained. All other cylinder heads use the short tube water discharge elbow.

The cylinder head is made of high strength cast iron alloy having special design cast passages for water and exhaust gases. Drilled water holes, Fig. 2-4, at the bottom of the cylinder head match the water discharge holes in the liner. Exhaust passages in the cylinder head line up with mating elbows in the crankcase, which conduct the exhaust gases through the water manifold to the exhaust manifold.

A well is located in the center of the cylinder head for application of the unit fuel injector. To ensure correct positioning of

Fig. 2-1 — Cylinder Head Installation

12541

Fig. 2-2 — Installing Seal Ring

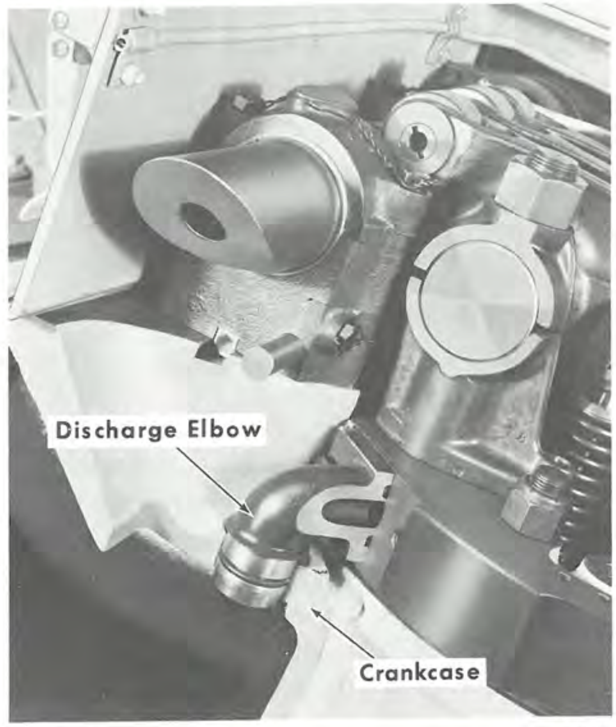
the injector in the head, a mating hole for the locating dowel on the injector is located in the head.

Fig. 2-5 shows the rocker arms, exhaust valves, valve bridges with springs, valve guides, overspeed trip pawl, fuel injector, and other related items making up a complete cylinder head assembly.

CYLINDER HEAD REMOVAL AND DISASSEMBLY

Engine cooling water system must be drained before attempting to remove the cylinder head. If the cylinder liner is to be removed, remove piston cooling pipe assembly and water jumper line before starting to remove cylinder head.

1. Remove cylinder test valve.



7258

Fig. 2-3 — Water Discharge Elbow

2. Remove rocker arms, rocker arm shaft, and valve bridges.
   a. Disconnect camshaft bearing to rocker arm oil line.
   b. Remove rocker arm shaft cap nuts and remove caps.
   c. Remove rocker arm assembly, being careful not to let shaft fall from rocker arms.
   d. Remove valve bridges.

12478 7262 5319

Fig. 2-4 — Cylinder Head

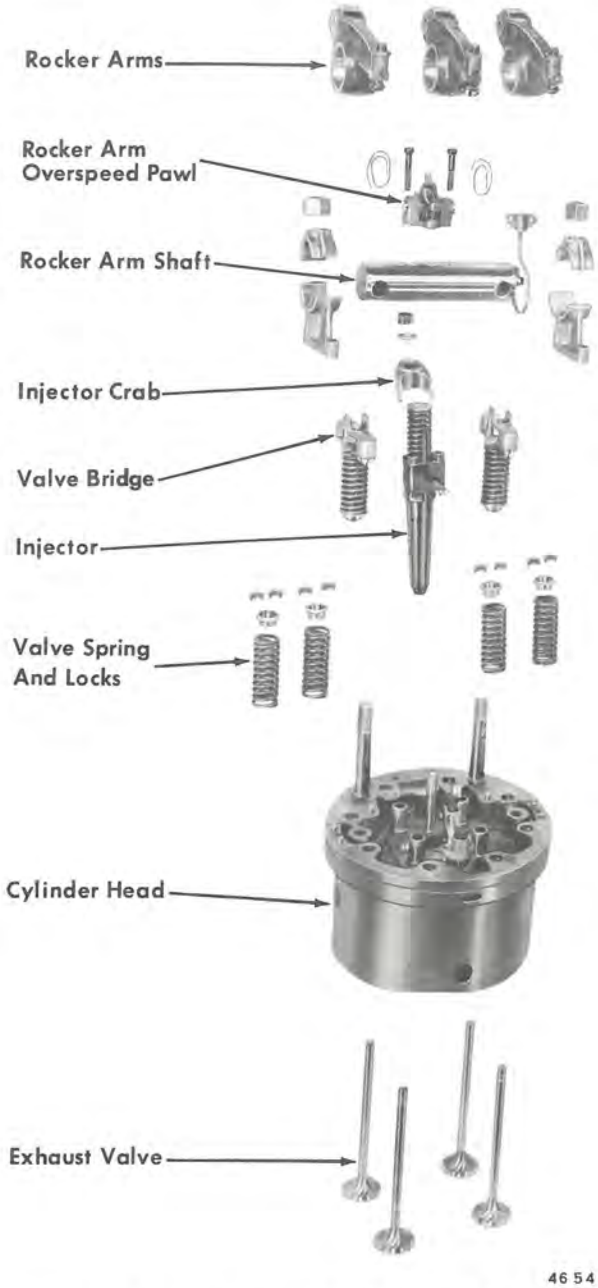


Fig. 2-5 — Complete Cylinder Head Assembly, Exploded View

3. Remove injector.

   a. Disconnect fuel oil lines from injector and fuel oil manifold.

   b. Remove adjustable injector link.

   c. Remove injector crab.

   d. Using a pry bar, Fig. 2-6, remove injector. Protect injector from dirt and damage by using a holding rack, or a shipping container.

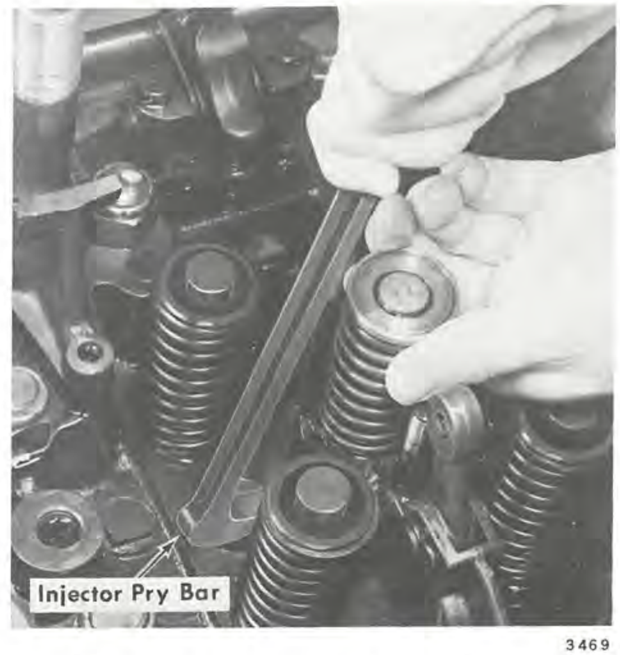


Fig. 2-6 — Removing Fuel Injector

4. Remove cylinder liner stud nuts and washers.

5. Remove crab nuts and crabs.

6. Place crab stud protector tubes over studs to protect threads.

7. Remove cylinder head, using a head removing fixture. Protect water outlet elbow. Place head in carrying basket to protect machined gasket seat surface from damage.

NOTE: Check the old cylinder head gasket for any indication of bulging on the diameter, as this is an indication of hydraulic lock due to liquid accumulation in the cylinder. In the event of a bulged gasket, the connecting rod should be thoroughly checked as it may be bent.

8. Remove cylinder head seat ring.

NOTE: Maintenance Facility Drawing, File 232, giving construction details on equipment for handling the cylinder head, liner, and piston and rod assembly is available upon request.

EXHAUST VALVE AND SPRING REMOVAL

Removal of the exhaust valves and spring assemblies completes the cylinder head disassembly.

1. As shown in Fig. 2-7, remove exhaust valve springs using single valve compressor and adapter screwed into the head, or the multiple valve compressor which compresses all four valve springs at the same time.
2. Compress the springs sufficiently to remove the valve locks and spring seats, and then remove the springs.

7291

SINGLE

8405

MULTIPLE

Fig. 2-7 — Compressing Valve Springs

3. After spring removal, the exhaust valves can be removed from the bottom of the head.

NOTE: Valve springs can be removed and replaced without removing the cylinder head from the engine. If this is done, the piston must be at top center to prevent the valves from falling into the cylinder when the valve locks are removed.

MAINTENANCE

Cleaning

1. Cylinder heads should be thoroughly cleaned after disassembly. Cleaning procedure should be in accord with accepted practice or as recommended by the supplier of cleaning material.
2. All loose material should be removed from the stud holes in the head using stud hole cleaner, Fig. 2-8.
3. Clean the cylinder test valve threads using a standard 1/2" pipe thread tap.

10281

Fig. 2-8 — Cleaning Stud Holes

Inspection

Inspect the cylinder head for cracks using the Magnaflux procedure outlined in Maintenance Instruction 1754. If satisfactory, proceed with the following service operations on the cylinder head.

Grinding Valve Seats

Either a 115-volt or 230-volt valve seat reconditioning tool set may be used in grinding the exhaust valve seats. Valve measurement points are shown in Fig. 2-9.

1. Dress grinding wheel before using on each cylinder head. Mount as in Fig. 2-10. Wipe pilot with oil-soaked cloth for lubrication. Do not get oil on the grinding wheel. Adjust the spiral sleeve on the dressing tool until the wheel touches the diamond. Make final adjustment with diamond adjusting screw. Holder and grinding wheel are then revolved with the high speed driver which should be held as straight as possible. Move the diamond steadily across the wheel, taking light cuts. Keep grinding wheel properly dressed for fast grinding, seat accuracy, and a smooth finish.

2. Using a valve guide cleaner and a 115-volt or 230-volt drill, clean guide as shown in Fig. 2-11. Any evidence of galling inside of guide must be entirely removed by reaming, or the guide should be replaced. The I.D. of the

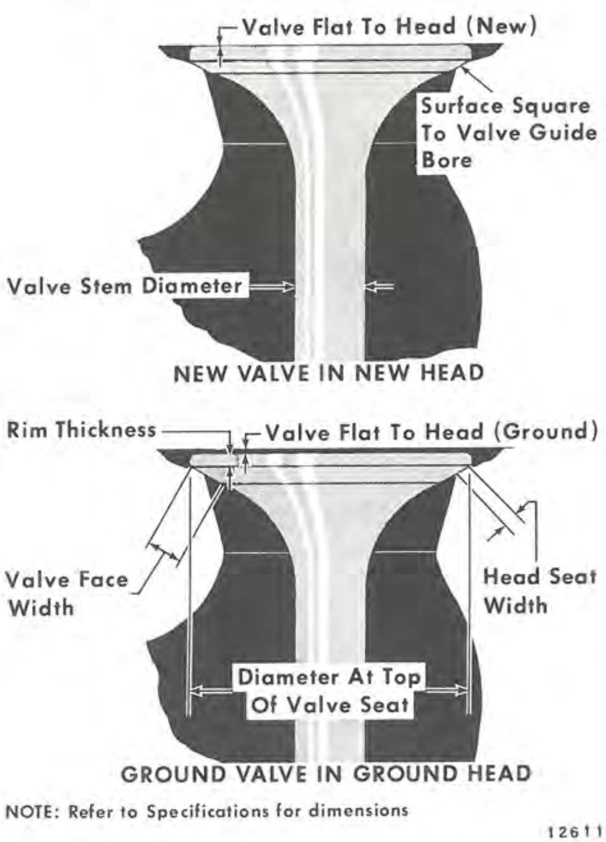


Fig. 2-9 — Valve Measurement Points

Fig. 2-10 — Dressing Valve Seat Grinding Wheel

Fig. 2-11 — Cleaning Valve Guide

guide should not exceed the limit when measured 1/2" from top and bottom.

3. Select a tapered pilot which will bring the shoulder on the pilot above the valve guide. Press pilot firmly into guide, using pin. Wipe pilot with an oily cloth.

A fixture, Fig. 2-12, is available for checking tapered pilots. To ensure satisfactory results, pilot runout should not exceed .0005".

4. Ream inside and outside of valve seat to dimensions listed in Specifications.

Fig. 2-12 — Tapered Pilot Checking Fixture

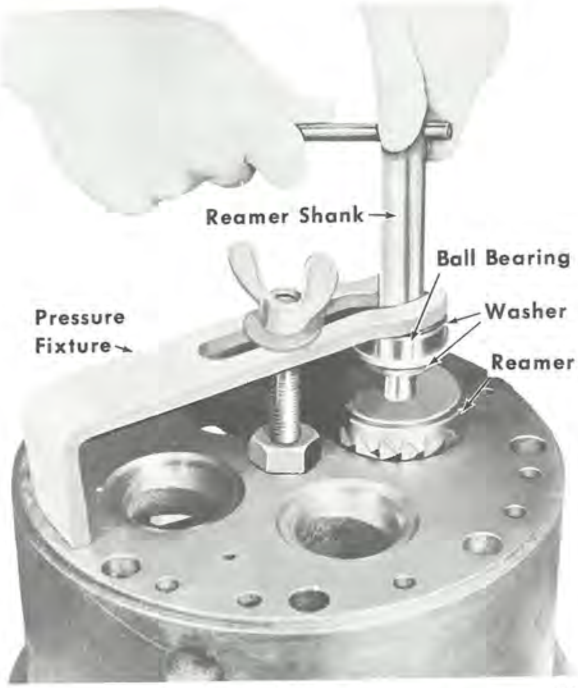


Fig. 2-13 — Reaming Valve Seat

Use a reamer pressure fixture, Fig. 2-13, to apply an even, adjustable pressure on the reamer. First, use an inside reamer to ream clearance inside of valve seat. Then use an outside reamer until the top outside of the valve seat is narrowed to the proper width. After completion of reaming operations, blow out cuttings with air hose and wipe parts clean.

5. Place grinding wheel holder with wheel over pilot. Insert abrasive cloth between the grinding wheel and valve seat, and clean seat by turning holder by hand. Remove abrasive cloth and proceed to grind with driving motor, as shown in Fig. 2-14. No pressure is required when grinding and the driving motor should be run at top speed. Hold driving motor as straight as possible and grind until valve seat is true. Raise grinding wheel off seat before stopping motor.

6. Check valve seat width. If over limit, ream with outside reamer, then grind lightly to remove any raised edge caused by reamer.

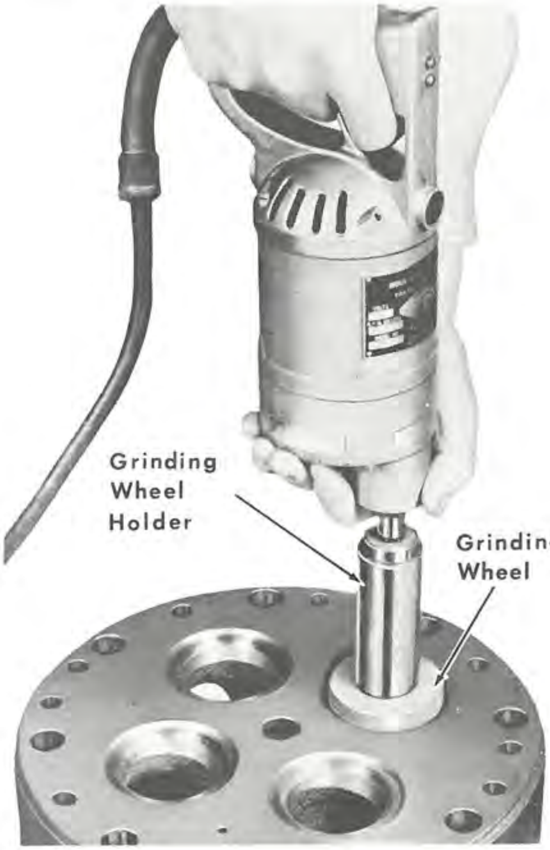


Fig. 2-14 — Grinding Valve Seat

7. Use dial indicator included in the valve seat reconditioning set to measure trueness of valve seat. Place indicator over pilot, Fig. 2-15, and adjust so indicator is depressed slightly and ball of valve seat rider is at the center of the valve seat. Rotate valve seat rider and observe indicator reading. Valve seat out-of-round will be indicated on dial. Indicator reading must not exceed the limit. An attempt should be made to obtain a perfect valve seat, since it is a very important factor in valve life.

Valve Guides

Cast iron valve guides treated with a nitriding process for longer wear are used in the cylinder heads. Nitride treated guides can be identified by the radius at the top of the valve guide, and a satin-like appearance. The valve guides are a press

Fig. 2-15 — Checking Valve Seat Roundness

fit in the cylinder head and can be pressed in or out without damage by using valve guide installing or removing tool. Although the valve guides are precision guides and generally do not require reaming after assembly, it is recommended that a .626" reamer or plug gauge be inserted after guide installation to ensure the minimum diameter.

EXHAUST VALVES

DESCRIPTION

The exhaust valves, Fig. 2-16, are the long stem design, having an extended stem end above the single valve lock groove. Single bead valve locks, having extended length, hold the valve in a tapered spring seat. Precision type valve guides provided with ample length, ensure excellent valve operation. Valve design together with heat resistant materials used in valve manufacture ensure a long service life.

MAINTENANCE

When exhaust valves are removed, they must be handled carefully to avoid nicks and scuffs that might make the valve unfit for use. Piling valves on top of each other may cause nicks on the outside diameter or throat radius and these can lead to valve failure. Before the valves can be reused, they must be reconditioned within the dimensional limits listed in the Specifications at the end of this section, and should meet the following visual inspection to ensure continued trouble-free service.

Cleaning

Thoroughly clean the exhaust valves using a suitable solvent to remove the carbonaceous material. If necessary, after drying, the valves may be given a finish cleaning using a soft wire brush.

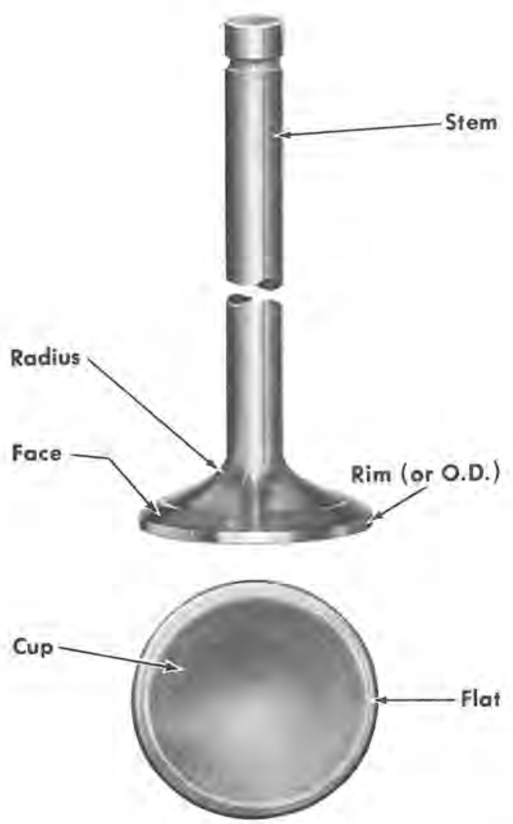


Fig. 2-16 — Exhaust Valve

Inspection

In the inspections listed herein, "acceptable" indications are those which will permit valve reuse, and "rejectable" indications are those which are cause for scrapping the valve. The valve surfaces referred to are identified in Fig. 2-16.

1. Acceptable Indications

   a. Light pitting on the valve face that can be cleaned up within the maximum allowable valve face limit.

   b. Lightly scuffed valve stems which can be reconditioned by buffing.

   c. Extremely light wear in lock groove.

2. Rejectable Conditions

   a. Indications found in the cup area, Fig. 2-17, are defects which reject a valve.

   b. Any cracks found on the outside diameter or rim section of the valve, Fig. 2-18, are cause for rejection.

   Such rim cracks are often difficult to see, but should be carefully watched for since they eventually lead to failure. They usually extend some distance into the valve face.

   The face area, Fig. 2-18, is the critical area of the valve. Grinding cracks, channeling, and thermal cracks are cause for valve rejection. It is recommended that this examination be made with the aid of a 3x magnifying glass.

   c. Reject and discard valves that may have been damaged to the extent that critical surfaces have been nicked or scuffed.

Fig. 2-17 — Cup Defects

Grinding Valves

For grinding valves, follow instructions supplied with the 115 or 230-volt grinder. A complete listing of the equipment required for the machines is contained in the Service Tool Catalog.

Exhaust Valve Installation.

After the exhaust valves have been reconditioned, they are applied to the reconditioned cylinder head.

Position the head properly and complete the assembly of valve springs, spring seats, and valve locks.

Valve Springs

1. The valve springs and valve bridge springs should be inspected, before installation, for any nicks or unusual wear. Valve springs should be cleaned with a suitable solvent and a soft wire brush. Do not hydro blast or grit blast. Valve springs should be protected so as to prevent rusting.
2. Minimum free length of the valve spring is 3-31/32". New valve springs are approximately 4-1/8" long (free length). With the spring applied and the valve closed, spring length is 3-3/8" and with the valve open 2-11/16". Pressure required to compress the spring to 2-11/16" dimension should be 213 to 225 pounds with a new spring, while a used spring should require at least 175 pounds to compress it to the 2-11/16" dimension. The spring should not show any set after being compressed with the coils touching.
3. Valve spring seats should be clean and smooth and the thickness of the spring seating surface should not be less than the minimum limit.

Fig. 2-18 — Face And Rim Defects

Valve Locks

1. Valve spring seat locks, Fig. 2-19, are single bead type to fit the single groove valves used. The valve locks may either be the smooth top type or the grooved top type. Lock halves used on the same valve may be either smooth or grooved top as locks are interchangeable.

Fig. 2-19 — Valve Spring Seat Locks

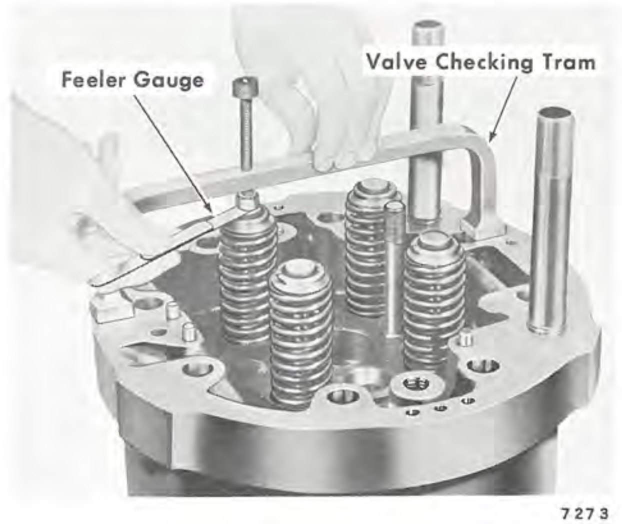


Fig. 2-20 — Checking Height Of Valve Stems

2. Examine the valve locks for signs of excessive wear on the upper portion of the bead and for evidence of excessive fretting in the ground diameter which engages the valve stem. If these conditions exist, the locks should be replaced.

Checking Valve Stem Height

After reconditioning valves and valve seats, the height of the valve stems above the cylinder head must be checked. This is done with the use of the valve checking tram as shown in Fig. 2-20. Clean off bottom feet of tram, and that portion of cylinder head on which tram rests. Hold tram down firmly on cylinder head and with use of feeler gauge and screw, determine the difference in valve stem heights. The difference between valve stems under the same bridge should not vary more than 1/16". If the difference varies more than 1/16", the high valve should be replaced or the low valve ground in, provided this does not exceed the limits. End of valve should not be ground off as tip is hardened.

Testing Valve Seats

To check valve seat seal, assemble valves and springs in cylinder head and place head in an angular position resting on the rocker arm studs, with the valve seats up. Be sure that the bottom of the head is clean.

Valve seat seal tester, Fig. 2-21, is used to test the valve seat seal. Apply soap or a suitable lubricant to the concave surface

Fig. 2-21 — Testing Valve Seat Seal

of the tester vacuum cup and attach to cylinder head, carefully covering one valve. Be sure seal is not formed on the head of the valve, thereby testing the cup portion of the valve instead of the seat. Place tester with the handle in the 6 o'clock position, so tester will fall off readily when vacuum is depleted. If the tester falls off in less than three minutes, the valve seating is defective and the head seat and/or valve face must be reworked. To remove the tester, open the trigger valve. Check the valve seat seal tester occasionally by applying it to a vertical piece of glass, as the release valve or rubber cup may become defective. New vacuum cups are available.

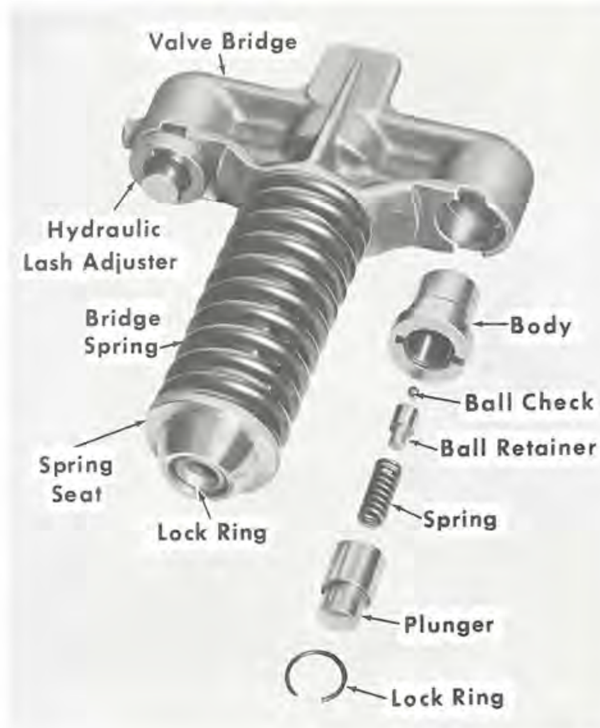
VALVE BRIDGE AND HYDRAULIC LASH ADJUSTER

DESCRIPTION

The valve bridge operates two exhaust valves from one rocker arm. A spring and spring seat are held on the valve bridge stem by a lock ring. The spring seat rests in a socket in the cylinder head and the spring applies pressure so that the valve bridges will stay in contact with the rocker arm.

The hydraulic lash adjuster maintains zero lash between the end of the valve stem and the valve bridge. The assembly consists of a body, plunger, spring, ball check, and ball check retainer. A lock ring retains parts within the body as shown in Fig. 2-22.

Lube oil flows from the rocker arm through a drilled passage in the valve bridge to the top of the lash adjuster, past the ball check and into the body. When the rocker arm depresses the valve bridge, a slight movement of the plunger in the lash adjuster seats the ball check, trapping the oil. Since the oil is practically incompressible, further movement of the rocker arm causes the lash adjuster plunger to force open the exhaust valve.



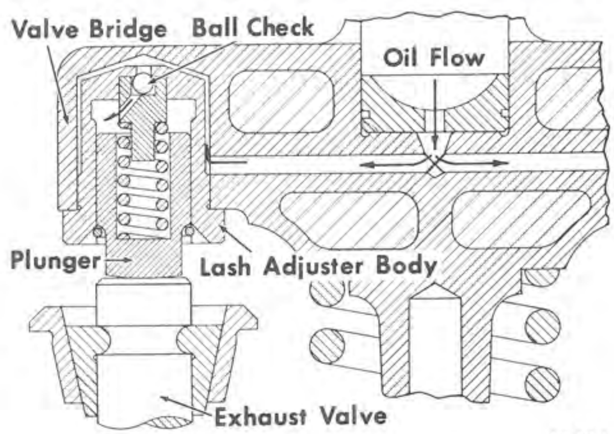


Fig. 2-22 — Valve Bridge And Hydraulic Lash Adjuster

MAINTENANCE

Clean valve bridge and lash adjuster assembly with solvent. Inspect for wear or damage. Rework as described in the following paragraphs.

VALVE BRIDGE

Remove and install valve bridge springs and spring seats.

1. Mount valve bridge spring compressor in vise, Fig. 2-23.

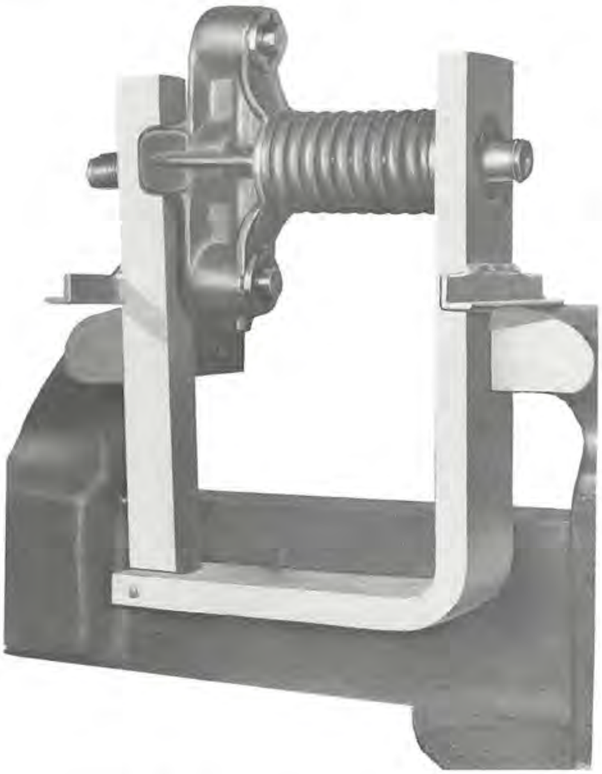


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Fig. 2-23 — Compressing Valve Bridge Spring

3478

Fig. 2-24 — Removing Hydraulic Lash Adjuster

2. Install valve bridge in compressor, compress spring, remove lock ring, and remove spring seat and spring.
3. Install new spring and/or spring seat and replace lock ring using lock ring guide.

LASH ADJUSTER

NOTE: Inoperative lash adjusters are noisy and can be located while engine is running at idle by their sharp tapping. To correct this condition, remove lash adjuster and clean or replace parts, as necessary. (Noise, caused by cold oil, may be noticed at times with good adjusters when first starting an engine.)

1. To remove lash adjuster assembly, clamp valve bridge in vise, as shown in Fig. 2-24, and use lash adjuster puller. Pulling arm is used with puller for removing long travel lash adjuster.

3816

Fig. 2-25 — Installing Lash Adjuster

2. To install lash adjuster assembly, use installer tool as shown in Fig. 2-25.
3. Internal parts of the lash adjuster can be removed for cleaning or replacement and reinstalled without removing lash adjuster body from valve bridge. Use installer tool with plug to compress the lash adjuster plunger, and remove the lock ring as shown in Fig. 2-26, using lock ring remover. However, proper reconditioning and testing can only be done if the lash adjusters

are completely removed from the bridge. They can then be disassembled, cleaned, inspected, reassembled, and qualified.

Disassembly

1. Disassemble the lash adjusters taking care not to damage the machined surfaces on the inside diameter of the body or the outside diameter of the plunger.
2. When the lash adjuster is disassembled, the spring and ball check should be replaced with new parts.

Cleaning

1. Lash adjuster parts may be cleaned using fuel oil. Lacquer deposits can be removed with alcohol, lacquer thinner, or other suitable solvent. Completely remove any dirt, lacquer, or metal particles.
2. Do not buff the outside or inside diameter of the body, the outside diameter of the plunger, or the spherical radius on the tip of the plunger.

Inspection

1. Inspect the body for scores, scratches, or galled areas on the machined outside diameter, and replace if any are found.
2. Inspect the plunger also for scores, scratches, or galling on the outside diameter, and replace if evidenced. Also, inspect the plunger tip, and if the contact point is worn flat more than .250" in diameter, the plunger should be replaced.
3. Inspect the ball retainer .166" diameter counterbore depth at the center of the ball depression. Replace the ball retainer if the depth is greater than .143".

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Fig. 2-26 — Removing Lock Ring

Assembly

The lash adjuster should be assembled in a clean area, as it must be free of dirt, lint, and metal particles.

Qualifying Lash Adjusters

It is recommended that lash adjuster test stand, Fig. 2-27, be used to qualify the lash adjusters for use in the engine. This test stand automatically measures the time required for the lash adjuster plunger to travel through .060" while it is subjected to a 30-pound ram load, and rotated about 10 RPM relative to the lash adjuster body.

A gauge block and oil loading tool, Fig. 2-27, are supplied with the stand. The gauge block is used to check and adjust

Gauge Block Application

Lash Adjuster In Position

Fig. 2-27 — Lash Adjuster Test Stand

the tripping point of the microswitches, if necessary, to ensure that the leak down time is measured over exactly .060" travel of the lash adjuster plunger. The oil loading tool is used to charge the lash adjuster with oil and bleed off any air which might cause incorrect leak down time intervals.

It is essential that only Electro-Motive hydraulic lash adjuster test oil be used in conjunction with this test stand since the operation of the test stand and limits governing the lash adjuster are based on the use of this oil.

1. Test Stand Operation

   The .060" travel of the ram starts when the tip of the ram is .375" from the top of the rotating cup. This starting point should be checked with the .375" gauge block supplied with the test stand, and it should be checked often enough to be sure it has not changed. This check is to be made by placing the gauge block on top of the rotating cup with the step facing up, and then lowering the ram by turning the ram release. The time clock on the test stand should start the very moment the ram load contacts the gauge block. If the timer does not start, or starts too soon, the ram should be readjusted. This is done by loosening the ram lock nut, turning the ram tip up or down to the proper adjustment, and retightening the lock nut. The time clock start and stop microswitches are permanently set so that the time for the .060" travel is automatically recorded on the time clock. (If a microswitch has to be replaced, the .060" between microswitch positions should be set by inverting the gauge block which has a .060" step on it.)

2. Test Procedure

   a. Place the lash adjuster assembly in oil loading tool and immerse it into a container of lash adjuster test oil that is deep enough for the hole in the lash adjuster to be well below the oil level.

   b. Completely depress the lash adjuster plunger at least 10 times to ensure that any air trapped inside is pumped out.

   c. Retract the spring-loaded plunger in the oil loading tool and allow the ball check to seat in the lash adjuster. Try to depress the lash adjuster plunger two or three more times to ensure that the ball check is seating. The assembly should feel firm, without any "give" to it.

d. Take the lash adjuster out of the test oil and remove the oil loading tool being careful that the spring-loaded plunger does not unseat the ball check. Wipe the excess oil off the lash adjuster and place it in the rotating cup on the test stand.

e. Turn the switch on to rotate the cup. Lower the ram until it rests on the lash adjuster plunger and release handle so that the plunger carries the full 30-pound load.

NOTE: Be sure the lash adjuster body is rotating around the plunger.

f. The time for .060" travel (leak down time) will be automatically recorded on the time clock. The "leak down time" should be within limits of seven seconds minimum and 40 seconds maximum, based on a normal temperature of 75° F. for the oil and lash adjuster. If the temperature of the oil and the lash adjuster is other than 75° F., the limits should be determined by the following Table 1.

TABLE 1

Oil and Lash Adjusters Temp. ° F.	Min. Leak Down Time Seconds	Max. Leak Down Time Seconds
60	12.8	70.6
65	10.2	54.8
70	8.4	45.2
75 (Base)	7	40.0
80	6	36.0
85	5	32.6
90	4.2	30.2
95	3.6	28.4
100	3.2	27.8

The temperature of the test oil and lash adjuster should be allowed to become stable before leak down checks are made. If a lash adjuster fails to pass the minimum "leak down time," it should be refilled and retested to be sure that the failure was not due to air trapped in the lash adjuster.

ROCKER ARM ASSEMBLY

DESCRIPTION

Three rocker arms, Fig. 2-28, are mounted on the cylinder head. Two rocker arms actuate the four exhaust valves, the third operates the injector. The rocker arms are operated directly by the camshaft through a cam follower roller mounted at the fork end of each rocker arm. The opposite end of each rocker arm has an adjusting screw and lock nut for setting the injector timing and adjusting the hydraulic lash adjusters. The injector rocker arm, although similar in appearance to the exhaust rocker arm, is stronger than the exhaust rocker arm, and can be identified by the yoke at the cam follower end which is square-shaped on the injector rocker arm, but V-shaped on the exhaust rocker arm. Also, only the injector rocker arm has the machined notch for the overspeed trip. Injector and exhaust rocker arms are not interchangeable.

An oil jumper line from the camshaft bearing carries oil to the rocker arms through drilled passages in the rocker arm shaft. Rocker arms are drilled to supply oil to the valve bridges, lash adjusters, and to the cam follower.

MAINTENANCE

1. Inspect the rocker arm bushings, cam follower rollers, inner race, Fig. 2-29,

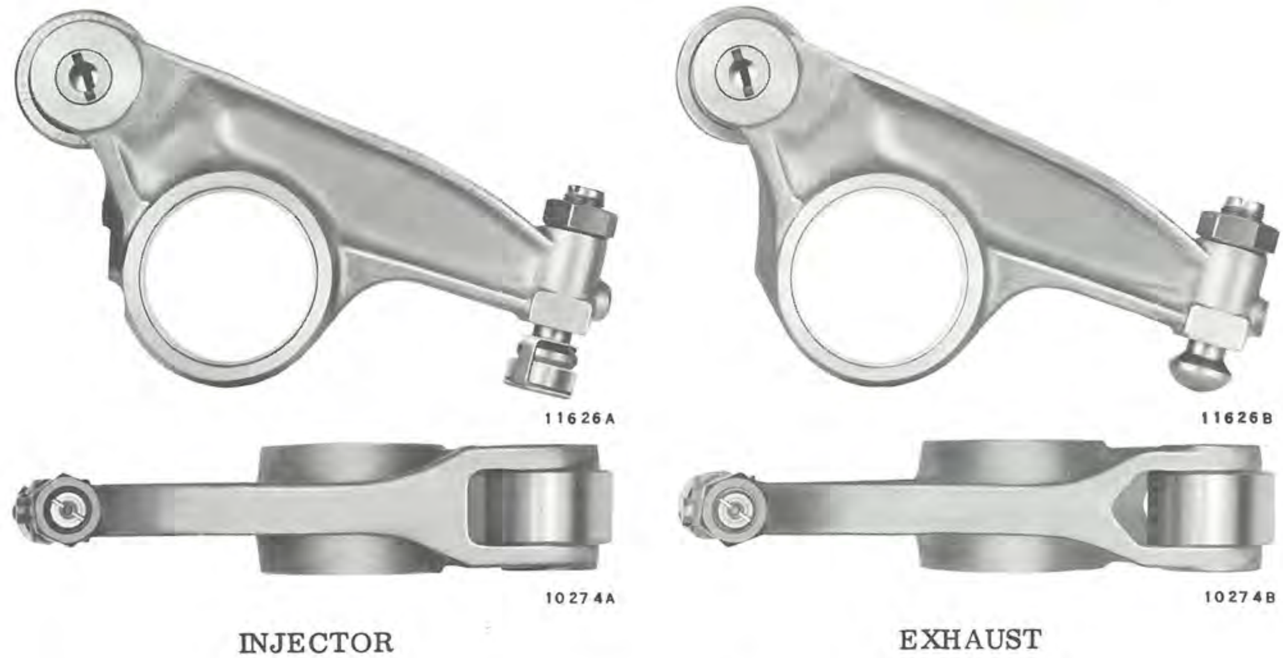

Fig. 2-28 — Rocker Arms

and rocker arm shaft for evidence of heat discoloration, excessive wear, shelling or scuffing due to lack of lubrication, and for fatigue cracks.

2. Check all oil holes to make certain that they are clean.

3. All adjusting screws should be checked for hand-free operation and any galling on the ball end.

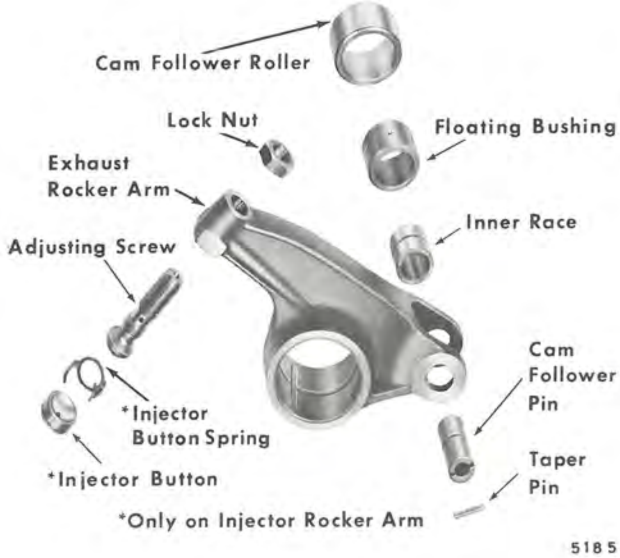

Fig. 2-29 — Rocker Arm, Exploded View

4. All adjusting screw buttons should be visually checked for galling or cracking.

CYLINDER TEST VALVE

DESCRIPTION

The cylinder test valve consists of a body, needle valve, packing nut, and seal. This assembly is inserted in a housing within the crankcase and screwed into the cylinder head, Fig. 2-30.

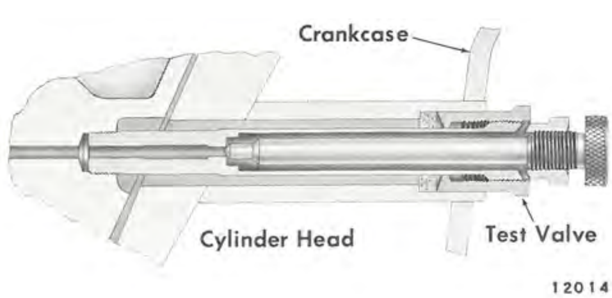

Fig. 2-30 — Cylinder Test Valve

Cylinder test valves are provided on the engine at each cylinder. At any time maintenance or inspection is performed, the valves are opened to relieve compression, thus reducing the effort required to rotate the crankshaft. A cylinder test valve wrench, Fig. 2-31, is used to open and close the valves.

MAINTENANCE

1. If the cylinder test valve leaks with normal tightening, remove the assembly from the engine and ream the valve seat, as shown in Fig. 2-32.

2. If reaming will not correct the leaking due to a scored or damaged valve stem face, it should be reconditioned within the limits shown in Fig. 2-33. Reharden the tip to a depth of .005"-.010".

3. The cylinder test valve body may be reworked to the dimensions shown in Fig. 2-33. Use reamer to recondition the valve seat. If necessary to exceed the 1/4" maximum diameter of valve seat, Fig. 2-33, recut bottom of 1/2" diameter counterbore and reface hexagon end to hold the 6-1/16" nominal dimension.


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Fig. 2-31 — Test Valve Wrench

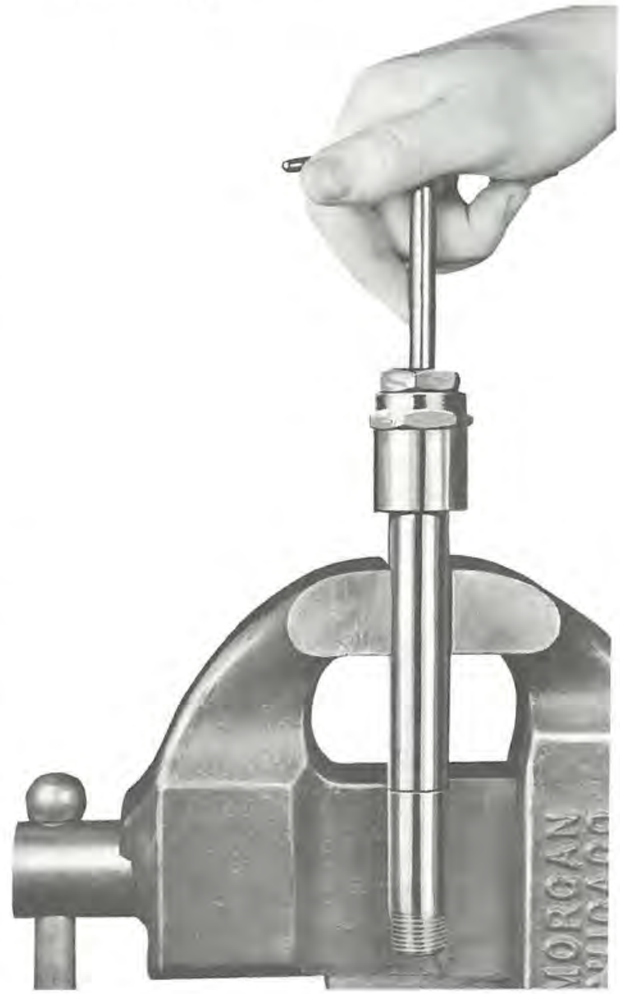

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Fig. 2-32 — Reaming Test Valve Seat

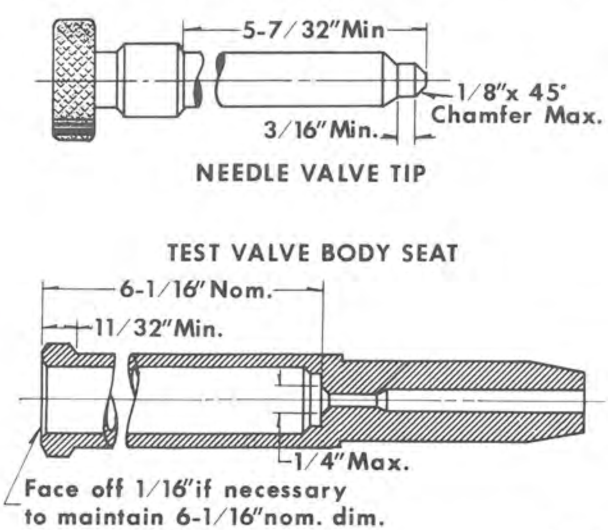

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Fig. 2-33 — Test Valve Reconditioning Limits

4. After reconditioning, air test the valve assembly at 90 psi air pressure.

CYLINDER HEAD INSTALLATION

PREPARATION

Before installing the cylinder head, be sure that the retainer inner surface and exhaust elbow in the crankcase are clean.

Examine the cylinder head to ensure that it is clean internally, and in particular that the bottom surface is clean and free of dirt, nicks, or scratches which would cause water seal or gasket leakage. Clean the liner stud holes, Fig. 2-8. If stud hole cleaner is not available, a wire brush can be used to remove rust, scale, or dirt from these holes. It is recommended that just prior to installation of any cylinder head, a small quantity of green soap be applied to the bottom of all water and stud holes to prevent dirt dropping on the water seals or cylinder head gasket surface during installation of the head.

Liner stud nuts should be examined and discarded when bottom of nut or threads are galled, or insert area cracked, torn, or frayed. Inspect cylinder head nut washers for damaged surface or warped condition, and replace if required.

The copper clad steel liner-to-head gasket is installed with the two notched holes in the gasket placed over the liner pilot stud and the stud to the left of the pilot. Examine counterbore in liner water holes to be sure these areas are free of dirt and nicks that would damage the water seals.

Install new seal rings in clean grooves of water discharge elbow. Clean flange surface on cylinder head for the elbow and apply elbow to head. Torque value of elbow to head socket-head screws is 30 ft-lbs. The discharge water elbow also serves to position the cylinder head in the crankcase. The elbow may be removed to change seals, if necessary, and reapplied with the head installed after removal of the crab above it, otherwise the cylinder head installation need not be disturbed. A thin shim used between the elbow flange and cylinder head, to hold the seal in place, aids in elbow application when the cylinder head is in place. It is important that the last cylinder head of the right bank (No. 8) and the first cylinder head of the left bank (No. 9) have a siphon tube water discharge elbow to permit water drainage from the discharge manifold when draining the engine cooling water.

INSTALLATION

1. Check cylinder head seat ring to be sure thickness and wear step conform to limits listed in the Specifications. Apply cylinder head seat ring to top of retainer. Lower head into position slowly. Line up water discharge elbow with mating hole in crankcase.

2. Apply cylinder liner stud nuts and tighten snugly. Use lube oil or a lubricant having specifications similar to Texaco Stud Lube #921 on threads and bottom of nuts. At this initial tightening, apply only 75 ft-lbs torque.

3. Apply crabs and crab nuts. Use a lubricant on the threads as in Step 2 above. Pull crab nuts down snugly.

4. Tighten liner stud nuts in proper sequence, Fig. 2-34, to a torque of 200 ft-lbs $\pm$ 5%.

5. Tighten crab nuts alternately forming the letter "X", and in two passes, half torque each pass. A powerench which has a mechanical ratio of 12:1 may be

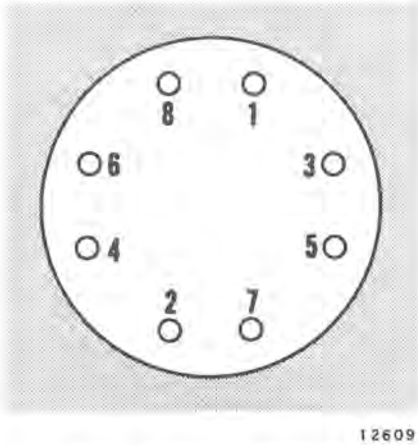

Fig. 2-34 — Stud Nut Tightening Sequence

used. A socket, box wrench, and a 60" extension can also be used. Torque value for the crab nuts is 1800 $\pm$ 90 ft-lbs.

6. Install injector. Connect fuel oil lines and adjustable link. Injector crab nut torque value is 40-50 ft-lbs. (Time injector as described in Fuel Oil System, Section 10.)

7. Install valve bridges (with protruding boss toward camshaft for uniform assembly), rocker arms, and lube oil lines. Set the valves as described in the next procedure, "Adjusting Hydraulic Lash Adjusters."

8. Install cylinder test valves.

9. If the liner water inlet line and piston cooling oil pipe were removed, clean the piston cooling oil pipe with the cleaning tool and apply to engine. Check alignment in piston carrier with "P" pipe gauge.

10. After assembly is installed, everything tightened properly, adjustments set, and engine is ready to run, start engine and raise water temperature to 170° F. After running, shut down the engine, recheck torque on crabs and liner stud nuts, and inspect condition of assemblies.

NOTE: When liner and crab nuts are being retightened, those which move at LESS than the specified torque values, should be tightened to the proper torque value. Those nuts which do not move below or up to the proper values, should be CHECKED by pulling up to a value not exceeding 10% more than the recommended torque. Special offset box socket wrenches used with a standard torque wrench are available to tighten inaccessible cylinder head nuts under installed rocker arms.

ADJUSTING HYDRAULIC LASH ADJUSTERS

Application of properly operating lash adjusters, correct setting, and subsequent inspection at regular maintenance intervals is very important to valve operation. Improperly set or defective lash adjusters cause the exhaust valves to be subjected to increased stress which leads to ultimate failure and probable damage to the engine.

After complete cylinder head assembly has been installed, the lash adjusters must be set.

1. Rotate crankshaft so that piston is at or near top center of the cylinder being set.

2. Loosen rocker arm adjusting screw locknuts.

3. Turn rocker arm adjusting screw down until the last valve just touches the hydraulic lash adjuster plunger, or use a .001" shim between valve tip and

adjuster plunger, and then turn it down 1-1/2 turns.

4. Check valve bridge spherical seat to be sure that it is spring-loaded against the cylinder head spherical seat. If the bridge spring spherical seat is not spring-loaded against the cylinder head spherical seat, turn down the rocker arm adjusting screw until no movement is felt, and then turn it another 1/4 turn.

5. Tighten rocker arm adjusting screw locknut.

6. After running the engine for two or three minutes, or after first squeezing oil out of lash adjuster by forcing down the rocker arm, check the clearance between lash adjuster bodies and the end of the valve stems with the piston near top center. If the clearance is less than minimum, the cylinder head should be removed for reconditioning or rejection. Use minimum clearance gauge, Fig. 2-35, to gauge clearance between lash adjuster and exhaust valve. This gauge is 1/16" thick and it should fit between lash adjuster body and valve stem top, to ensure the minimum clearance.

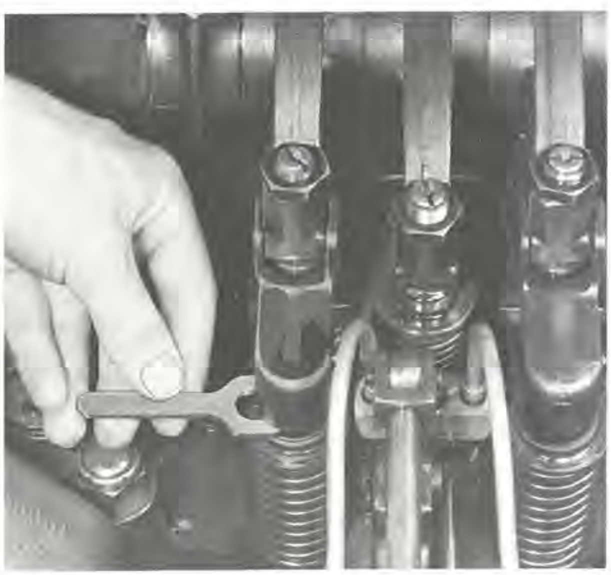

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Fig. 2-35 — Checking Lash Adjuster To Valve Clearance

TRACING A DEFECTIVE OR NOISY CYLINDER

A cylinder that is not firing properly will have a cooler exhaust stack, compared to one that is firing properly (engine at idle). This is caused by:

1. Badly leaking exhaust valves.
2. Defective injector.
3. Improper injector timing or control rack setting.
4. Dirty injector filter.
5. Air bound injector.
6. Excessive ring blow-by.
7. Cracked piston.

To determine if injector is at fault, disconnect injector adjustment link on the suspected cylinder and, with engine running at idle, push control rack open slowly and return to idle position as soon as observation has been made. If injector is operating properly a pronounced laboring of the cylinder will be detected.

Erratic injector operation can also be determined by making each cylinder injector inoperative, when the engine is running at idle speed, and noting any change in the operation of the engine. Injectors can be made inoperative by inserting a brass bar between the cam follower roller and the rocker arm, using the bar as a lever to lift the cam follower roller from contact with the camshaft.

An exhaust valve leak can be detected when standing outside the engineroom by a pronounced blow at the exhaust stack, with engine idling or with the layshaft lever held to reduce engine speed slightly below idle engine speed.

REPAIR OF DAMAGED SEATING SURFACES

It is permissible to rework cylinder heads which have damaged seating surfaces to the limits shown in Fig. 2-36.

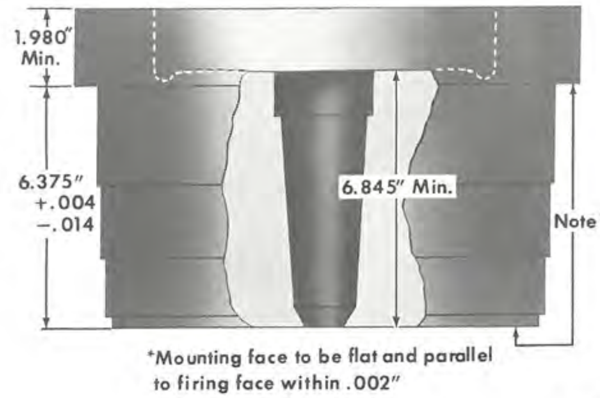

Fig. 2-36 — Rework Limits

SERVICE DATA

CYLINDER HEAD AND ACCESSORIES

SPECIFICATIONS

Exhaust Valves

Diameter of stem - New	.6215" - .6225"
Valve stem diameter - Limit	.6205"
Diameter of head	2-1/2"
Valve seat angle	30°
Valve seat out-of-round	.002"
Lift	.686"
Number per cylinder	4

Valve Springs

Free length (approximately) - New	4-1/8"
Min.	3-31/32"
Length - valve open	2-11/16"
Length - valve closed	3-3/8"
Pressure with valve open - New	213-225 lbs.
2-11/16" length - Min.	175 lbs.

Valve bridge spring - same as valve spring. Spring must not show any set after being compressed with coils touching.

Valve spring seat thickness - Min.	.145"

Rocker Arm

Rocker arm shaft diameter - Min.	2.246"
Rocker arm bushing inside diameter - Max.	2.254"
Press bushing to rocker arm	.002" - .004"
Inner race outside diameter - Min.	1.048"
Floating bushing inside diameter - Max.	1.055"
Floating bushing outside diameter - Min.	1.4435"
Cam follower roller inside diameter - Max.	1.4505"

Valve Guide

Inside diameter (Not installed) - New	.627" - .630"
(Installed in head) - Min.	.626"
Limit (1/2" from bottom and top)	.632"
Valve stem to guide clearance - Limit	.010"
Press fit in head	.0005" - .002"

Cylinder Head Seat Ring

Thickness standard - New	.190" - .194"
Minimum thickness	.184"
Uniform thickness within	.002"
Maximum wear step	.003"

Lash Adjuster

Lash adjuster body and end of valve stem (piston near TDC) - Min.	1/16"

EQUIPMENT LIST

	Part No.
Test Valve Wrench	8032587
Valve Spring Compressor (single)	8033783
Adapter (use with 8033783)	8034054
Box Socket Wrench	8034085
Crab Stud Protector Tubes	8034600
Valve Seat Reconditioning Tool Set (115 volt)	8035775
Injector Removing Pry Bar	8041183
Valve Seat Reconditioning Tool Set (220 volt)	8041445
Valve Checking Tram	8042773
Electric Drill, 1/4" (115 volt)	8045450
Cylinder Head Carrying Basket	8060247
Electric Drill, 1/4" (230 volt)	8062140
Cylinder Test Valve Seat Reamer	8064804
Crab Nut Socket	8065580
Lash Adjuster Puller	8070866
Valve Bridge Spring Compressor	8070883
Valve Bridge Lock Ring Guide	8070903
Piston Cooling Pipe Gauge	8071720
Lash Adjuster Installer	8072927
Cylinder Head Removing Fixture	8075894
Lock Ring Remover - Lash Adjuster	8080632
Crab Nut Box Wrench Handle - 60"	8084091
Piston Cooling Pipe Cleaning Tool	8087086
Lash Adjuster Minimum Clearance Gauge	8107788
Valve Guide Cleaner	8141439
Lash Adjuster Pulling Arm (long travel adjusters)	8154408
Injector Holding Rack	8159228
Tapered Pilot Checking Fixture	8173996
Valve Seat Reamer (inside)	8192191
Pressure Fixture - Valve Seat Reamer	8194884
Cylinder Head Stud Hole Cleaner	8211907
Valve Seat Seal Tester	8213518
Vacuum Cup (spare for 8213518)	8213519
Valve Grinder (115 volt)	8218405
Valve Grinder (230 volt)	8218998
Valve Guide Installer - Remover	8224241
Valve Seat Reamer (outside)	8227358
Valve Spring Compresser (multiple)	8239430
Crab Nut Powerench	8250885
Lash Adjuster Test Stand	8267432

PISTON ASSEMBLY AND CONNECTING RODS

PISTON ASSEMBLY

DESCRIPTION

The piston assembly, Fig. 3-1, consists of a cast iron alloy piston, four compression rings, and two oil control rings. The piston is identified by a "T-4" cast inside the piston wall. A "trunnion" type piston carrier, Fig. 3-2, is used with the piston assembly to allow the piston to rotate or "float" during engine operation. The carrier supports the piston at the internal piston platform. A thrust washer, Fig. 3-2, is used between the platform and the carrier. The carrier is held in position in the piston by a snap ring inside the piston as shown in Fig. 3-3. Oil taken up by the two oil control rings passes through the three rows of oil holes in the piston.

The piston carrier has a circular boss located centrally on its upper platform which pilots in a bore in the center of the piston platform, and also pilots in the piston at the bottom outside diameter of the carrier. A bearing insert, Fig. 3-4, is applied in a broached slot in the carrier. Tangs at each end of the bearing insert are bent into a counterbore on the carrier to prevent endwise movement. The bearing insert is steel backed, about .150" thick having a .010"-.015" thick silver plated surface and an overlay of lead .0003"-.0006" thick. The highly polished piston pin, Fig. 3-4, is applied in the carrier in contact with the bearing insert, and the assembly is bolted to the upper end of the connecting rod, as shown in Fig. 3-3.

Fig. 3-1 — Piston Assembly

Fig. 3-2 — Piston Carrier And Thrust Washer

Internal parts of the piston are lubricated and cooled by the piston cooling oil. Cooling oil is directed through a drilled passage in the piston carrier, circulates about the piston crown area, and then drains through two 5/8" holes in the carrier located at the taper as shown in Fig. 3-4.

Pistons are given a phosphate treatment to aid skirt lubrication during engine operation. This process etches the surface and produces a non-metallic, oil absorbent, antifriction coating that promotes rapid break-in and reduces subsequent wear. Information on piston treatment is given in Maintenance Instruction 1758.

The piston pin, Fig. 3-4, is made of steel alloy material, with the outer surface carburized, ground, lapped, and polished to a mirror finish. The pin is mounted in the concave "saddle" at the top of the connecting rod and oscillates in the bearing insert in the carrier. Two 7/8" bolts, each provided with a non-removable spacer, pass through the upper end of the connecting rod and screw into the piston pin. These bolts are tightened to 450 ft-lbs torque and lockwired.

INSPECTION

Piston and connecting rod assemblies can be inspected while installed in an engine provided the engine is shut down and the air box and oil pan inspection covers are removed.

Precautions should be taken before proceeding to prevent the engine from being started.

Open all cylinder test valves to facilitate rotation of the crankshaft, using the turning jack.

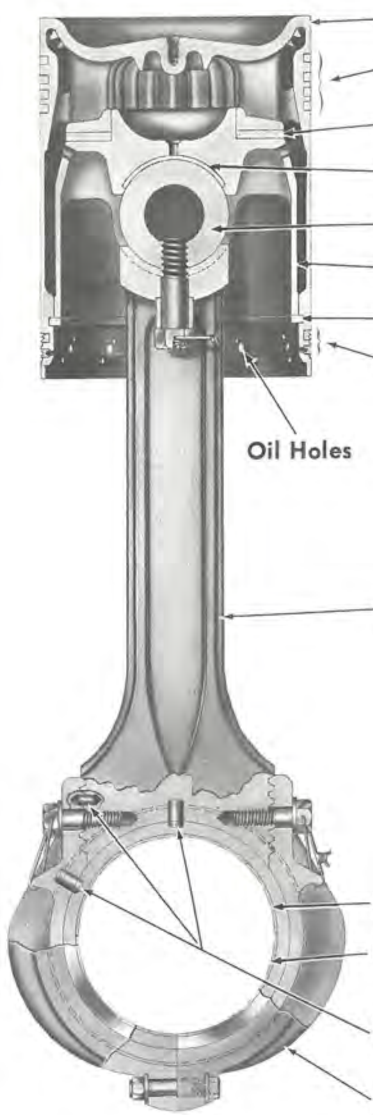

Fig. 3-3 — Piston And Connecting Rod Assembly, Cross-Section

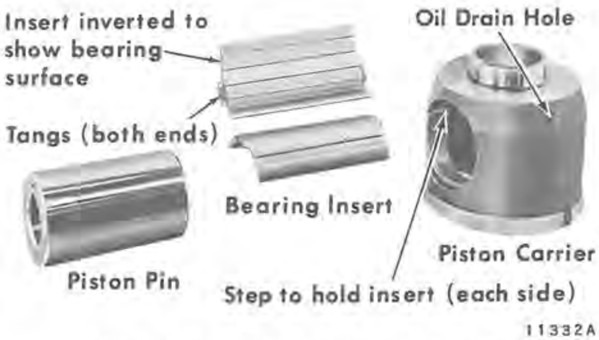

Fig. 3-4 — Piston Pin, Insert, And Carrier

1. Rotate crankshaft until piston of cylinder being inspected is at bottom center.
2. Inspect cylinder wall and top of piston. A wet piston crown would indicate a leaky injector. Check cylinder walls to make sure there is no scoring and inspect for water leaks.
3. Visually inspect for the following ring conditions at the liner ports.
   a. A ring in good condition will be bright and free in its groove.
   b. Broken ring. The ring face will normally be black if broken opposite the gap. Milling may also be evident above and below the liner ports.
   c. Worn ring. Replace all rings when chrome plating is worn through on first ring. While the ductile cast iron used in the chrome plated top ring will function satisfactorily in contact with the liner, the degree to which a ring is allowed to wear before replacement should be governed to some extent by the severity of the service. An engine which seldom runs at full power is more tolerant of ring condition than an engine which usually operates at or near full load. The chrome ring wear classifications shown in Fig. 3-5, used in conjunction with the description of each ring wear "type," will serve as a guide during ring inspection.
   d. Ring blow-by. Vertical brown streaks on the face of the ring indicate blow-by. Replace these rings when the condition becomes severe.
4. Inspect piston skirt for scoring or scuffing.
5. Inspect air box for foreign material, and any signs of water or oil leakage.

OIL PAN INSPECTION

1. Inspect back of upper connecting rod bearing for cutting or signs of overheating.
2. To check for thrust bearing, piston pin bearing, and connecting rod bearing wear, take a lead reading of piston to cylinder head clearance. Any increase since previous lead reading will indicate wear.
3. With piston at top center, inspect lower liner walls for scoring.
4. Inspect oil pan for foreign matter.

MAINTENANCE

PISTON AND CONNECTING ROD REMOVAL

When inspection indicates service on the piston is necessary, the piston and connecting rod should be removed as an assembly.

Preparation

1. Remove cylinder test valve assembly.
2. Remove piston cooling oil pipe.
3. Remove cylinder head as outlined in Section 2.
4. Apply piston pulling eyebolt in tapped hole in piston crown.

Fork Rod Removal

1. Remove fork rod basket bolts. Remove basket halves and lower bearing shell.
2. Pull piston and rod assembly, holding rod as it clears crankshaft to prevent it striking piston skirt or liner. Apply fork rod protector boot and complete removal of piston and rod assembly.

A new or like new ring. This classification will only be evidenced during the first phase of top ring life.

On a shallow groove ring, these classifications will be evident on the top ring for a relatively short time. On a deep groove ring, these classifications will be evident for the major portion of ring life.

Chrome grooves are completely worn away, showing only a smooth chrome face. This will exist for the major portion of shallow groove ring life. It will be evident for a short time on only a small percentage of deep groove rings.

This wear pattern designates that rings are starting to wear into the cast iron, except for the grooves, which still contain chrome. Inspection will readily reveal the alternate bands of chrome and cast iron.

Chrome is completely worn off and wear is concentrated on the cast iron. Rings in this classification are to be considered worn out and should be replaced.

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Fig. 3-5 — Chrome Ring Wear Classifications

Blade Rod Removal

1. If opposite fork rod and piston are not to be removed, then it will be necessary to hold this assembly out of the way using a fork rod support. This is done by removing basket and lower bearing then placing fork rod piston at top center. The support is then applied to outboard side of fork rod using two basket bolts. Rotate crankshaft in normal direction so that support will rest in oil pan. Protect upper bearing and continue rotation to position blade rod for removal.

2. Raise piston and blade rod assembly and carefully remove upper bearing

shell. Prevent rod from striking piston skirt or liner.

3. Apply blade rod protector boot and complete removal of blade rod assembly.

Piston And Rod Disassembly

1. Place piston and rod assembly on a wooden topped work bench and remove piston snap ring, Fig. 3-6, using snap ring remover. Care should be taken in handling piston assembly to avoid nicking or scraping the piston skirt.

2. Place rod and carrier in holding fixture, Fig. 3-7, and remove piston pin bolts. This fixture has two mandrels which enter the piston pin bore to hold the pin while the rod bolts are removed. It must be securely mounted on a work surface. If fixture is unavailable, a vise having copper protected jaws may be used to hold the connecting rod.

10269A

Fig. 3-6 — Removing Piston Snap Ring

8558

Fig. 3-7 — Carrier Holding Fixture

Clamp rod horizontally with pin close to vise so pin bolts may be removed without bending rod.

3. Remove pin from carrier.

4. At the time of piston and rod disassembly, check that the thickness of the thrust washer exceeds the minimum dimension listed in the Specifications.

CLEANING

Cleaning procedures should be in accord with accepted practice or as recommended by the supplier of cleaning material.

Pistons

1. Remove the piston rings using ring expander as shown in Fig. 3-8, and discard the old rings.

10280A

Fig. 3-8 — Removing Piston Rings

2. Immerse the piston in an alkaline solvent solution and allow to remain until the carbon deposits are loosened.

3. Wash the piston using steam or hot water and blow dry using compressed air.

4. Remove any carbon deposits from the compression ring grooves. Light grit blasting or a piece of compression ring can be used for this purpose.

5. Using 3/32" and 5/32" drills in the respective holes, clean the oil passages in the oil ring grooves.

Piston Pin And Carrier

CAUTION: Abrasive material, including steel wool, should not be used to clean piston pins or bearing inserts.

1. It is recommended that the piston pin and carrier assemblies be cleaned using a high flash point petroleum solvent, such as Stoddards solvent (140° F. flash point) or equal. These parts should never be washed in an alkaline or caustic solution.

2. Clean the carbon from the oil grooves in the insert with a suitably pointed wooden stick. Embedded particles do no harm if they do not project above the bearing surface; no attempt should be made to remove them. Parts of the assembly should be adequately protected against rust and corrosion at all times.

INSPECTION

Piston

1. The phosphate treated surface of the piston skirt should be inspected for satisfactory condition. If the coating is worn through and bare metal in excess of approximately three square inches is exposed, the piston should be re-coated as outlined in Maintenance Instruction 1758.

2. Inspect the piston surface for excessive scoring or other mutilation which would reject the piston.

3. Check all points of measurement as shown in Fig. 3-9. Discard any pistons that exceed the limits listed in the Specifications.

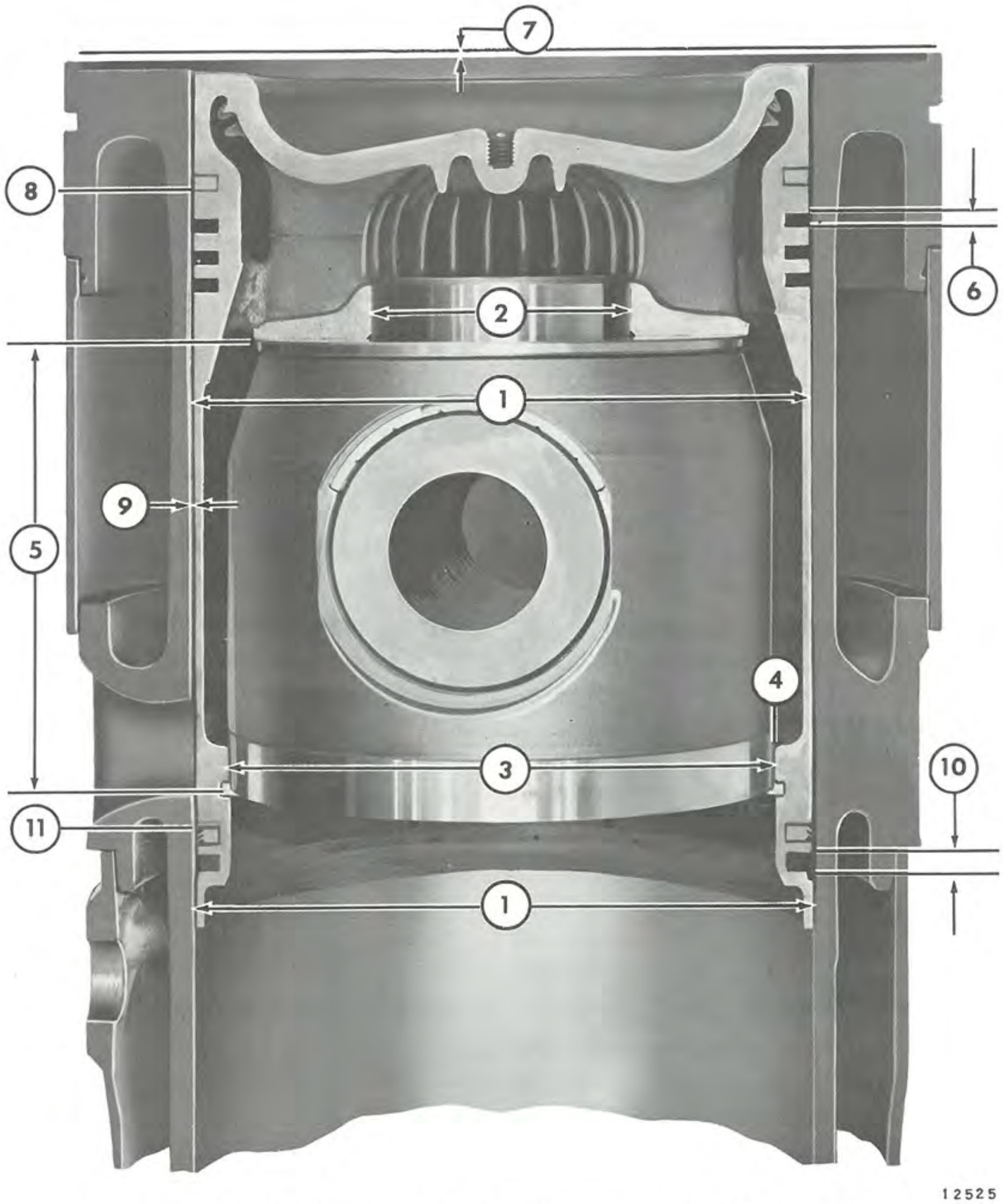
4. Check piston ring groove wear step. Check wear step on top ring groove lower face, Fig. 3-10. Top ring breakage can be caused by excessive wear step.

   A piston ring groove gauge, Fig. 3-11, is available to make the wear step measurement. Gauges also are available for measuring wear step in oversize ring grooves. Each gauge consists of a number of separate width indicators precise to .001". Standard ring groove gauge has indicators from .194" through .203". See Tool Catalog for oversize ring gauge numbers.

   To measure wear step, it is first necessary to determine the original ring groove width, because it may vary from .194" to .197". Insert gauge blocks in ring groove, and by trial, determine the largest one which enters its full depth. This will indicate the original width of the ring groove being measured. Then insert the largest block that will enter the groove up to the wear step. The size of the wear step is determined by subtracting the small block dimension from the large block dimension.

   When a wear step, in excess of maximum allowable, is found on the lower face of the top compression ring groove, the groove may be recut to remove the wear step, provided the finished width does not exceed .201" for use with a standard ring.

   If the ring groove is worn beyond a width of .201", it is possible to machine



Refer to "Specifications" at end of section for applicable dimensions.

1 - Piston skirt diameter
2 - Piston platform bore
3 - Piston inside diameter
4 - Piston to carrier pilot clearance
5 - Piston platform to bottom of snap ring groove
6 - Compression ring groove width
7 - Piston to cylinder head clearance
8 - Compression ring to land clearance
9 - Piston to liner clearance
10 - Oil ring groove width
11 - Oil ring to land clearance

Fig. 3-9 — Piston Measurement Points

the top ring groove to use oversize ring. See Fig. 3-12 and Specifications for measurement points and limits.

When performing either of the preceding operations, care must be taken to keep the ring groove faces parallel to each other and at right angles to the centerline of the piston. The surface finish must be smooth to avoid excessive wear.

See Parts Catalog for oversize pistons and rings. For instructions regarding

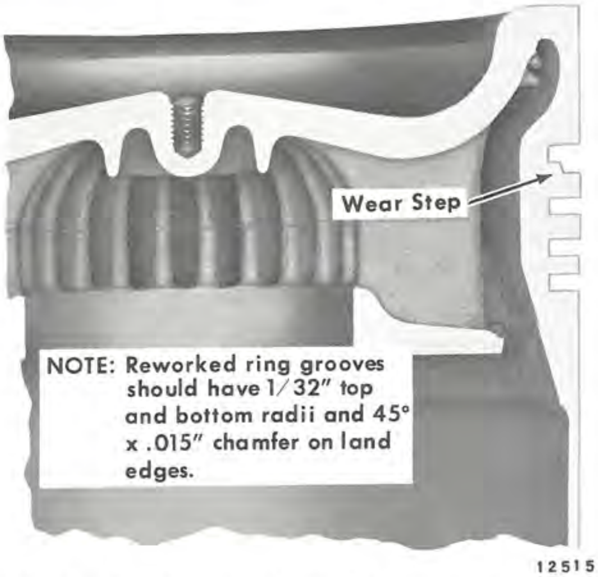


Fig. 3-10 — Piston Ring Groove Wear Step

return of pistons to be reconditioned, see Factory Rebuild Service Bulletin #308.

5. Inspect the piston for cracks using Magnaflux method as outlined in Maintenance Instruction 1754.

6. Remove undercrown deposits. Pistons that have been found dimensionally and structurally satisfactory for reuse, should also have the heat dam area thoroughly cleaned of undercrown deposits. Undercrown cleaning should be accomplished using a sand or grit blast cleaning in conjunction with liquid cleaning. Maintenance Instruction 1759 outlines a recommended procedure and details of construction for a fixture to use in grit blast cleaning of pistons.

Fig. 3-11 — Piston Ring Groove Gauge

Carrier

In this assembly, Fig. 3-4, a broached slot or recess in the carrier, receives a precision, steel-backed, silver bearing insert having a lead overlay. A hardened polished piston pin runs against the bearing insert.

Normal bearing wear does not affect the carrier. Maximum permissible wear on the insert, piston pin, and carrier pilots are given below. Used parts in good condition should not be interchanged. A new bearing insert should be used when a new piston pin is used. The piston pin should always be applied in the same relative position to the bearing insert. The small hole in the piston pin should be matched with the piston cooling oil inlet hole in the carrier as a convenient means of keeping the pin and insert in the same relative position for maximum performance.

Except in extraordinary cases of pilot wear, carriers may be expected to have

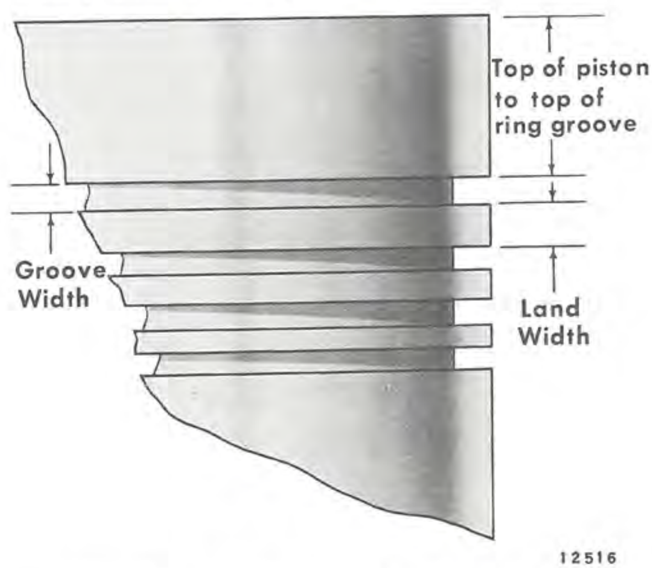


Fig. 3-12 — Oversize Ring Groove Measurement Points an indefinitely long life. Also, the bearing insert need not be removed for measurement unless its appearance is questionable and/or the wear on the piston pin is well advanced.

Measure the carrier to determine that the dimensions do not exceed the limits shown in the Specifications.

Piston Pin

1. Inspect the pin. The bearing surface should be free of any roughness and have a mirror finish.

2. Fretting on the pin, only where it contacts the connecting rod, may be removed using a fine stone.

3. Check the 7/8"-14 bolt threads in the pin by retapping. If the threads are damaged, replace the pin.

4. Check the pin diameter.

CONNECTING ROD ASSEMBLY

DESCRIPTION

The "trunnion type" connecting rods, Fig. 3-13, are interlocking, blade and fork construction. The blade rod moves back and forth on the back of the upper crankpin bearing and is held in place by a counterbore in the fork rod.

One end of the blade rod slipper foot is longer than the other and is known as the "long toe." The blade rods are installed in the right bank of the engine, with the long toe toward the center of the engine.

The fork rods are installed in the left bank of the engine. Serrations on the sides of the rod at the bottom match similar serrations on the fork rod basket, Fig. 3-13. The rod basket consists of two halves, held together at the bottom by

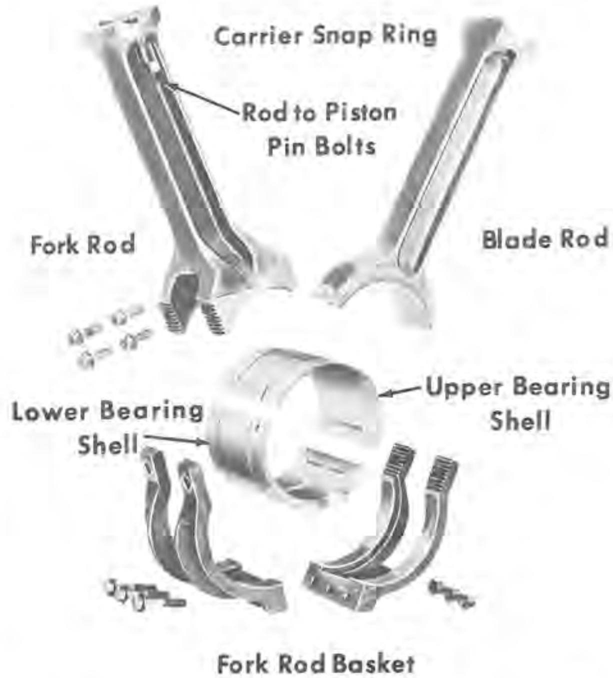


Fig. 3-13 — Connecting Rods, Bearing Shells, And Basket

three bolts and self locking nuts. The fork rod and basket are bolted together at the serrations. Fork rods and baskets are not interchangeable since they are line bored as an assembly. Both the fork rod and basket are stamped with an identical assembly serial number for matching and identification purposes.

The top of each rod is machined to the contour of the piston pin. Piston pins are held to the connecting rod by two bolts, having non-removable spacers.

MAINTENANCE

CLEANING

Cleaning procedures should be in accord with accepted practice or as recommended by the supplier of cleaning material.

CAUTION: Abrasive material, including steel wool, should not be used to clean connecting rods or bearing shells.

INSPECTION

Fork Rod

1. After all parts are clean, check the tapped holes in the fork rod. If threads are worn, the bolts holding the basket may loosen during operation and damage the engine.

   Plug gauge, Fig. 3-14, is available to check the fork rod bolt threads. One end of the gauge is marked "GO" and the opposite end "HI." The gauge should be used according to the following procedure.

   a. Thread the "GO" portion of the gauge into each of the holes, Fig. 3-14, and check for binding, which may indicate damaged threads. Normally, this gauge should enter the holes freely and a slight shake or wobble is permissible.

   b. An attempt should then be made to screw the "HI" portion of the gauge into each of the holes. This is not a "no go" gauge, therefore, rods may be entirely satisfactory even though the gauge may be screwed in the threads, even to the extent of bottoming.

   Normally, in rods having little wear, this gauge will be difficult to thread into the holes more than a couple of turns. In many cases, however, the gauge can be threaded into the rod but will be snug and tight. While threaded in, check for shake or wobble taking care that the gauge is not bottomed in the hole which would cause binding and a false reading.

   The fork rod should be scrapped if shake or wobble is experienced with the "HI" gauge.

   To further ensure proper torque values, it is recommended that new bolts be used.

   If bolts are reused, they should first be qualified by careful inspection, discarding any that may be bent or have threads showing signs of galling, wear, nicks, or other imperfections.

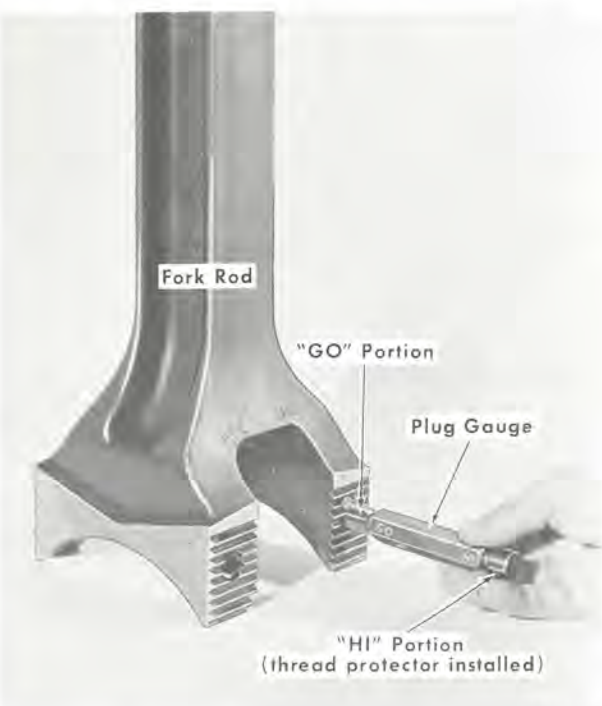


Fig. 3-14 — Checking Fork Rod Bolt Threads

2. Fork rod serrations should be checked for nicks, burrs, and cleanliness. Check tightness of upper bearing locating dowels. Step dowels are available in the event oversize dowels are required. Inspect for cracks in serrations and rod visually and by Magnaflux. Maintenance Instruction 1754 covers connecting rod Magnaflux inspections.

3. Check fork rod bore by fastening basket securely in place using 175 ft-lbs torque on basket bolts. (Normal basket bolt torque is 190-200 ft-lbs on assembly.) Torque value of lower basket

bolts is 75 ft-lbs. Measure bore at points 60° apart as indicated in Fig. 3-15. The average of these dimensions must not exceed the specified maximum. If bore is beyond this dimension, the rod and basket should be reworked. For information on connecting rod rework see Factory Rebuild Service Bulletin No. 305.

4. Fork rod rework will be required for any of the following conditions:

   a. Average of three 60° measurements across fork rod and basket bore exceeds specified maximum.

   b. Nicks, burrs, or fretting on fork and basket serrations.

   c. Damaged threads in bolt holes (see step 1), or loose dowels.

   d. Damaged or distorted basket.

   e. Excessive rod twist in length of saddle.

   f. Out-of-parallel in excess of limit in length of saddle.

   g. Length of rod between bore centers is less than the minimum.

   h. Fork counterbore exceeds maximum depth.

5. Fork rod assembly should be scrapped if any one or more of the following conditions exist:

   a. Fatigue cracks through basket serrations and rejectable Magnaflux indications as outlined in Maintenance Instruction 1754.

   b. Heat discoloration in basket or fork.

   c. Rod bent or damaged beyond repair.

   d. Length of rod between bore centers is less than minimum.

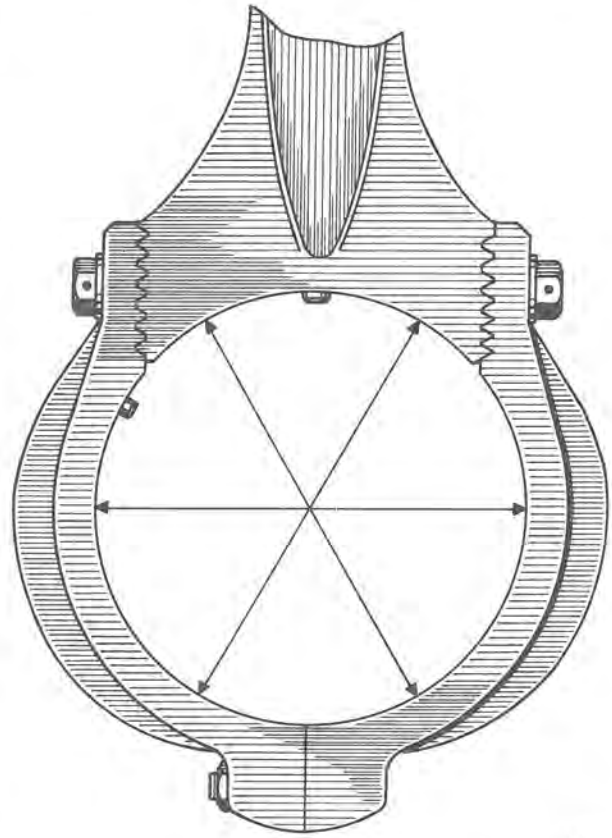


Fig. 3-15 — Checking Fork Rod Bore

Blade Rod

1. The blade rod is checked on a 7.692" diameter mandrel to observe slipper surface for "open" or "closed" ends. Blade surface should be bright, shiny, and smooth. Rod should be scrapped if this surface shows heat discolorations.

NOTE: The flame hardening process, produces a blue black color on the top side of the blade rod slipper foot. This discoloration is normal and has not been caused by overheating during operation. The slipper surface, however, should show no discoloration.

2. Blade rod rework will be required for any of the following conditions.

   a. Scarred, pitted, or deeply rust-etched slipper surface.

b. End of slipper closed in beyond limit.

c. End of slipper opened beyond limit.

d. Excessive twist along saddle length.

e. Out-of-parallel exceeds limit along saddle length.

f. Length of rod between bore centers is less than minimum allowable.

3. Blade rod should be scrapped if any one or more of the following conditions exist.

a. Rejectable Magnaflux indications as outlined in Maintenance Instruction 1754.

b. Heat discoloration on slipper surface.

c. Less than minimum flange thickness on slipper shoulder.

d. Twist, out-of-parallel, or damage beyond repair.

e. Length of rod between bore centers is less than minimum.

NOTE: Refer also to Factory Rebuild Service Bulletin No. 305 for return and rework of connecting rods.

CHECKING ROD LENGTH, TWIST, AND BORE PARALLELISM

The connecting rod checking fixture, Fig. 3-16, is available for accurate inspection of the connecting rod length, twist, and parallelism of piston pin saddle to bearing bore. All 567 series engine connecting rods can be checked on this fixture. When used to check "trunnion" type connecting rods, a 1" spacer plate "A" is used as shown in Fig. 3-16. Also, the contact point and the gauge plate having a 1.4126" dimension, included with the carrier fixture, are used when checking "trunnion" type connecting rods.

With the 1" spacer plate applied under indicator assembly as shown in Fig. 3-16, place the 1.4126" indicator gauge plate on

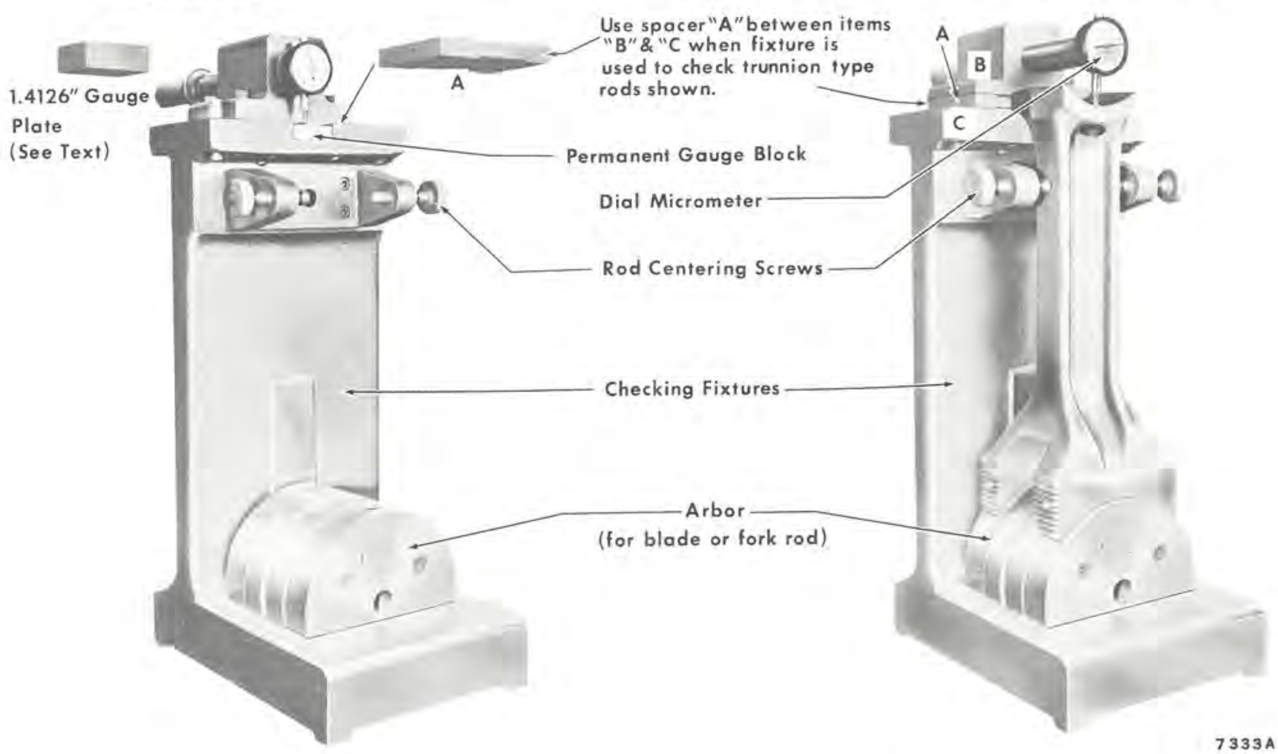


Fig. 3-16 — Checking Connecting Rods

permanent gauge block of fixture, and with the contact point on the 1.4126" plate, set indicator to "0." Place rod on fixture and by placing the contact point at each top edge of contour, determine the screw adjustment needed to bring rod to vertical position and then tighten screws.

Check slipper surface for open ends by trying a .003" feeler gauge at each toe end, between slipper surface and arbor. Blade rods with open ends may be used providing a .003" feeler gauge cannot be inserted more than two inches from each end of slipper when rod is mounted on the 7.692" arbor. Slipper surface close-in is evidenced by the ends having no clearance and the slipper surface being open. Rods with closed-in slipper surface may be used providing a clearance less than the limit is obtained when measured any place between ends of slipper on 7.692" arbor.

After adjusting indicator and placing rod in vertical position, set indicator contact point at top inside edge of saddle, and run indicator along length of saddle. Indicator deflection shows rod twist which should not exceed limit in the length of the saddle.

Place indicator at one end of bottom of saddle and note indicator reading. Check along length of saddle bottom, circumventing bolt holes, to check out-of-parallel. Indicator must not show more than maximum deflection along length of saddle.

Replace indicator on 1.4126" gauge plate and check indicator dial "0" setting. Slide indicator contact point off block to bottom of saddle and note deflection to indicate a bent or shortened rod. Deflection or reading must not exceed .010" to allow reuse of the rod, to give a generated rod bore centerline dimension not less than minimum allowable. A .021" indicator reading shows the rod bore centerline dimension below limit, and the rod should be scrapped.

CONNECTING ROD BEARINGS

DESCRIPTION

Connecting rod bearings consist of upper and lower shells, Fig. 3-13. They are semicircular in shape and have a steel back with a layer of lead bronze bearing material covered by a lead tin coating on the inside diameter. The upper bearing has, in addition, a bearing surface in the center of the outer diameter consisting of a layer of silver bearing material with pure lead overlay. This provides a bearing surface for the slipper of the blade connecting rod.

Dowels in the fork rod and basket hold the bearing shells in proper position. Two dowels in the fork rod locate the upper shell and one dowel in the basket locates the lower shell.

There is no provision for connecting rod bearing adjustment. When bearing clearance exceeds the limit given in the specification, they should be replaced. After bearing shells are once used on a crankpin and have accumulated numerous dirt scratches, they must not be used on any other crankpin.

Lubricating oil is supplied to the crankpin bearing through a drilled passage in the crankshaft from an adjacent main bearing. A circumferential oil groove at the center of the lower bearing supplies oil to a drilled passage in the upper bearing for the blade rod bearing surface. Oil is distributed over this surface by a "fish-back" or oil groove down the bearing center having grooves at right angles along its length.

MAINTENANCE

CHECKING CONNECTING ROD BEARINGS

The connecting rod bearings should be checked whenever the piston and rod assembly is removed from the engine. To make this check, apply bearings to fork rod and basket in which they are to be used. Tighten basket bolts to 175 ft-lbs torque and measure across the bearing bore at points 60° apart. This is similar to the procedure used when checking fork rod basket bore, Fig. 3-15. The average of these three readings must not be less than is necessary to ensure a clearance between crankpin journal and bearing within the specified limits. After operation, rod bearings may give indication of being tight across the split line when loose on the crankpin. However, rod bearings intended for use should be mounted in the fork rod and then checked.

NOTE: After bearings have once been used, they should not be used on any other journal.

Check upper bearing step thickness as shown in Fig. 3-17. This will indicate blade rod bearing surface wear. Step thickness should not be less than minimum limit.

Bearing shells will usually be dirt scratched to some degree, but unless condition is severe, the bearings can be reused.

ASSEMBLY AND INSTALLATION

ASSEMBLY

APPLYING PISTON RINGS

1. Place the cleaned and inspected piston on clean work bench and check the ring grooves to be sure that they are free of all foreign material.

2. Using piston ring expander, as shown in Fig. 3-8, carefully apply all new piston rings.

   To apply the spring loaded oil control ring in the bottom groove, apply the spring to the groove, then apply the ring so the spring will fit in the groove in the ring.

NOTE: The end junctions of the spring should not line up with ring gap.

3. Stagger the compression rings so the gaps of the first and second rings are 180° to each other, the third 90° to the second ring and the fourth ring 180° to the third. The oil control ring gaps should be at 180° to each other.

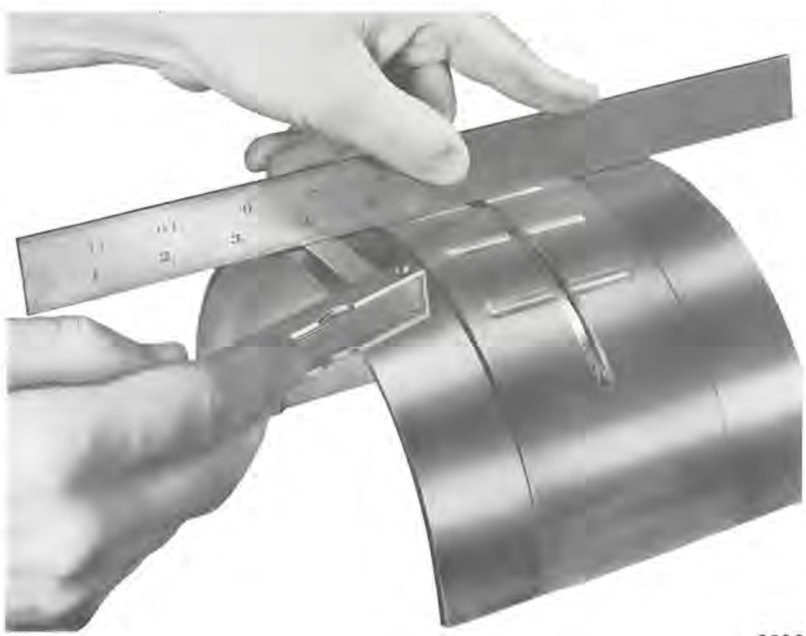


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Fig. 3-17 — Checking Rod Upper Bearing Shell

APPLYING BEARING INSERT TO THE CARRIER

If the bearing insert in the carrier is damaged or worn to the minimum thickness or if a new piston pin is to be used, a new carrier insert bearing should be installed.

The bearing insert, Fig. 3-4, is installed in the carrier by centering the insert so that the slotted tangs, when bent into the carrier counterbores, will prevent endwise movement of the insert. Carefully wipe out the insert slot in the carrier. Also, examine the insert to make sure it is clean. Apply the insert by entering it at one end of the carrier slot, and sliding it along the carrier bore. Center the insert so that the tang slots when bent will be adjacent to the counterbores of the carrier. Using indenter tool or a pointed tool with a 1/16" radius, strike the center of the tangs, so as to bend them into the carrier counterbore.

ASSEMBLY OF CARRIER, PISTON PIN, AND CONNECTING ROD

1. Examine all mating surfaces of the parts to be sure they are clean and smooth.

2. Apply some clean oil to the carrier bearing insert and to the piston pin, and insert the pin in the carrier.

NOTE: Install the piston pin so hole in end of the pin is at the same end as the piston cooling oil inlet hole in the carrier. Maximum performance is obtained when these parts are kept in their same relative positions.

Manually oscillate the pin while slowly moving it across the bearing insert, to check freedom of movement.

3. Place the connecting rod on the pin and apply the connecting rod to piston pin bolts.

NOTE: When assembling rod and carrier, the piston cooling oil hole in the carrier must be on the same side as the dowel pin in the serrations of the fork rod and on the side opposite to the "long toe" of the blade rod. This will ensure proper position of the hole when assembly is installed in the engine.

4. Place the assembly in carrier holding fixture, Fig. 3-7, to torque bolts. (If fixture is not available, place rod horizontally in vise with pin close to vise, and torque in vertical plane. If the rod is held improperly, the applied torque is sufficient to permanently twist the rod.) Torque value of rod to pin bolts is 450 ft-lbs (plus or minus 5 per cent). Use 300 ft-lb torque wrench with extension to torque pin bolts. The extension end with plug and socket fits the bolt head, and the torque wrench drive is connected to the other end. To torque bolts to 450 ft-lbs, a torque reading of 300 ft-lbs is required, using the extension.

5. The pin bolts have three holes for lockwiring after assembly. Use approximately .072"diameter lockwire. When securing the lockwire, twist the wire at the bolt, but not where the wire passes over the rod.

ASSEMBLY OF CONNECTING ROD, CARRIER, AND PISTON

1. Place piston open end up and check that the interior is clean and that platform is free of any foreign material. Apply some clean oil to the platform.

2. Oil the carrier platform and apply the thrust washer to the carrier.

Check that thrust washer thickness is within specified limits.

3. Place the carrier and rod assembly in the piston. Check the carrier for free rotation in the piston.

4. Using snap ring remover as shown in Fig. 3-6, install the snap ring in the piston to hold the carrier.

   Check that snap ring to carrier clearance does not exceed maximum limit.

INSTALLATION

Before installing piston and rod, the liner should be serviced as outlined in Section 4.

1. Set piston ring compressor and guide in place on cylinder liner. Oil cylinder wall, ring compressor, and piston. Place crankpin on bottom center.

2. Apply connecting rod protector boot, then lower assembly into liner, using eyebolt in piston crown. Be sure piston cooling hole is positioned to outboard side of engine, on same side as short toe on blade rod and dowel in serration of fork rod.

3. Suspend piston and rod assembly and prepare connecting rod bearing for application. Oil inside and outside of bearing shells and install upper bearing in position on crankpin.

4. Lower blade rod to rest on upper bearing. Remove eyebolt from piston and apply to fork rod piston. Apply boot to fork rod and lower rod to bearing. Fork rod dowels should enter bearing dowel holes without binding. Remove piston eyebolt.

5. Apply lower bearing to doweled basket half and install basket half to fork rod, tightening basket to fork rod bolts just sufficient to mesh the serration and hold the bearing in place. Then apply other basket half to fork rod, tightening rod bolts to mesh the serrations.

   When applying fork rod baskets, be sure that the serial number on prong of dowel half is on the dowel side of the rod. Current assembly basket halves, without dowel holes, have the serial number at the bottom, making it easy to spot misapplication of this basket half to the dowel side. If fork rod 5/8"-18 tapped holes are damaged or are too large, replace the fork rod and basket, as outlined under Connecting Rod Assembly.

6. Apply the three 1/2" lower basket bolts, washers, and lock nuts. Torque value of these bolts is 75 ft-lbs.

7. Complete basket to fork rod bolt application by tightening to 190-200 ft-lbs torque, and apply lockwire. Retighten assembly according to the Scheduled Maintenance Program.

8. Install cylinder head as outlined in Section 2.

9. Install piston cooling oil pipe and check alignment. Use piston cooling pipe gauge, Fig. 3-18. Insert small end of gauge in piston cooling pipe. Turn crankshaft slowly to bring piston to its lowest position. At same time, rotate gauge by hand to make sure it does not bind in hole. If gauge indicates misalignment, replace pipe assembly. Do not use gauge to align pipe. Piston cooling pipes should be checked before application, with cooling pipe cleaner.

PISTON TO CYLINDER HEAD CLEARANCE

The piston to cylinder head clearance governs to a great extent the efficiency of the engine and should be maintained within

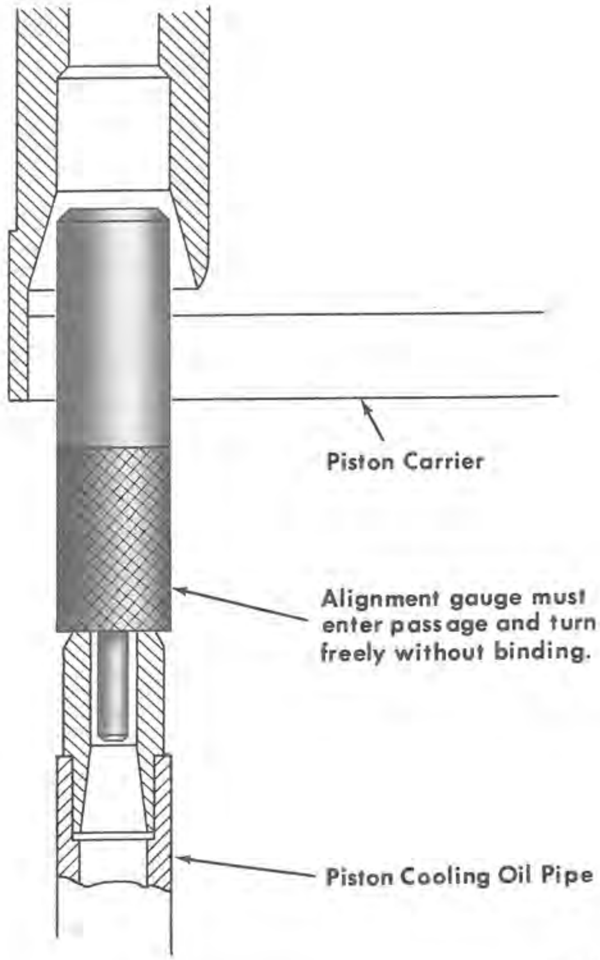

Fig. 3-18 – Piston Cooling Oil Pipe Alignment

specified limits for best operation. In addition, if regular inspections are made, piston to head clearance may be used as an indication of wear in the parts of the piston and connecting rod assembly. Recorded or charted clearance readings will aid in the prevention of serious trouble resulting from excessive wear of parts, as their condition will be indicated by comparing successive piston to head clearances.

The engine records that are furnished include piston to head clearance readings taken at the time of manufacture. Such readings are listed for each cylinder and should be checked against subsequent readings to determine condition of the assembly. By recording the original and each successive reading in its proper place on a chart, a definite indication of the condition of the parts will be apparent. Readings of the piston to head clearance may also be started on reinstalled piston and rod assemblies, by taking the clearance of the new installed assembly.

It is recommended that compression lead readings be taken on all cylinders at intervals specified in the Scheduled Maintenance Program. More frequent inspections should be made on assemblies which show excessive or dangerous rates of increase in the clearance.

The following method is recommended to obtain the piston to head clearance. Rotate the crankshaft to place the piston to be checked at bottom dead center. Place a 1/8" soft lead or solder wire shaped to the contour of the piston crown, with the ends of the wire not over 8-1/4" apart, on top of the piston, through the liner ports. Position the lead wire directly above the piston pin parallel to the engine crankshaft. The engine is then barred over one revolution and the wire removed and both ends measured with a micrometer. The clearance reading will be the average of the two measurements taken. If the difference between the two ends of the wire is more than .005", the clearance should be rechecked as the wire may have rotated on the piston to a point at right angles to the piston pin.

The time necessary for taking readings on an engine may be lessened considerably with a saving of wire by using the wire holder and wire as listed in the Equipment List. Also, observing the location of various pistons as crankshaft is rotated, will make it possible to take all readings in two revolutions of the crankshaft.

The new and condemning limits of piston to head clearance are listed in the Specifications. The limits of various individual parts of the assembly govern their respective replacement. These limits may be found in the Specifications at the end of this section.

In conjunction with the piston to head clearance, the snap ring clearance should also be checked. If it is found that the piston to head clearance is within the limit, but the snap ring clearance is at, or sufficiently near, the condemning limit, the piston assembly should be removed and the piston thrust washer checked.

SERVICE DATA

PISTON ASSEMBLY AND CONNECTING RODS

SPECIFICATIONS

Connecting Rod

Connecting rod basket bore (See Text) - New .... 7.624" - 7.625"

Blade rod bearing seat diameter (See Text) - New .... 7.692" - 7.693"

Clearance between shoulder on blade rod
and counterbore in fork rod - New .... .008" - .013"
Max. .... .025"
(This clearance measured by placing feeler gauge between blade rod and top of upper bearing.)

Depth of counterbore in fork rod for
slipper on blade rod - New .... .385" - .3865"
* Limit .... .400"
(* Provided the preceding maximum .025" clearance is held.)

Blade rod shoulder thickness - New .... .3445" - .346"
* Limit .... .335"
(* Provided the preceding maximum .025" clearance is held.)

Connecting rod length - New .... 22.998" - 23.002"
(Generated bore centerline dimension) - Rework Limit .... 22.990"
Scrap Limit .... 22.979"

Saddle end for piston pin
Twist (In length of saddle - see text) - Limit .... .006"
Parallelism (In length of saddle - see text) - Limit .... .004"

Blade rod slipper
"Closed in" (Checked on 7.692" arbor - see text) - Limit .... .007"
"Opened out" (Limit of feeler that can be inserted
2" from end of 7.692" arbor - see text) - Limit .... .003"

Connecting Rod Bearings

Bearing inside diameter
(Average of three 60° measurements) - New .... 6.5066" - 6.5100"

Bearing to crankpin clearance - New .... .007" - .011"
Limit .... .015"

Bearing shell thickness - New .... .5587" - .5595"

Thickness limit (Standard) - Min. .... .5530"
(1/32" U.S.) - Min. .... .5686"
(1/16" U.S.) - Min. .... .5843"

Upper connecting rod step thickness - Limit .... .027"

Piston

Refer to Fig. 3-9 — circled numbers coincide with callouts on illustration.

(1) Piston Skirt diameter - New .... 8.488" - 8.490"
Limit .... 8.485"
Out-of-round .... .005"

(Check diameter 2" below the compression ring grooves and below the oil ring grooves. Take two readings 90° to each other, at each location.)

(2) Piston platform bore (upper carrier pilot) - New .... 3.565" - 3.567"
Limit .... 3.570"

(Check at two places 90° to each other.)

Piston platform should be square to piston O.D. within .003" total indicator reading.

(3) Piston inside diameter (lower carrier pilot) - New .... 7.487" - 7.490"
Limit .... 7.494"

(4) Piston to carrier pilot clearance - New .... .003" - .007"
Limit .... .011"

(5) Piston platform to bottom of snap ring groove - New .... 6.376" - 6.380"
Limit .... 6.387"

(6) Standard compression ring groove width - New .... .194" - .197"
Max. .... .201"

No. 1 compression ring groove may be recut for
1/64" Oversize rings (.209" + .003" - .000") - Max. .... .216"
1/32" Oversize rings (.225" + .003" - .000") - Max. .... .232"
providing
Top of piston to top of ring groove - .... 1.480" - 1.490"
Width of land - Min. .... .343"

(7) Piston to cylinder head clearance - New Min. .... .026"
Max. .... .068"

An increase in compression clearance of .030" from the assembly value at the time of installation condemns the assembly. Any sudden increase should be investigated immediately.

(8) Compression ring to land clearance

No. 1 groove, chrome ring - New .... .004" - .0085"
Max. .... .012"

No. 2 and 3 groove, chrome ring - New .... .0075" - .012"
Max. .... .016"

No. 4 groove, taper ferrox ring - New .... .0075" - .0115"
Max. .... .016"

(9) Piston to liner clearance
When measured 6" below top of liner,
except at liner ports - New .... .0095" - .0135"
Max. .... .018"

(10) Oil ring groove width - New .... .251" - .254"

(11) Oil ring to land clearance - New .... .002" - .006"

Carrier

Carrier height (top of platform to bottom of carrier) - New ... 5.999" - 5.995"
Limit .... 5.992"

Carrier top pilot diameter - New .... 3.560" - 3.562"
Limit .... 3.557"

Carrier bottom pilot diameter - New .... 7.483" - 7.484"
Limit .... 7.480"

Clearance (carrier to piston snap ring) - New .... .002" - .015"
Limit .... .025"

Carrier bearing insert thickness - New .... .150" - .151"
Min. .... .146"

Piston Pin

Diameter - New .... 3.684" - 3.685"
Min. .... 3.664"

Piston Thrust Washer

Thickness - New .... .185" - .188"
Limit .... .175"

Thickness variation - Max. .... .003"

EQUIPMENT LIST

	Part No.
Piston ring compressor and guide (standard size) .... (.030" and .060" oversize - 8065453)	8034087
Piston pulling eyebolt	8040413
Fork rod support	8052958
Blade rod protector boot	8062033
Fork rod protector boot	8062034
Piston cooling pipe alignment gauge	8071720
Motor driven flexible shaft buffer, 115 V.	8084282
Motor driven flexible shaft buffer, 230 V.	8084283
Piston cooling pipe cleaning tool	8087086

Wire (lead, 1/8" dia. - 50 lb. spool)	8136471
Torque wrench, 3/4" drive (0-300 lbs.)	8157121
Snap ring remover	8171633
Piston ring expander	8194036
Torque wrench extension (used with torque wrench 8157121)	8210136
Piston carrier holding fixture	8236589
Wire holder (has contour of piston crown to hold small lengths of lead wire for piston to head clearance)	8243220
Wire (lead, 1/8" dia., used with holder 8243220 or alone - 5 lb. spool)	8243661
Connecting rod checking fixture	8257730
Fork connecting rod basket thread gauge	8265955
Piston ring groove gauge Standard (.194" - .203")	8275503
Bearing insert to carrier indenter tool	8311268

CYLINDER LINER

DESCRIPTION

The 15 port cylinder liner, Fig. 4-1, is designated as a fabricated design liner because of the method of construction. Fabricated liners consist of a cylinder casting having two separate water jackets applied and brazed to the casting making an integral cylinder liner assembly.

A row of 15 air inlet ports completely encircle the liner as shown in Fig. 4-1. The bottom of the ports are even with the top of the piston when it is at bottom dead center. A water inlet flange on the outboard side of the liner, below the ports,

Fig. 4-1 — Cylinder Liner

provides a connection for the individual liner water supply line. A water deflector, Fig. 4-2, at the water inlet, prevents the inlet water from impinging directly on the inner liner wall.

The inlet water circulates around the bottom of the liner, progressing upward to discharge into the cylinder head through twelve drilled holes. A counterbore, Fig. 4-3, around each drilled hole accommodates a synthetic rubber water seal which seals the water passage when the cylinder head is installed. A thin copper clad steel gasket provides a combustion seal between the cylinder head and the liner.

The liner is secured to the cylinder head by eight studs and nuts, and this entire assembly is held in place in the crankcase by the cylinder head crabs. A "pilot stud" locates the liner in proper angular relation to the cylinder head and ensures alignment with the piston cooling pipe mounted at the bottom of the liner.

The liner is piloted in the crankcase at the upper and lower pilots. The upper pilot bears directly against the crankcase, while the lower pilot fits into an insert ring in the crankcase. A single seal ring is used in the upper groove at the top pilot and two seal rings are applied at the lower pilot to prevent loss of air from the air box.

MAINTENANCE

INSPECTION IN ENGINE

The air box handhole covers provide access to the cylinder liner upper bores while the oil pan handhole covers provide access to the lower bores.

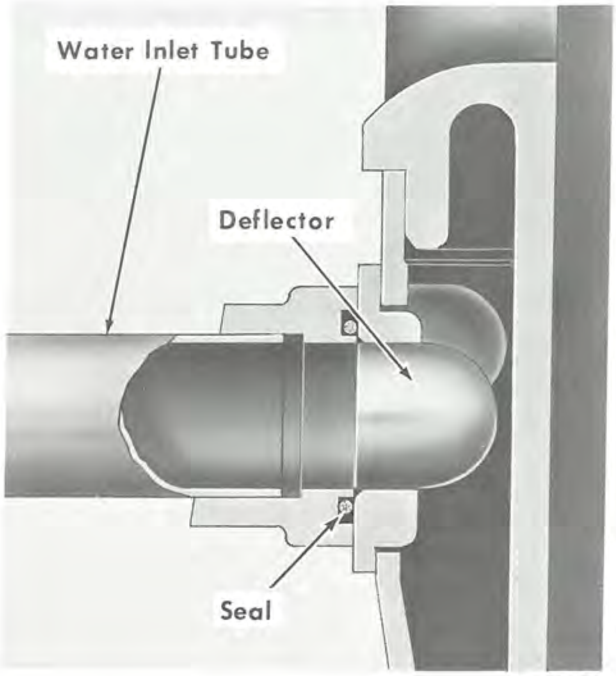

Fig. 4-2 — Water Inlet Deflector

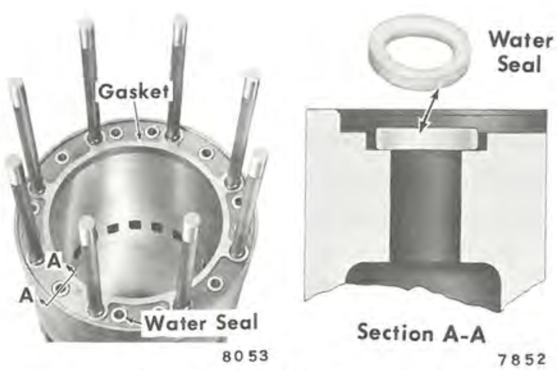

Fig. 4-3 — Water Seal

1. Open the cylinder test valves and position the piston either below the ports for upper bore inspection or near top dead center for lower bore inspection.
2. Check the liner walls for scuffing or scoring above the ports.
3. Inspect externally for evidence of water leaks at liner to cylinder head gasket and water inlet line.

REMOVAL

1. Remove cylinder head and piston and connecting rod assemblies as described in Sections 2 and 3.
2. Remove piston cooling oil pipe and liner water inlet line.
3. Apply cylinder liner lifter to liner studs and remove the liner.

   Use care when handling to avoid damage to the liner studs and liner pilot.

NOTE: Check the head to liner gasket. A bulged gasket is an indication of hydraulic lock and a careful check of the connecting rod is required.

CLEANING

Cleaning procedure should be in accord with accepted practice or as recommended by the supplier of cleaning material.

MEASURING LINERS FOR WEAR

The cylinder liner should be measured in planes parallel and at right angles to the crankshaft.

Wipe interior of liner clean before measuring bore, and check for physical defects that would require rework on the liner. A liner bore gauge, Fig. 4-4, or

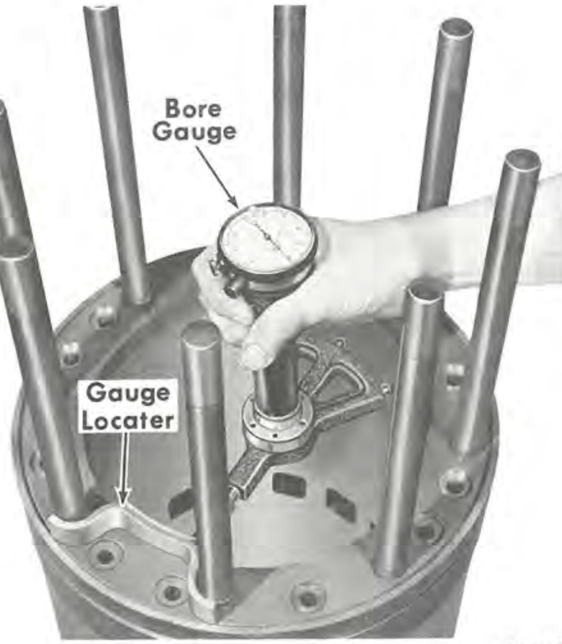

Fig. 4-4 — Liner Bore Gauge

standard inside micrometers may be used to measure liner bore diameter. The gauge is of a special design for liner bore measurement, and will provide accurate measurement when used carefully. It has a three-pronged centering and measuring end that fits the liner bore. A dial indicator, mounted on an upright that extends down to the measuring prongs, gives instant reading of bore diameter. The upright allows the gauge to be raised and lowered in the bore with visual measurement shown on the dial. A master gauge is used to calibrate the bore gauge.

A dial gauge locator should be used with the liner bore gauge. The gauge locator fits over the top of the liner and hangs down inside the liner bore. It has four 1/2" drilled holes spaced at 2", 6", 12", and 16" from the top to locate the measurement positions.

A special box to protect the liner bore gauge also provides a place for the master gauge and the gauge locator.

New cylinder liners have a bore diameter which falls between a low and a high limit, except through the port relief zone.

Accumulated liner and piston wear will increase piston to liner clearance and this clearance is a limiting factor at time of reapplication. No liner should be matched with a new or used piston where the diameters result in a piston to liner clearance exceeding the maximum limit, at a point six inches below the gasket face of the liner.

The liner bore should be checked for out-of-round at two points 2" and 6" below top of liner, Fig. 4-5, using the dial gauge locator as a guide. Take two readings 90° apart, to determine wear and out-of-round. Should the out-of-round exceed the limit, the liner must be rebored to the next oversize, regardless of other wear measurements which still may be within limits.

Using the maximum piston to liner clearance as a guide, worn liners may be used again, providing they are not over out-of-round limit, and are matched with pistons

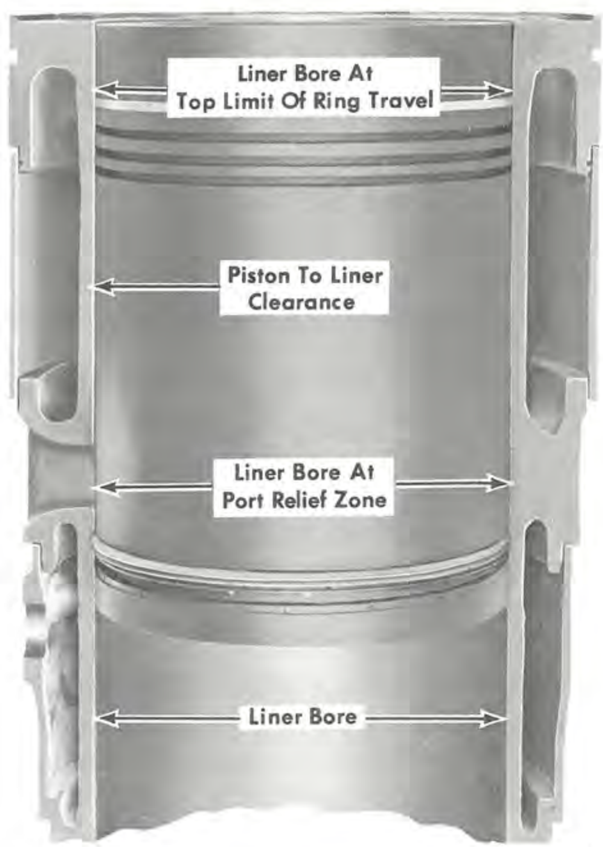

Fig. 4-5 — Liner Measurement Points

having a diameter which will not exceed the limit on piston to liner clearance. Maximum piston and liner usage is obtained by selective assembly within the clearance limit.

Liners will wear tapered, with maximum wear normally occurring at the top limit of piston ring travel. Check that wear at top of ring travel, taking two readings 90° apart, is within specified limit. A liner worn to this dimension will leave some stock to allow for cleaning up the bore to the first oversize. If this limit is exceeded, it may not be possible to rebore liner to the first oversize. It would then have to be rebored to the next oversize, losing a great amount of its wear life. Consequently, it is suggested that no liner be reinstalled if the bore diameter at top of ring travel exceeds the maximum.

OVERSIZE LINERS

Liners can be rebored to .030" or .060" oversize. The dimensions of oversize liners are the same as shown in the Specifications, except that the diameters are increased by .030" or .060", as the case may be. Standard or .030" oversize liners worn beyond their limits may be returned to Electro-Motive for refinishing to the next oversize. (Corresponding oversize piston assemblies must be used with oversize liners.)

REMOVING LINER RIDGE

After a long period of use, a wear ridge, caused by piston ring action, will appear near the top of the liner bore. After the liner is removed from the engine, the wear ridge must be entirely removed before honing the liner. Unless complete removal of the wear ridge is accomplished, it is not possible to properly hone the critical area of the liner at the top of the ring travel. In addition, removal of the wear ridge precludes any possibility of interference with new piston rings.

The cylinder liner ridge reamer, Fig. 4-6, is used to remove the ridge at the top inside bore of the liner. A reamer is also available for 1/32" - 1/16" oversize liners. Reamers may either be manually or motor operated. If the reamer is motor operated, a speed reducer must be used, which is mounted on the reamer. The operating motor used with the speed reducer can be an ordinary heavy-duty electric drill having a no load speed of approximately 500 RPM.

Extra cutting blades may be obtained for reamers. Refer to "Equipment List" at the end of this section.

Reamer cutting blades also may be resharpened. To resharpen a dull cutter, it is necessary only to lightly grind the leading angle which does the cutting, using a grinding wheel suitable for grinding tungsten carbide tools. The clearance angle is 8° and must not be exceeded when grinding. It is better to provide "less" than more clearance, as these cutters will not stand up if given greater clearance.

In addition, a cutter should not be used if the guide portion has been reduced to a

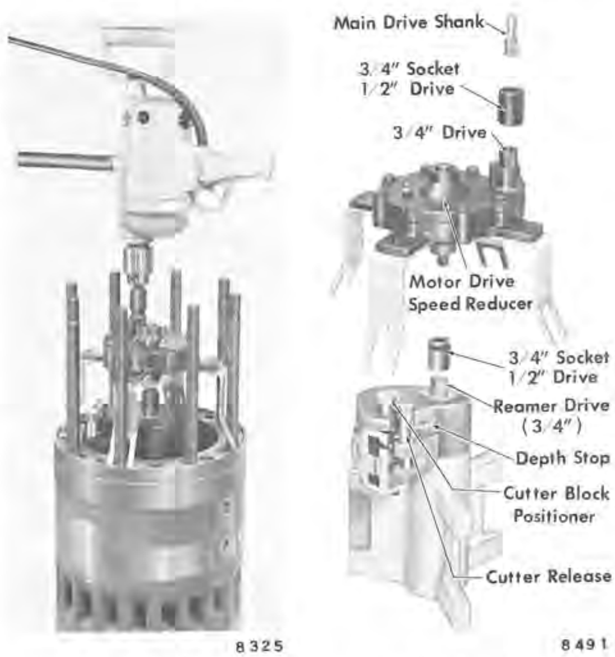

Fig. 4-6 — Application Of Liner Ridge Reamer And Speed Reducer length of 21/32" by resharpening, because the guide will not extend far enough past the pin hole to prevent undercutting. For resharpening service on the cutters, refer to the reamer manufacturer.

Liner ridge is removed as follows:

1. Oil liner wall just under the ridge, and see that felt pad in back of cutter is full of oil.
2. Retract cutting blade so it will be away from the liner wall when the reamer is installed, and position the depth stop on the blade retard cam. Position cutter blade at bottom of its travel.
3. Lower reamer into the liner until the depth stop rests on top of the liner.
4. Tighten reamer centering nut to hold reamer in correct position in the liner. Rotate the reamer to check centering, and adjust if required.
5. Operate the blade retarder cam to swing stop out of the way and release cutter so it can move out to contact the liner wall.
6. Operate reamer manually or by motor until ridge is entirely removed, carrying the cut into chamfer at liner top if necessary.
7. After completing ridge removal, remove reamer, and clean liner by wiping off oil and cuttings.

HONING LINERS

After removing the cylinder liner ridge, the cylinder liner must be honed. The purpose of honing is to remove glaze and to provide a wall finish that will hold lubrication and provide quick and proper seating of new piston rings. Light scuffing and scoring on the liner wall may also be removed by honing. However, if this condition is too advanced, the liner should be scrapped or returned to be rebored oversize, depending upon its condition.

Equipment Required

1. Hone kit.
2. 1/2" heavy-duty electric drill with 345-500 RPM motor - 115 or 230 volt.
3. Stone cleaning brush.
4. It is also necessary to provide a fixture to hold the liner during honing. Construction details of a liner honing fixture is given in Maintenance Facility Drawing, File No. 543, which is available upon request. This fixture provides for the support of the liner, a counterbalance arrangement to facilitate motor and hone handling, and other details that should be provided when honing liners.

Honing Procedure

1. Install the liner properly in the honing fixture. Chuck the driving shank of the hone in the drill motor as shown in Fig. 4-7. Place stone support on the hone body. Note that one end is marked top. Check that stones and guides are firmly secured in their master holders. Remove the center pinion and adjustment assembly from the hone body by pulling it straight out. Wire brush stones to ensure they are clean. Insert stones and guides as far as they will go in their proper holes, marked "X" on the hone body. The two stones are applied on opposite sides of the body. Apply splined shaft and lower hone into the liner bore. Raise spline shaft assembly about 1/4" to prevent adjustment gears from meshing, and turn to expand hone to fit the liner bore. Push the spline shaft assembly back down, engaging its internal gear with gear on the hone body. Expand the stones firmly against the walls by turning the wing nut micrometer adjustment. (During the adjustment the stones should not protrude more than 1/2" out of the liner bore.)

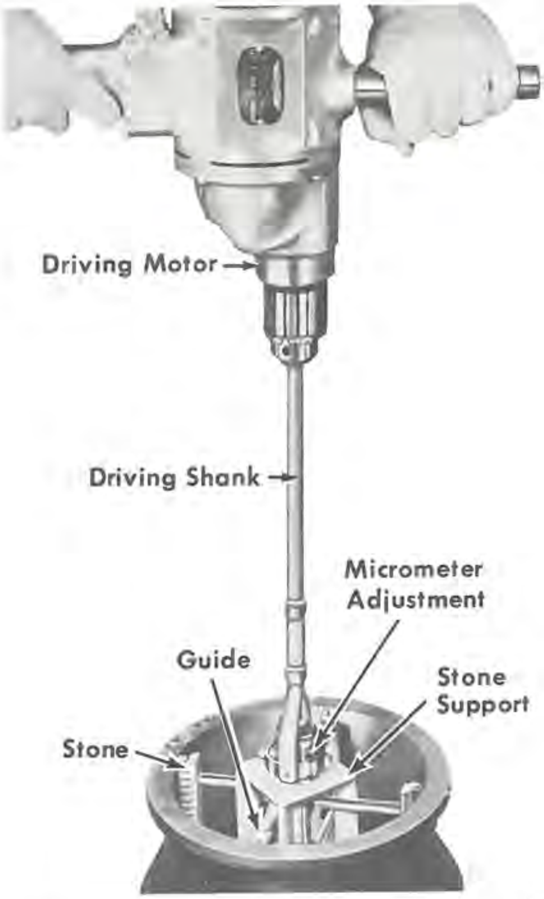

Fig. 4-7 — Honing Cylinder Liner

2. Always maintain firm stone pressure against the liner walls to ensure fast stock removal and accurate work. To ensure a constant heavy pressure it may be necessary to increase the pressure after several strokes. If pressure is correct, the stones will emit a steady grinding noise. The driving shank is made with a weak section, so that if the hone is improperly used, causing it to bind, the shank will break.

3. The liner may be honed "wet" or "dry." Both methods produce identical results. However, if stones and guides are once used with "wet" honing, they should not again be used for dry honing. Also, stones and guides must be kept together in sets. Keep same guide blocks with the same stones, do not mix sets. When honing "dry" the liner and hone must be absolutely dry. Kerosene is considered best for "wet" honing. During wet honing the liner must be continuously flooded. There cannot be any "in-between" in the method used.

4. If the liner does not have a scuffed or scored condition, merely break the glazed surface by stroking rapidly a maximum of 15 strokes, being sure that a heavy pressure is retained on the stones.

5. If the liner is scuffed or scored, remove any material buildup (and consequent scuffing) and any heavy scoring. Do not attempt to remove any isolated dirt scratches as they do not significantly affect operation. Honing out these scratches needlessly reduces liner life. After the surface has been "cleaned up" the hone should be removed and the stones brushed, using a wire brush to remove any loading of the stones. The liner should then be honed with the clean stones using a heavy pressure and 6 to 10 rapid strokes.

6. A correct honing operation should result in a characteristic "cross-hatch" pattern on the liner wall surface. In no case should an attempt be made to produce a polished or mirror finish. It is important to remember that when using the correct stones (identified by W47J43 stamped on stones and guides), too rough a finish will not be produced. Do not remove any more metal than is necessary to obtain the desired finish.

7. After honing, the liner should be thoroughly cleaned of abrasive or iron dust and given storage protection until ready for use.

MARKING USED LINERS AND PISTONS IN STOCK

It is suggested that used pistons and liners, which are not going back into an engine immediately, but are to be placed in stock, be thoroughly cleaned, inspected and checked for size. The dimensions as checked can be chalk marked on the outside of the liners and on the crown of pistons. This will allow liner and piston combinations to be selected with a minimum of delay.

INSTALLATION

Check the liner pilot surfaces in the crankcase to see that they are clean and smooth. Refer to Fig. 4-8 for crankcase and liner measurement points and to the Specifications at rear of section for dimensional limits.

Before installing the liner, inspect it for cleanliness and general condition. Check water seal counterbores around the drilled water discharge holes. Make sure they are free from nicks which may cut the seals, and be sure they are clean. A cleaning tool, Fig. 4-9, is specially made for cleaning these counterbores. Apply the water seals at the gasket surface, as shown in Fig. 4-3. Check water inlet tube deflector for fit and position. The deflector has a press fit in the liner and its cup edge should be positioned 15° from vertical, counterclockwise, Fig. 4-2. Wipe the inside of the liner with a clean oily cloth. Apply the synthetic rubber seal in the upper groove around the liner pilot.

Using liner lifter, install liner into position in the crankcase bore. Preliminary alignment can be obtained by centering water inlet connection with relation to the inspection hole in the stress plate.

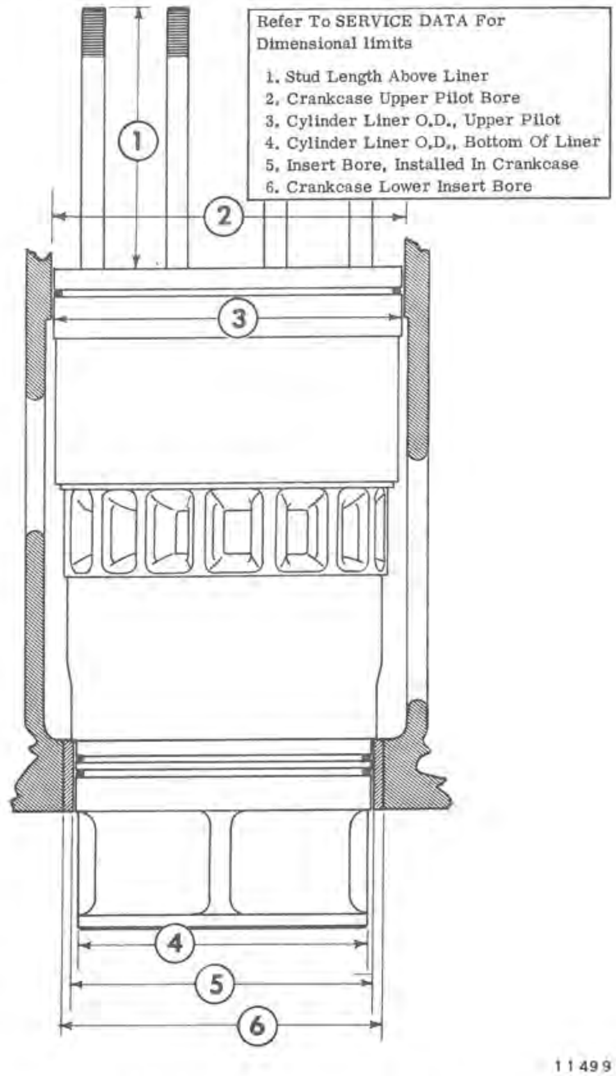

Fig. 4-8 — Crankcase And Liner Measurement Points

Fig. 4-9 — Cleaning Tool

After liner is in position, complete assembly by installing connecting rod assembly as outlined in Section 3 and cylinder head as outlined in Section 2. Then apply piston cooling oil pipe and water inlet tube assembly, using new seals.

SERVICE DATA

CYLINDER LINER

SPECIFICATIONS

Cylinder liner bore (except through port relief zone) - New	8.4990" - 8.5015"
Cylinder liner bore (port relief zone only) - New	8.5125" - 8.5165"
Piston to liner clearance (6" below liner gasket face) - New	.0095" - .0135"
Max.	.020"
Cylinder liner bore out-of-round (measure at two points 2" & 6" below top of liner - 90° apart) - Max.	.005"
Cylinder liner bore (top limit of piston ring travel) - Max.	8.520"
Length of studs above top of liner	9-1/2"
Crankcase upper pilot bore - New	12.091" - 12.094"
Limit	12.104"
Cylinder liner O.D. (at upper pilot) - New	12.0865" - 12.0895"
Limit	12.085"
Cylinder liner O.D. (bottom of liner) - New	10.3725" - 10.3755"
Limit	10.371"
Insert bore (installed in crankcase) - New	10.377" - 10.382"
Limit	10.386"
Crankcase lower insert bore - New	11.062" - 11.065"
Limit	11.066"
Cylinder liner stud torque - Min.	50 ft-lbs

EQUIPMENT LIST

	Part No.
Hone kit (less motor)	8039177
Wire brush (honing stones)	8078883
Drill (1/2") - 345-500 RPM, 115 volt (AC or DC)	8104770
Drill (1/2") - 345-500 RPM, 230 volt (AC or DC)	8104771
Cylinder liner lifter	8116358
Cleaning tool (water seal counterbore)	8190175
Cylinder liner ridge reamer	8228303
Reamer speed reducer (used with 8228303)	8228304
Cutter blade (reamer)	8228305
Liner bore gauge	8275258
Master gauge (used with 8275258)	8278540
Gauge locator	8278541
Cylinder liner ridge reamer (1/32" - 1/16" oversize)	8295520
Honing fixture (facility drawing)	File 543

CRANKSHAFT AND ACCESSORIES

CRANKSHAFT

DESCRIPTION

The crankshaft, Fig. 5-1, consists of two drop forgings of carbon steel material with induction hardened main and crankpin journals. Main bearing journals are 7-1/2" in diameter and crankpins 6-1/2" (nominal). The two crankshaft halves are joined at a flanged connection. Counterweights are provided to give stable operation and all crankshafts are dynamically balanced.

As shown in Fig. 5-2, all main bearings are supplied with clean lubricating oil under pressure from a main lubricating oil manifold extending the length of the engine. The oil is introduced into the unloaded top half of the bearing, and is carried by a groove in the upper bearing shell to spreader grooves at the split line and a drilled oil passage in the main journal. This permits the use of a lower main bearing shell of greater area, with no oil groove in the load zone. Drilled oil passages conduct the oil from the main crankshaft journal to the crankpin journal. Additional oil passages conduct oil to the harmonic balancer and accessory drive gear at the front end of the crankshaft.

MAINTENANCE

INSPECTION

Whenever main or connecting rod bearings are removed, the crankshaft journals should be inspected. Check for scoring and cracks, and signs of distress, as will generally be evidenced first in the bearings. When the crankshaft is removed from the engine, it should be visually and dimensionally inspected, and Magnaflux inspected if possible. See Maintenance Instruction 1754 for crankshaft Magnaflux inspection.

The journals of the crankshaft are induction hardened. Excessive heat resulting from lack of lubrication, insufficient bearing clearance, or other causes will usually produce thermal cracks on the journal. Damaged crankshafts can usually be reconditioned at EMD to re-establish journal size and condition to use standard size bearings. In some instances, crankshafts may have to be reground requiring the use of undersize bearings. Full particulars on reconditioning procedure and return of crankshafts can be found in the Rebuild Service Bulletins.

Attempts to grind crankshafts in the field have proven unsuccessful as during the

Fig. 5-1 — Engine Crankshaft

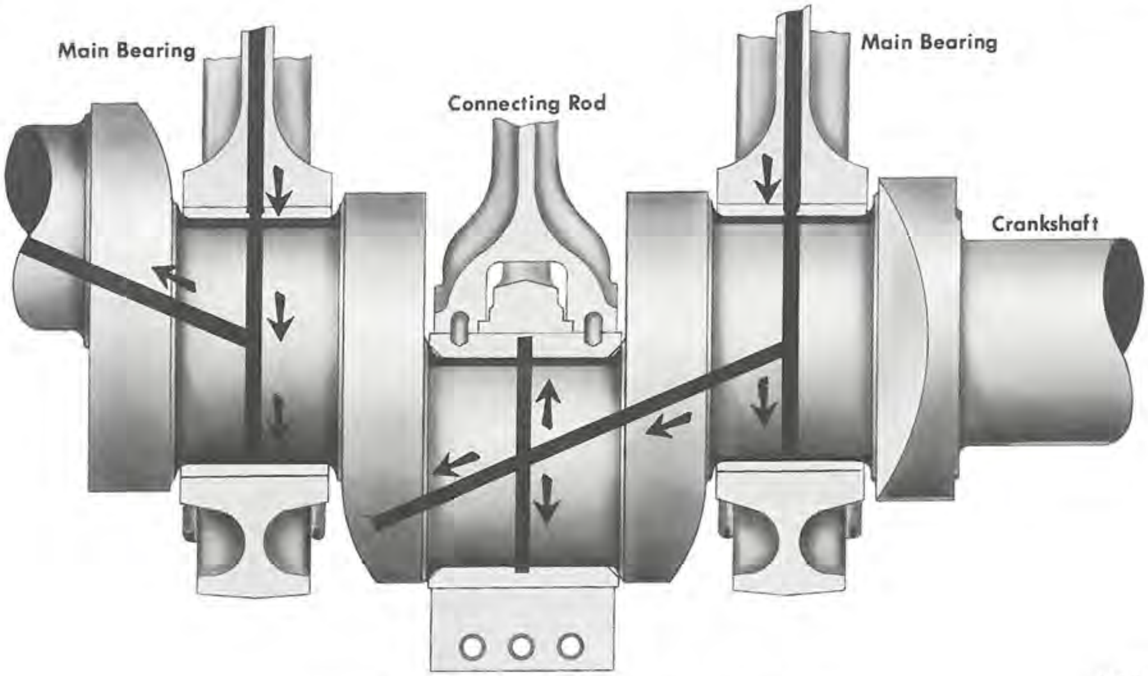

Fig. 5-2 — Crankshaft Oil Passages

regrinding process, the depth of the induction hardened zone must be checked, and when necessary, rehardened. This requires special induction hardening equipment. It is therefore recommended that the crankshaft be returned for grinding. To aid identification, reground crankshafts with undersize journals or oversize thrust bearings will have this information stamped on the same cheek as the serial number.

INSTALLATION

1. Place the crankcase on its side to facilitate application of the crankshaft.
2. Be sure that the crankcase "A" frame bores are clean and dimensionally satisfactory when the "A" frame caps are torqued as outlined under Main Bearing Stud Bolt Application in Section 1.
3. Apply the main bearings to the "A" frame bores and caps, lining up the bearing tangs properly.

   If a new crankshaft is used, all new lower main bearings should be applied. However, used upper main bearings in satisfactory condition may be applied with either a new or used crankshaft.

   If the crankcase has been reconditioned by line boring the "A" frames, all original lower main bearings regardless of condition must be replaced, even if the same crankshaft is used. Upper main bearings in satisfactory condition may be reapplied.
4. Check the inside diameter of the main bearing bores with the main bearings applied and nuts torqued to 650 ft-lbs. The diameter should be such that the specified clearance is maintained between the main bearings and the crankshaft being applied. Then remove the bearing caps.
5. Inspect the crankshaft and be sure it is clean. Oil the crankshaft journals and main bearing shells using clean oil.
6. Position the crankshaft in the "A" frame bearings. Apply end bearing caps to hold the crankshaft in place.
7. Place the thrust collars in their respective "A" frame counterbores, as

shown in Fig. 5-3, and apply the remaining caps and bearings.

8. Torque the main bearing nuts to 500-800 ft-lbs and apply lockwire.

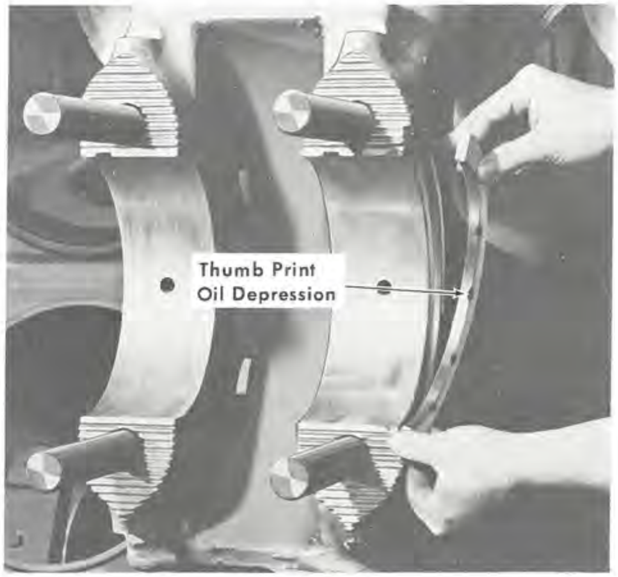

Fig. 5-3 — Applying Thrust Collar

MAIN BEARINGS

DESCRIPTION

The main bearing shells, Fig. 5-4, are precision type steel-backed lead-bronze, with a thin layer of lead-tin for break-in purposes. Tangs in the bearings locate them in the proper axial position and prevent bearing turning. Upper and lower bearing shell halves are not interchangeable.

Fig. 5-4 — Main Bearing Shells And Caps

Lower main bearing shells have two tangs on each side which fit into the main bearing cap. Upper main bearing shells have one tang which fits into a groove on the right side of the "A" frame bore. Upper shells can be rotated out, in a direction opposite to normal crankshaft rotation, when the lower bearing and cap are removed.

MAINTENANCE

REMOVAL AND INSTALLATION

The lower main bearings are removed with the caps. All upper main bearings, except the two center bearings, are removed by inserting the upper main bearing shell remover into the journal oil passage and rotating the crankshaft opposite to normal rotation. Upper bearings on journals without oil holes can be removed by using a small piece of brass to push out the bearing while rotating the crankshaft. When installing upper bearings, they should be rotated into position by hand. This will ensure proper alignment of bearing tang. Do not install bearing with remover tool.

SCHEDULED RENEWAL

Lower main bearings should be replaced at the intervals specified in the Scheduled Maintenance Program. This renewal should be made in complete engine sets. Steel-backed upper main bearings have approximately twice the life expectancy of the loaded lower half. Upper main bearings should not be removed at scheduled lower bearing maintenance intervals unless lower bearing shows signs of distress. However, upper half main bearings should be inspected at major overhaul periods and, if dimensionally satisfactory, should be cleaned up and reused. See preceding crankshaft installation procedure for additonal information.

INSPECTION

Interim inspection of the lower main bearings should only be necessary when abnormal conditions are observed in the engine, such as contamination of lube oil due to dilution with fuel or water, or foreign material being found in the lube oil filters, screens, or engine oil pan.

This should be a visual inspection made by dropping the cap and bearing. The lead-tin overlay on the bearing is primarily provided for "break in" purposes. The fact that part, or all, of this coating may have worn away should cause no concern, as long as all bearing shells have the same relative appearance. DO NOT UNDER ANY CIRCUMSTANCES REVERSE THE BEARING IN THE CAP.

Replacement of an individual lower main bearing in distress should be made only if all other lower main bearings have some lead-tin overlay remaining in the loaded areas. If one or more of the other lower main bearings has all the lead-tin overlay worn off the loaded area, then ALL lower main bearings must be renewed to ensure crankshaft alignment. If any lower main bearing shows definite signs of distress, the upper main bearing should also be examined. Used lower bearings should not be installed on any crankshaft journals other than the journals from which they were removed. Used bearings must be installed in their original position relative to shaft rotation.

CRANKSHAFT THRUST COLLAR

DESCRIPTION

The two thrust collars, Fig. 5-5, are solid bronze and are semicircular in shape. One face of each collar has "thumb print" oil depressions to ensure adequate lubrication. They are placed in the counterbore of each center bearing "A" frame and are held in position by the bearing caps. Their purpose is to limit the longitudinal movement of the crankshaft.

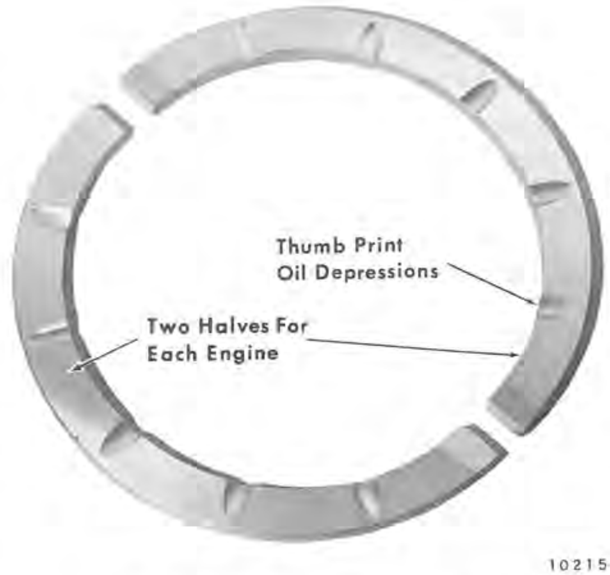

Fig. 5-5 — Crankshaft Thrust Collars

The thrust surfaces are lubricated by main bearing leak-off oil and are installed with their "thumb print" oil depressions away from the "A" frame in which they are placed.

MAINTENANCE

Thrust collars which exceed clearance limit should be replaced.

HARMONIC BALANCER

DESCRIPTION

The harmonic balancer, Fig. 5-6, is used on the engine to dampen torsional vibration in the crankshaft. Construction and parts of the harmonic balancer are shown in Fig. 5-7. The harmonic balancer drive springs receive oil from the crankshaft through radial passages in the spring housing.

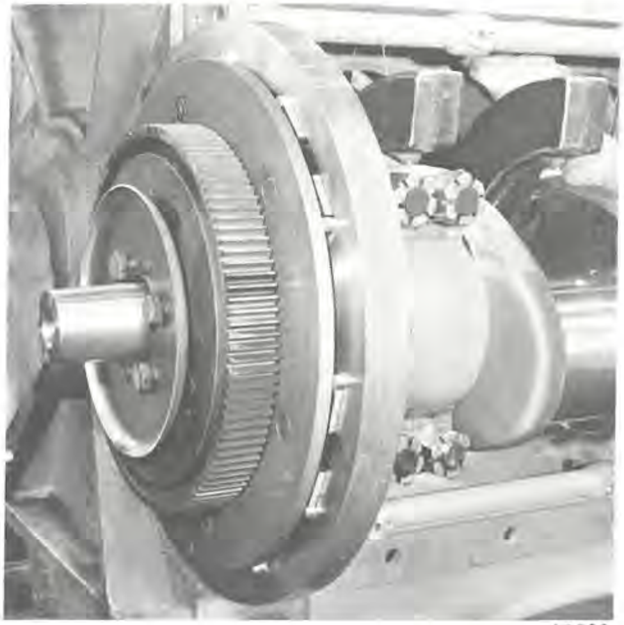

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Fig. 5-6 — Harmonic Balancer And Accessory Drive Gear

MAINTENANCE

The harmonic balancer should be inspected at intervals specified in the Scheduled Maintenance Program. The balancer should be removed from the crankshaft, disassembled, spring leaves or packs replaced, and push pins rotated to present a new contact surface to the springs.

DISASSEMBLY

Prior to disassembly, identify the assembly of the front and rear couplings so that they will be reassembled in the same position. Place supports around the outer periphery of the spring housing to raise balancer above top of work bench. Using a brass or other soft metal drift, slightly smaller than end of push pins, drive push pins from top of coupling. Drive alternately on push pins, 180° apart, until front coupling can be removed. After front coupling is removed, drive push pins from spring packs and housing. Support rear coupling and drive out push pins.

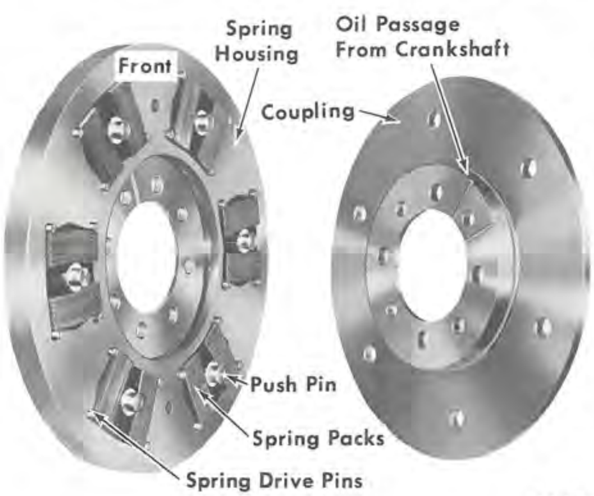

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Fig. 5-7 — Harmonic Balancer With Front Coupling Removed

INSPECTION

Examine balancer parts and remove burrs, particularly on spring pins and push pins. Spring pins having 1/8" flat or more should be rotated. Spring pins which are loose or galled on the end should be replaced with oversize pins. (See Parts Catalog for available oversizes.) Check spring pins for equal height on each side of the spring housing. Although it is doubtful that the 1/2" spring pins will make impressions in the coupling inner face, the face should be checked. Couplings having impressions exceeding maximum allowable depth should be replaced. Impressions less than maximum allowable depth should be blended.

Check surfaces of spring cells nearest circumference of spring housing for non-uniform wear, due to centrifugal force and flexing of the springs. Replace spring housing if wear exceeds maximum limit. Replace all outer spring leaves. If inner spring leaves are galled, replace with new leaves as required.

Clean oil passages in couplings and spring housing.

When a spring housing is replaced, stamp "FRONT" on the new housing near the perimeter, on the same side as the deepest portion of the radial oil groove in the bore.

ASSEMBLY

Prior to reassembly, remove any burrs or roughness from coupling mating surfaces. Place the rear coupling on a work bench and drive push pins in place, being sure worn surfaces of pins are not in a position to contact springs. Use white lead or other suitable lubricant on push pin ends.

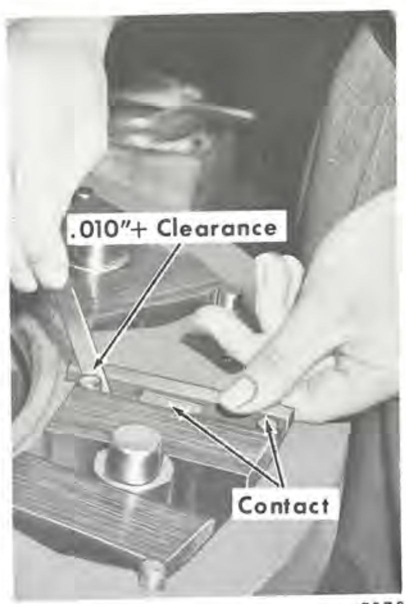
Place spring housing on the coupling, with side marked "FRONT" up. Apply spring packs to each side of push pins. About 82 to 84 spring leaves are required for each pack and their weight is about 4 lbs. 5-1/4 ozs. Stack leaves before applying and remove any that are longer, shorter, or wider than the majority of other leaves. The leaves do vary in thickness. Space springs to obtain same clearance on both sides in relation to spring pins. Apply packs with several leaves less than normally required, as it is much better to add leaves when checking, than to attempt leaf removal once assembled. Leaves can be added by starting one corner of the leaf and tapping down into the pack, using a light steel hammer.

After all packs of about right quantity have been applied, each pack should be gauged using a deflection gauge. Apply gauge as shown in Fig. 5-8A and check for clearance between springs and gauge block. With gauge in position, there should not be any clearance between gauge block and springs. Make this check on each pack. If one pack has more clearance than the opposite pack, insert leaf in side having least clearance. If clearance still exists, add leaves to each pack until there is no clearance between gauge block and springs as shown in Fig. 5-8A, and the gauge bar ends just clear the spring pins.

When gauge is held so center block contacts the springs and one end of the bar contacts a spring pin as shown in Fig. 5-8B or C, there should be a minimum clearance between the opposite bar end and spring pin. This clearance should also be obtained with the gauge bar placed against the other pin.

Follow the preceding gauging sequence on pairs of spring packs diametrically opposite starting packs. Repeat sequence on adjacent packs until all packs have been

Block To Spring
A



Bar To Pin - L.S.
B

Bar To Pin - R.S.
C

Fig. 5-8 — Harmonic Balancer Spring Gauging gauged and proper quantity of spring leaves added. Recheck all spring packs.

Upon completion of spring pack assembly, install front coupling. Line up identification marks which were placed on front and rear couplings at disassembly. Place coupling over push pins. Drive coupling down evenly against the shoulder of the push pins. Mark location of oil passages on coupling hub to aid installation of balancer to crankshaft, as oil passage must line up with oil hole in crankshaft.

Raise the assembled balancer clear of the bench using a sling in the mounting holes. Using a .0015" feeler gauge, check that gauge can not be inserted between the coupling mounting flanges. If it can be inserted, foreign particles or burrs are present on the flange surface which will require disassembly of the balancer to clean.

With the balancer still suspended, check clearance between top of spring pack and coupling. A .010" feeler gauge should pass between coupling and spring pack. If gauge does not pass, lightly tap the coupling above the pack with a rawhide mallet, at the same time checking with the gauge. This procedure will provide the necessary clearance.

INSTALLATION

Prior to installing the harmonic balancer on the crankshaft, use an air hose to remove any foreign matter, and oil spring packs with engine oil.

Place balancer on crankshaft with side stamped "FRONT" facing out. Apply two mounting bolts diametrically opposite and tighten alternately to draw balancer against flange on crankshaft.

If original spring housing and couplings are being used, the four dowels can probably be installed without reaming. However, if a new coupling and/or a new spring housing is used, it will probably be necessary to ream the dowel holes before dowels can be installed.

After the four dowels are installed, remove the two mounting bolts. Install the dowel retainer plate and apply the four 1/2" bolts to the dowels, hardened washers, and the four 7/8" mounting bolts. Torque 7/8" mounting bolts to 400 ft-lbs, tighten 1/2" bolts, and lockwire.

Oversize dowels are available. Refer to Parts Catalog.

ACCESSORY DRIVE GEAR

DESCRIPTION

The coil spring design accessory drive gear, Fig. 5-6, dampens the transmission of crankshaft torsional vibrations to the accessory gear train. The accessory drive gear meshes directly with and provides the drive for the lube oil scavenging pump and the main lube oil and piston cooling oil pump. It also provides drive, through intermediate gears, to the governor drive gear and the water pump drive gears.

As shown in Fig. 5-9, the gear consists of two discs, hub, gear, four coil springs, eight spring segments, two dowels, and four mounting bolts. The oil slinger is applied when the gear is installed on the crankshaft. Each coil spring is contained within two spring segments, these assemblies being spaced 90° apart in the gear. Slots in the outer disc align with tabs on the front of the segments. The hub serves as a pilot for the gear and spacer for the discs. The complete assembly is mounted on the crankshaft, and force is transmitted through the discs, spring segments, and coil springs to the gear.

Lubrication for the gear is supplied from the crankshaft through drilled holes in the hub to the gear.

Fig. 5-9 — Accessory Drive Gear, Exploded View

MAINTENANCE

The accessory drive gear should be removed and inspected at intervals specified in the Scheduled Maintenance Program or at the time of a complete engine overhaul. The accessory drive gear requires very little maintenance. At inspection intervals, it should be disassembled for inspection of parts.

Parts which show obvious damage should be replaced.

GEAR

The gear should be inspected for rough or scored surfaces on the gear teeth, and Magnaflux inspected as outlined in Maintenance Instruction 1754.

If wear in excess of maximum limit occurs on the drive side of holes, the gear should be reversed. The serial number side of the gear is placed adjacent to the oil slinger at original installation. To identify the drive side when gear is reversed, the original serial number should be ground off and restamped on the opposite side.

The maximum bore diameter is permissible, provided that the hub to gear clearance does not exceed the maximum limit. (This bore may be chrome plated and reground to new dimension.)

HUB

A hub having a 7.4975" diameter may be used if the maximum hub to gear clearance is not exceeded.

DISC

The disc may be re-used providing the spring segment bores do not exceed maximum diameter and are otherwise in good condition.

SPRING SEGMENTS

Spring segments should be marked, prior to disassembly, as to their relative position in the gear.

Wear should be checked on the right hand segment half (viewed at 12 o'clock position) where the segment contacts the gear bore when driving the gear. If wear at this point exceeds maximum limit, the segment half should be replaced.

When reassembling spring segments, relocate the segment, originally on the driven side, to the drive side, and place the replacement segment at the driven side of the gear.

SPRINGS

Springs may be re-used providing a preload exists at assembly of the spring and segments in the gear.

PHOSPHATE TREATMENT

It is recommended that the gear, hub, discs, and segments be phosphate treated before reassembly.

ASSEMBLY

Before reassembling the drive gear, be sure all parts are clean and well lubricated. Place the slotted disc on the bench with the slots facing down, and apply the gear over the disc. Align the holes in the gear and disc. Place a coil spring between two segments, and with the tabs down, and the assembly pressed together, start it into the gear. Drive the assembly all the way down, using a rawhide mallet, until the tabs enter the slot in the disc. Repeat this operation for the three remaining spring assemblies. After they are in place, install the hub in the gear bore, and apply the top disc. Line up the dowel holes in both discs and hub, and apply the dowels. A snug dowel fit should be maintained by reaming, and if necessary, applying oversize dowels. A bolt and nut should be used to clamp the assembly together until it is applied to a crankshaft.

When applying the assembly to the crankshaft, apply the oil slinger, dowel bolts, hardened washers, and mounting bolts. Torque the mounting bolts to 250 ft-lbs and lockwire.

FLEXIBLE COUPLING (FLYWHEEL)

DESCRIPTION

The generator armature or rotor is in effect the flywheel for the engine and is joined to the engine crankshaft by means of a flexible coupling.

The flexible coupling consists of an engine coupling disc mounted on the crankshaft and a generator coupling disc mounted on the alternator spider assembly, Fig. 5-10. Each disc is mounted at its center to the respective flange by six mounting bolts, and both halves are joined at the rim or outer circumference by twelve through bolts. The rim of the engine coupling disc has degree markings around its circumference, and holes are provided for an engine jack or turning bar for rotating the crankshaft. A flywheel pointer installed on the engine, as shown in Fig. 5-11, permits accurate positioning of the flywheel during maintenance.

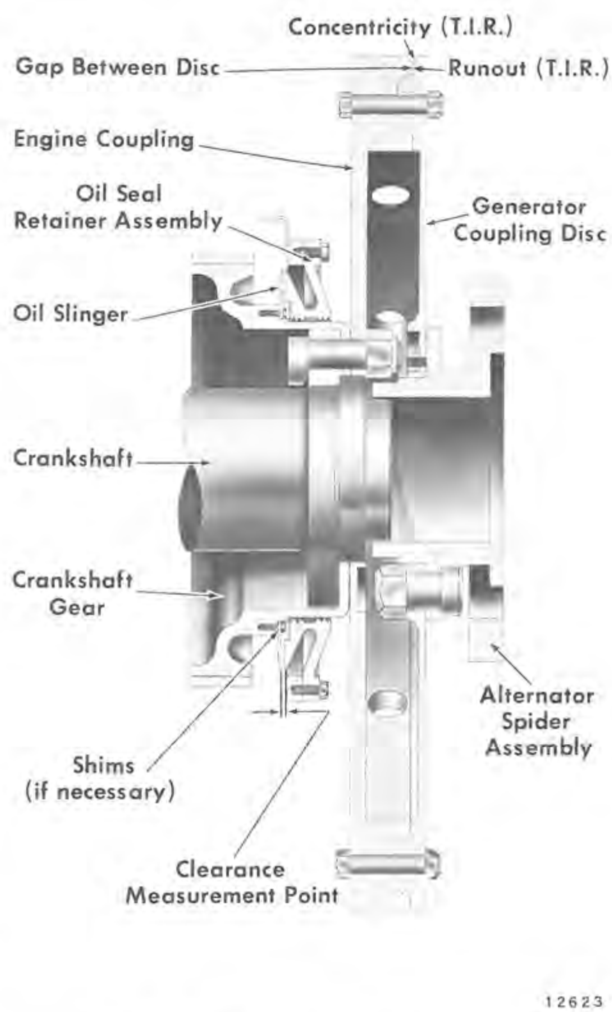


Fig. 5-10 — Engine To Generator Coupling Details

Fig. 5-11 — Flywheel Pointer Location

The flexible coupling is termed a serrated coupling because of the joint between the two discs. A "V" channel is provided in the rear face of the engine coupling disc rim, while a "V" serration is located on the forward face of the generator coupling disc near the rim. This design results in a self-centering unit, with the serration acting as a guide when the coupling is assembled.

MAINTENANCE

Engine coupling discs are interchangeable, providing top dead center pointer location on the engines is the same. Engine half couplings can also be aligned to different generators equipped with serrated coupling disc. The serrated coupling is assembled without using body bound bolts and for this reason has no reamed holes. All rim bolts are the same size. The engine disc should be applied to the crankshaft with the small "0" marks on the coupling and crankshaft coinciding. This will position the coupling with the pointer at the 0° mark on the rim when the No. 1 piston is at TDC.

Tighten the 1-1/2" engine coupling bolts to a torque value of 1500 ft-lbs. Tighten the rim bolts uniformly (to avoid cocking the coupling on the serrations) to a torque value of 295 ft-lbs. The gap between the coupling halves at the rim bolts should not be less than minimum after the rim bolts have been properly torqued.

Face runout and rim concentricity should be checked after installation of coupling disc to crankshaft, and with crankshaft positioned to avoid thrust interference. Eccentricity of rim taken at the machined groove and runout on rim face should not exceed specified maximum indicator reading.

CRANKSHAFT GEAR

DESCRIPTION

The crankshaft gear, Fig. 5-12, is mounted on the crankshaft at the rear end of the engine. The gear meshes with the No. 1 idler gear and provides the drive for the No. 1 and 2 idler gears, the camshaft drive gears, and the turbocharger drive gear. It is bolted to the engine coupling disc portion of the flexible coupling, providing the drive for the main generator. The gear is lubricated by leak off oil from the camshaft gear train.

MAINTENANCE

Gear teeth should be inspected for indications of fatigue, cracks, pitting and

Fig. 5-12 — Crankshaft Gear

other signs of distress. When possible, Magnaflux inspection in accord with Maintenance Instruction 1754 is recommended. Although no wear should occur at the oil slinger attached to the crankshaft gear, the clearance between the oil slinger and the oil seal retainer assembly should be checked when reassembled.

AUXILIARY DRIVE COUPLING

DESCRIPTION

The auxiliary drive coupling assembly, Fig. 5-13, is bolted and keyed to the tapered front end of the crankshaft to provide a power takeoff connection for components driven from the front of the engine.

MAINTENANCE

The auxiliary drive coupling does not require any routine maintenance. However, replacement of the rubber center-bonded joints may be required or desired.

To facilitate removal and replacement of the rubber joints, use a remover-installer tool. When installing the rubber joints, a small amount of rubber lubricant should be applied only on the leading pressed rubber edge of the joint. Lubricant should be mixed well with three to five parts water and should be stirred occasionally while in use.

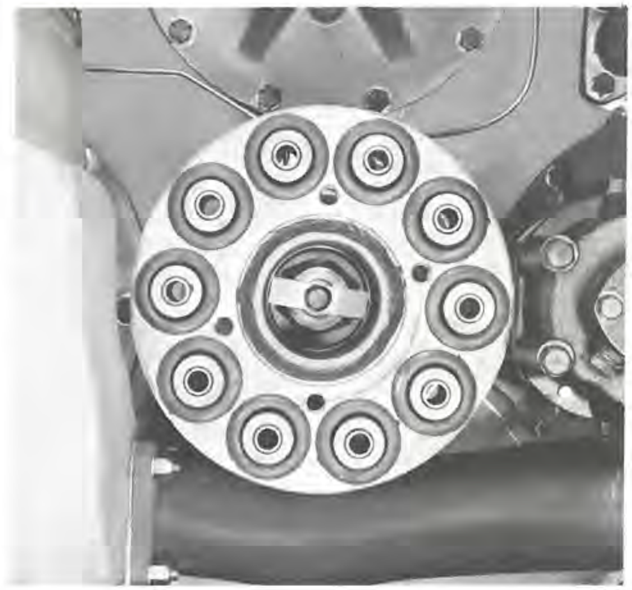

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Fig. 5-13 — Auxiliary Drive Coupling

The rubber joint must be installed past the normal location to properly seat the lips on the joint. The remover-installer tool must then be reversed and the joint positioned so that the required dimension is obtained from the outer surface of the coupling assembly to the shoulder of the joint. A gauge is available to measure this distance.

A minimum of 72 hours drying time is recommended before installing or utilizing the rubber center-bonded joint.

When installing the auxiliary drive coupling, the 1-1/4" - 12 bolt should be tightened to a torque of 500 ft- lbs.

SERVICE DATA

CRANKSHAFT AND ACCESSORIES

SPECIFICATIONS

Crankshaft

Diameter, main journal - New . . . . 7.498" - 7.500"
Limit . . . . 7.4965"

Diameter, crankpin journal - New . . . . 6.498" - 6.500"
Limit . . . . 6.4965"

Main Bearings

Diameter (inside) installed, with main bearing nuts torqued to 650 ft-lbs. (average of 6-60° measurements) - New . . . . 7.5065" - 7.5095"
Min. . . . . 7.505"

Clearance (diametric) main and connecting rod bearings to crankshaft - New . . . . .007" - .011"
Limit . . . . .015"

Number Of Main Bearings 10

The following measurements are not applicable to normal main bearing maintenance, but they should be checked when an engine has been torn down for reasons other than main bearing trouble.

Wall thickness variation between adjacent lower main bearings having crankpin between them - Max. . . . . .002"

Wall thickness variation between center lower main bearings with no crankpin between them - Max. . . . . .0015"

Main Bearing Thickness

Standard - Min. . . . . .368"
Undersize 1/32" - Min. . . . . .3835"
Undersize 1/16" - Min. . . . . .3990"

Thrust Bearing Clearance - New . . . . .008" - .018"
Limit . . . . .030"

Thrust Bearing Collar Thickness . . . . .368" - .369"

Harmonic Balancer

Number of leaves per spring pack (approximate) 84

Inner coupling face spring pin wear depth - Max. . . . . .020"

Wear limit on end of spring pack cell (housing) - Max. . . . . .050"

Clearance between end of gauge bar and spring pin (center block touching springs and opposite end of bar touching spring pin) - Min. .... .010"

Clearance between coupling mounting flanges - Less than .... .0015"

Clearance between top of spring pack and coupling - Min. .... .010"

Accessory End Gear Train

	No. Of Teeth	Ratio To Crankshaft
Governor drive gear	113	1:1
Water pump drive gear	37	3.05:1
Lube oil pump drive gear	80	1.412:1
Scavenging oil pump drive gear	80	1.412:1
Accessory drive gear	113	1:1

Backlash (all drive gears above) - New .... .008" - .016"
Limit .... .025"

Accessory Drive Gear

Hub to gear clearance - New .... .0015" - .003"
Max. .... .0035"

Diameter of gear spring segment holes - New .... 2.006" - 2.010"
(wear on drive side of gear) - Max. .... .001"

Gear bore diameter - New .... 7.500" - 7.501"
Max. .... 7.502"
(If hub to gear maximum clearance is not exceeded)

Hub outside diameter - Min. .... 7.4975"
(If hub to gear maximum clearance is not exceeded)

Disc spring segment bore - Max. .... 2.013"

Spring segment wear (right half as viewed from 12 o'clock position) - Max. .... .001"

Flexible Coupling

Clearance between coupling discs at rim bolts, after bolts are torqued - Min. .... .0015"

Eccentricity of rim (taken at machined groove) - Max. .... .005" T.I.R.

Rim face runout - Max. .... .005" T.I.R.

Crankshaft Gear

Clearance between oil slinger and oil seal retainer .... .090" - .110"

Shims to obtain required clearance

8035526	.010"
8035527	.020"
8035528	.030"

Auxiliary Drive Coupling

Dimension from outer surface of coupling assembly to shoulder of joint .... .460" - .480"

EQUIPMENT LIST

	Part No.
Upper main bearing shell remover	8055837
Spring pack deflection gauge (harmonic balancer)	8080197
Harmonic balancer dowel puller	8225989
Auxiliary drive coupling rubber joint remover - installer tool	8239562
Rubber joint checking gauge	8254465
Rubber lubricant (1 pt.)	8258834

(For additional engine tools, see Tool Catalog)

CAMSHAFT GEAR TRAIN

CAMSHAFT GEAR TRAIN

DESCRIPTION

Power necessary to drive the camshafts, and the turbocharger before it becomes free wheeling, is supplied through the gear train at the rear of the engine. Fig. 6-1 shows the gear train before the camshaft drive housing and turbocharger are installed, and Fig. 6-2 shows a cross-section of the gear train.

As shown in Fig. 6-1, the gear train consists of a crankshaft gear mounted on the crankshaft, two idler gears, and the left and right camshaft drive gears all of which are spur gears. The turbocharger drive gear is mounted on the No. 2 idler gear assembly. Rotation of the camshaft drive gears is inboard of the engine, at the same speed as the crankshaft.

Oil passages in the base of the idler gear stubshaft receive oil from the main oil manifold at the rear of the engine. One passage conducts oil from the manifold upward to the left camshaft drive gear stubshaft bracket through a jumper, and downward from the manifold to the lower idler gear stubshaft and bearing. Another passage conducts oil from the main oil manifold to the right bank camshaft drive stubshaft bracket and on to the turbocharger oil filter manifold supply line. After passing through the filter, the oil enters the return line of the filter oil manifold, returning to the upper idler gear stubshaft bore and bearing. Filter oil enters the turbocharger oil system from the upper idler gear stubshaft.

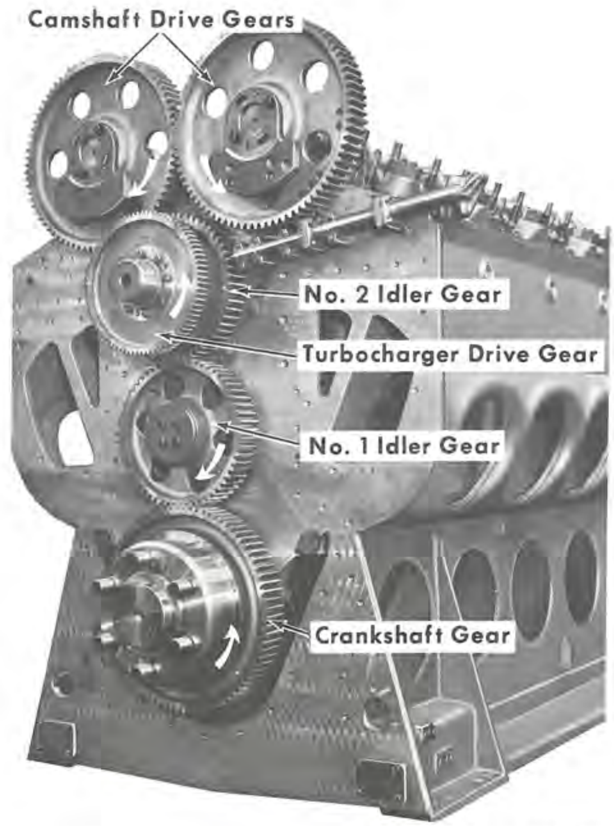


Fig. 6-1 — Camshaft Gear Train

Installation of the camshaft drive housing and turbocharger assembly completely encloses the gear train.

MAINTENANCE

Gear teeth should be inspected for fatigue indications, cracks, pits, or other evidence of failure. Whenever possible, inspection by Magnaflux methods is recommended in accord with the procedures in Maintenance Instruction 1754. Gears should also be inspected for excessive backlash by inserting a feeler gauge the entire length between teeth. Excessive

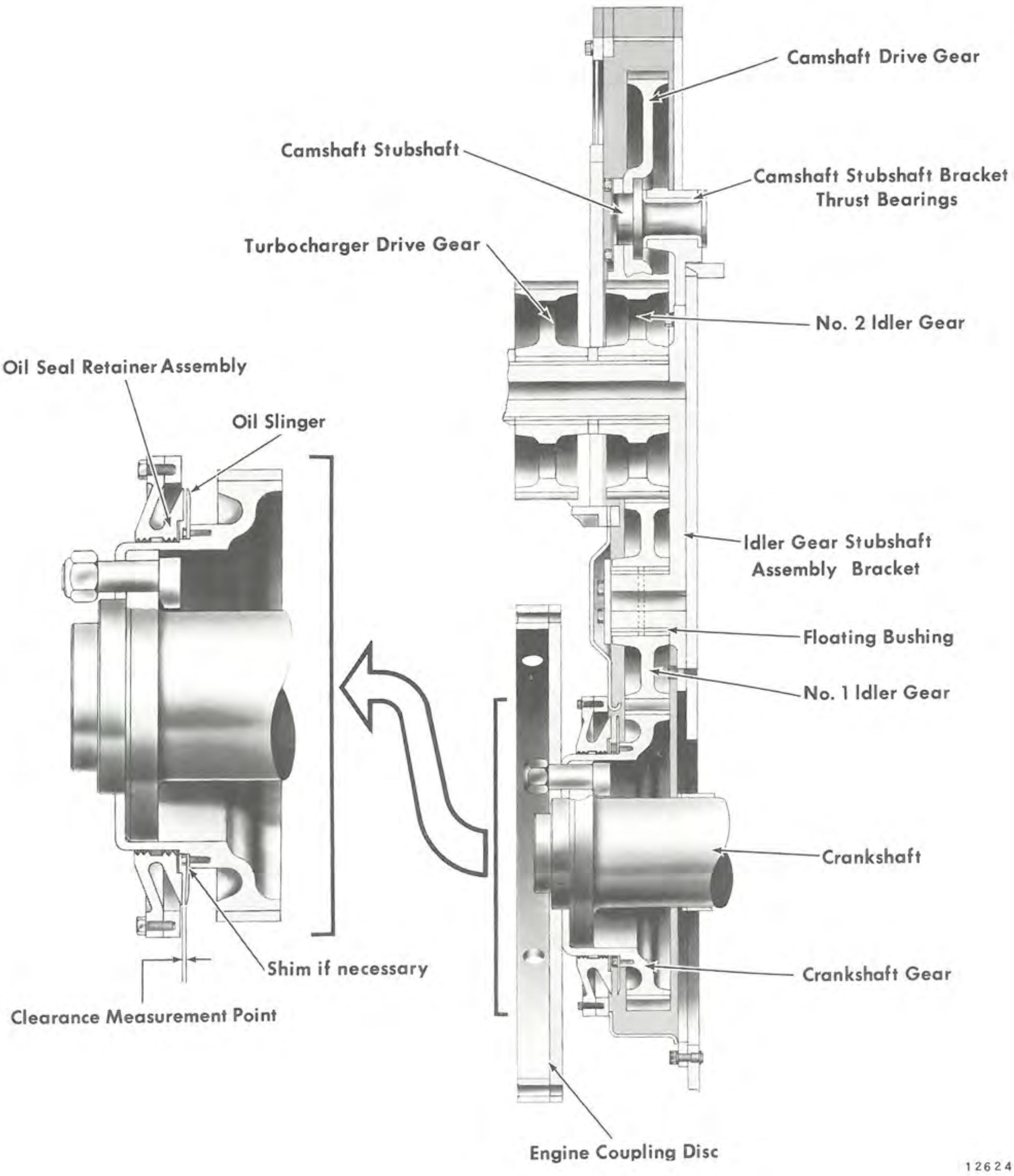


Fig. 6-2 — Camshaft Gear Train, Cross-Section backlash can cause improper valve operation and injection periods. Backlash clearance limits are given in the Specifications. Clearances between gear stubshaft and bushings and thrust clearances must also be maintained within specified limits.

Although no wear should occur at the oil slinger, Fig. 6-2, the dimension between crankshaft gear oil slinger and the oil seal retainer should be checked with the crankshaft positioned toward the generator. Measure the distance from the outer face of the camshaft drive housing to the face of the oil slinger. Then measure the distance from the inner face of the oil seal retainer mounting flange to the inner face of the retainer tapered flange. The difference between the two measurements equals the clearance. If required, add or remove oil slinger shims to obtain proper clearance.

AUXILIARY DRIVE ASSEMBLY

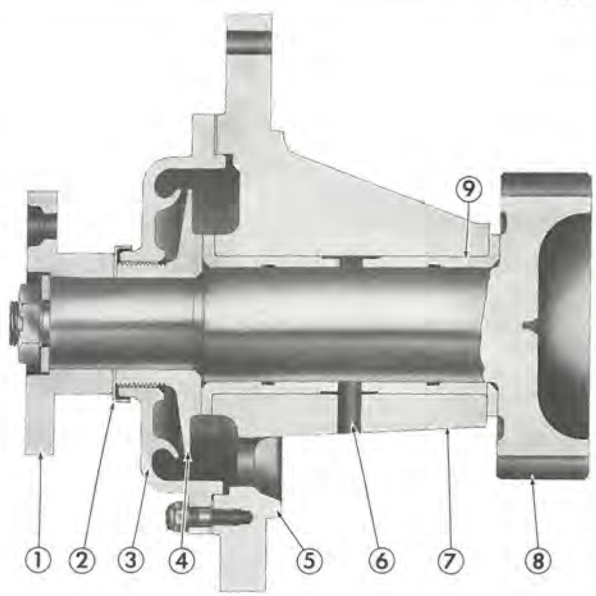
DESCRIPTION

The auxiliary drive assembly, Fig. 6-3, is mounted on the turbocharger housing and is driven from the right bank camshaft drive gear. Bearings of the assembly are provided with oil from the turbocharger oil system through drilled passages in the housing. This assembly drives the traction motor and generator blowers as well as the auxiliary generator.

MAINTENANCE

After mounting the assembly on the turbocharger housing, the backlash between the gears must be checked and adjusted, if necessary.

Check the backlash with a dial indicator, Fig. 6-4. Attach a small "C" clamp to the coupling flange so that clamp contacts the outer edge of the flange. Position the dial indicator with the contact point touching the "C" clamp. Remove play from gear teeth by turning the coupling flange. Set the dial indicator to zero and move flange in the opposite direction of the previous movement and note reading on dial indicator. Refer to Specifications for backlash limits. Backlash is adjusted by loosening the turbocharger mounting bolts and repositioning the turbocharger on the camshaft drive housing.



1. Coupling Flange
2. Dust Shield
3. Cover
4. Oil Slinger
5. Mounting Pilot
6. Drain
7. Support Housing
8. Drive Shaft And Gear
9. Bushing

Fig. 6-3 — Auxiliary Drive Assembly

After correct backlash is obtained, the turbocharger mounting bolts are tightened, and the backlash checked to see that it has not changed.

CAMSHAFT ASSEMBLIES

DESCRIPTION

The camshaft assembly, Fig. 6-5, consists of flanged segments, front and rear stubshafts, and a spacer used between the center segments. Each segment spans four cylinders. Segment flanges are marked as shown in Fig. 6-5 to aid in correct assembly. At each cylinder there are two exhaust cams, one injector cam, and two bearing journals. Two bearing blocks at each cylinder, equipped with steel-backed lead base babbitt lined inserts, support the camshaft.

Flanged stubshafts, mounted at each end of the camshaft in stubshaft bearing brackets, provide support for the drive gears and counterweight assemblies. One piece, thin steel-backed bronze bearing inserts are used in the stubshaft brackets. The camshaft drive gears and counterweight

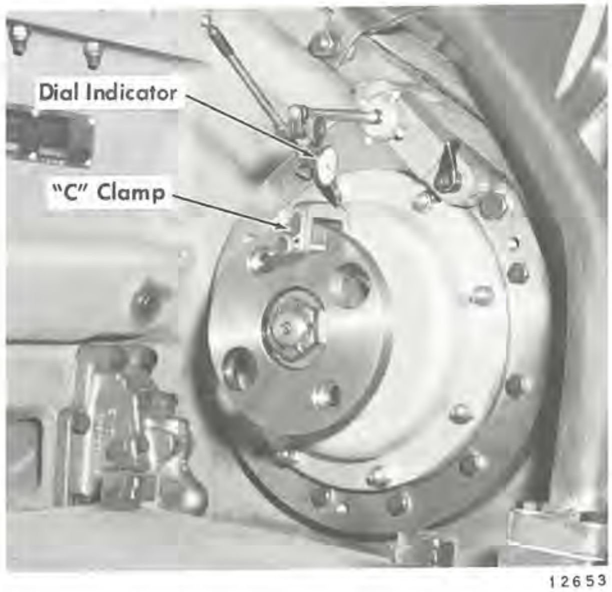


Fig. 6-4 — Checking Auxiliary Drive Gear Backlash

assemblies are bolted and doweled to the rear stubshafts, which are provided with thrust bearings. Counterweights are bolted and doweled to the front stubshafts also. The overspeed trip is incorporated in the right front counterweight.

Oil reaches the hollow camshafts through the rear stub shaft bearings which receive the oil from the main oil manifold through

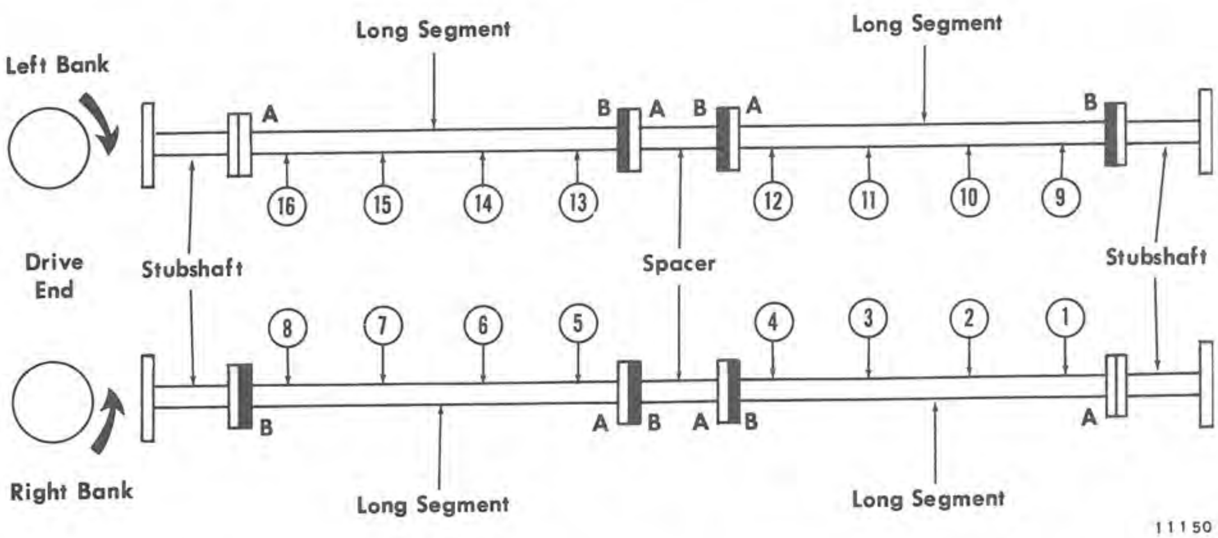


Fig. 6-5 — Camshaft Assembly

connecting oil lines. Each camshaft bearing is supplied with oil from the camshaft center bore. One bearing cap at each cylinder location is flanged for an oil line to the rocker arm shaft.

MAINTENANCE

CAMSHAFT REMOVAL

The camshaft may be removed without disturbing the stubshafts by removing the dowel bolts connecting the segment and stubshaft flanges, removing oil lines from segment bearing blocks to rocker arms, and removing rocker arms. Remove segment bearing block caps to allow camshaft removal. If the camshaft is removed for reasons other than bearing replacement, an attempt should be made to retain relative position of the bearing shells on reinstallation of the camshaft. This may be accomplished by immediately replacing caps after camshaft removal, or if the entire block is removed, by inserting block bolts and wiring the free ends of the bolts.

CAMSHAFT INSPECTION

After removal of camshaft, wash and remove all dirt from oil passages. Visually inspect stubshafts and segments paying particular attention to cam lobes and journals for pitting, chipping, excessive scoring, and heat discoloration. Journals and cams with light pit marks, minute flat spots, and light score marks may be reused after blending and removal of sharp edges by hand polishing. Check inside of dowel bolt holes for burrs and remove.

Camshaft segments and stubshafts that show heat discoloration should be Magnaflux inspected and hardness tested. See Maintenance Instruction 1754 for Magnaflux procedures. Discoloration on the unfinished portion of the camshaft should be disregarded as it results from a production process and may be seen even on a new camshaft.

CAMSHAFT ASSEMBLY

The camshaft must be assembled as shown in Fig. 6-5. One dowel bolt hole in each segment flange is smaller than the others to ensure correct angular position.

After assembly of camshaft and stubshaft, check for concentricity between the stubshaft and camshaft journals and maximum runout over total length of the shaft. Support the camshaft on precision rollers at the number 1, 7, 10, and 16 camshaft bearing journals. See Specifications for limits.

CAMSHAFT INSTALLATION

Camshaft assemblies installed on an engine must conform to segment sequence and position as indicated in Fig. 6-5. On right bank camshafts, the "A" marking on each flange is toward the front of the engine. On left bank camshafts, the "B" marking on the flange must be toward the front of the engine.

Check segment journal to bearing clearance and thrust clearance at rear stubshafts. Limits are listed in the Specifications. Clearance measurement can be obtained with feeler gauges.

Upon installation or replacement of the camshaft, lubricate freely all moving parts, place the assembly in properly aligned position after replacing blocks and bearings as removed. Rotate camshaft to check for binding. Apply flange dowel bolts and reassemble rocker arms and associated parts. Check valve timing of at least one cylinder to check segment positioning and then make other adjustments such as exhaust valve setting and injector timing.

CAMSHAFT COUNTERWEIGHT APPLICATION

Counterweight replacement usually is not necessary. However, when counterweights are installed, they should be applied in the position as shown in Fig. 6-6.

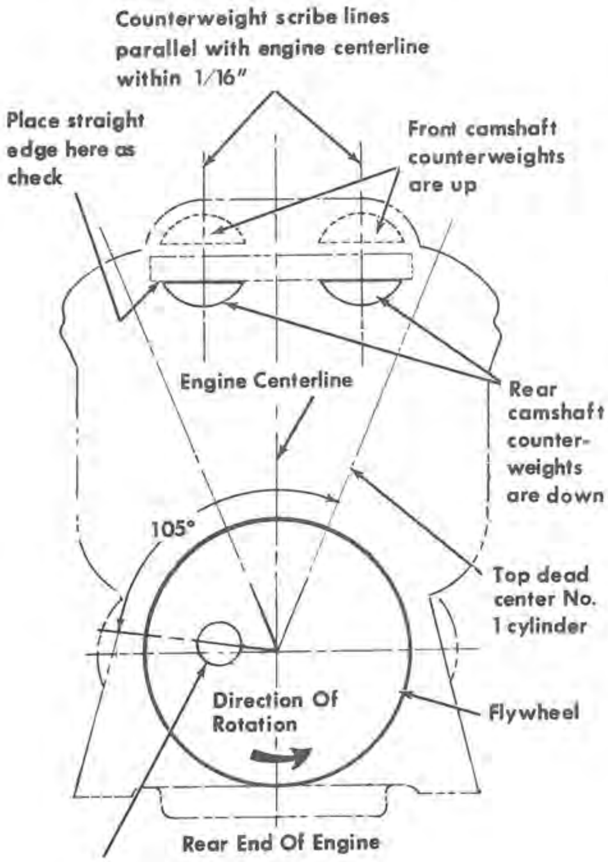


Fig. 6-6 — Camshaft Counterweight Timing

VALVE TIMING

DESCRIPTION

Valve timing is very important as it ensures correct relationship of valve operation with the other events in the cylinder power cycle.

Items which govern correct valve timing are given in the following procedures.

MAINTENANCE

FIRING ORDER AND TOP DEAD CENTER

A	B	A	B
1	0 deg.	4	180
8	22-1/2	5	202-1/2
9	45	12	225
16	67-1/2	13	247-1/2
3	90	2	270
6	112-1/2	7	292-1/2
11	135	10	315
14	157-1/2	15	337-1/2

Column A - Firing Order

Column B - Position of flywheel in degrees when piston is at top dead center

LOCATING TOP DEAD CENTER

If it should become necessary to check the position of the flywheel or the flywheel pointer for top dead center, proceed as follows:

1. Remove injector from No. 1 cylinder.
2. Turn crankshaft in normal direction of rotation until piston is just before top center.
3. Insert top dead center checking rod through injector hole and screw into piston puller hole in crown of piston.
4. Attach dial indicator to a bolt screwed into threaded lifter hole in cylinder head, Fig. 6-7. Place indicator as shown, and depress a few thousandths of an inch.
5. Set indicator at zero and mark flywheel at pointer. Turn crankshaft in normal direction until piston moves up to and past top dead center and indicator returns to zero.

NOTE: The distance the piston travels after the indicator is attached should be within the range of the indicator.

6. Continue turning crankshaft until piston moves approximately .010" past zero, then turn crankshaft in opposite direction until indicator returns to zero. This will compensate for clearance in bearings and piston assembly.

7. Mark flywheel again at pointer. Divide distance between the two marks. This point will be top dead center for No. 1 piston.

3636

Fig. 6-7 — Locating Top Dead Center

CHECKING EXHAUST VALVE TIMING

To check timing, place a dial indicator on the rocker arm adjusting screw as shown in Fig. 6-8. Valve end of rocker arm must be in its highest position, so that the exhaust valves are closed. Press indicator down approximately .100" and set dial to zero.

3637

Fig. 6-8 — Timing Exhaust Valves

Turn crankshaft in normal direction of rotation until flywheel is at 106° A.T.D.C. of cylinder being checked.

If timing is correct, the valve bridge will have moved down .014". Timing must not be later than 110° or earlier than 104° A.T.D.C. of cylinder being checked.

TIMING EXHAUST VALVES

When any items at the back of the engine are removed for replacement, such as camshaft assembly, stubshafts, or gears, the exhaust valves should be timed as follows:

1. Remove or loosen all rocker arms except the one on which the dial indicator is resting, as shown in Fig. 6-8. Each camshaft must be timed to the crankshaft. Checking timing of any one cylinder of each bank is sufficient.

2. Locate top dead center for the cylinder to be checked. Remove the dowels and bolts from the camshaft drive gear and remove gear. The camshaft can be rotated by placing a socket and wrench on flange bolt nuts.

3. Rotate the camshaft in its normal direction of rotation until the valve bridge on which the dial indicator is resting moves down .014".

4. Turn the crankshaft in the normal direction until flywheel pointer is at 104° after top dead center of the cylinder being checked. If a new gear train has been installed, the timing may be as early as 104° but not later than 106°. Unless a new gear train has been installed, it is preferable to set timing as near to the 106° mark as possible. With flywheel at 104° A.T.D.C. of the cylinder being checked, the dowel holes in the camshaft drive gear applied and dowel holes in the camshaft stubshaft should be in line or approximately in line with each other. If by turning the crankshaft from 104° to 106° A.T.D.C., the dowel holes can be made to line up, then the bolts should be tightened. If the dowel holes do not line up within this tolerance, remove the camshaft gear from its stubshaft. Turn the gear 180° and replace on stubshaft or move the gear one tooth and replace on the stubshaft. The dowel holes should then line up.

5. If it is not possible to line up the dowel holes perfectly, they may be reamed oversize and oversize dowels installed. This will eliminate the necessity of redrilling the gear and stubshaft. Secure gear to its stubshaft.

6. The crankshaft should now be rotated in its normal direction and the timing checked so that the valve bridge of the valve being checked has moved down .014", when the flywheel timing pointer is at 104°-106° A.T.D.C.

7. After timing has been completed, the relative positions of the mating parts should be identified similar to the method used on new engines, shown in Fig. 6-9. The mating parts are marked with No. 1 piston at top dead center.

OVERSPEED TRIP

DESCRIPTION

An overspeed mechanism is provided as a safety feature to stop the injection of fuel into the cylinders should the engine speed become excessive.

Fig. 6-10 shows the mechanical overspeed trip mechanism. If the engine speed should increase to between 990-1005 RPM, the overspeed mechanism will shut down the engine.

A trip shaft extending the length of each engine bank under the camshaft is provided with a cam at each cylinder, which when rotated, contacts a spring loaded catch pawl mounted on each cylinder head, and located directly under the injector rocker arm. In the overspeed trip housing on the front of the engine, the trip shafts are connected to spring operated links and a lever mechanism. A reset lever on the spring lever shaft, when rotated counterclockwise puts tension on an actuating spring; this tension being held by a trip lever engaging a notch in the reset lever shaft. This is the normal running position, in which the cams on the trip shaft are held away from the rocker arm catch pawls.

The overspeed trip release mechanism is incorporated in the right bank front camshaft counterweight. It consists of a flyweight held by an adjustable tension spring. When engine speed exceeds the set limit, the tension of the spring is overcome by the centrifugal force acting on the flyweight, causing the flyweight to move outward to contact the trip lever. This allows the actuating spring, acting through connecting links, to rotate the trip shafts. Consequently, the trip shaft cams contact and raise the injector rocker arm pawls

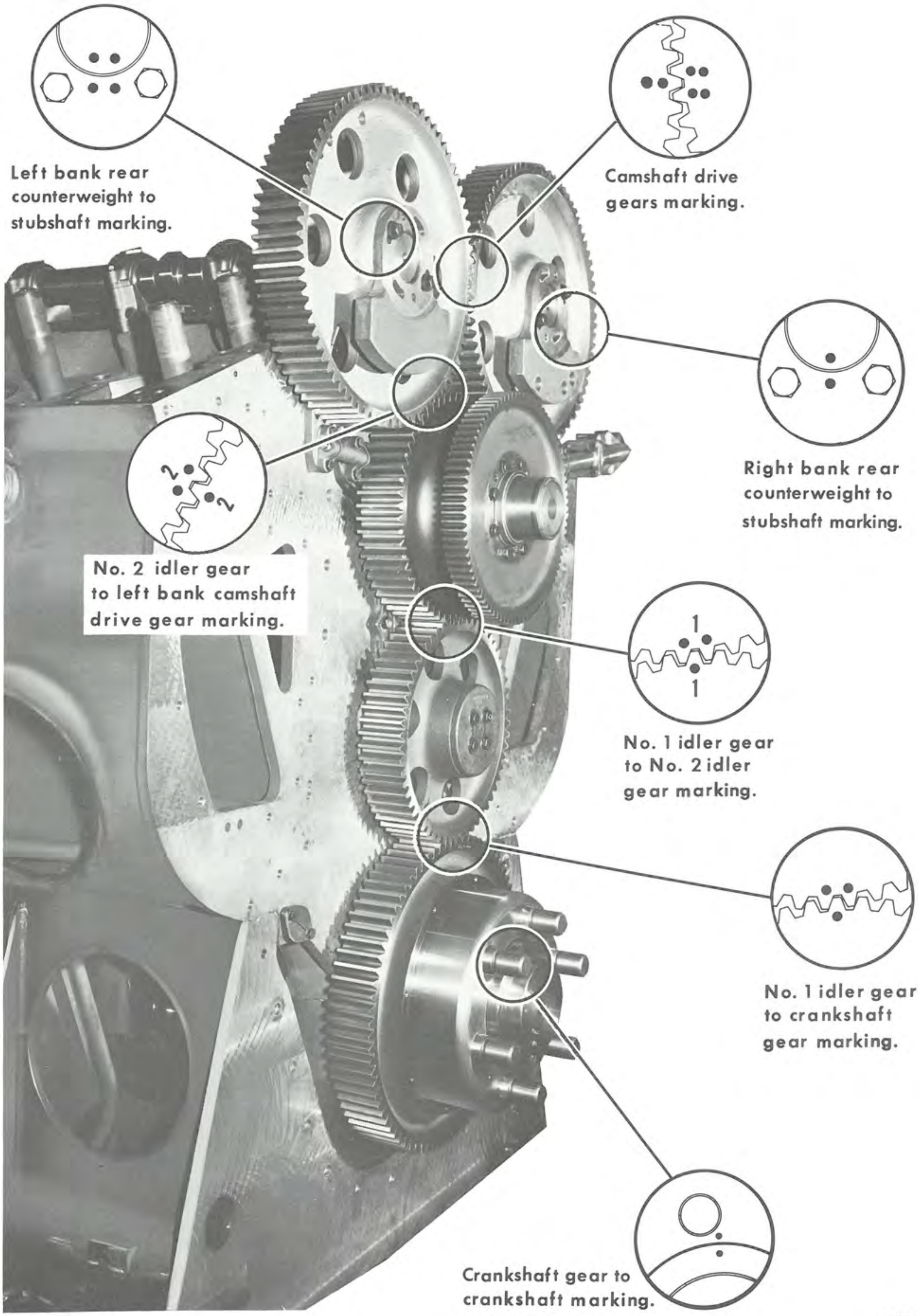


Fig. 6-9 — Camshaft Gear Train Marking

preventing full effective injector rocker arm roller contact on its cam. This prevents fuel injection and stops the engine.

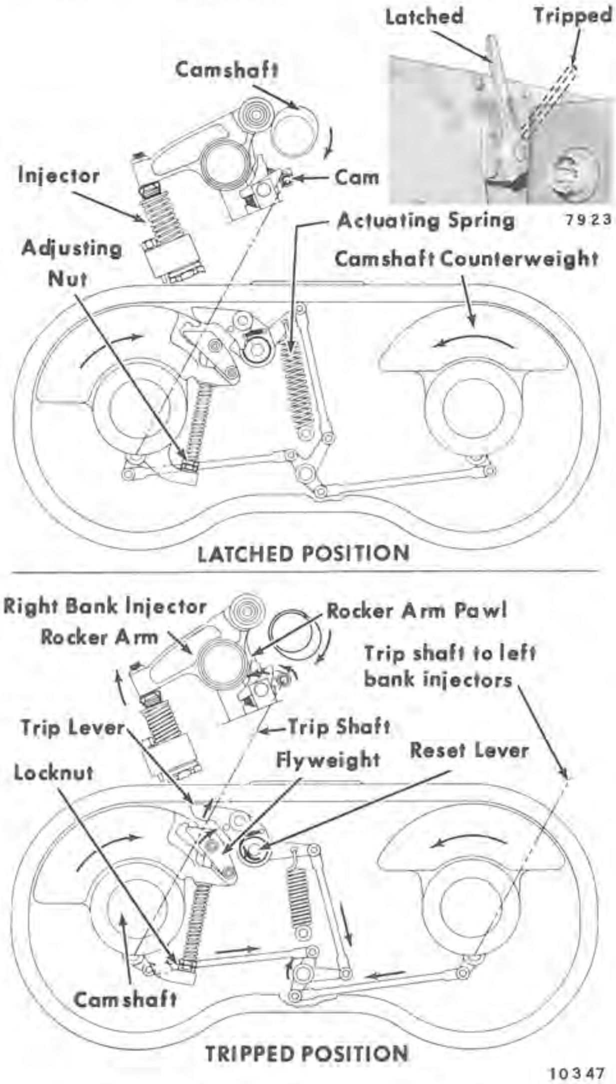


Fig. 6-10 — Overspeed Trip

Upon resetting, by counterclockwise movement of the reset lever, the trip shaft cams release the injector rocker arm catches. Rotation of the camshafts on starting the engine lift the rocker arms slightly allowing the catch pawls to resume unlatched position, releasing the injector rocker arm for normal operation.

MAINTENANCE

ADJUSTING MECHANICAL OVERSPEED TRIP

To adjust the overspeed trip, shut engine down, remove the cover from right side of overspeed trip housing and turn adjusting nut to increase or decrease spring tension as required. To increase engine speed at which overspeed trip operates, increase spring tension.

After the adjusting nut has been moved, the locknut must be tightened and the engine run to test speed at which trip operates. The speed rise of the engine from idle to trip should be made in 20 to 30 seconds. Several adjustments may be required before final setting of tripping speed is reached.

See Scheduled Maintenance Program for frequency of checking the overspeed trip.

Litho in U.S.A.

SERVICE DATA

CAMSHAFT GEAR TRAIN

SPECIFICATIONS

Crankshaft Gear

Oil slinger to oil seal retainer clearance .... .090" - .110"

Gear Data

	No. of Teeth	Ratio to Crankshaft Gear
Crankshaft	79	1:1
Idler, Nos. 1 & 2	58	1.362:1
Camshaft Drive	79	1:1
Turbo Drive (on No. 2 idler)	87	1.362:1
Auxiliary Drive	26	3.037:1

Gear Backlash

Crankshaft gear to No. 1 idler - New .... .007" - .014"
No. 1 to No. 2 idler - New .... .007" - .014"
No. 2 idler to camshaft drive - New .... .007" - .016"
Camshaft drive to camshaft drive - New .... .007" - .022"
Auxiliary drive to camshaft gear - New .... .010" - .014"
Limit (all gears above) .... .025"
Turbocharger drive to turbocharger - New .... .006" - .010"
Limit .... .020"

Gear Train Clearance

No. 1 idler gear assembly

Bushing to stubshaft - New .... .005" - .008"
Limit .... .016"
Bushing to gear - New .... .008" - .010"
Limit .... .018"
Thrust clearance - New .... .009" - .017"
Limit .... .025"
Bushing minimum length .... 3-27/32"

No. 2 idler gear assembly

Bushing to stubshaft - New .... .004" - .007"
Limit .... .011"
Stubshaft sleeve diameter - New .... 3.999" - 4.001"
Limit .... 3.9975"
Idler gear bushing diameter - New .... 4.005" - 4.006"
Limit .... 4.0085"
Thrust clearance - New .... .045" - .077"
Limit .... .080"

Auxiliary Drive

Housing

Pilot diameter - New	8.498" - 8.499"
Limit	8.496"
Bearing diameter - New	2.5025" - 2.5035"
Limit	2.506"
Thrust dimension - New	6.487" - 6.495"
Limit	6.478"

Drive shaft

Bearing diameter - New	2.499" - 2.500"
Limit	2.4985"
Thrust dimension - New	6.505" - 6.508"
Limit	6.512"

Clearance

Shaft to bushing - New	.0025" - .0045"
Limit	.0075"
Thrust - New	.010" - .021"
Limit	.033"

Camshaft And Stubshaft

Camshaft journal diameter - New	2.496" - 2.498"
Limit	2.495"
Diametric clearance, segment journal to bearing - New	.002" - .006"
Limit	.010"
Taper length of journal - Limit	.001"
Runout (journal) T.I.R. when supported on adjacent journals - Limit	.002"
Runout (base circle relative to journal) - Limit	.003"
Mounting flange (not convex) flat within* - Limit	.0005"
Mounting flange square with longitudinal centerline within, T.I.R.* - Limit	.001"

*(Correct by grinding faces)

Dowel bolt holes in flanges

One hole	.439"
Three holes	.5015"
Stubshaft journal diameter - New	2.497" - 2.498"
Limit	2.495"
Diametric clearance, journal to bearing - New	.0035" - .0075"
Limit	.010"
Stubshaft thrust clearance - New	.010" - .018"
Limit	.025"
Dimension between thrust faces - Max.	4.195"

Camshaft Timing

Ideal timing setting, valve open .014" - A.T.D.C.	106°
Timing of new gear train not earlier than - Max.	2°
or	
at .014" valve opening - A.T.D.C.	104°
Limit of lag - camshaft behind crankshaft due to worn gears - Max.	4°
or	
at .014" valve opening - A.T.D.C.	110°
Flywheel pointer setting - T.D.C. of No. 1 cylinder	0°

Overspeed Trip

Clearance, trip latch to flyweight - Min.	.010"
Trip setting - RPM	990-1005

EQUIPMENT LIST

	Part No.
Top dead center checking rod	8051833
Dial indicator	8255423
Feeler gauge set	8067337

AIR INTAKE AND EXHAUST SYSTEMS

TURBOCHARGER

DESCRIPTION

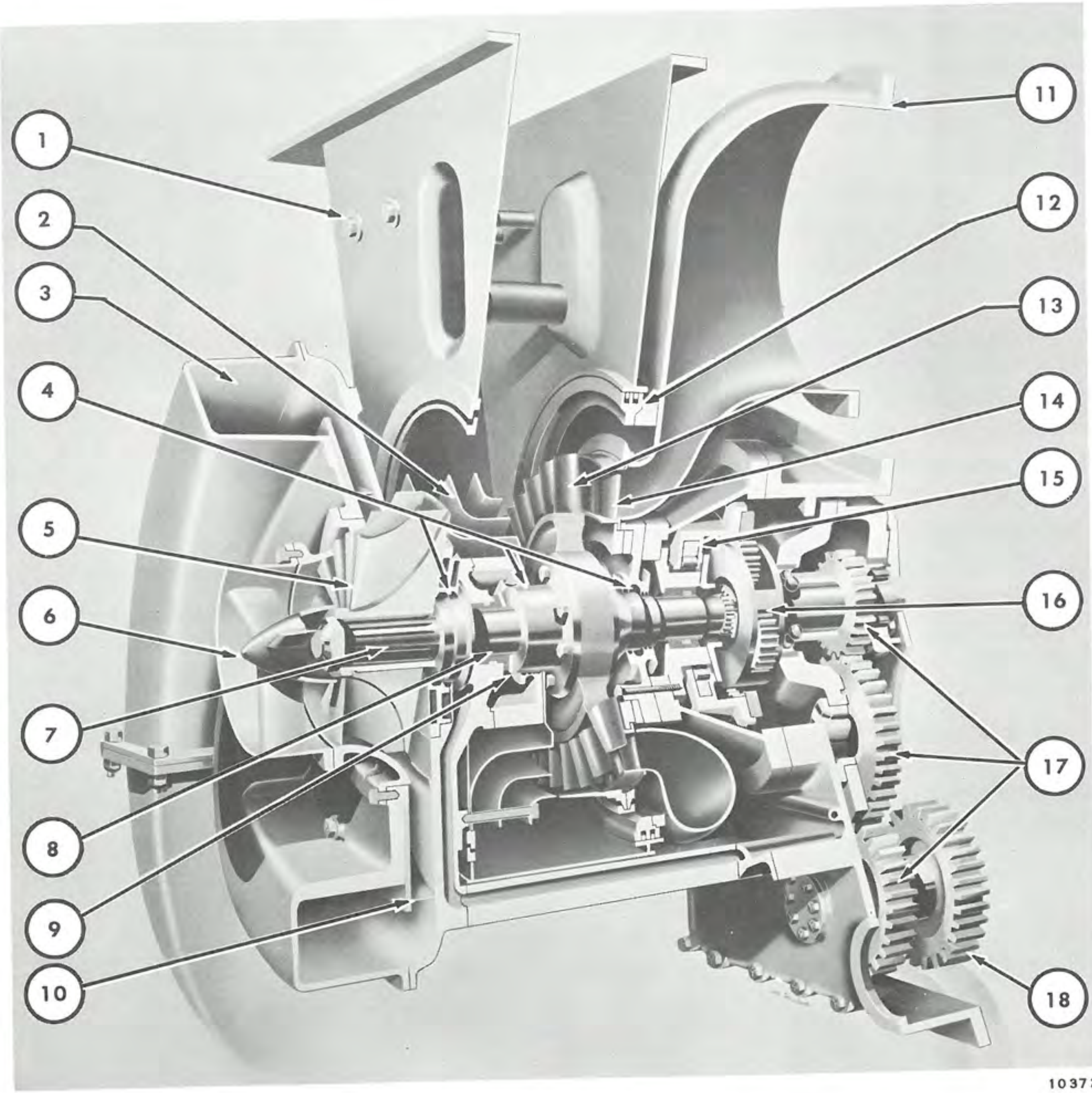
The turbocharger assembly, Fig. 7-1, is primarily used to increase engine horsepower and provide better fuel economy through the utilization of exhaust gases. As shown in Fig. 7-2, the turbocharger has a single stage turbine with a connecting gear train. The connecting gear train is necessary for engine starting, light load operation, and rapid acceleration. Under these conditions there is insufficient exhaust heat energy to drive the turbine fast enough to supply the necessary air for combustion, and the engine is actually driving the turbocharger through the gear train assisted by exhaust gas energy. When the engine approaches full load, the heat energy in the exhaust, which reaches temperatures approaching 1000° F., is sufficient to drive the turbocharger without any help from the engine. At this point, an overrunning clutch in the drive train, Fig. 7-2, disengages and the turbocharger drive is mechanically disconnected from the engine gear train.

The turbine shaft is driven by the engine gear train through a series of gears in the turbocharger. A turbocharger drive gear is bolted to the No. 2 engine idler gear, which is mounted on a stubshaft. The drive gear meshes with the turbocharger idler gear, driving the carrier shaft gear. The carrier shaft drives the sun gear on the turbine shaft through three planet gears when the turbocharger is being driven by the engine. The sun gear meshes with the planet gears which, in turn, mesh with a ring gear in the

Front View

Rear View

Fig. 7-1 — Turbocharger Assembly



1. Exhaust Duct
2. Exhaust Diffuser
3. Compressor Discharge Scroll
4. Labyrinth Oil Seals
5. Impeller
6. Compressor Air Inlet Nose Cone
7. Turbocharger Shaft
8. Bearing
9. "Heat Dam" Thrust Washer
10. Compressor Diffuser
11. Turbine Inlet Scroll (Engine Exhaust Inlet)
12. Exhaust Seal Rings
13. Turbine Blades
14. Stationary Nozzle Ring
15. Overrunning Clutch
16. Planetary Gear Assembly
17. Drive Gear Train
18. Engine Idler Gear

Fig. 7-2 — Cutaway View of Turbocharger

overrunning clutch assembly. The ring gear is fixed when the engine is driving the turbine because the direction of torque at the ring gear locks the overrunning clutch. When the turbine is being driven entirely by exhaust gas energy, the direction of torque is reversed and the clutch overruns, allowing the ring gear to rotate.

The overrunning clutch consists of 12 rollers in tapered slots, as shown in Fig. 7-2. The slots are formed by the combination of a stationary clutch support and the pockets in the cam plate. The cam plate, ring gear support, and the ring gear are dowelled and bolted together, and rotate as a unit. When the engine is driving the turbine, the rollers are wedged in the small side of the cam plate pockets, as a result of the direction of torque, locking the cam plate to the stationary clutch support. This locking action prevents the ring gear from turning. Because the planet gear shafts are driven as a part of the carrier shaft, the planet gears rotate in the locked ring gear to drive the sun gear on the turbine shaft. When the exhaust energy becomes great enough to drive the turbine without help from the engine, the torque at the sun gear, planet gears, and ring gear reverses direction. This causes the rollers to move to the wide end of the cam plate pocket, unlocking the clutch, permitting it to overrun, and allowing the ring gear to rotate. From this point on, with increased load and speed, the turbocharger overruns the engine drive and the planet gears slowly turn the ring gear.

When the engine is running, the turbocharger is supplied with engine oil that has passed through a separate turbocharger oil filter mounted on the camshaft drive housing at the right rear side of the engine. Oil leaving the turbocharger empties into the gear train housing and returns to the oil pan. A low oil pressure protective device is connected through an oil line into the turbocharger oil system.

A separate electrically driven auxiliary circulating oil pump is used to pump engine oil through a "soak back" oil filter and then to the turbocharger. The pump motor is controlled to operate the oil pump when the engine is started and for approximately 15 minutes after the engine is stopped. In this way, lubricating oil is provided for the moving parts requiring lubrication, at the time the engine is started and is supplied, after stopping the engine, to prevent overheating by absorbing the heat that penetrates the bearing areas. A check valve prevents soak back oil from flowing back through the engine lube oil system and confines the soak back oil pressure to the turbocharger lube oil system when the engine is stopped. An additional check valve in the soak back oil supply line prevents the normal engine lubricating oil under pressure, from entering the soak back oil system during normal operation. The oil pump motor is controlled by a turbine oil pump motor circuit breaker, which must be closed to permit operation of the motor.

Except under emergency conditions, the engine should be allowed to run at idle speed for two minutes after every start. This applies also if the cooling system water temperature is below 130° F. at the time the engine is started; and when starting the engine after oil filter changes, to provide a full oil system. It is recommended that the engine not be run above 500 RPM until water temperature reaches 130° F., with the exception of emergency operation. Prolonged operation at no load is not recommended above the 5th throttle position.

MAINTENANCE

Since it would not be practical to attempt any reconditioning of the turbocharger in the field, it is recommended that it be returned to EMD for this service.

The following removal and installation procedures are provided for field service.

REMOVAL

1. Remove roof hatch.
2. Disconnect and remove the water lines to and from the aftercooler assemblies.

3. It is advisable to remove the aftercoolers from the ducts rather than to remove them as an assembly, because of the weight involved.

4. Remove both aftercooler duct assemblies.

5. Remove the auxiliary drive assembly.

6. Disconnect the oil pressure gauge line and the flexible oil line from the soak back filter.

7. Remove the oil separator assembly.

8. Remove the expansion joint between the turbine and the engine exhaust manifold.

9. Disconnect the exhaust stack from the top of the turbine exhaust duct. Remove the stack through the roof hatch.

10. Remove air duct assembly from turbocharger nose cone and remove nose cone.

11. Connect lifting chains to eyes screwed into the four tapped bosses on the turbocharger. Maintain even tension on all four chains so that turbocharger will hang properly. If a hand-operated chain hoist is available, it should be used between the chain device and the main lifting crane to simplify vertical positioning and tension adjustment during turbocharger removal. Do not allow chains to drag against the exhaust duct.

12. Remove bolts attaching turbocharger housing to camshaft gear train housing. The turbocharger is now held in position by the No. 2 idler gear stubshaft and the lifting device.

13. Using jackscrews between the turbocharger housing and the gear train housing, jack the turbocharger away from the engine. The turbocharger should clear the No. 2 idler stubshaft after it has been moved out approximately 2-3/16".

NOTE: Care should be exercised, when removing turbocharger, that No. 2 idler gear is not disengaged from camshaft drive gear, as engine timing will have to be checked if gear is disengaged.

14. Using a 1-ton crane, lift the turbocharger clear of the engine and place it in shipping container for transportation.

PREPARATION FOR INSTALLATION

The following steps should be adhered to if the turbocharger is being replaced because of a failure, if not, some of the steps may be ignored. The turbocharger should remain in the shipping container until actual application.

Air Box Inspection

1. Clean the air box to remove all evidence of aluminum dust and chromate or borate water stains.

2. Inspect the cylinder assemblies for broken valves, valve blow, cracked pistons, broken piston rings, scored pistons and liners.

3. Determine the cause of the turbocharger failure and correct any conditions that might have aggravated the failure.

4. Clean all gasket surfaces on the engine, the turbocharger to be applied, and the air ducts. Remove any nicks or burrs so as to present a smooth surface.

Gear Train Inspection

1. Visually check the gear train for nicks, burrs, evidence of improper backlash, and uneven or excessive wear. Make any necessary corrections.

2. Clean the No. 2 idler turbocharger locating stubshaft, using an oil stone. Remove all indications of fretting. Inspect the seal groove for nicks and burrs, and smooth the surface after removal of any nicks or burrs.

3. Check the gear train area and remove any metallic debris that might be found.

Exhaust Manifold Inspection

1. Inspect the exhaust manifold for any foreign material, such as, pieces of exhaust valve heads, debris from any cylinder assembly failure, and fragments of manifold expansion joints. Completely remove any foreign material found. The manifold should be removed, if in doubt, to look for foreign material, cracked leg baffles, which should be removed, and cracked expansion joints, which should be replaced.

2. Inspect the condition of the exhaust manifold leg gaskets and the torque on the bolts, which should be 130 ft-lbs. Also, check the manifold connector fasteners which should be 80 ft-lbs. Check the condition of the adapter to turbocharger bellows connections, and other locations where possible leaks might occur in the exhaust system.

3. Inspect the adapter assembly between rear expansion joint and chamber assembly for condition of screen. If foreign material is present in the exhaust manifold, it is recommended that the screen be Magnaflux inspected.

Lubricating Oil System

1. Remove the disposable turbocharger oil filter and soak back filter elements. Install new elements and check that the filter bowls are full of clean lubricating oil and that the springs and gaskets are in place.

2. If required, drain and completely clean the system.

   a. If the oil system is contaminated with debris, flush the system as outlined in Maintenance Instruction 1757, and install new filter elements.

   b. Install new main oil filter elements, and clean and check the main oil filter relief valves.

   c. Recharge the oil system after the replacement turbocharger is applied and the oil system and all filters have been conditioned to receive the new clean oil.

   d. Check the soak back pump function and operation. Check the soak back pump bypass relief valve for proper operation.

INSTALLATION

1. Apply the lifting device to the turbocharger as described in the turbocharger removal procedure. (The turbocharger shipping container, plus the masking of all openings on the turbocharger is the best protection and insurance against damage, rust, and contamination that can be given the turbocharger prior to installation.)

2. To determine the impeller eye clearance, remove the nose cone before removing the turbocharger from the container pedestal. Chalk mark an

impeller blade at the 12 o'clock position when the eye clearance is rechecked after turbocharger installation. Two sets of feeler gauges should be used when making this check. Clearances should be determined with a heavy drag on the feelers. Perform check as follows:

a. Insert approximately the same feeler gauge thicknesses at the ends of the impeller blades at the 3 and 9 o'clock positions simultaneously to determine the available horizontal clearance. Record the clearances.

b. A feeler gauge should be used at the 12 o'clock position to determine the upper vertical clearance. Leaving the feeler gauge in position at the 12 o'clock position, use another feeler to determine clearance at the 6 o'clock position. Record the clearances obtained.

3. Apply a thin coat of gasket compound to the camshaft drive housing and apply a new gasket to the housing.

4. Apply a new "O" ring seal to the engine No. 2 idler stubshaft.

5. Apply some clean lubricating oil to the No. 2 idler stubshaft and to the turbocharger drive gear.

6. Lift the turbocharger and remove covering from all openings, except the exhaust stack and exhaust inlet duct.

7. Align the turbocharger, guiding it onto the No. 2 idler stubshaft and into position. Care must be taken to ensure proper mesh of the turbocharger idler gear and the turbocharger drive gear on the engine.

8. Use hardened washers under the 3/4" bolts, and apply all the turbocharger to camshaft drive housing bolts before removing the lifting device. Snug up bolts, but do not tighten.

9. Install the auxiliary drive assembly on the turbocharger and check the gear backlash between the camshaft drive gear and the auxiliary drive gear.

a. Check the backlash with a dial indicator, Fig. 7-3. Attach a small "C" clamp to the coupling flange so that clamp contacts the outer edge of the flange. Position the dial indicator with the contact point touching the "C" clamp. Remove play from gear teeth by turning the coupling flange. Set the dial indicator to zero and move flange in the opposite direction of the previous movement and note reading on dial indicator. Refer to Specifications for backlash limits. Backlash is adjusted by loosening the turbocharger mounting bolts and repositioning the turbocharger on camshaft drive housing.

b. When the correct backlash is obtained, torque the 1/2" turbocharger and auxiliary drive mounting bolts

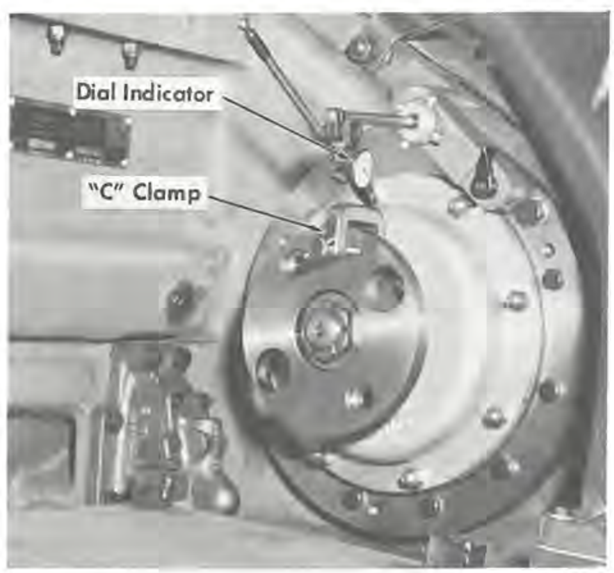


Fig. 7-3 — Checking Auxiliary Drive Gear Backlash to 65 ft-lbs, the 3/4" bolts to 175 ft-lbs, and the 3/8" bolts to 24 ft-lbs. After the bolts are properly tightened, recheck the auxiliary drive gear backlash.

10. Apply and connect the soak back pump lube oil line and turbocharger oil filter lines, as required.

AIR DUCT AND AFTERCOOLER APPLICATION

1. Apply the gaskets to the air duct assemblies.

2. Carefully maneuver the right bank air duct into position and apply the bolts at the engine and turbocharger flanges. Make sure that air duct flange on the engine side is not touching the camshaft drive housing. Snug the bolts only at the turbocharger end, but torque the bolts at the engine end to 65 ft-lbs. Then remove the bolts from the turbocharger end of the air duct, and with the gasket in place, and using a .008" feeler gauge, determine the clearance at the mating flanges. If a .008" feeler gauge can be entered between the turbocharger and the air duct, the duct must be relocated. If necessary, the holes in the engine flange may be enlarged so as to position the duct properly.

3. Apply the left bank air duct using the same procedure as used on the application of the right bank air duct.

4. Tighten the air duct to turbocharger bolts to 30 ft-lbs.

5. Using a .001" feeler gauge, check that no clearance exists between the gasket and turbocharger flange, and the gasket and air duct flange.

6. Apply gaskets to air ducts, and using a lifting device, install aftercoolers in air ducts. Apply attaching bolts and torque to 27 ft-lbs.

7. Attach water pipe to aftercoolers and torque bolts to 75 ft-lbs.

8. Attach water pipe to engine and torque bolts to 75 ft-lbs.

FINAL ASSEMBLY

1. Apply gaskets and install oil separator assembly.

2. Install the expansion joint between the turbine inlet scroll and the engine exhaust manifold. When assembling the expansion joint, the tapered end of the interior liner should be facing toward the front of the engine. This taper will not be evidenced by external viewing of the expansion joint.

3. Coat the threads of the expansion joint bolts with high temperature thread lubricant, apply, and torque to 80 ft-lbs.

4. In bolting the expansion joint to the manifold, it is recommended that one flange of the expansion joint be securely bolted to the manifold before attempting to bolt the other flange. If the holes of the second flange do not align with the flange of the inlet scroll, do not pry into alignment. This will result in undue stress placed on the expansion joint and will also reduce the internal liner clearance required for trouble-free operation. If alignment can not be acquired through repositioning the expansion joint, enlarge the holes in the flange until bolts can be freely inserted and tightened.

5. Lower the exhaust stack through the roof hatch and attach to the top of the turbine exhaust duct with bolts coated with high temperature thread lubricant.

6. Check the impeller eye clearance as previously done in Step 2 of "Turbocharger Installation" to see if the measurements can be duplicated. If the clearances cannot be duplicated, it indicates that the turbocharger has been distorted in installation. In this event, the air ducts should be removed and eye clearance rechecked. If turbocharger is still distorted, the turbocharger mounting bolts must be loosened and the turbocharger realigned so that no stresses or distortion are introduced during installation.

7. Install nose cone and air duct assembly on turbocharger.

8. Replace roof hatch.

STARTING THE ENGINE

1. Actuate the soak back oil pump and allow it to run through a full cycle of operation before starting the engine. The soak back pump is timed so as to run approximately 15 minutes through one cycle.

2. Make the necessary preparations and start the engine. Do not force the injector layshaft levers beyond the idle position when starting the engine in an effort to aid the engine in starting. If the engine is forced on starting, the excess fuel and the resulting engine exhaust might cause an increase in load on the turbocharger thrust bearing when it should not be loaded.

3. Load test the engine as outlined in Maintenance Instruction 313, to qualify the engine for service.

EXHAUST MANIFOLD

DESCRIPTION

The exhaust gases from the engine cylinders are discharged from the cylinder heads into the exhaust manifold, Fig.7-4, and to the turbocharger turbine. Going through the turbine, the gases expand to atmospheric pressure, pass through the turbocharger ducting, and are then expelled from the engine.

The exhaust manifold is made up of chamber assemblies, expansion joints, and adapter assembly. The expansion joints, which are used between chamber assemblies and between the rear chamber assembly and the turbocharger, provide the necessary flexibility to compensate for expansion and contraction of the manifold due to temperature changes. The

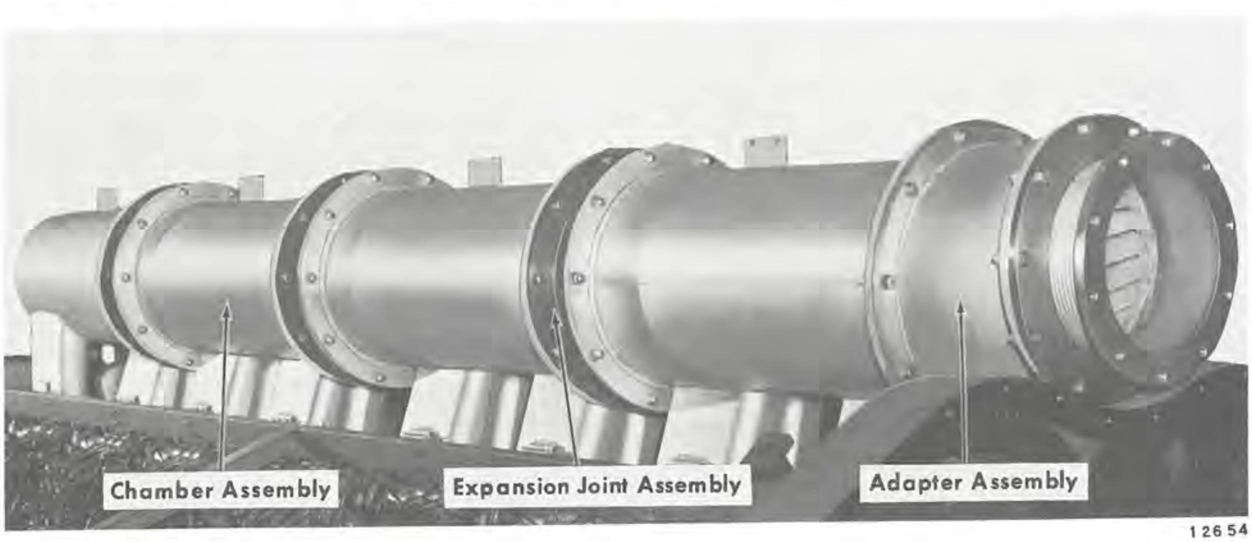


Fig. 7-4 — Exhaust Manifold

adapter assembly contains a stainless steel screen to prevent the entry of foreign objects into the turbocharger.

MAINTENANCE

Inspect the adapter assembly between rear expansion joint and chamber assembly for condition of screen. If foreign material is present in the exhaust manifold, it is recommended that the screen be Magnaflux inspected.

The exhaust manifold is essentially "maintenance free," but should the manifold be disassembled for any reason, the following assembly provisions should be observed.

When assembling the expansion joints, the tapered end of the interior liner should be facing toward the front of the engine. This taper will not be evidenced by external viewing of the expansion joint.

In bolting the expansion joints to the chamber assemblies, it is recommended that one flange of the expansion joint be securely bolted to the chamber assembly before attempting to bolt the other flange. If the holes of the second flange do not align with the flange of the turbocharger inlet scroll, do not pry into alignment. This will result in undue stress being placed on the expansion joint and will also reduce the internal liner clearance required for trouble-free operation. If alignment can not be acquired through repositioning the expansion joint, enlarge the holes in the flange until bolts can be freely inserted and tightened.

SERVICE DATA
AIR INTAKE AND EXHAUST SYSTEMS

SPECIFICATIONS

Clearances And Backlash

Impeller eye clearance (check at 3 and 9 o'clock positions at same time, and at 6 and 12 o'clock positions at same time)	.012" - .026"
Backlash between camshaft and auxiliary drive gears	.010" - .014"
Clearance between turbocharger and turbocharger end of air duct (with turbocharger to duct bolts removed)	Less than .008"
Clearance between gasket and turbocharger flange (bolts installed and torqued, and using a .001" feeler gauge)	.000"
Clearance between gasket and air duct flange (same conditions as step above)	.000"

Torque Values

	Bolt Size	Torque
Turbocharger to Crankcase	3/4"-16	175 ft-lbs
Turbocharger to Camshaft Housing	1/2"-20	65 ft-lbs
Turbocharger to Air Duct	3/8"-16	30 ft-lbs
Air Duct to Crankcase	1/2"-20	65 ft-lbs
Auxiliary Drive to Camshaft Housing	1/2"-20	65 ft-lbs
Auxiliary Drive to Turbocharger	3/8"-16	24 ft-lbs
Aftercooler to Air Duct	3/8"-24	27 ft-lbs
Water Pipe to Aftercooler	1/2"-13	75 ft-lbs
Water Pipe to Engine	1/2"-13	75 ft-lbs
Turbocharger to Manifold Self Lock Nuts, Oiled	1/2"-20	80 ft-lbs

NOTE: Renew washers at reassembly.

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. 8-1.

MAIN LUBRICATING SYSTEM

The main lubricating 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.

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 and to the harmonic balancer 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 manifold enters the gear train at the rear of the engine, at the idler gear stubshaft. Oil passages in the base of the stubshaft distribute the oil. One passage conducts oil upward to the left bank camshaft drive gear stubshaft bracket through a jumper, and downward to the lower idler gear stubshaft and bearing. Another passage conducts oil to the right bank camshaft drive stubshaft bracket and on to the turbocharger oil filter supply line. After passing through the filter, the oil enters the return line, returning to the upper idler gear stubshaft bore and bearing. Filtered oil enters the turbocharger oil system from the upper idler gear stubshaft.

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.

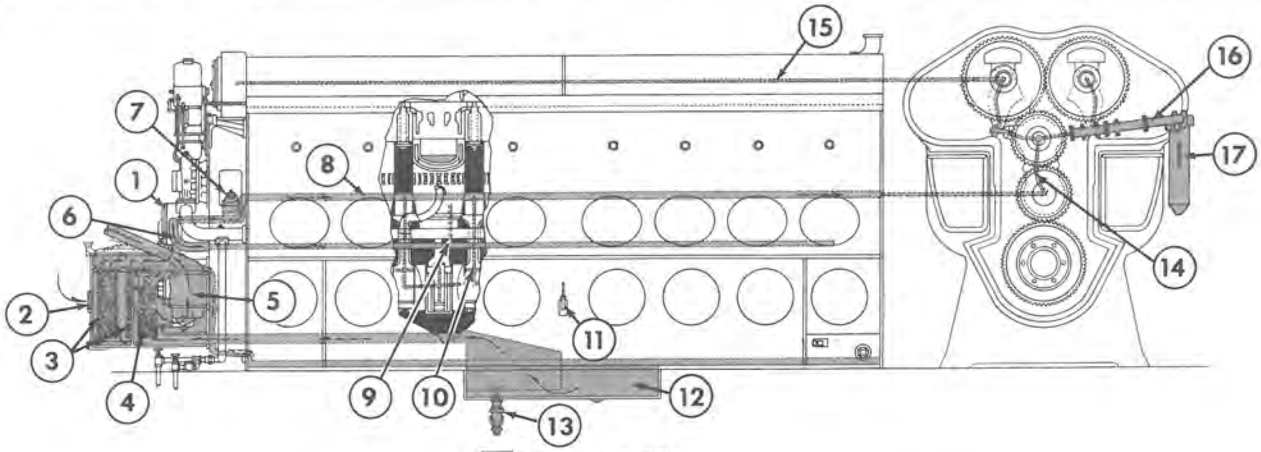
Passages in the turbocharger conduct oil to the turbocharger bearings, idler gears, planet gear assembly, auxiliary generator drive bore, and through a connecting line to the governor low oil pressure connection on the camshaft drive housing. Considerable heat will remain in the metal parts of the turbine 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 bearings, oil is automatically supplied to the bearings for a short time after stopping the engine.

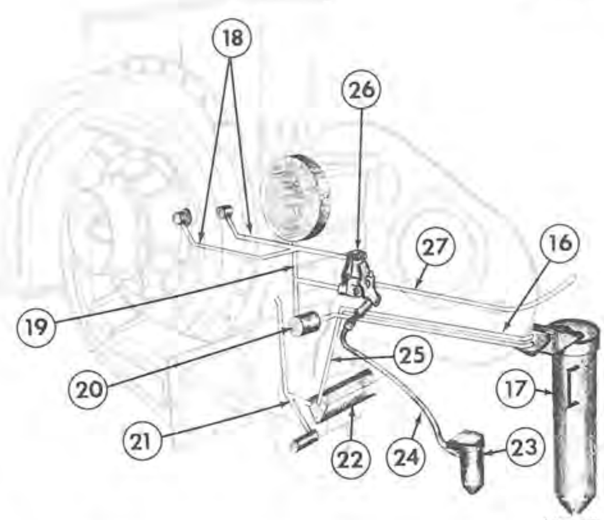
PISTON COOLING OIL SYSTEM

The piston cooling oil system pump receives its 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 skirt to the sump.

SCAVENGING OIL SYSTEM

The scavenging oil system pump, Fig. 8-1, takes oil through the scavenging oil





1. Piston Cooling Oil And Lubricating Oil Pump
2. Lube Oil Inlet To Strainer Housing
3. Lube Oil Strainers
4. Scavenging Oil Strainer
5. Scavenging Oil Pump
6. Piston Cooling Oil Discharge
7. Oil Pressure Relief Valve
8. Lube Oil Manifold
9. Piston Cooling Oil Line
10. Oil Supply To Crankshaft And Bearings
11. Oil Gauge (On Right Bank)
12. Oil Pan Sump
13. Oil Sump Drain Valve
14. Gear Train Oil Lines
15. Camshaft Oil Passage (To Camshaft Bearings And Cylinder Rocker Arms)
16. Filter Oil Supply And Return Manifold
17. Turbocharger Oil Filter
18. Turbocharger Bearing Oil Supply Lines
19. Main Turbocharger Oil Supply Line
20. No. 2 Idler Gear Stubshaft
21. Oil To Left Bank Camshaft Drive And No. 1 Idler Gear Stubshaft
22. Lube Oil Manifold - Gear Train End
23. Soak Back Oil Filter
24. Oil Line To Check Valve
25. Oil Line To Right Bank Camshaft Drive And To Oil Filter
26. Check Valve
27. Oil Line To Housing Bore And Low Oil Pressure Safety Device
28. Cooling System Water Drain Valves

Fig. 8-1 — Lubricating Oil System

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 oil spills over a dam in the strainer housing and returns to the oil pan.

OIL GAUGE

An oil level gauge, Fig. 8-2, 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.

10320

9831

Fig. 8-2 — Oil Level Gauge

MAINTENANCE

LUBRICATING OIL PRESSURE

Adequate lubricating oil pressure must be maintained at all times when the engine is running. Upon starting and idling an 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 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. Thus no specific operating pressures can be given.

The oil pressure is approximately 8-12 psi at idle and 25-29 psi at full speed. Operation above the maximum pressures is entirely satisfactory. 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 of 125 psi.

PISTON COOLING OIL PRESSURE

No gauge is provided for piston cooling oil pressure. Piston cooling oil pressure can be determined by connecting a gauge at the 3/4" plugged opening at the pump discharge elbow. Pressure of the piston cooling oil will be governed by oil viscosity, speed of engine, temperature of oil, and wear of pump parts. The minimum piston cooling oil pressure at idle engine speed is 10 psi and at full speed 45 psi.

POSSIBLE LUBRICATION TROUBLES

NO OIL IN STRAINER CHAMBER

This may be caused by inoperative scavenging system or open drain valve. Failure of scavenging system may be due to a broken or loose oil line connection, scavenging strainer not properly seated causing an air leak, a faulty scavenging pump, clogged strainer, or low oil level.

LOW OIL PRESSURE

This may be due to a stuck oil relief valve, foreign material on valve seat holding valve open, broken oil lines, clogged strainers, excessive bearing wear, low oil viscosity, faulty pump, diluted oil, or insufficient oil in strainer housing.

PUMP FAILURE

This may be due to sheared pump gear keys, broken housing, or damaged gears.

OIL DILUTION

It is possible for fuel oil to get into the lubricating oil if a fuel line connecting the injector to the fuel manifold is loose or broken, or an injector is defective. If this occurs, the lube oil viscosity should be checked. The lube oil may also be contaminated by water. This can be checked visually on top of the cylinder heads or in the oil pan, also by taking test sample of oil. See Checking Oil Viscosity.

EXCESSIVE OIL CONSUMPTION

This may be caused by oil leaks, broken or stuck piston rings, worn cylinder liners, clogged oil separator screen, improper grade of oil, or clogged oil drain holes under piston oil control rings.

UNUSUALLY LOW OIL CONSUMPTION

This may be due to water or fuel leaking into the oil.

LUBE OIL PRESSURE RELIEF VALVE

DESCRIPTION

The lube oil pressure relief valve, Fig. 8-3, is installed on the lube oil crossover manifold, inside the accessory gear train housing on the left side of the engine, Fig. 8-1. A cover plate provides access to the valve for inspection and adjustment.

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.

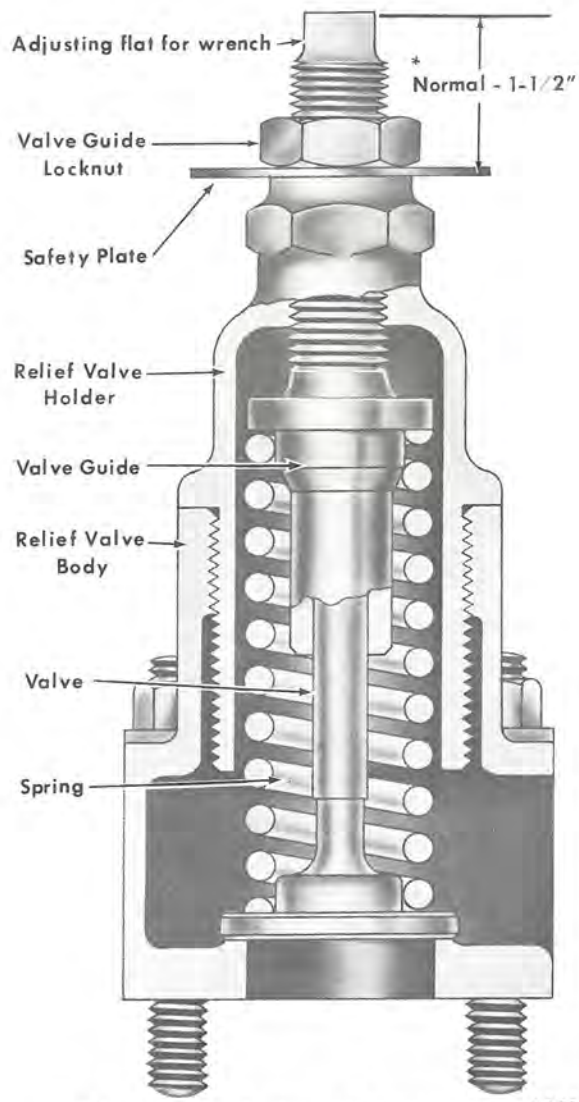


Fig. 8-3 — Lube Oil Pressure Relief Valve

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 310 lbs. Under this load the spring length should not be less than 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 hand-stoned 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.

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 the valve, loosen the locknut, Fig. 8-3, and position the valve guide so that it extends 1-1/2" above the safety plate.

This setting will permit a maximum oil pressure of about 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 specifically located at each cylinder to direct a stream of oil through the piston carrier to the top of the piston. This cooling oil is very important to the function of the piston, as without piston cooling oil of a sufficient quantity, the piston would be overheated in a short time and damage would occur to the piston and subsequently to the other engine parts. 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. 8-4.

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 covered in the preceding paragraph, 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.

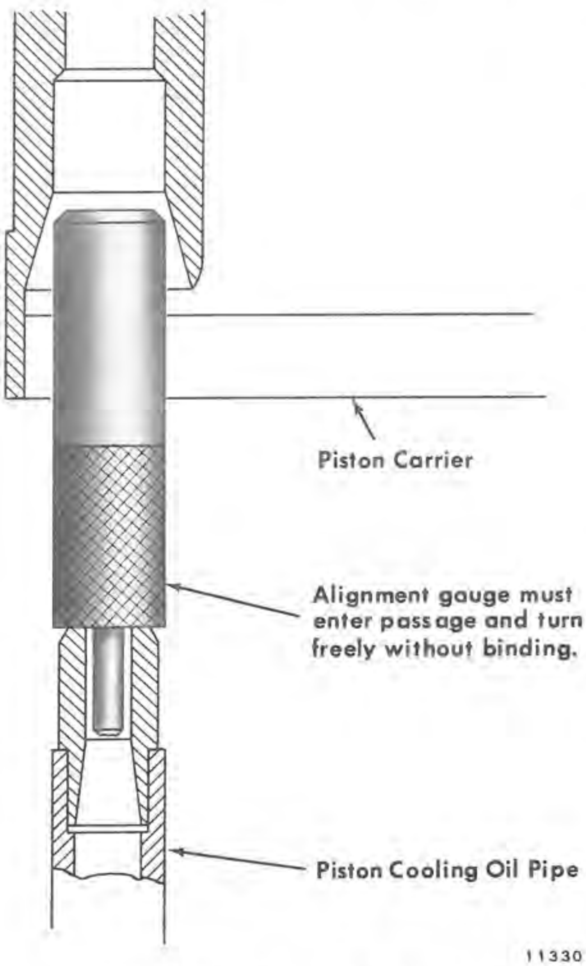


Fig. 8-4 — Piston Cooling Oil Pipe Alignment

A piston cooling oil pipe cleaner is available from the EMD Parts Center.

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 and 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.

Therefore, to provide protection to the engine, the oil and system components should be carefully observed for proper functioning and corrective steps taken where necessary. Oil and filter change periods should be followed closely since the oil is not only oxidizing but contaminants are coming into the engine from the process of 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 valves 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 valves. 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 as specified in Maintenance Instruction 1752. Add oil through square filler opening in strainer housing.

NOTE: Be sure strainer housing internal drain valves are closed.

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 handholes, so care must be taken when the oil pan handhole covers are removed.

OIL STRAINER HOUSING

DESCRIPTION

The oil strainer housing, Fig. 8-5, is a large box-shaped cast aluminum housing which is mounted on the right front side of the engine on the accessory drive cover, Fig. 8-1. 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. 8-6, each consists of a replaceable element made 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.

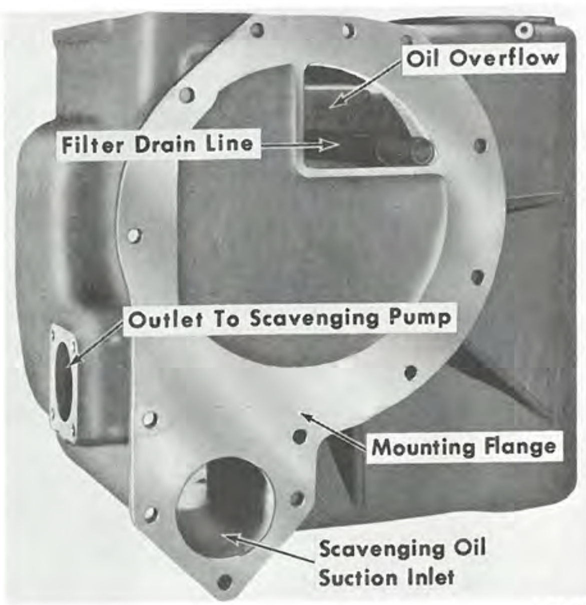


Fig. 8-5 — Oil Strainer Housing

The scavenging oil pump strainer, Fig. 8-7, has a rigid perforated metal screen which retains its shape and is easily cleaned.

Fig. 8-6 shows one of the main lube oil pump strainers removed from the housing.

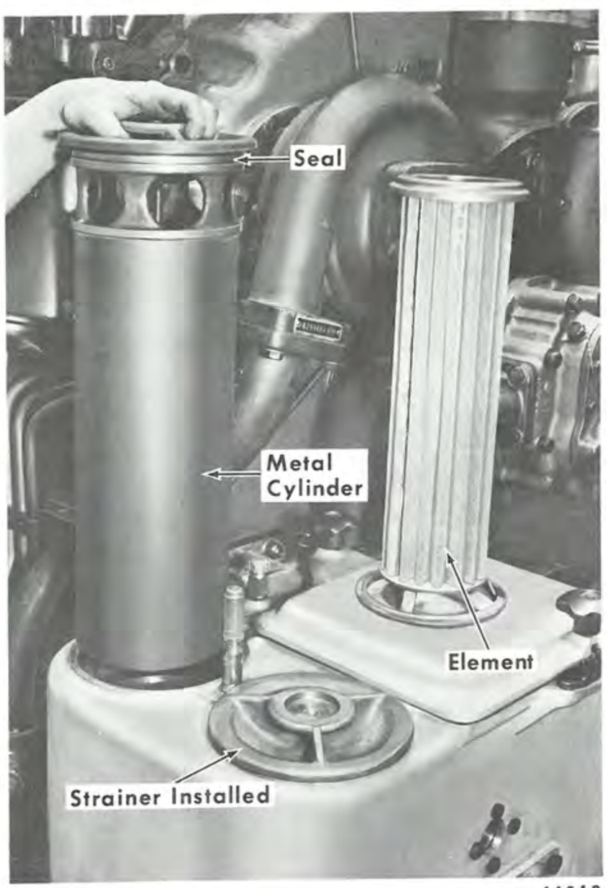


Fig. 8-6 — Main and Piston Cooling Oil Pump Strainers

Fig. 8-7 — Scavenging Oil Pump Strainer

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 the pump through a cast passage in the housing.

The scavenging oil pump strainer is shown removed in Fig. 8-7. When the strainer is installed in the housing, it is held in position with three nuts. The scavenging oil strainer inlet and outlet openings are shown in Fig. 8-5.

An oil level is maintained in the strainer housing up to the bottom of the overflow opening, Fig. 8-5. Excess oil returns to the oil pan sump. A spring-loaded valve, Fig. 8-8, 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. 8-8, 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.

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

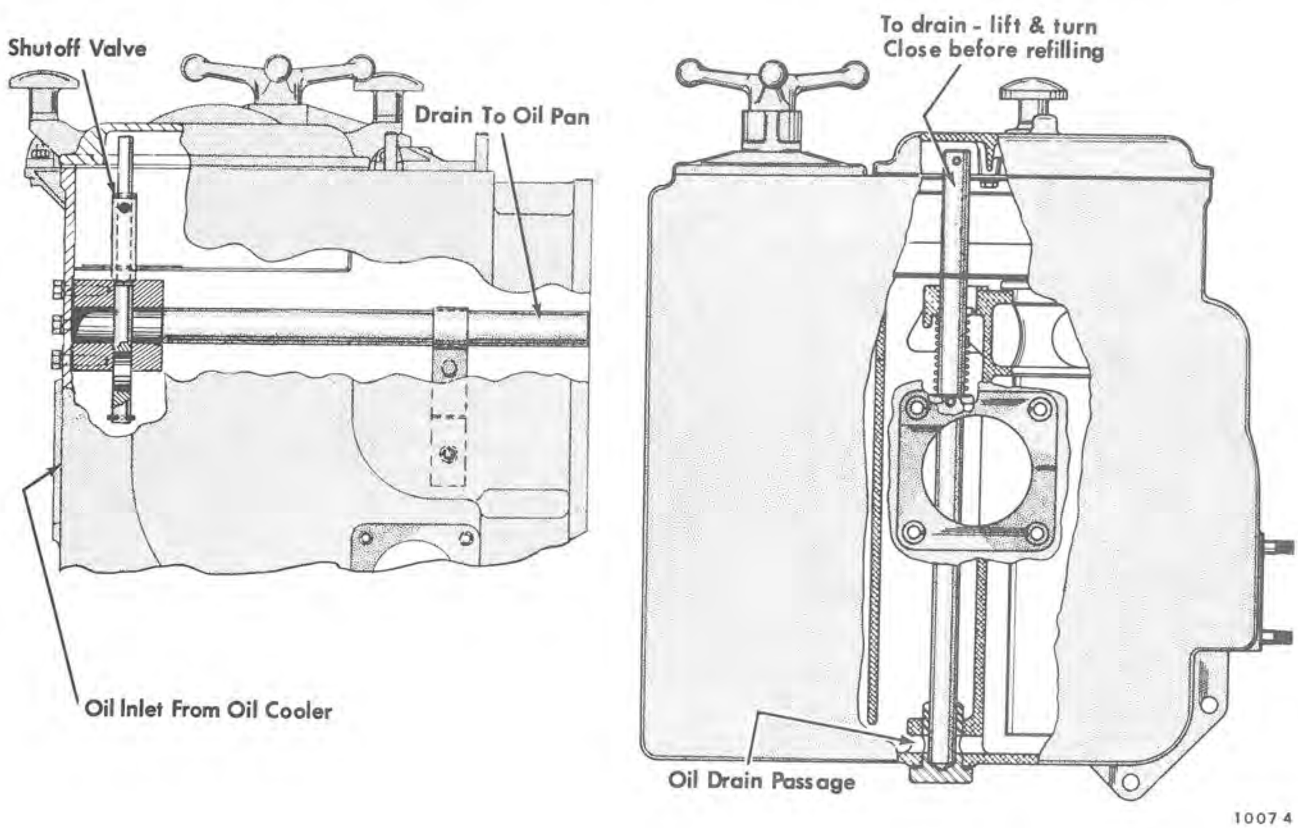


Fig. 8-8 — Strainer Housing Drain Valves rings are in good condition. Also, that the oil passages to the seals are open and clear.

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.

LUBE OIL SEPARATOR

DESCRIPTION

The oil separator, Fig. 8-9, is an elbow-shaped cylindrical housing containing a wire mesh screen element. It is mounted on the turbocharger housing. An elbow assembly connects the separator to the ejector tube assembly in the exhaust stack.

The ejector tube in the exhaust stack creates a suction which draws up oil vapor from the engine through the separator element. The oil collects on the element and drains back to the engine. The remaining gaseous vapor is discharged into the exhaust and vented to atmosphere.

MAINTENANCE

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

1. Shut the engine down.
2. Disconnect the exhaust tube assembly from the ejector tube and remove the housing cover and exhaust tube elbow as an assembly.
3. Remove the screen element assembly and wash it in a petroleum solvent. Then rinse the element with hot water and blow dry with air.
4. Replace the element and the cover and elbow assembly.


12656

Fig. 8-9 — Lube Oil Separator

MAIN LUBE OIL AND PISTON COOLING OIL PUMPS

DESCRIPTION

The main lube oil and piston cooling oil pumps, Fig. 8-10, 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, Fig. 8-1, and is driven by the accessory drive gear.

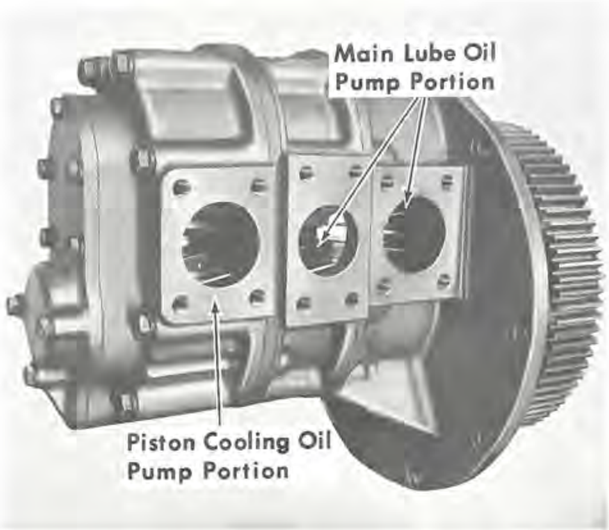


Fig. 8-10 — Main Lube Oil And Piston Cooling Oil Pumps

MAINTENANCE

DISASSEMBLY (Refer to Fig. 8-11)

1. Clean 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.

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 cotter pin, 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 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 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 drive key.

11. Remove the spacer plate and collar.

12. Remove the lube oil pump center driven gear, drive gear, and key.

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

14. Remove the lube 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.

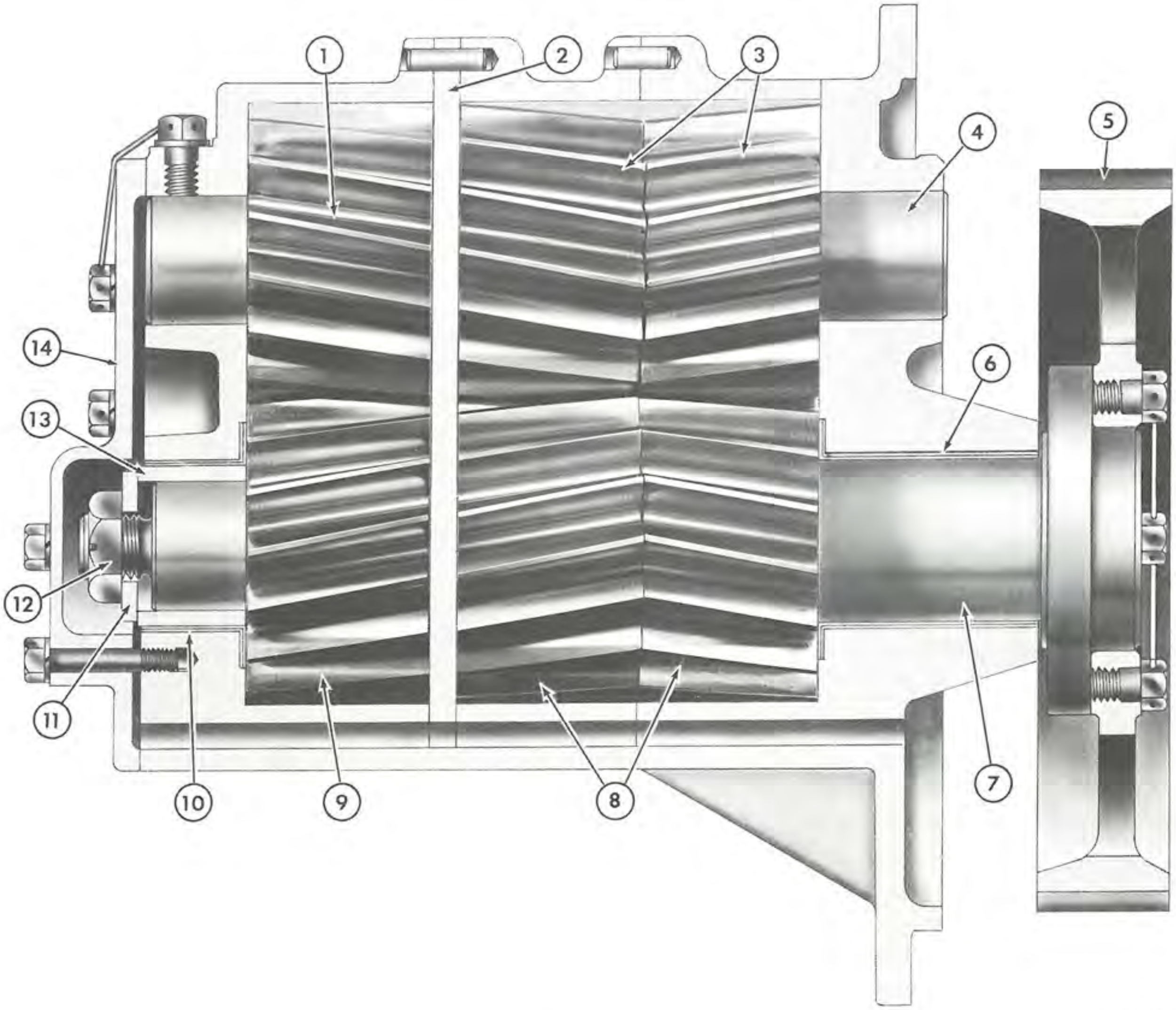
CLEANING

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



1. Piston Cooling Driven Gear
2. Spacer Plate
3. Lube Oil Pump Driven Gears
4. Idler Shaft
5. Drive Gear
6. Inner Bushing
7. Drive Shaft
8. Lube Oil Pump Drive Gears
9. Piston Cooling Drive Gear
10. Front Bushing
11. Washer
12. Shaft Nut
13. Shaft Sleeve
14. Cover

Fig. 8-11 — Main Lube Oil And Piston Cooling Oil Pumps, Cross-Section

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. 8-12.

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

1. 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. 8-13.

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

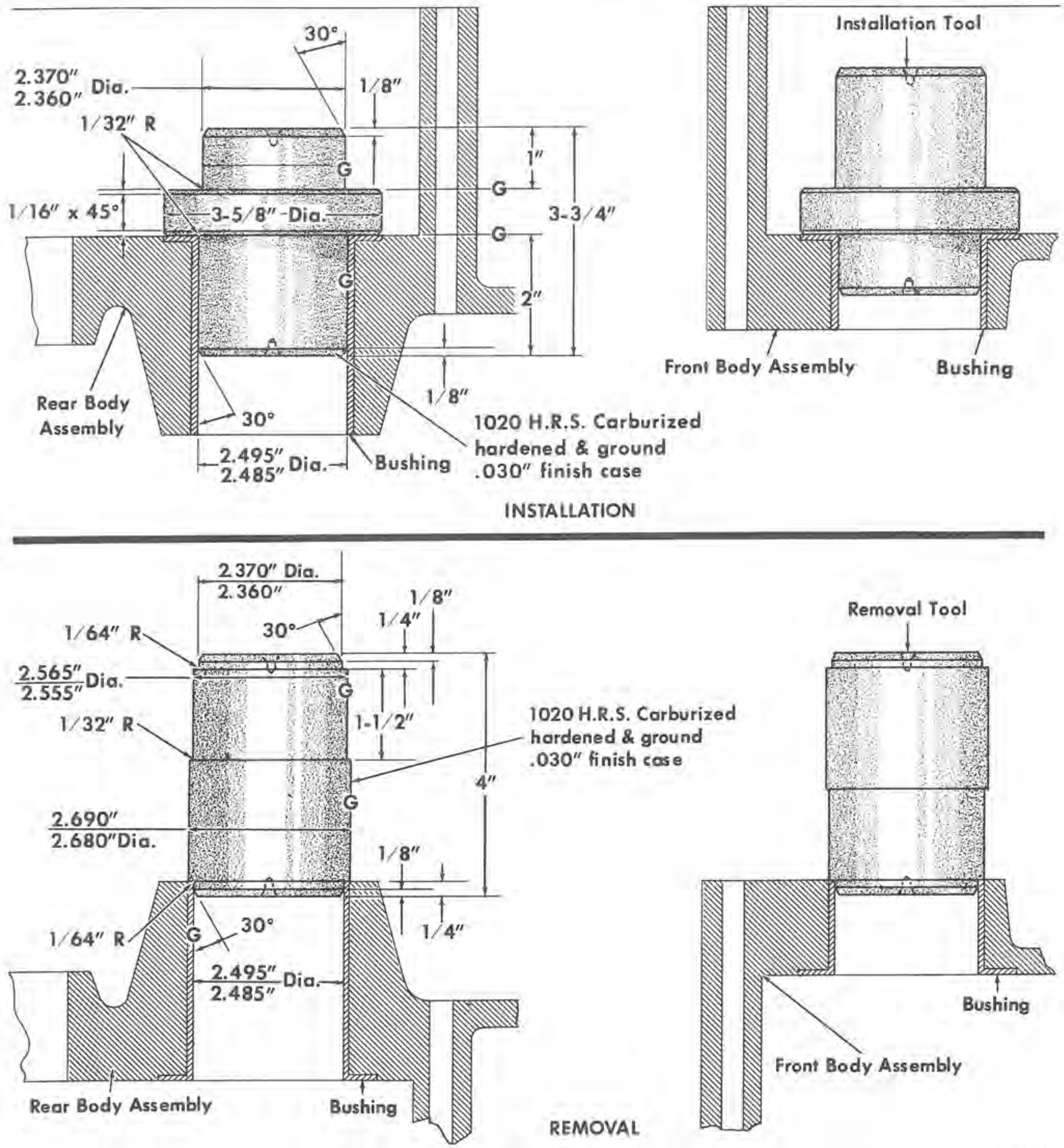


Fig. 8-12 — Oil Pump Body Bushing Tools

6. The drive shaft gear may be Magnaflux inspected in accordance with procedures in Maintenance Instruction 1754.

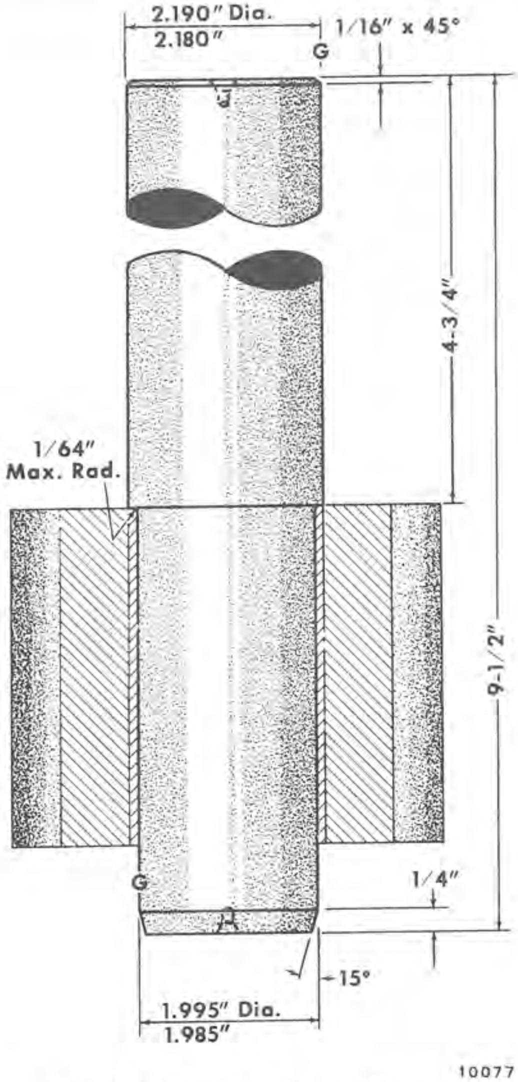


Fig. 8-13 — Oil Pump Driven Gear Bushing Tool

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.
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 in the bench vise with the drive shaft bore uppermost. Refer to Fig. 8-11 for assembly.
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. (Refer to Fig. 8-11.)
4. Next after oiling the bushing, apply the mating driven gear, meshing it with the top gear in the pump body.
5. Fit the center drive gear key in the drive shaft.
6. 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.
7. Apply the center body to the rear body.
8. Install the center drive gear and its mating driven gear.
9. Oil the body gasket and apply it to the center body.
10. Apply the spacer plate to the center body and apply the collar to the drive shaft.
11. Install the piston cooling drive gear key in the drive shaft and apply the drive gear. Make sure that the identification groove on the outer gears are facing the spacer plate.
12. Apply the sleeve, washer and nut to the drive shaft. Tighten the nut, aligning the cotter pin passage and apply the cotter pin.
13. Oil the spacer plate gasket and apply it to the spacer.

14. 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. Make sure that the identification groove on the outer gears are facing the spacer plate. If the front body, cover, and idler shaft were disassembled, apply these parts individually as shown in Fig. 8-11, using new oiled gasket between the cover and the front body.

15. Complete assembly of the pump by installing the long bolts through the cover. 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 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. 8-14. 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.

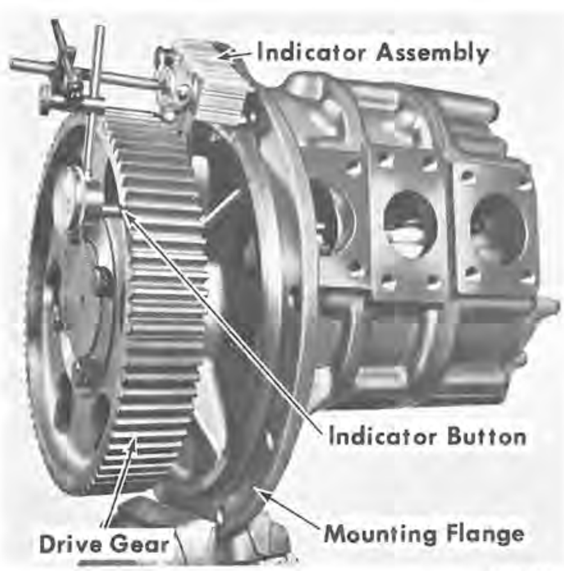


Fig. 8-14 — Checking Pump Drive Gear End Thrust

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. 8-15, 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

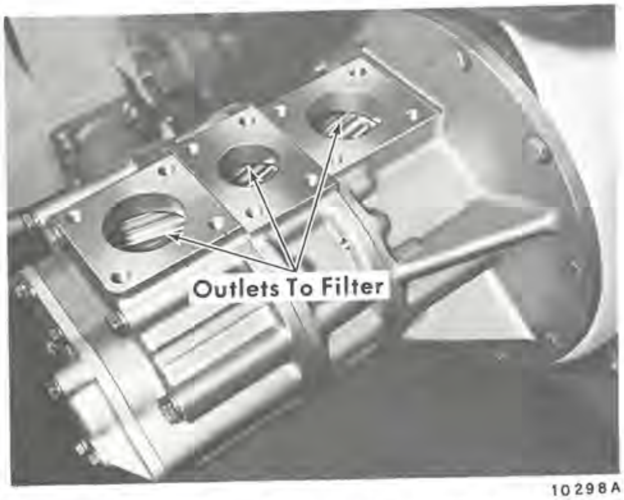


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Fig. 8-15 — Scavenging Oil Pump

by Woodruff 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, Fig. 8-1, in line with and to the left of the crankshaft, and is driven by the accessory drive gear.

MAINTENANCE

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 cotter pin, drive shaft nut, washer, and sleeve from the drive shaft.
6. Remove the front 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 in the vise with the drive shaft bore uppermost. Refer to Fig. 8-16 for pump assembly.
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.

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

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

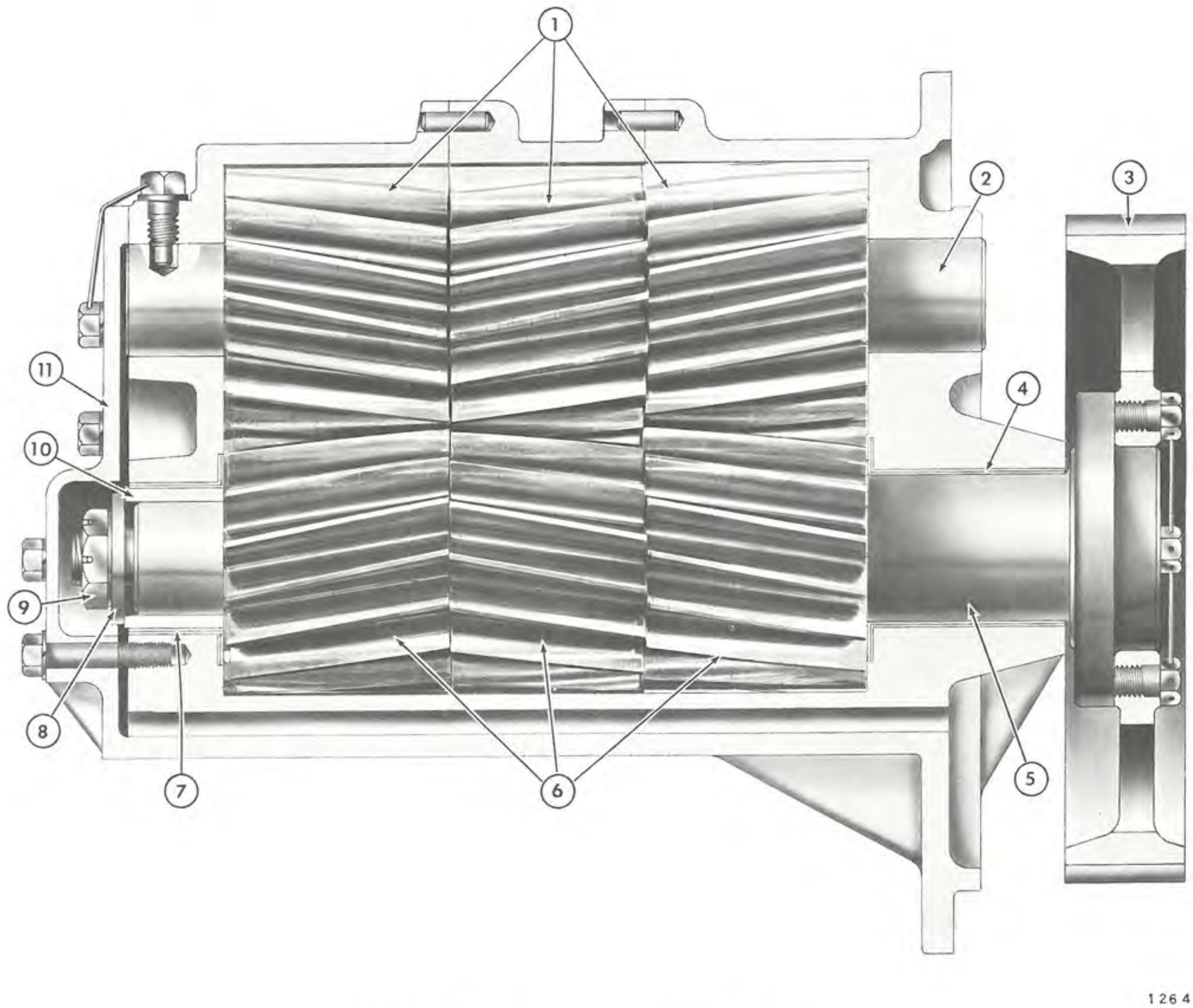
6. Apply the center housing to the rear housing.

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

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



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. 8-16 — Scavenging Oil Pump, Cross-Section

11. Apply the sleeve, washer and drive shaft nut to the shaft. Tighten the nut lining up the hole in the shaft and nut, and apply the cotter pin.

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. Complete assembly of the pump by installing the long bolts through the cover. 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. 8-14 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 of 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. 8-17, 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.

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

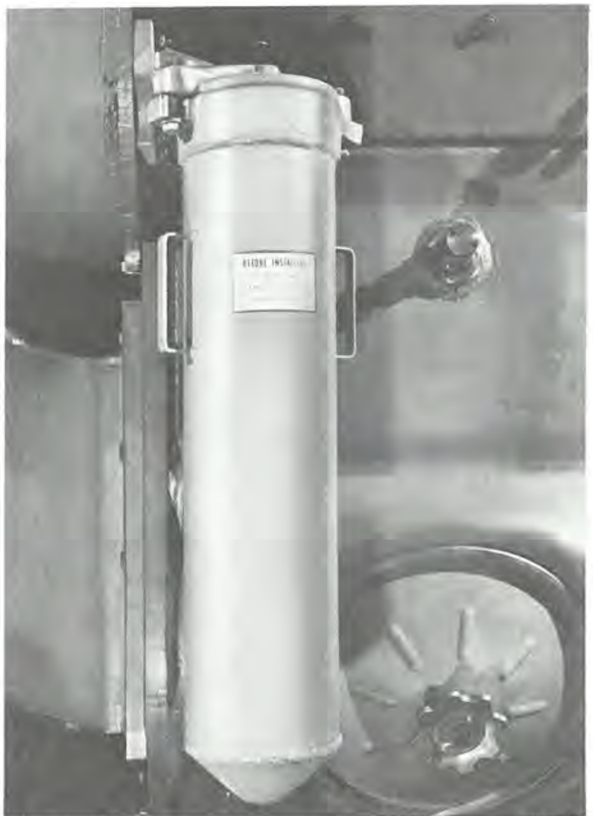


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Fig. 8-17 — Turbocharger Oil Filter

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, if required. Fill the container with clean oil and reassemble to the upper housing. Do not over-tighten attaching bolts as the seal may be damaged.

SOAK BACK OIL FILTER

DESCRIPTION

The soak back oil filter, Fig. 8-18, is a part of the system to supply oil to the turbocharger immediately after the engine has been shut down. This prevents residual heat in the turbine from possibly damaging the turbocharger bearings. The filter purifies the oil being supplied by the soak back oil pump to the turbocharger. A relief valve in the filter bypasses oil back to the oil pan when the outlet pressure exceeds 125 psi. The filter contains a paper type disposable element. The system supplies oil to the turbocharger until an automatic time delay shuts it down. During the time the pump is running, an indicator light on the cab control panel is on.

MAINTENANCE

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

To remove the element from the filter assembly, remove the two bolts from the top of the head and remove the bowl, element, and spring from the upper housing.

PRELUBRICATION OF ENGINES

The prelubrication of newly installed overhauled engines or engines which have been in storage a considerable length of time, is a necessary and important practice. This procedure alleviates loading of unlubricated engine parts during the interval when the lube oil pump is filling the passages with oil. Also, it offers protection by giving visual evidence that oil distribution in the engine is satisfactory. The oil supply from an external pump should be warm. Oil pressure need not exceed 35 psi.

When pumping the oil through the engine, inspection should be made at the rocker arms, camshaft bearings, and main bearings to see that oil is reaching these parts. The crankshaft should be rotated at least one revolution so as to distribute oil over various moving parts. Sufficient oil should be pumped to ensure oil reaching all parts of the engine.

Before starting the engine, pour a liberal quantity of oil over the cylinder mechanism of each bank. This applies also to new engines.

Inasmuch as new engines have been filled with oil and run before leaving the factory, prelubrication of such engines is considered unnecessary, unless they have been stored for more than thirty days.

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,

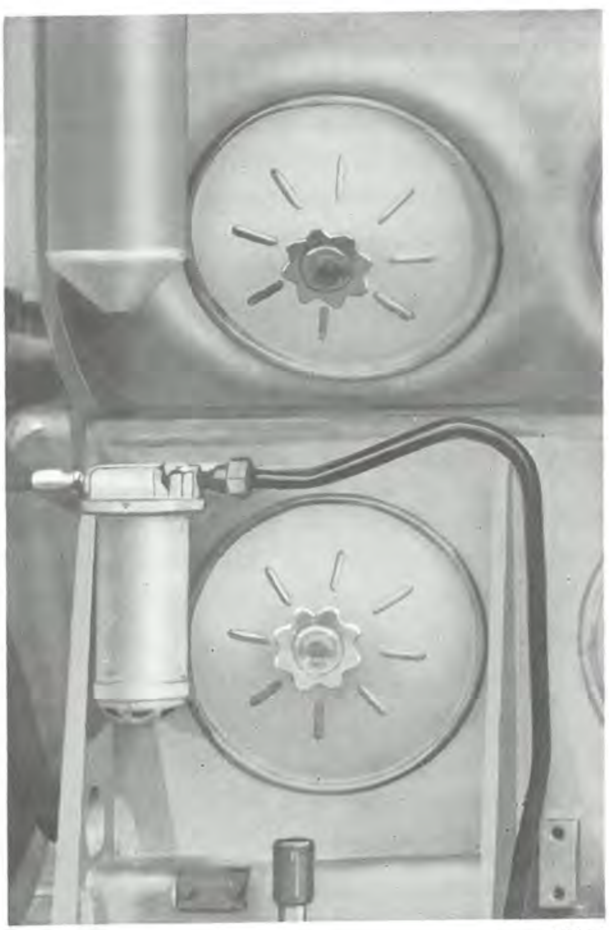

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Fig. 8-18 — Soak Back Oil Filter

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 the 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, flushing instructions, and cleaning information.

Engine lubricating oil should be qualified for use as specified in Maintenance Instruction 1752.

SERVICE DATA

LUBRICATING OIL SYSTEM

SPECIFICATIONS

Lube Oil Pressure Relief Valve

Valve guide inside diameter - Max. .... .5025"
Valve stem outside diameter - Min. .... .4925"
Valve face to stem squareness
(outer edge of valve face) - T.I.R. Limit .... .002"

Oil Pumps

Capacity (approximate GPM at 900 RPM)

Scavenging pump 396
Piston cooling pump 91
Lube oil pump 186

Drive shaft to rear housing
bushing clearance - New .... .0015" - .0045"
Limit .... .007"

Sleeve to bushing clearance - New .... .0015" - .0050"
Limit .... .007"

Idler shaft to gear bushing clearance - New .... .0015" - .0051"
Limit .... .007"

*Driven gear to body thrust clearance
(front or rear) - New .... .016" - .024"
Limit .... .000"

**Outer driven gear to front body or to spacer
plate thrust clearance - New .... .019" - .023"
Limit .... .000"

**Center driven gear to spacer plate and inner
driven gear to rear body thrust clearance - New .... .016" - .023"
Limit .... .000"

*Drive gear to body bushing thrust clearance
(front or rear) - New .... .008" - .016"
Limit .... .022"

**Outer drive gear to spacer plate
thrust clearance - New .... .001" - .019"
Limit .... .022"

**Inner drive gear to rear body bushing
thrust clearance - New .... .004" - .018"
Limit .... .022"

Thrust face of bushing to body clearance (front and rear) - New	.001" - .007"
Limit	.000"
Drive and driven gear backlash - New	.012" - .016"
Limit	.030"
Radial clearance of drive and driven gear to body - Min.	.0015"
Max.	.010"
Pump drive gear backlash - New	.008" - .016"
Limit	.025"
Front body bushing diameter - New	2.3745" - 2.3765"
Max.	2.3790"
Rear body bushing diameter - New	2.4995" - 2.5015"
Max.	2.5040"
Driven gear bushing diameter - New	1.9995" - 2.0021"
Max.	2.0040"
Pump drive gear face runout - T.I.R. Limit	.003"
Pump flange face runout - T.I.R. Limit	.005"
Pump flange pilot concentricity - T.I.R. Limit	.002"

NOTE: * Scavenging pump only

** Lube and piston cooling pump only

EQUIPMENT LIST

	Part No.
Gauge - piston cooling pipe alignment	8071720
Cleaner - piston cooling oil pipe	8087086
Spray gun	8193041
Testing device - lube oil suction	File 110
Lube oil system - pretest diagram (includes diagram for fuel and water system)	File 294

For additional tools, see Tool Catalog.

COOLING SYSTEM

DESCRIPTION

The engine cooling system consists of engine driven centrifugal water pumps, replaceable inlet water manifolds with an individual jumper line to each liner, cylinder head discharge elbows, and an outlet manifold through which cooling water is circulated. The centrifugal water pumps are mounted on the accessory drive housing and are driven by the governor drive gear. A representative illustration of the engine cooling system is shown in Fig. 9-1.

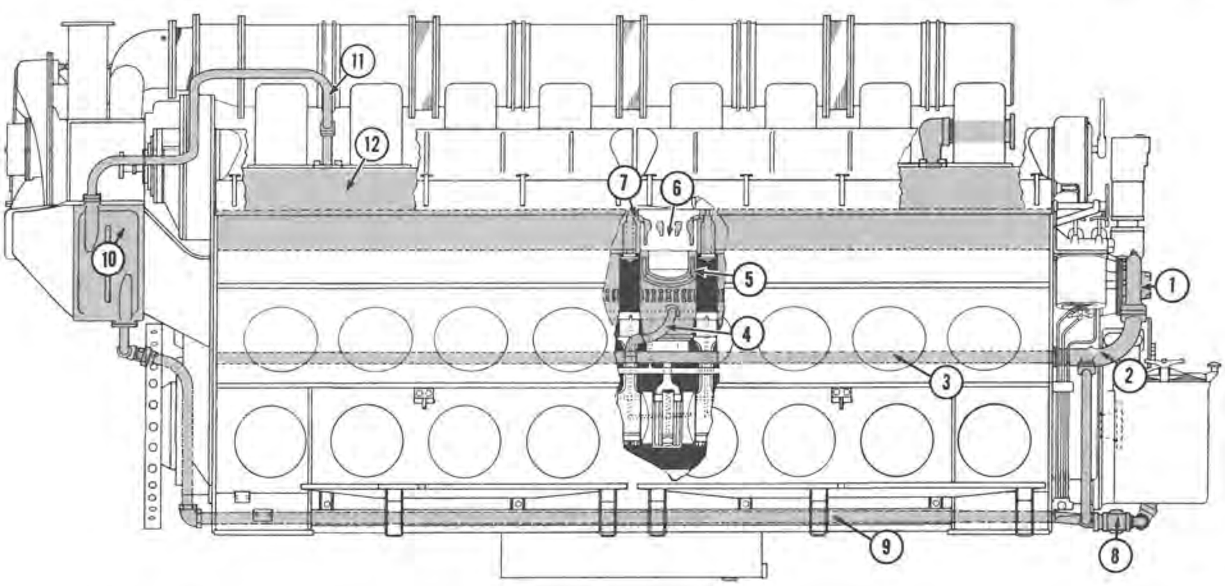
Engine water is also circulated through each aftercooler, Fig. 9-1, located in the turbocharger air discharge duct, to cool the air before it enters the engine air box.

The engine discharge water flows through an external cooling system to dispel the heat taken up in the engine. This system consists of a water tank, water level gauges, temperature gauges, radiators and connecting piping.

MAINTENANCE

ENGINE WATER TEMPERATURE

Temperature gauges are provided in the cooling system to visually check that the engine water temperature is within the recommended range of about 160° - 190° F. Automatic temperature controls are set to maintain the water temperature within set limits. It should be noted, however,



1. Water Pump
2. Water Inlet Elbow
3. Water Inlet Manifold
4. Water Inlet Tube
5. Liner Water Passage
6. Cylinder Head
7. Cylinder Head Outlet Elbow
8. System Drain Valve
9. Water Line To Aftercoolers
10. Right Bank Aftercooler
11. Aftercooler Water Discharge
12. Water Discharge Manifold

Fig. 9-1 — Cooling System Schematic

that the engine should not be run above the 3rd throttle position until the water temperature is above 130° F.

A hot engine alarm indicates excessively high water discharge temperature. Hot engine water could result from faulty water cooling equipment or excessive loss of cooling water. In the event of a hot engine alarm, engine load should be removed and speed reduced in an attempt to obtain normal temperature. Before resuming operation, the cause of the hot engine water should be found and the condition corrected.

ENGINE COOLING WATER

Using the proper coolant and good maintenance practices is extremely important to efficient cooling system operation.

The coolant used should meet three basic requirements; it must not be corrosive, it must not deposit scale, and it must not leave sludge deposits. Failure to recognize the value of these requirements can increase maintenance, damage cooling systems necessitating repair and/or replacement of parts, and increase maintenance costs.

The water used in the cooling system should not contain excessive solids, lime, or corrosive elements such as chlorides. With the use of a proper corrosion inhibitor, the water qualities in Table 1 are considered suitable for use in the cooling system.

TABLE 1

	Parts Per Million	Grains Per Gallon
Total Solids	340	20
Total Hardness	170	10
Chlorides	40	2.5
Sulfates	100	5.8

NOTE: 1. If chlorides and/or hardness are doubled, use of water becomes questionable.
2. If they are tripled, the water should not be used.

INHIBITORS

There are different types of inhibitors which are approved and recommended for use in the engine cooling system. Some types have advantages over others, but if specific directions for use are carefully followed, the cooling system should operate efficiently using any one of the approved types. The types of inhibitors are chromate and borate-nitrite. The dosage for each type is described in the following paragraphs.

Chromate Type

Chromate type inhibitors such as National Aluminate Corporation - Nalco 38, Dearborn Chemical Company - Dearborn No. 517, or equivalent are recommended as approved inhibitors.

When the cooling system is filled for the first time, 0.6 ounce of inhibitor per gallon of water should be added to the system. After initial filling, the inhibitor concentration should be maintained at a minimum of 0.4 ounces per gallon of water. If coolant is lost from the system, the added coolant should be to the 0.4 ounce inhibitor per gallon of water proportion.

The use of chromate type inhibitors can be a factor in certain types of skin irritations when carelessly handled and/or proper skin care neglected. Chromate type inhibitors should not be used with ethylene glycol antifreeze solutions.

Borate-Nitrite Type

Borate-nitrite type inhibitors such as National Aluminate Corporation - Nalco 39 (pellet, pulverized, or liquid) and Nalco 40 (pulverized), Dearborn Chemical Company - Dearborn No. 527, or equivalent are recommended as approved inhibitors.

When the cooling system is filled for the first time, 1 ounce of inhibitor (except Nalco 39 liquid) per gallon of water should be added to the system.

NOTE: Borate-nitrite inhibitors (pellet and pulverized) are difficult to dissolve, therefore it is recommended that they be dissolved in water before adding to the system.

After the initial filling, the inhibitor concentration should be maintained at a minimum of 0.75 ounce per gallon of water. If coolant is lost from the system, the added coolant should be to the 0.75 ounce inhibitor per gallon of water proportion.

If Nalco 39 liquid is being used, when the cooling system is filled for the first time, 3 fluid ounces of inhibitor per gallon of water (10 quarts per 100 gallons) should be added to the system. After initial filling, the inhibitor concentration should be maintained at a minimum of 2 fluid ounces per gallon of water (6 quarts per 100 gallons). If coolant is lost from the system, the added coolant should be to the 2 fluid ounces per gallon of water proportion.

It is recommended also, that samples of make-up water and inhibited coolant solutions be tested when the engine is put in service and at regular intervals thereafter. In this way, the quality of the coolant will be known and may be maintained as required.

Furthermore, it is also important to note that a coolant operating satisfactorily in some other engine may not be satisfactory for use in the 567 series engine. Difference in load factors, coolant velocities, temperature, and the type of metals and seals used may cause a coolant to be unsatisfactory in the 567 series engine, even though the coolant may be satisfactory in some other equipment.

COOLING SYSTEM PIPING

DESCRIPTION

Refer to Fig. 9-2 for piping details. Pump outlet elbows conduct water from the pumps to the removable water inlet manifolds located in each air box. Each manifold is positioned at the rear end plate by the recessed end of the manifold fitting over a pipe support assembly. The pipe support assembly, held in place by two bolts through the end plate, is correctly located by dowels which fit into counterbores in the end plate. A flange at the front end of the manifold contacts the outer face of the front end plate when the manifold is installed. One gasket is used between the manifold flange and end plate, and one between the manifold flange and water pump discharge elbow.

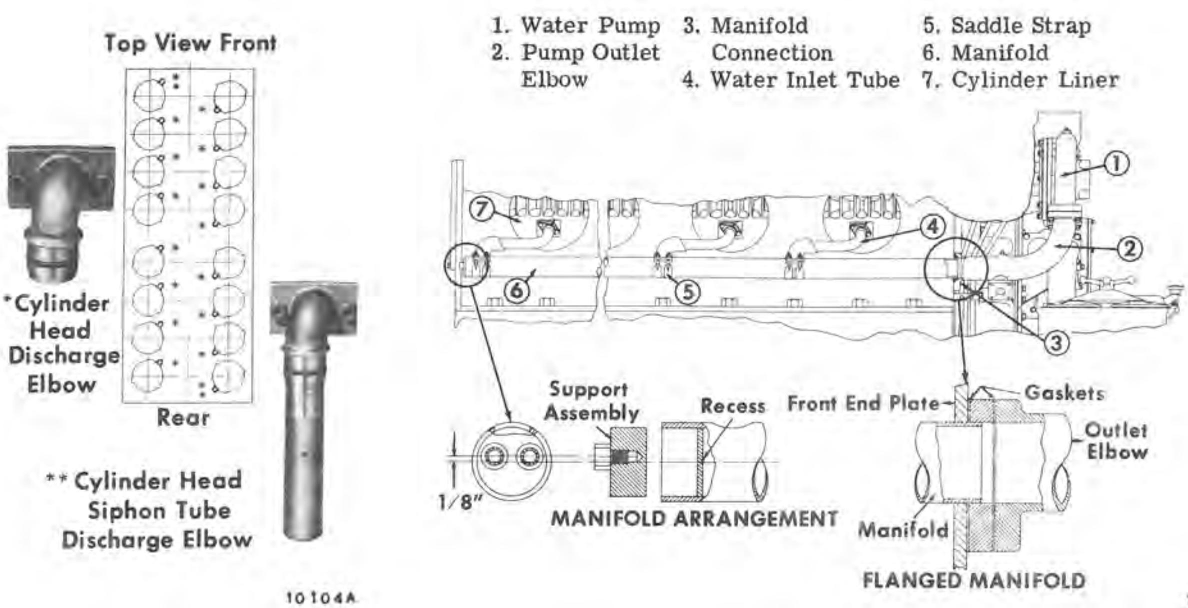


Fig. 9-2 — Cooling System Piping

Each liner is individually supplied with coolant from the water manifold through a water inlet tube assembly. The inlet tube is bolted to the liner and connected to the manifold by saddle strap assemblies around the manifold. A gasket is used at the saddle connection while a synthetic rubber seal ring is used at the liner. A deflector is used at each liner water inlet to turn the water and prevent direct impingement on the inner liner wall. Water enters the cylinder head through 12 discharge holes at the top of the liner. A counterbore around each hole accommodates a water seal ring. A water discharge elbow bolted to each cylinder head provides water passage to the water discharge manifold extending along the top of the crankcase. The cylinder head water discharge elbows are applied to each cylinder head before installation, and act to properly position each cylinder head. Seal rings are used at the elbow connections. The seals may be replaced if required, by removing the elbow, after first removing the crab above it, without disturbing the cylinder head. There are two types of discharge elbows; siphon tube elbows, two of which are used in an engine, and elbows without siphon tubes. The siphon tube extends down into the discharge manifold, its end close to the bottom to drain the manifold when engine water is drained. It is important that the last cylinder head of the right bank and the first cylinder head of the left bank have a siphon tube water discharge elbow. This will provide for engine cooling water draining in the event the engine is not level.

MAINTENANCE

PIPING INSTALLATION

After the cylinder head and liner are properly installed in the engine, the water inlet manifold and liner water inlet tube may be applied.

1. Apply and position the pipe support assembly at the rear end of the air box, with the locating dowels in the counterbores of the crankcase end plate.

   Position the pipe support assembly so that the small area above the dowels is at the top, and hold in place with the mounting bolts.

   If the air duct housing assembly is not installed, the pipe support assembly should be temporarily secured until manifold is applied, which will hold the support.

2. Inspect the water manifold for any dirt or roughness in the area of the discharge holes and at the end plate flange and correct if necessary. Clean off the end plate flange area for the flange gasket.

3. Place the manifold flange gasket over the manifold and insert the manifold into the air box, with the recessed end held by the support assembly.

4. Apply and tighten the manifold flange to end plate bolts. Temporary bolts may be used if the water discharge elbow is not ready to be applied.

5. Apply the seal to the liner water inlet tube, and apply the tube to the liner, leaving the bolts loose. (The seal used on the liner water inlet tube is the same as that used at the cylinder head water discharge elbow.)

6. Apply the saddle strap and tighten the nuts finger tight, leaving sufficient space between the saddle and manifold for the gasket.

7. Bend the manifold to inlet tube gasket slightly to conform to the manifold and insert the gasket between the manifold and the saddle.

8. Tighten the liner to water tube bolts to 30 ft-lbs torque and the saddle strap nuts to 15 ft-lbs torque.

9. After all liner water inlet tubes are properly applied, the manifold will be securely held and the temporary bolts applied to either the pipe support assembly or front flange may be removed.

WATER LEAKS

If loss of water in the cooling system is noticed, check for leakage at piping, pump seals, jumper tube connections, cylinder head outlet elbow, junction of head to liner, and check for liner or cylinder head cracks.

Unless very obvious, the location of a crack in the cylinder head or liner is very difficult to find, and requires careful examination. Any indication of a water leak in the head or liner requires removal and thorough inspection. Inspect cylinder interior through liner ports.

Water may leak and enter the lube oil at the cylinder head outlet elbow seals. These seals can be replaced without disturbing the cylinder head, provided a crab nut and crab are removed and the water is drained. Water contamination of lubricating oil will necessitate draining the oil. Before the oil is renewed, the system should be flushed as outlined in Maintenance Instruction 1757.

Lube oil contamination is best determined by laboratory analysis, but in the absence of such means, the following method of checking for water in the oil may be used.

Draw or dip a gallon of lube oil from the bottom of the engine lube oil sump. Let it stand for about 10 minutes, then spill about 3/4 of the oil from the container. Place the remaining 1/4 in a glass bottle and allow sample to stand another 10 minutes. If any water is indicated in the bottom of the bottle, it is recommended that the lube oil system be drained and flushed. Replace with new oil after source of contamination is eliminated.

AFTERCOOLER

DESCRIPTION

An aftercooler is located on each side of the turbocharger to cool the air entering each bank of the engine. Cooling the air compressed in the turbocharger reduces the temperature of the air thereby increasing air density and improving engine operating efficiency.

The aftercoolers, Fig. 9-3, are heat exchangers of box-like construction consisting of a tube nest, through which the water is circulated, and fins to aid the transfer of heat from the compressed air entering the engine air box. The aftercoolers receive water directly from the discharge side of the engine water pumps, and water leaving the aftercoolers is piped to the engine discharge manifold. No valves are located in the aftercooler piping, so cooling water is provided whenever the engine is running.

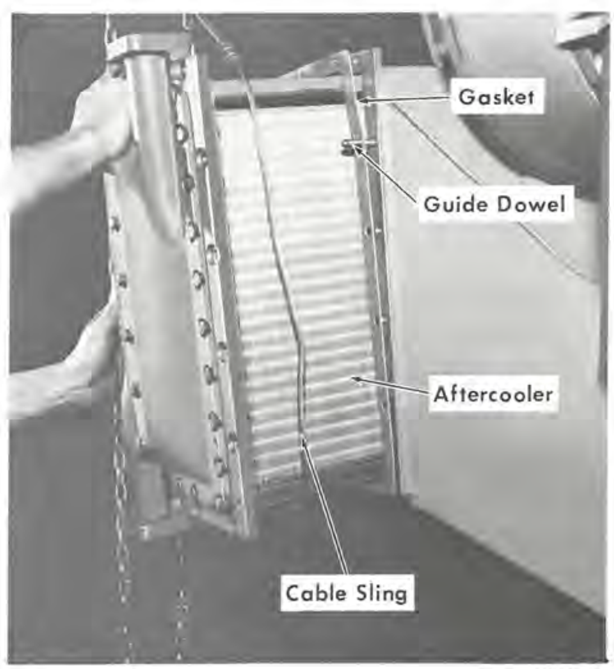


Fig. 9-3 — Removing Aftercooler Assembly

MAINTENANCE

Any evidence of water leakage in the core of the aftercooler will necessitate removal of the aftercooler assembly. Leakage can usually be detected by inspecting the interior of the air duct assembly at the air box side when the engine is shut down.

REMOVAL

1. After draining the engine water, disconnect the water discharge or vent line flange at the top of the aftercooler.
2. Loosen the water inlet line at the bottom of the aftercooler.
3. Remove the mounting bolts securing the aftercooler to the air duct, both at the front and at the back, and free the assembly. Jacking screw holes in the aftercooler flange will receive screws to aid in breaking the joint between the air duct and aftercooler.
4. When the aftercooler is sufficiently free, Fig. 9-3, apply a cable sling and using a suitable hoist, remove the entire assembly from the air duct.

INSTALLATION

1. Check the air duct and aftercooler mounting surfaces to make certain that there are no nicks, dirt or roughness on these areas.
2. Apply the support pad to the back plate dowels of the aftercooler, Fig. 9-4, with the gasket in position at the outside so as to contact the air duct.
3. Apply the aftercooler to air duct gasket over two guide dowels, Fig. 9-3, and using a suitable sling and hoist, install the aftercooler in the air duct.
4. Line up the support pad bolt holes, Fig. 9-5, at the back of the air duct and apply, but do not tighten the support pad bolts.
5. Correctly position the aftercooler flange over the air duct gasket and flange holes, apply and tighten the bolts holding the aftercooler to the air duct.
6. When the aftercooler flange bolts have been tightened, tighten the support pad bolts at the back of the air duct, Fig. 9-5, to 130 ft-lbs and lockwire.

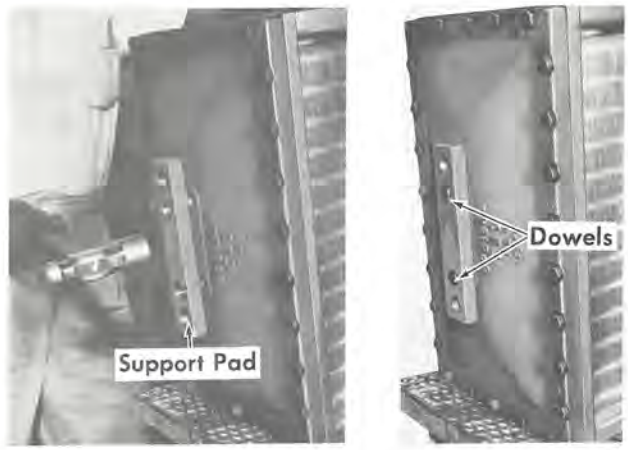


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Fig. 9-4 – Support Pad To Dowel Installation

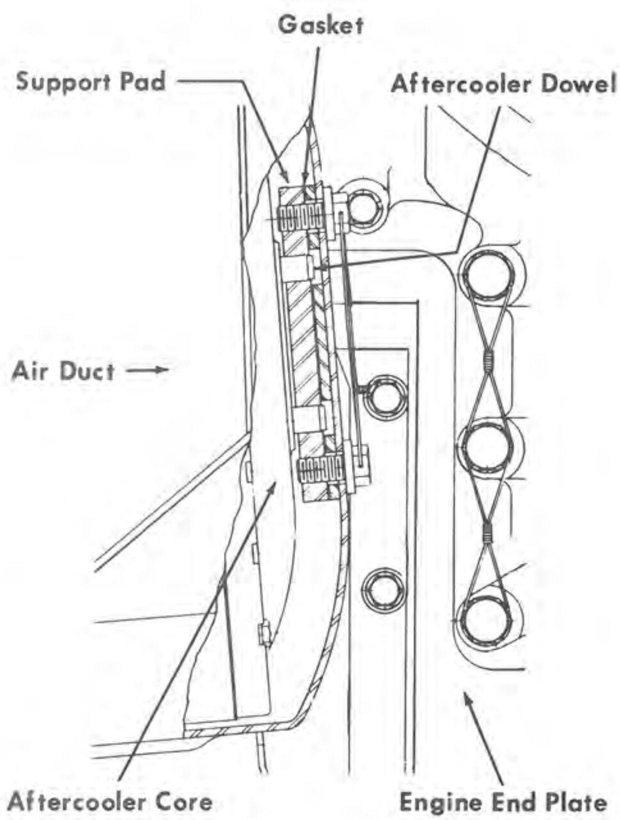

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Fig. 9-5 – Air Duct Support Pad Application

CORE REPLACEMENT

In the event that an aftercooler is removed due to a leaking core, the core may be replaced using the following procedure.

1. Gaskets used in the aftercooler assembly should be prepared in advance of assembly by being soaked in ASTM (American Society For Testing Materials) No. 3 oil for 15 minutes at a temperature of 160° F. After soaking, the gaskets should be removed and permitted to drain before using.

2. Place the core on the work bench and apply the cover gasket and cover.

3. Apply the cover bolts and tighten to 35 ft-lbs. Tighten from the center bolt out to the end bolts.

4. Invert the assembly and apply the header to core gasket and header.

5. Apply the header to core bolts and tighten from the center bolt out to the end bolts. Tighten the bolts to 35 ft-lbs.

6. After the assembly has been completed, blank off all flanges except one, and apply an air test arrangement on the remaining flange.

7. With 50 psi air pressure in the water passage of the core, submerge the assembly in water and check for leaks.

8. After water test, recheck the torque of the header and cover bolts to 35 ft-lbs.

WATER PUMPS

DESCRIPTION

The two engine cooling water pumps, Fig. 9-6, are high capacity centrifugal pumps, which rotate counterclockwise. The components of the water pump are shown exploded in Fig. 9-7. The pumps are carried under two part numbers to identify the right and the left bank pumps. The only difference between right and left bank pumps is the position of the impeller

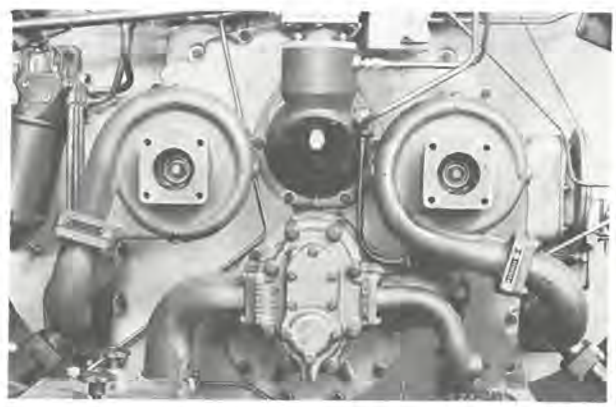

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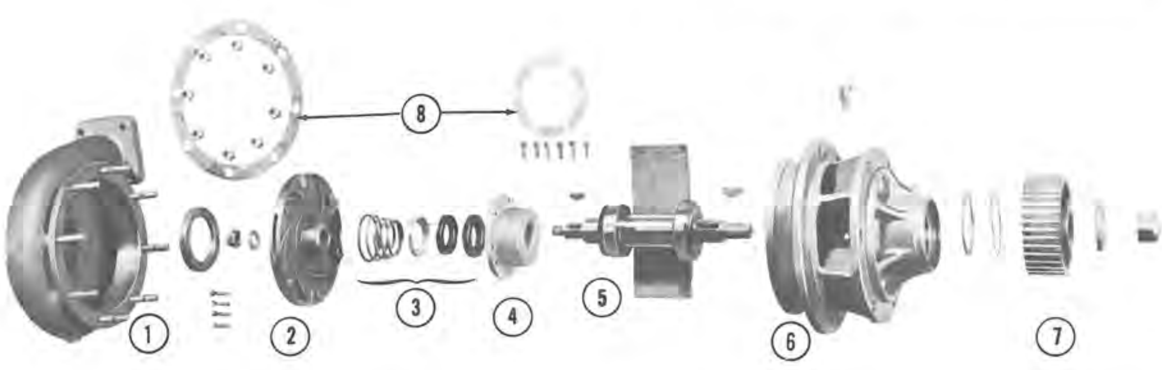
Fig. 9-6 – Water Pump Installation



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1. Impeller Housing
2. Impeller
3. Seal Assembly
4. Stationary Bushing
5. Drive Shaft Assembly
6. Drive Shaft Housing
7. Drive Gear
8. Gaskets

Fig. 9-7 — Water Pump, Exploded View

housing in relation to the pump shaft housing. The position of the impeller housing may be changed on either pump to permit its use on the opposite bank.

Current production water pumps are self-draining and do not have a drain cock in the right bank pump or pipe plugs in the left bank pump as were in the previous model pumps.

The pump drive shaft is supported in the main pump housing by two ball bearings separated by a steel spacer. The spacer is covered by a felt pad which receives the bearing lubricating oil from the oil cup in the housing. The outer bearing adjoins a water slinger which bears against a shoulder on the shaft. The inner bearing is held in place by a retainer and snap ring to absorb any thrust in the shaft. The pump drive gear is keyed to the pump shaft abutting the inner bearing and is held on the shaft by a washer and nut.

The stationary bushing, Fig. 9-7, is applied to the drive shaft housing. The carbon of the seal assembly, Fig. 9-8, faces against the smooth inner surface and is held by a spring. Any water leakage past the seal is indicated at a tell-tale drain in the drive shaft housing, which permits runoff, and prevents water from reaching the engine side of the pump.

The impeller is keyed to the pump shaft and is secured to the shaft by a washer and capped nut. It is enclosed by the impeller housing, which is assembled to the main pump housing by eight studs and nuts.

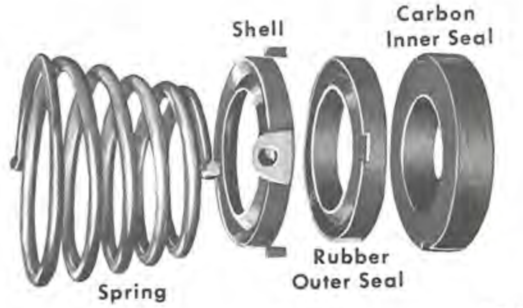


Fig. 9-8 — Spring And Seal Assembly

MAINTENANCE

PUMP REMOVAL

1. Drain cooling system.
2. Remove water pump inlet flexible connection.
3. Disconnect pump discharge flange connection.
4. Remove pump mounting bolts and pump from engine.

HOUSING AND IMPELLER REMOVAL

1. Remove nuts holding impeller housing and remove the housing. The impeller housing can be more easily removed if the pump is held suspended slightly above the work bench by a hoist, impeller end down, while tapping on the housing with a rawhide or wooden mallet.
2. Remove impeller shaft nut and washer and apply impeller puller to remove the impeller as shown in Fig. 9-9. The

Fig. 9-9 — Removing Pump Impeller

tapered tip, which is part of the puller, is placed in the center of the shaft to center the puller and ensure equalized pull on both sides of the puller.

REMOVAL AND APPLICATION OF PUMP SEALS

Seal Removal

1. After impeller removal, remove spring and seal assembly, Fig. 9-10. Use care to prevent damage to the stationary bushing seal surface. Some seal assemblies offer little resistance to removal, but some are quite firm on the shaft. Seal assemblies tight on the shaft may be removed with the stationary bushing.

2. Remove the bolts from the stationary bushing. In the event the bushing is not easily removed, insert 3/8" × 2" bolts in the puller holes provided in the bushing, Fig. 9-10, and force the bushing out from the housing. Sometimes the bushing may be loosened by tapping on the bushing flange with a rawhide mallet, allowing removal without using puller bolts.

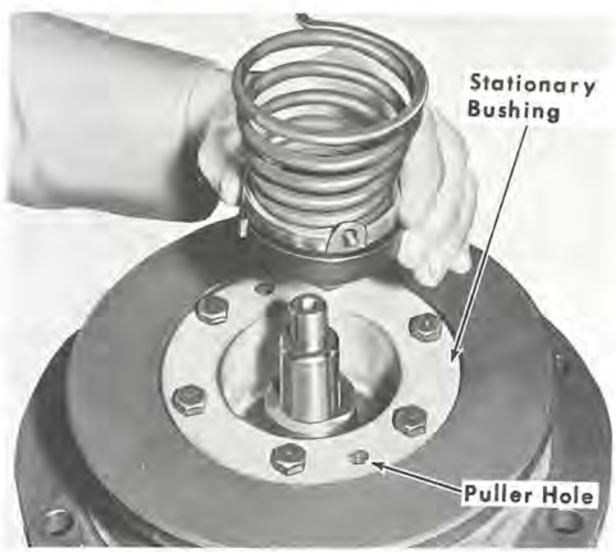


Fig. 9-10 — Seal And Bushing Removal

Seal Application

1. Clean the stationary bushing and pump shaft.

CAUTION: The sealing surface of the stationary bushing must be absolutely smooth and flat to prevent wear of the carbon washer. A stationary bushing having a rough surface must be refinished or be replaced with a new bushing.

2. Before applying the stationary bushing, be sure the bushing and mounting surfaces are clean. Foreign material can cause the bushing to cock and interfere with effective sealing. Also, be sure that the smooth and flat carbon seal surface of the bushing is clean and dry. Apply new stationary bushing gasket and bushing. Tighten the bolts evenly and torque to 6 ft-lbs.

   After applying the stationary bushing, check runout of the carbon seal surface using an indicator mounted on the end of the pump shaft. If runout limit is exceeded, reposition bushing 180° and/or scrape off mounting surface in area of high reading.

3. Install the new seal assembly, refer to Fig. 9-8. Apply carbon inner seal with the narrow end contacting the stationary bushing. Check carbon face for cleanliness. Apply rubber outer seal to shell, and apply to carbon seal so ears of shell fit into the slots in the carbon seal. One end of the drive spring fits into the shell while the other end must be fitted into a slot at the bottom of the impeller when it is assembled.

PUMP SHAFT AND BEARING REMOVAL

1. Remove gear retaining nut and washer from drive gear end of pump shaft.

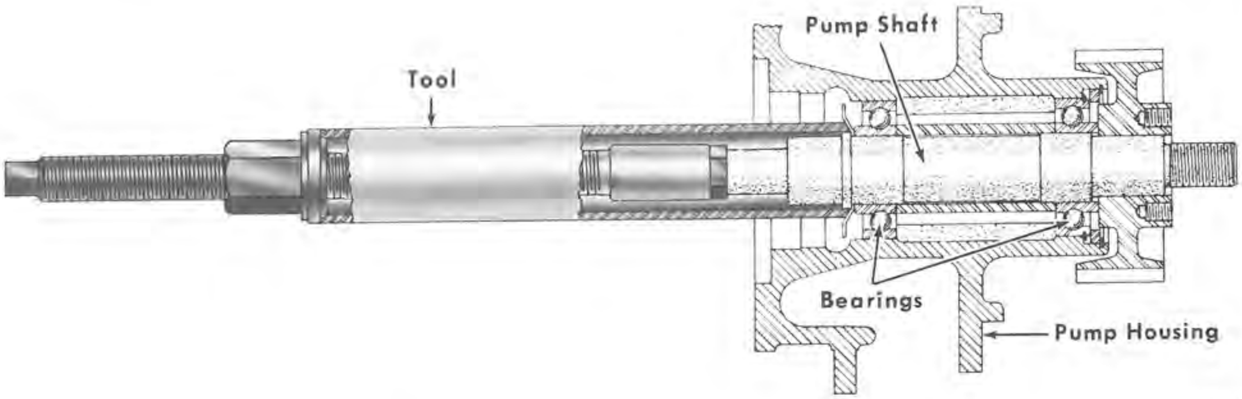


Fig. 9-11 — Pump Shaft Removal

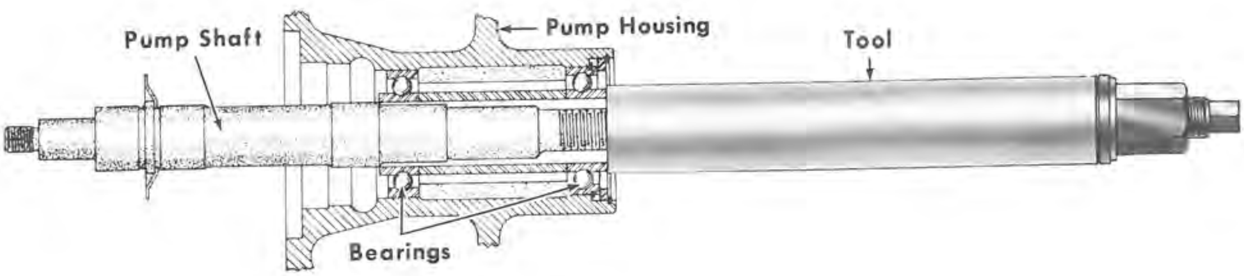


Fig. 9-12 — Pump Shaft Installation

2. Remove drive gear using puller.

3. Remove snap ring and retainer ring.

4. Unscrew oil cup several turns to ensure tip end will not restrict shaft removal. Remove shaft and bearing assembly from the housing at the impeller end, Fig. 9-11, using a pump shaft and bearing puller.

5. Press bearing assembly off the shaft from the gear end.

NOTE: Pump shaft and bearing puller may be used for disassembly and assembly of these parts. Figs. 9-11, 9-12, and 9-13 show application of this tool.

6. Clean and inspect parts for defects and replace damaged parts.

Bearings with seals or shields on both sides should be wiped clean but not washed. Inspect bearings for excessive end play, roughness, seizing, galled, worn or abraded surfaces, broken or bent seals or shields, and fractured outer races.

Pump shaft seal contact surfaces must be smooth.

See Service Data at end of section for wear limits.

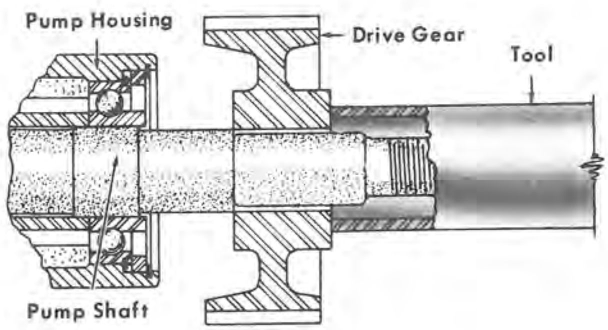


Fig. 9-13 — Pump Drive Gear Installation

DRIVE SHAFT HOUSING ASSEMBLY

1. Assemble water slinger, outer bearing, spacer, and inner bearing to the pump shaft, making sure that the rear bearing with the retainer ring is positioned correctly with the retainer ring to the outside. These parts are assembled, Fig. 9-7, first with the slinger next to the shoulder on the shaft, concave side toward the impeller end, followed by the outer bearing (without retainer), spacer and inner bearing, abutting each other snugly. The seal sides of the bearings go toward the outer ends of the assembly, being distinguished by the seal side of the bearing protruding slightly beyond the outer race.

2. To apply the shaft and bearing assembly to the support housing, place the impeller end on the inlet flange of the impeller housing or provide a wooden block having a center bore to allow the shaft end to extend down.

3. Start the assembly in the housing, tapping lightly with a wooden mallet. Using pump shaft and bearing puller tool, Fig. 9-12, press shaft and bearing assembly into pump housing. Wrap the oil soaked felt pad around the spacer when the first bearing clears the housing boss, and continue down with the assembly until the outer bearing rests on the housing boss.

NOTE: If the felt pad feels gritty or is dirty, replace with a new oil soaked pad.

4. First apply the bearing retainer and then the snap ring back of the rear bearing.

5. Apply drive gear to shaft, Fig. 9-13, puller holes facing out. Check shaft key and key way fit. Check that pump shaft diameter to gear bore fit is within the maximum limit. Inspect gear nut insert, for any signs of disintegration. Nuts may be reused if fiber collar drag is 92 in.-lbs. Gear nut (1" - 14) torque is 265 ft-lbs.

6. Replace seal assembly as previously described.

PUMP IDENTIFICATION

Prior to completing assembly of the pump by the installation of the impeller and impeller housing, check to ensure that only high capacity pumps are being assembled for use on these engines. To determine whether the pump is a high or standard capacity pump, check that the impeller and housing water inlets conform to the applicable configuration as shown in Fig. 9-14. Incorrect pump application can result in improper engine cooling.

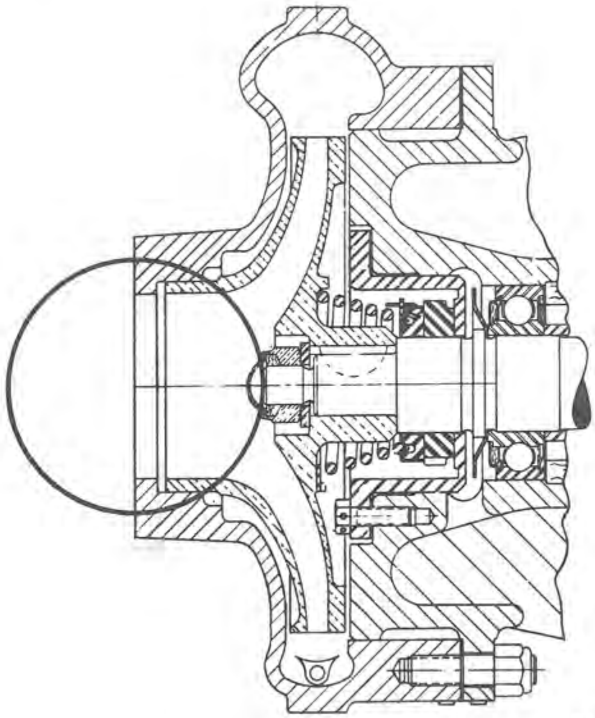
INSTALLING IMPELLER

1. Fig. 9-15 shows the impeller installer being used to assemble the impeller to the drive shaft housing. The threaded bushing is screwed on pump shaft threads and then by turning outer portion of installer tool, the impeller is pressed into position. Care must be taken to start the impeller straight on the shaft and to see that the key and keyway are aligned. Before the impeller is brought all the way down, check the underside to see that the seal spring is in the spring slot under the impeller and then finish the impeller application.

2. Check the insert in the impeller shaft nut to see that it is free from tears and disintegration. Nuts may be reused if the fiber collar drag is 32 in.-lbs. Apply the impeller retaining washer and nut. Torque value of the impeller nut is 80 ft-lbs.

INSTALLING IMPELLER HOUSING

1. Check that drilled drain passage on self draining pumps is free of obstruction.



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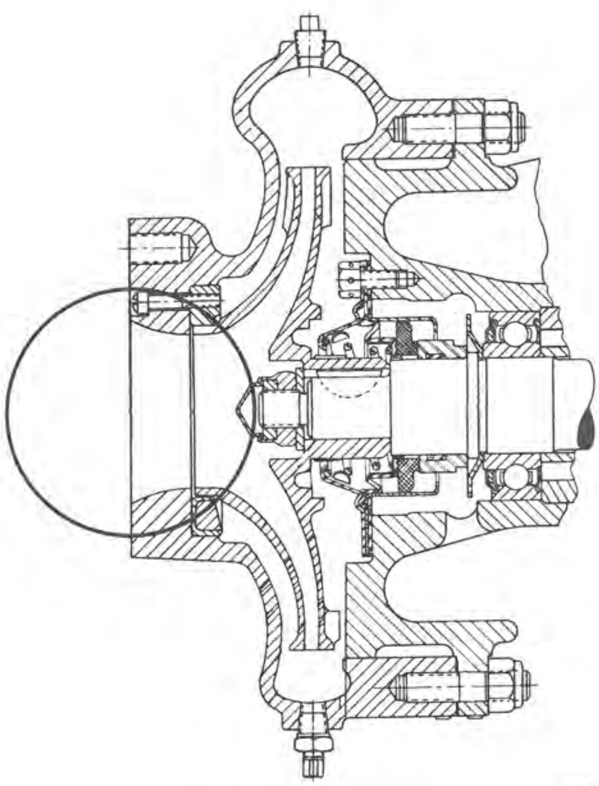
HIGH CAPACITY



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STANDARD CAPACITY

Fig. 9-14 — Water Pump Capacity Identification

3524

Fig. 9-15 — Installing Pump Impeller

2. Determine whether the pump is to be used on the right or left bank of the engine since the impeller housing is positioned differently in each case.

3. An arrow is cast at the bottom of the pump shaft housing and the impeller housing has a letter "R" and "L." For a right bank pump assemble the impeller housing so that the "R" is opposite the arrow on the shaft housing or for a left bank pump the "L" is opposite the arrow, as shown in Fig. 9-16.

4. Install housing in the correct position, using new gasket between the impeller and shaft housing. Apply housing nuts to studs and carefully tighten.

INSTALLING PUMP

1. The pumps are installed in the position shown in Fig. 9-16 for the right or left bank. Torque value for the pump to accessory cover mounting bolts is 65 ft-lbs.

2. The part number of the pump is located on a plate attached to the pump discharge flange, as shown in Fig. 9-16.

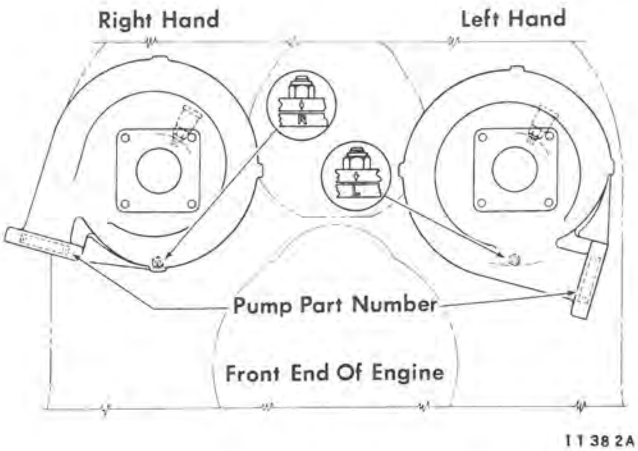


Fig. 9-16 — Pump Housing Positioning

It should be noted also on pump installation that the water inlet elbow is the proper one as listed in the parts book for the engine installation.

3. When installing a water pump, care should be taken with the application of the water inlet connection. This connection consists of a sleeve, synthetic rubber seals, seal retainers and bolted clamps. Make sure that the synthetic rubber seals are not damaged prior to or during assembly of the flexible coupling.

SERVICE DATA
COOLING SYSTEM

SPECIFICATIONS

Pump drive gear backlash - New .... .008" - .016"
Limit .... .030"

Bearing bores in support housing may be oversize or bearing outer diameter undersize. The limits governing the fit are:	Interference - Max.	.0001"
	Clearance - Max.	.0025"
Pump shaft bearing mounting diameters to bearing bores. No wear allowed. The limits governing the fit are:	Interference - Max.	.0009"
	Clearance - Max.	.0001"
Pump shaft drive gear mounting diameter to gear bore. The limits governing the fit are:	Interference - Max.	.0005"
	Clearance - Max.	.001"
Pump shaft impeller mounting diameter to impeller bore. The limits governing the fit are:	Interference - Max.	.0025"
	Interference - Min.	.0005"

Stationary bushing seal seat squareness with drive shaft — T.I.R. .... .001"

EQUIPMENT LIST

	Part No.
Impeller installer	8052959
Water pump shaft and gear puller assembly	8219743
Water pump collar puller	8220578
Water pump impeller puller	8354367
Engine cooling system water test (schematic pumping diagram)	File 292

For additional tools see Tool Catalog

FUEL SYSTEM

DESCRIPTION

The engine fuel system, Fig. 10-1, consists of the fuel injectors, the engine mounted fuel filter, and fuel supply and return manifolds.

Components external to the engine such as the fuel tank, flame arrester, fuel suction filter, single cartridge filter, and connecting lines complete the fuel system.

In operation, fuel from the fuel tank is drawn up by the fuel pump through a suction strainer and cartridge filter and is delivered to the engine mounted filter. It then passes through the filter elements to the fuel manifold supply line and from there through a jumper line and injector inlet filter at each cylinder into the injector. A small portion of this fuel supplied to each injector is pumped into the cylinder, at a very high pressure, through the needle valve and spray tip of the injector. The quantity of fuel injected depends upon the rotative position of the plunger as set by the injector rack and governor. The excess fuel not used by the injector, flows through the injector, serving to lubricate and cool the working parts.

The fuel leaves the injector through the return fuel filter. This filter protects the injector in the event of a backward flow of fuel into the injector from the return fuel line. From the return fuel filter in the injector, the excess fuel passes through the fuel return line in the manifold to the relief valve inlet of the "return fuel" sight glass on the engine mounted fuel filter.

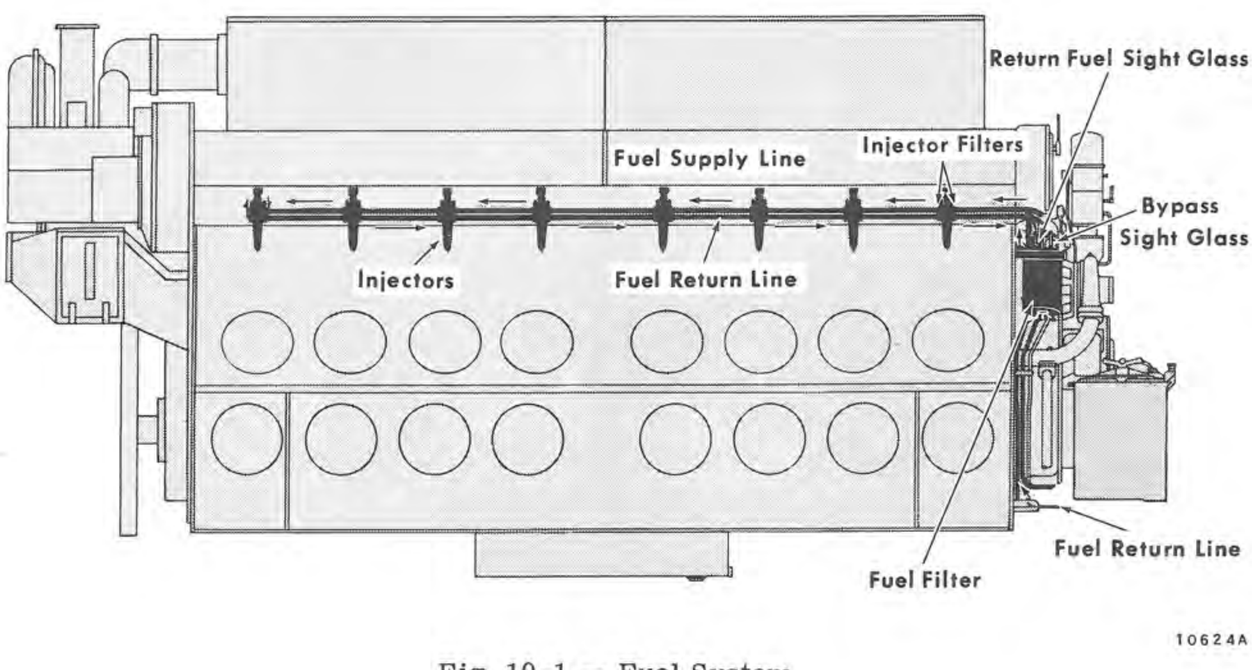


Fig. 10-1 — Fuel System

This valve restricts the return fuel, maintaining a back pressure on the injectors. The fuel continues into the "return fuel" sight glass, filling the glass, down through the standpipe under the glass and through the return line to the fuel supply tank.

FUEL INJECTORS

DESCRIPTION

An injector, Fig. 10-2, is located and seated in a tapered hole in the center of each cylinder head, with the spray tip protruding slightly below the bottom of the head. It is positioned in the head by a dowel and held in place by an injector hold down crab and nut.

The external working parts of the injector are lubricated by oil from the end of the injector rocker arm adjusting screw. The internal working parts are lubricated and cooled by the flow of fuel oil through the injector.

A cross-section of the unit injector and names of the various parts are shown in Fig. 10-3.

The plunger is given a constant stroke reciprocating motion by the injector cam acting through the rocker arm and plunger follower. The timing of the injection period during the plunger stroke is set by an adjusting screw at the end of the rocker arm. Fig. 10-4 shows flow of fuel through the injector during one downward stroke.

Fig. 10-2 — Fuel Injector

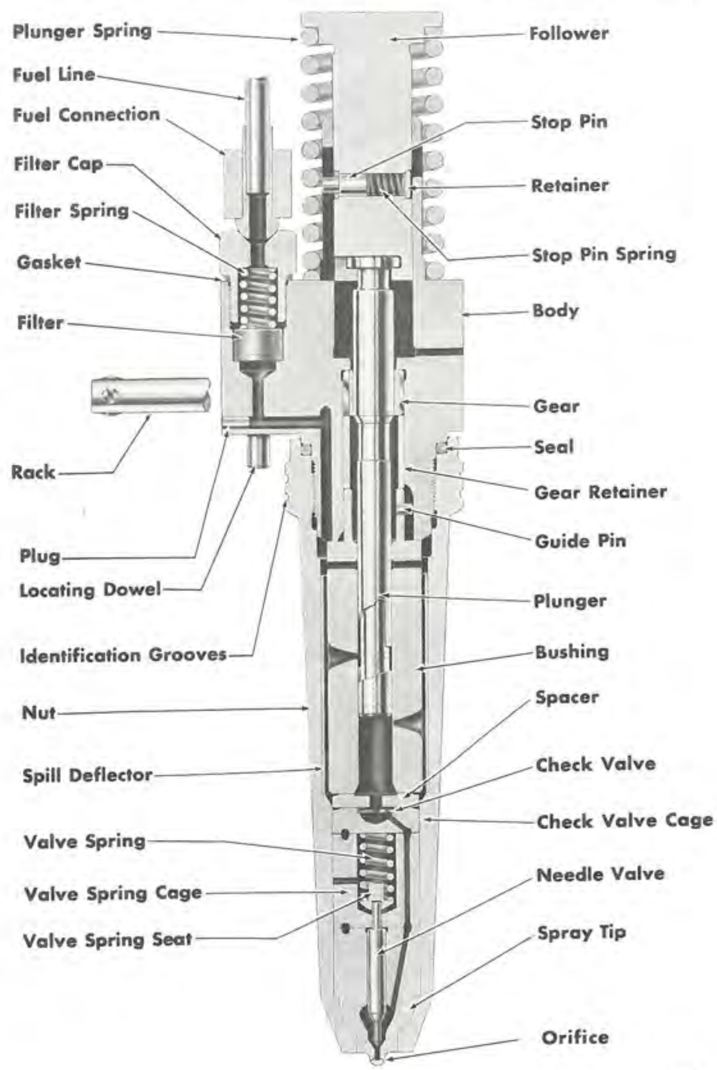


Fig. 10-3 — Fuel Injector, Cross-Section

Rotation of the plunger, by means of the rack and gear, controls the quantity of fuel injected into the cylinder during each stroke. Rack position is controlled by the governor through the injector layshaft and linkage. The gear is keyed to and is a sliding fit on the plunger to allow plunger vertical movement.

The helices near the bottom of the plunger control the opening and closing of both fuel ports of the plunger bushing. Rotation of the plunger regulates the time that both ports are closed during the downward stroke, thus controlling the quantity of fuel injected into the cylinder as shown in Fig. 10-5. As the plunger is rotated from idling position to full load position, the pumping part of the stroke is lengthened, injection is started earlier, and more fuel is injected.

Proper atomization of the fuel is accomplished by the high pressure created during the downward stroke of the plunger, which forces fuel past the needle valve and out through the six spray holes in the tip of the injector.

The injectors have an adjustable calibrating slide mounted on the side of the injector body, adjacent to the rack. This

Fig. 10-4 — Injector Fuel Flow

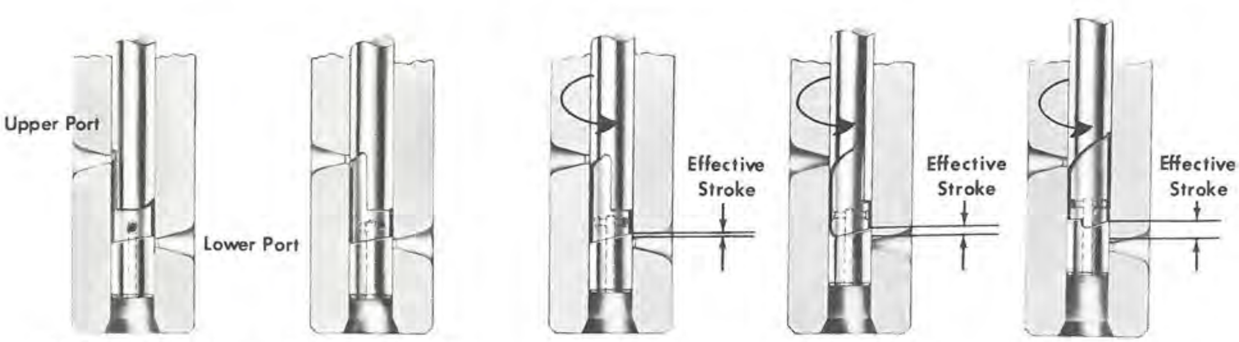


Fig. 10-5 — Plunger Fuel Control

slide is incorporated solely as a means of adjusting injector output on a calibrating stand.

Filters at the fuel inlet and outlet connections protect the working parts of the injector.

MAINTENANCE

INSTALLATION

1. When installing an injector in an engine, make sure it is the correct injector for the engine in which it is to be applied.
2. See that injector body and tapered hole in cylinder head are clean.
3. Install injector and apply injector hold down crab, spherical washer and nut. Torque nut to 40-50 ft-lbs.
4. Connect injector rack to lever assembly.
5. Install and tighten fuel supply and return lines to injector and engine fuel manifold.
6. Install rocker arm shaft and rocker arms. Loosen injector rocker arm locknut and back off on adjusting screw before tightening rocker arm shaft nuts. Injector is now ready for timing.

TIMING THE INJECTOR

With the injector installed, make timing adjustment as follows:

1. Set the flywheel at 0° top dead center of the cylinder being timed.
2. Insert injector timing gauge into the hole provided for it in the injector body, Fig. 10-6.
3. Loosen locknut and turn the rocker arm adjusting screw until the shoulder of the gauge just passes over the injector follower guide.

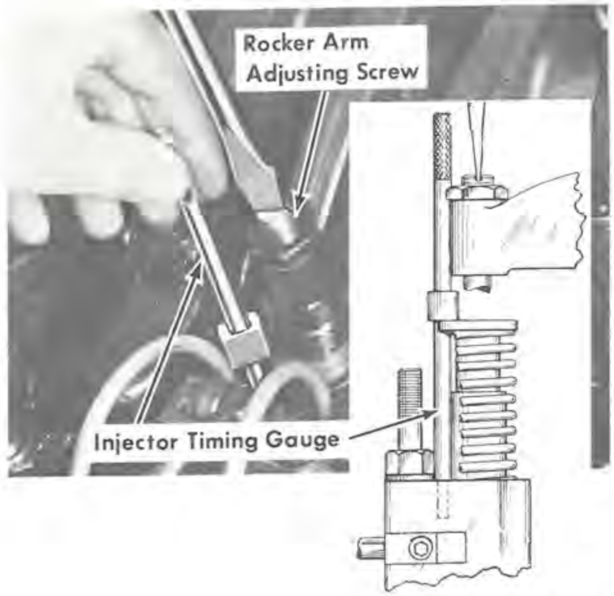


Fig. 10-6 — Timing Injector

NOTE: Injectors cannot be timed if the overspeed has been tripped. It must first be reset and the engine crankshaft barred over at least one revolution.

4. Tighten adjusting screw locknut, holding adjusting screw in position with a screwdriver.
5. Recheck setting.

STICKING INJECTORS

Engines may encounter sticking injectors due to fuel, lube oil, or filter maintenance conditions. Since these conditions very often are momentary, injector removal may be minimized by utilizing alcohol to free up injectors while installed. This is done by applying ordinary commercial methanol to the injectors through a hole opposite the timing tool hole, and "popping" the injectors or motoring the engine. This sticking condition usually occurs on injectors which are held with the plungers down when the engine is stopped. Should injector racks show signs of sticking, they should be checked for gum or varnish deposits. If present, the rack should be cleaned with alcohol and rechecked. If sticking persists, the injectors should be removed and replaced with operational injectors. In no case should injectors be "crutched out" or cut out and the engine operated. If injectors operating unsatisfactorily cannot be remedied or replaced, the engine should be shut down until corrective action has been taken.

SERVICING INJECTORS

When servicing injectors, clean working conditions must be maintained. Dust or dirt in any form is a frequent cause of injector failure. When an injector is in an engine it is protected against dirt, dust, and other foreign materials by the various filters employed. When an injector is in storage, it is protected against harmful material by the filters sealing the body openings, which are in turn protected by shipping blocks.

However, an entirely different set of conditions is encountered when it becomes necessary to disassemble an injector for repair or overhaul. These conditions necessitate special shops, equipment, and trained personnel. Adequate maintenance facilities are expensive, and in most cases the customer would not be warranted in the expense. Electro-Motive maintains this service for our customers and recommends that injectors be returned to their nearest factory branch for rebuild or unit exchange. For particulars on this service, see Factory Rebuild Bulletin No. 302.

INJECTOR TEST STAND

In order to ensure efficient engine performance, injectors should be tested whenever removed from an engine, regardless of the reason for removal. In addition, it is advisable to test all injectors in an engine during each annual inspection. It is recommended that injectors be tested with the same oil used for protection against rust as given under "Storing Injectors."

It is important that the individual doing the testing understands the basic principles of injector operation and testing procedures in order to prevent acceptance of defective injectors and rejection of good ones. Instructions in the use of the injector test stand and an outline of each separate test procedure along with a basic explanation of operation follows.

These instructions cover the testing of all needle valve injectors using the test stand shown in Fig. 10-7. The procedures are not applicable to other types of testing equipment, since injector leakoff rates vary greatly in proportion to the volume of fuel contained in the high pressure portion of the test stand.

SETTING UP TEST STAND

Basically, the stand consists of a fuel reservoir, filter, high pressure pump, pressure gauge, and necessary connecting lines and fittings to supply fuel to the injector under test. The test stand should be set up as instructed by the manufacturer. Inspect carefully for dirt or foreign material in the tank and lines. Fill the tank with clean fuel and operate the pump to purge all free air from the system.

Investigation has shown that the viscosity of the fuel oil used in the test stand has a

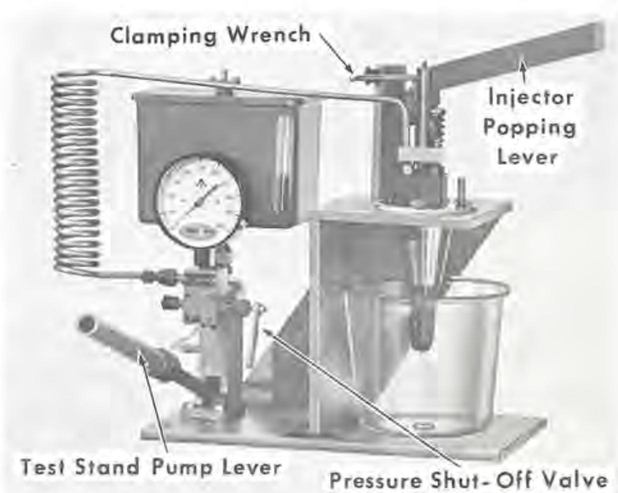


Fig. 10-7 — Injector Test Stand

marked effect on the test results obtained. Regular fuel oil may be used provided the viscosity is not less than 32 S.S.U. at 100° F. Do not reuse fuel oil which has been pumped through the injectors into the plastic bowl.

CHECKING TEST STAND

Install the test block in place of an injector in the stand and pump up pressure to 2000 psi, as indicated by the gauge. After five minutes, the pressure should not have dropped below 1975 lbs. Release the block and recheck at 500 and 1000 psi. These pressures should hold one minute with no apparent gauge drop. Make these tests with the pressure shutoff valve, Fig. 10-7, open all the way. If the tests are satisfactory, all injector tests may be made without using the shutoff valve. If the preceding tests indicate leakage in the stand, repeat the tests, closing the shutoff valve before timing the leakoff rates. If the tests are satisfactory with the shutoff valve closed, it will be necessary to use the shutoff valve when making the injector holding pressure test.

When placing a new test stand in operation, or after removing and replacing the gauge, fuel tank, filter, or pump, for any reason, the test block should be installed and pressure raised to 2500 psi and vented at least six times before making an operational check.

TEST STAND OPERATION

The operator must consider the test stand as an instrument, rather than a tool. Every effort should be made to make the manual operation of repeated tests the same. The following general information is provided to help in obtaining uniform operation:

General Information

1. When operating the pump, use a rate of 60 strokes per minute. This provides a fuel rate to operate the check valve smoothly and to circulate fuel within the injector.
2. When using the popping lever, do not use such force as to damage either the injector or the lever. Do not permit the lever to fly up freely.
3. In making holding tests, do not pump the stand above 2500 psi.
4. Test stands regularly in use should be checked daily for leaks, using the test blocks.
5. Fuel oil used for testing should not be reused.

INJECTOR TESTS

Preparation

1. Install the injector in the test stand.
2. Fill the injector with fuel oil, but do not connect the fuel line from pump to injector at this time.
3. Set the injector rack at maximum fuel output position (minimum rack length).
4. "Pop" the injector with the popping lever, Fig. 10-7, using smooth even strokes. A finely atomized spray should show at each of the six holes in the tip. Rapid closing of the needle valve should produce a sharp "chatter."

   If the valve opens without producing a finely atomized spray or the valve seats without producing the sharp "chatter," make several rapid strokes with the lever to dislodge any foreign material on the valve seat. If the needle valve still fails to function properly, a stuck needle, dirt on the valve seat, or a defective valve seat may be the cause.

Holding Pressure And Leak Test

1. All injectors lose pressure due to leakage at any of several points, but this leakage must be controlled during injector manufacture to prevent engine lube oil dilution. The holding pressure test will qualify injectors having specified leakoff rates, providing this leakage is at the proper point and is satisfactorily controlled.
2. Connect the fuel line to the injector and apply 1800 to 2000 psi pressure to the injector. No leakage is permitted at the nut to body seal, filter cap gasket, body plugs, or between spray tip and injector nut.
3. Injectors should be qualified on the pressure holding test by timing the interval for a drop in pressure from 2000 psi to 1500 psi. If this interval is less than 30 seconds, repeat the test, but close the pressure shutoff valve on the test stand immediately after establishing the 2000 psi pressure. This is to ensure that the leak down time is not being affected by possible leakage in the test stand itself. If the timed interval for the pressure drop from 2000 psi to 1500 psi is still less than 30 seconds, the injector should be rejected. Do not attempt to "pop" the injector, except with the popping lever.

Rack Freeness Test

1. The rack engages with a small pinion on the injector plunger and serves to rotate the plunger with respect to two ports in the injector bushing, which regulates the amount of fuel injected with each stroke of the plunger. Binding of the rack is generally caused by damaged gear teeth, scored plunger and bushing, or galling of rack itself. A binding rack may cause sluggish or erratic speed changes and overspeed trip action.
2. To be considered satisfactory, the rack must fall in and out through full travel by its own weight when injector is held horizontally and rotated about its axis.

Binding Plunger Test

1. Failure of the injector plunger to move up and down freely indicates scoring of the plunger and bushing or weak or broken spring. A binding plunger will cause erratic cylinder firing and, in extreme cases, overspeed trip action.
2. Place injector in test stand but do not attach the fuel line. Place rack in the full fuel position and pump all the fuel out of the injector with injector popping lever, Fig. 10-7. When all of the fuel has been removed, depress the injector plunger to full extent of its travel and release popping lever. Plunger should return to the top of its stroke with a definite snap action. Repeat this test with the rack in the half fuel and no fuel positions. Care should be used in the test to prevent the plunger from snapping back so violently that the plunger stop pin is broken.

REPLACING INJECTOR FILTERS

Injector filters should not be disturbed or removed except during injector reconditioning (when all parts are completely washed), or in the event of fuel stoppage to the injector.

STORING INJECTORS

When injectors are not to be used for a considerable length of time, they should be protected against rust by using a stable, noncorrosive straight-run petroleum distillate in the kerosene volatility range. It is also recommended that injectors be tested using this oil. If this is done, treatment will be taken care of at time of injector test.

After treatment, the injectors should be stored in a protective container until needed. A drawing, File 207, giving details of construction of an injector storage box, may be obtained on request. This box will accommodate an injector holding rack (holding 16 injectors) similar to that shown in Fig. 10-8.

6793

Fig. 10-8 — Injector Holding Rack

INJECTOR LINKAGE

DESCRIPTION

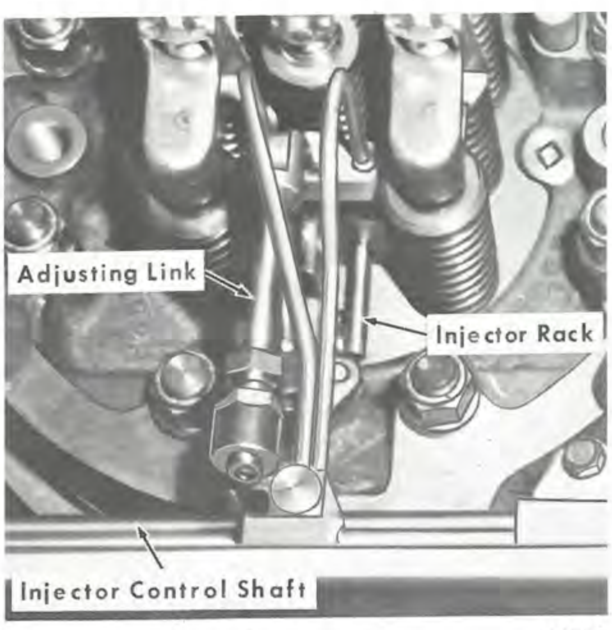
The injector linkage, Fig. 10-9, consists of the mechanical arrangement between the governor and the injector permitting all injector rack positions to be changed simultaneously when the governor terminal shaft is rotated. Two injector control rods connect the lever on the governor terminal shaft to the injector control shafts. One of the control rods is adjustable in length. The injector control shafts, one for each bank, extend the length of the cylinder banks under the cylinder head cover frames. At each cylinder location, a lever is pinned to the control shaft. An adjusting link connects the control shaft lever to an injector control lever mounted on the cylinder head, one end of which straddles the ball at the end of the injector rack.

MAINTENANCE

Before attempting to set injector racks, all racks and linkage should be checked for binding, sticking, or wear which would affect operation.

SETTING INJECTOR RACKS

Injector racks should be set with the engine at operating temperature. If racks are set when engine is not at operating temperature, the settings should be rechecked when operating temperature is reached. As engine temperature increases, the right



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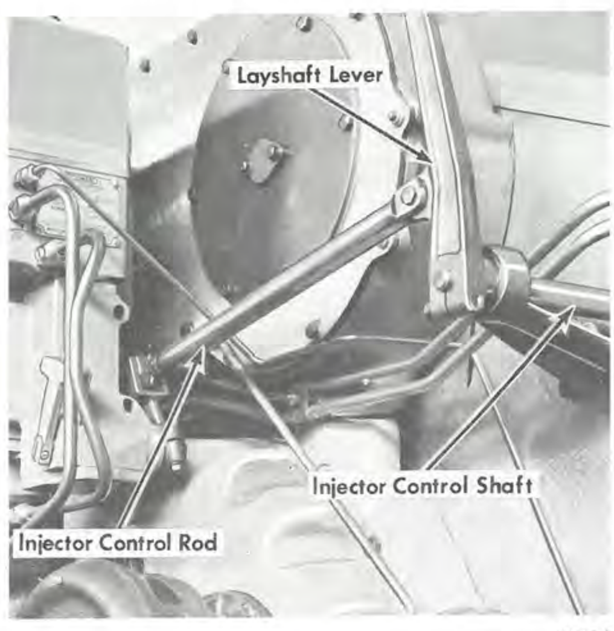

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Fig. 10-9 — Injector Linkage

bank rack length shortens and the left bank rack length increases. The change on the left bank is insignificant, but the change on right bank may shorten the racks beyond the minus 1/64" tolerance.

NOTE: Every time a governor is installed on an engine the injector rack setting should be checked.

Set the injector rack on the engine as follows:

1. Position the layshaft lever so that the pointer on the governor aligns with the governor terminal shaft scale at approximately the 1.00" position.
2. Place one hook of the governor jack, Fig. 10-10, around the lever on the governor terminal shaft. Place the other hook on the bearing brackets forward of the layshaft lever. Adjust the turnbuckle on the governor jack until the governor pointer aligns within ± 1/64" of the 1.00" position on the scale.
3. After the layshaft lever has been properly positioned, the injector rack is set, using a rack gauge, Fig. 10-11. The rack setting gauges are 8 to 1 multiplying gauges which indicate the plus or minus 1/64" rack setting tolerance by means of marks 1/8" each side of the center mark on the gauge scale.

   It is important that the proper rack gauge be used, as previous model rack gauges will measure the rack length from the body of the injector instead of from the face of the calibrating slide. The correct gauge for setting injectors with calibrating slides can be readily identified by the red plastic handle. This gauge can be used for all injectors.

12693

Fig. 10-10 — Rack Positioning

12694

Fig. 10-11 — Injector Rack Gauge

4. Place the gauge over the injector rack and hold the gauge firmly against the face of the adjustable calibrating slide on the injector, Fig. 10-12, and check the gauge pointer. If the pointer is to the short ("S") end of gauge scale center mark, the rack is not extending out far enough from the injector. Loosen the locknut on the adjusting link, Fig. 10-12, and turn adjusting nut on link until pointer is at long ("L") end of the scale; then reverse pointer travel until it aligns within ± 1/64" of the scale center mark. Hold adjusting nut and tighten locknut. The reason for exceeding the scale center mark when making adjustment is so that, in setting all of the racks, the backlash will be taken up in the same direction.

   When pointer is at long ("L") end of scale, set pointer within ± 1/64" of the center mark. The accuracy of the

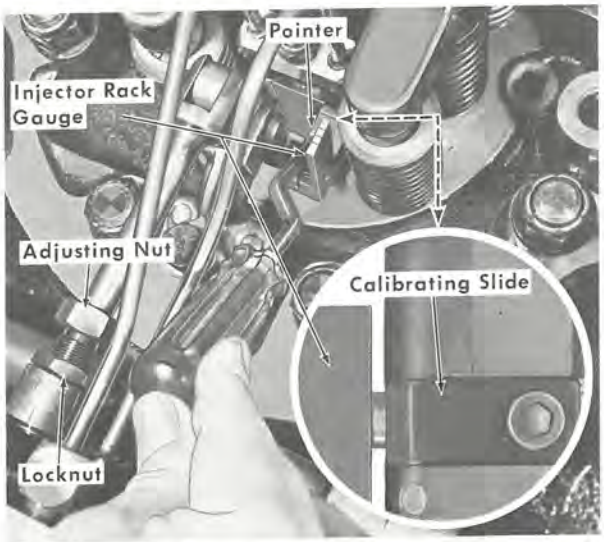


Fig. 10-12 — Injector Rack Gauge Application

injector rack can be checked by inserting the master block in the gauge body. Pointer should align with center mark on scale.

FUEL FILTER

DESCRIPTION

There is only one fuel filter, Fig. 10-13, mounted on the engine. However, other filters which vary in design depending on the engine installation and are not a part of the engine, are used in the fuel system. See the Service Publications Index for the number of the Maintenance Instruction for the specific external filter used.

The engine mounted fuel filter is located at the right front of the engine. Two sight glasses are provided on top of the filter housing to provide a visual indication of the condition of the fuel system. The flow diagram, Fig. 10-14, indicates fuel flow through the filter.

Fuel returning from the injectors passes through the "return fuel" sight glass nearest the engine and returns to the fuel tank. Under normal operation this glass is full of fuel. A relief valve (10 psi) at the inlet to the "return fuel" sight glass establishes a fuel back pressure at the injectors for improved operation.

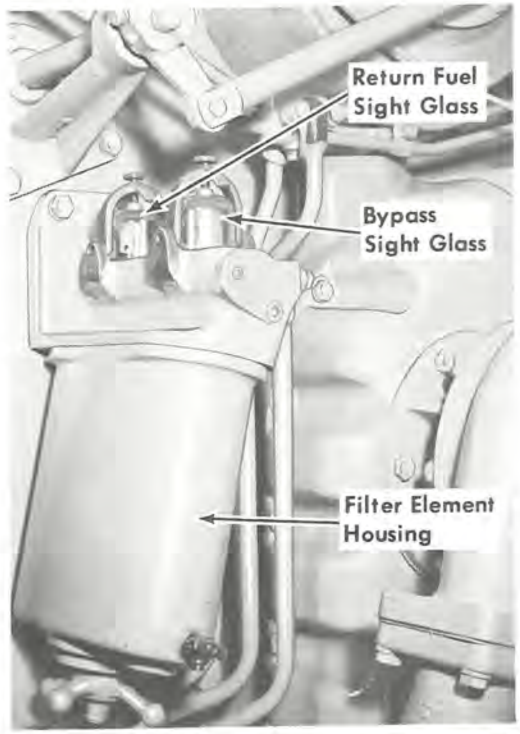


Fig. 10-13 — Fuel Filter

Air or gas in the fuel system will appear in the "return fuel" sight glass as bubbles. Air entering the fuel at any place in the suction line may cause the engine to misfire or stop. Bubbles in the "return fuel" sight glass with the fuel pump running and the engine stopped, indicates air entering the suction side of the fuel pump. If bubbles appear only when the engine is running, it indicates leaky valves in the fuel injectors,

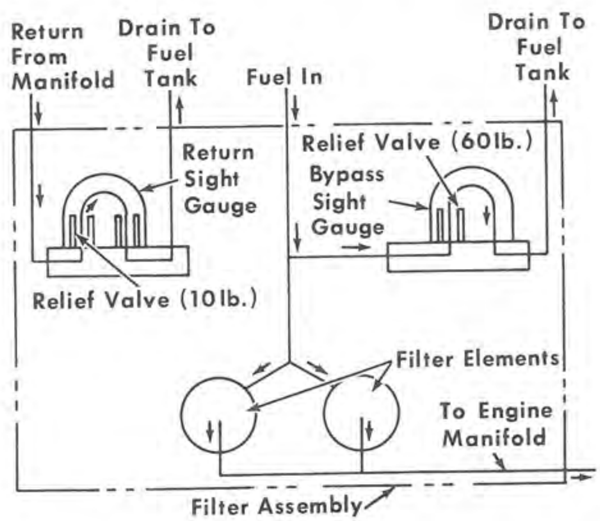
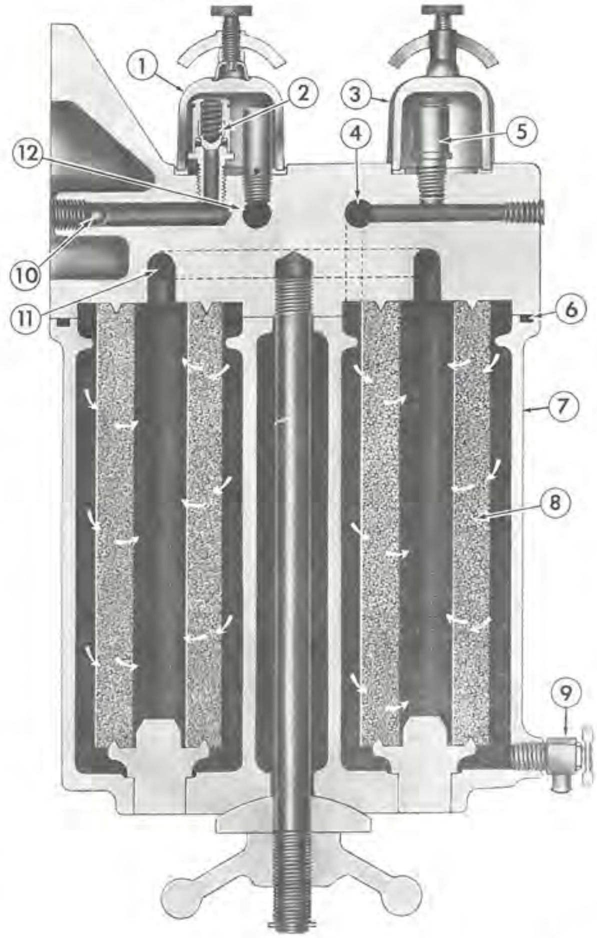


Fig. 10-14 — Fuel Flow Through Filter

allowing combustion gases to get into the fuel. Little or no fuel in the "return fuel" sight glass, with the bypass sight glass empty, indicates insufficient fuel supply to the engine.

Under normal operation, the "bypass" sight glass farthest from the engine should be empty of fuel. As the elements of the filter become dirty, the fuel pressure in the filter will increase. When fuel pressure in the element housing is approximately 60 psi, the relief valve under the glass will open, fuel will enter and fill the "bypass" sight glass, and then return to the fuel tank, starving the engine.

As shown in the cross-section view, Fig. 10-15, two filter elements are positioned by bosses in the housing and the housing is held against the filter body by the center bolt assembly. The filters are large wound elements to provide adequate filter surface and ensure protection against foreign material reaching the fuel injectors.



1. Return Fuel Sight Glass
2. Relief Valve (10 psi)*
3. Bypass Sight Glass
4. Fuel Inlet
5. Relief Valve (60 psi)*
6. Seal
7. Housing
8. Filter Element
9. Drain Cock
10. Fuel from Engine Manifold
11. Fuel to Engine Manifold
12. Return Fuel to Tank

*Relieving pressure and Part No. are stamped on these valves to avoid misapplication.

Fig. 10-15 — Fuel Filter, Cross-Section

MAINTENANCE

The filter elements should be removed and new ones installed at intervals specified in the Scheduled Maintenance Program.

At the time of element replacement, the housing and sight glasses should be cleaned.

1. Shut down the engine and the engine fuel supply.
2. Open housing drain valve to empty fuel from the housing.
3. Loosen the filter housing handwheel to permit the housing to be tilted from the filter body for element removal.
4. Remove the used filter elements and discard them.
5. Clean the housing with fuel oil and wipe clean, using lint-free cloths.
6. Check the condition of the sight glasses, and clean.
7. Check the filter housing to body seals and replace, if necessary.
8. Carefully place the new filter elements in the housing, and reapply the housing to the filter body.

For information on fuel oil specifications and recommendations for the engine, see Maintenance Instruction 1750.

SERVICE DATA

FUEL SYSTEM

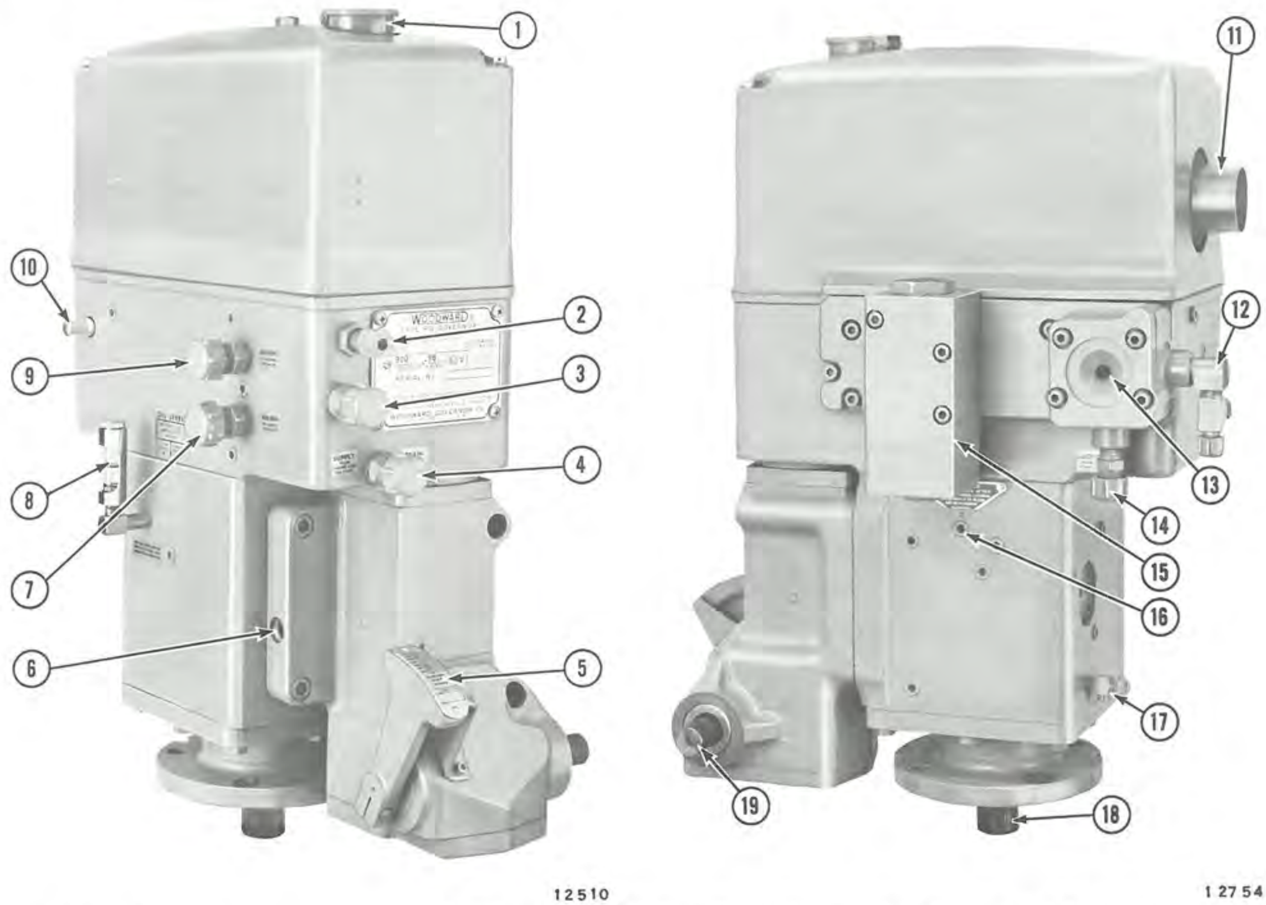
EQUIPMENT LIST

	Part No.
Injector timing gauge	8034638
Injector prybar	8041183
Injector holding rack (16 injectors)	8159228
Plastic spray cup (extra - used with 8202944)	8171780
Injector test stand (complete)	8202944
Oil (injector test, storage, and rust prevention - 50 gal. drum)	8203258
Governor jack	8291936
Injector rack gauge (1")	8331960
Injector storage box	File 207
Fuel system, pre-test (including water and oil system piping, for checking systems)	File 294

GOVERNOR

DESCRIPTION

The limiting and rebalancing type PG governor, Fig. 11-1, is used on the turbocharged engine. An electro-hydraulic speed control maintains the engine speed selected by the engine operator. The governor is provided with a sensor assembly, sensitive to absolute air pressure, which operates to adjust the engine load in proportion to the air supply, within the range of the load regulator, to ensure correct air-fuel ratio. In addition a rocker



1. Oil Filler
2. Air Box Pressure Connection
3. Pilot Valve Engine Oil Supply
4. Pilot Valve Oil Drain
5. Terminal Shaft Scale
6. Compensating Needle Valve
7. Vane Motor Oil Line Connection; Increase Excitation
8. Oil Level Sight Glass
9. Vane Motor Oil Line Connection; Decrease Excitation
10. Low Oil Pressure And High Suction Shutdown Plunger
11. Electrical Receptacle
12. Engine Oil Pressure Connection
13. Vacuum Diaphragm Stop Screw
14. Engine Oil Pump Suction Connection
15. Rebalancing Servo Oil Filter
16. Vent Plug
17. Oil Drain Cock
18. Drive Shaft
19. Terminal Shaft Control

Fig. 11-1 — Electro-Hydraulic Governor

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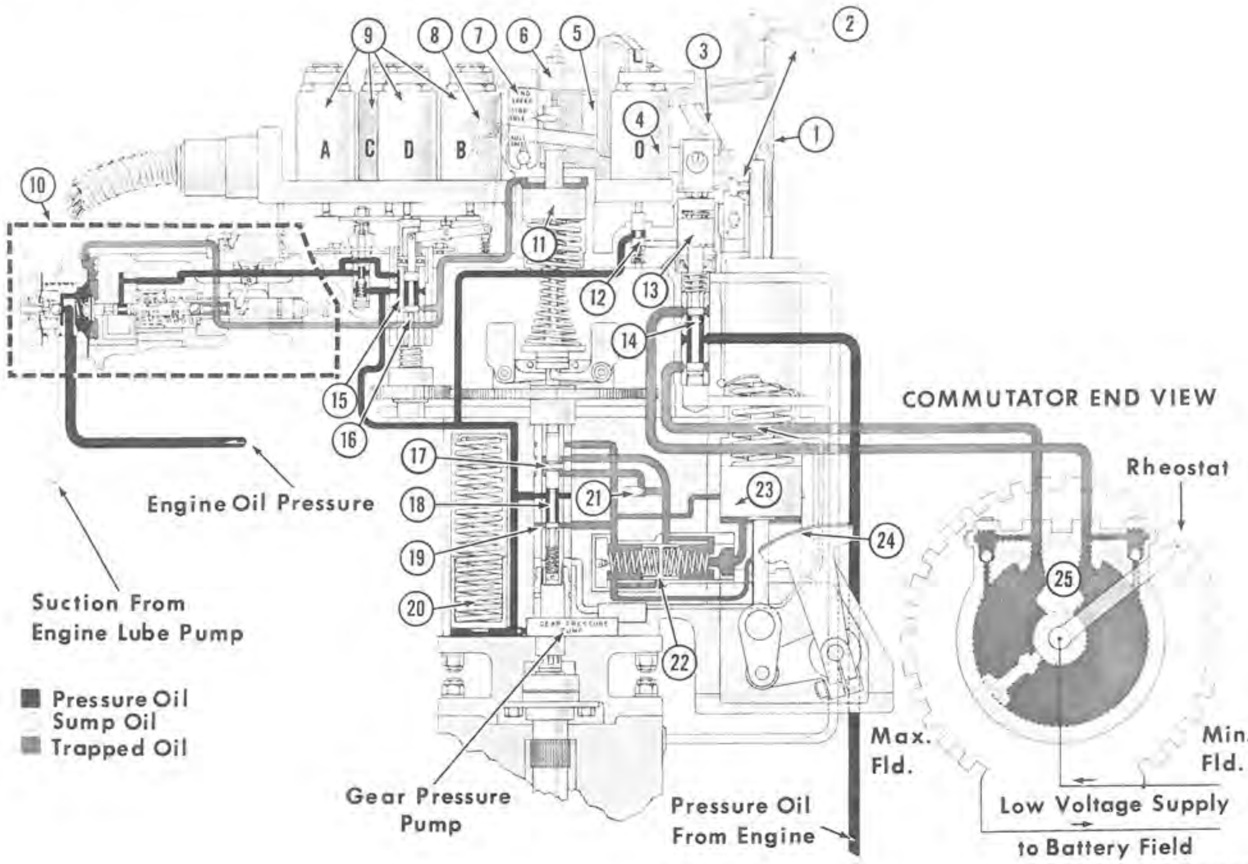
arm and lever arrangement is provided on the governor to stop upward movement of the power piston through the action of the fuel limiter.

The governor incorporates an engine protective device, Fig. 11-2, which shuts the engine down when actuated by low engine oil pressure, high lube oil pump suction, or as a result of the operation of the low water and crankcase pressure detector. Refer to Section 12 for description and maintenance of the protective device. A visual indication and an alarm is actuated in the event of an engine protection shutdown. A normal engine shutdown is obtained by actuating one of the speed setting solenoids with the stop button. Other auxiliary devices which are a part of the governor include the load regulator pilot valve, which controls oil to the load regulator, and the ORS solenoid which when energized raises the load regulator pilot valve to the minimum field position.

The main parts of the speed and fuel control portions of the governor are: a speed sensing arrangement (speeder spring and flyweights), fuel adjustment control (power piston), compensating mechanism (compensating land integral on power piston pilot valve and buffer



1. Power Piston Tail Rod
2. Load Regulator Pilot Valve Scale
3. Pilot Valve Linkage And Eccentric
4. Overriding Solenoid
5. Air Pressure Sensor Assembly
6. Shutdown Block
7. Speed Scale
8. Speed Linkage Fulcrum Point
9. Speed Control Solenoids
10. Protective Device
11. Speed Setting Piston
12. ORS Device
13. Overriding Cylinder Piston
14. Load Regulator Pilot Valve
15. Speed Control Rotating Bushing
16. Speed Control Pilot Valve
17. Receiving Compensating Piston
18. Power Piston Pilot Valve
19. Regulating Port
20. Governor Oil Pressure Accumulators
21. Compensating Needle Valve
22. Buffer Piston
23. Governor Power Piston
24. Terminal Shaft Scale
25. Load Regulator

Fig. 11-2 — Governor Schematic Diagram

piston and springs), and an independent oil system (oil sump, oil pump, accumulators, external filter, and connecting passages).

The governor has a self-contained hydraulic oil system, consisting of storage sump, rotary gear pump, and accumulators. The oil lubricates the moving parts and provides force necessary to operate various parts of the governor.

To vary the speed of the engine with throttle changes, or to maintain a constant engine speed with load changes, the amount of fuel injected into the cylinders must be varied. This is determined by the position of the power piston. To move the power piston, the tension on the speeder spring is varied. Whether the throttle changes or the engine speed changes (due to a load change), the flyweights will move. This changes the position of the pilot valve plunger and controls the supply of oil to the power piston.

The power piston moves the injector control rack through the governor rotary shaft and injector linkage. The upward motion of the power piston results from oil under pressure, controlled by the power piston pilot valve plunger, raising the piston against the pressure of the power piston spring.

The compensating mechanism prevents the engine from racing or hunting by arresting the movement of the power piston after it has traveled an amount sufficient to give the desired speed. The compensating mechanism includes the integral receiving compensating piston, buffer piston and springs, and compensating needle valve.

The governor drive shaft, pump gears, rotating bushing and flyweights rotate together. Two accumulators provide for the storage of governor oil under pressure, and the maximum pressure of this governor oil is regulated by a bypass in one of the accumulators. A buffer piston centered by springs is located between the pilot valve plunger and the power piston. This piston is bypassed by the needle valve, and also by passages which are uncovered when it moves a certain distance away from its central position. The small difference in oil pressure on the two sides of the buffer piston is transmitted to the receiving compensating piston on the pilot valve plunger.

OPERATION

Fig. 11-3 illustrates the operation of the fuel control portion of the governor. The power piston spring acts to shut off fuel to the engine. Oil under pressure is used only to raise the power piston and increase the supply of fuel to the engine. The following paragraphs describe the sequence of events under different operational conditions.

LOAD DECREASED OR THROTTLE DECREASED

As shown in Fig. 11-3, the engine is running normally under steady load and at constant speed. The flyweights, pilot valve plunger and buffer piston are in normal position. The control land on the pilot valve plunger covers the regulating port holes in the rotating bushing. The power piston is stationary.

Assume that the engine load is decreased, thus increasing the speed. As the speed increases, the flyweights move out, raising the control land of the pilot valve plunger and uncovering the regulating ports in the rotating bushing. Uncovering the regulating ports in this direction permits oil to escape from the area to the right of the buffer piston; it then moves to the right, and the power piston moves down. It is apparent that since this compresses the right-hand buffer spring, the oil pressure on the left of the buffer piston is a little

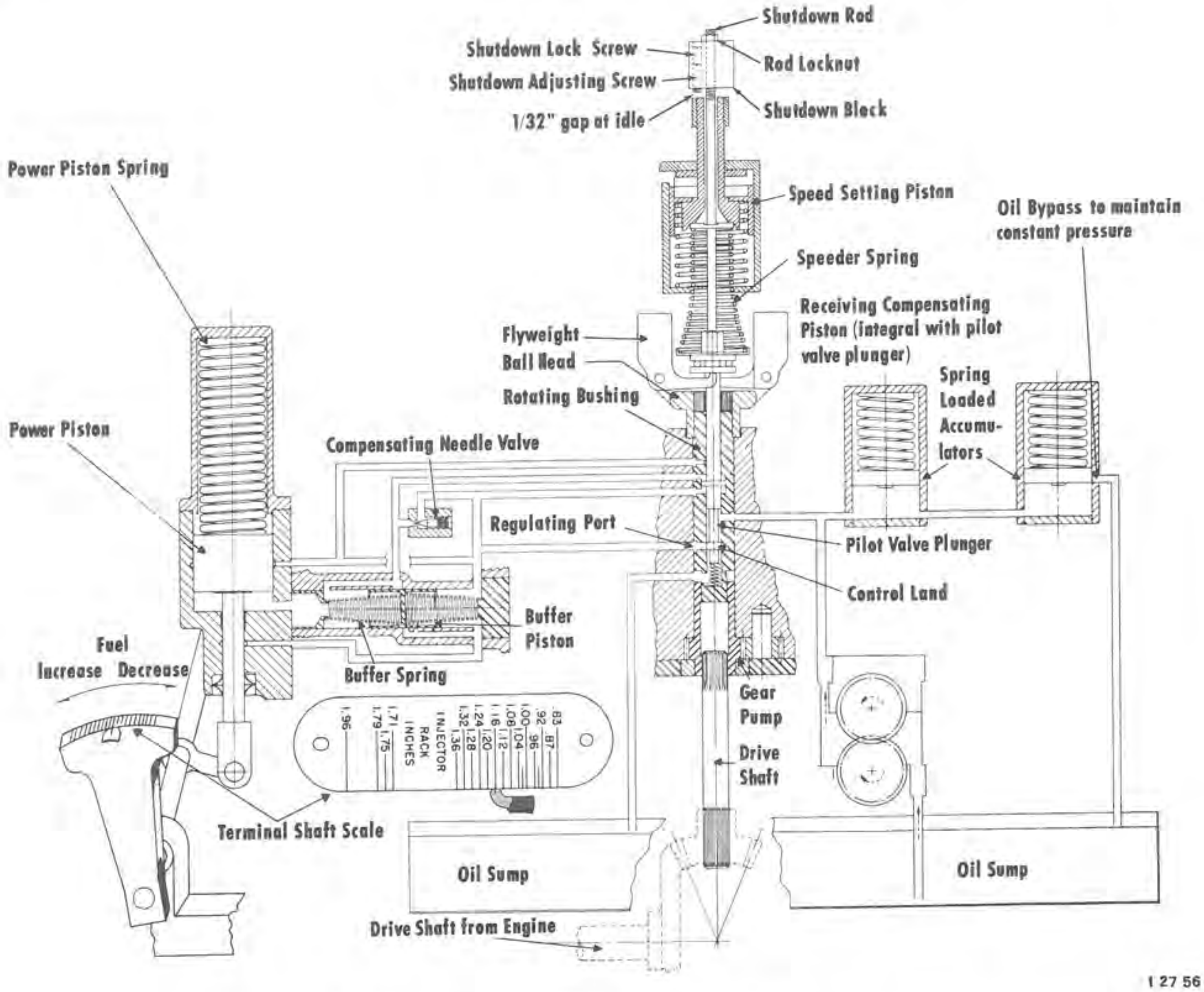


Fig. 11-3 — Fuel Control Schematic Diagram

higher than that on the right. These pressures are connected to the areas above and below the receiving compensating piston on the pilot valve plunger, and since the higher pressure is above this piston, it is forced downward, so that the land of the pilot valve plunger starts to close the ports and stop the power piston movement. The governor is so designed that this action will stop the movement of the power piston when it has moved far enough to correct for the load change that started the action.

Oil leaking through the compensating needle valve then allows the buffer piston to return to center, which gradually releases the force on top of the receiving compensating piston. This force is no longer needed to hold the pilot valve plunger in its central position, because during this time the engine speed has been returning to normal, and the outward force of the flyweights has been reduced until it is balanced by the speeder spring.

It is apparent that the compensating mechanism described above produces stable operation by permitting the governor to move rapidly in response to a speed change, and then wait for the speed to return to normal.

LOAD INCREASED OR THROTTLE INCREASED

As before, all parts of the governor are centered, and there is no power piston movement. Assume that the engine load is increased, resulting in a decrease in speed. The governor will go through a cycle of operations as follows: The decrease in speed will cause the flyweights to move inward, which lowers the pilot valve plunger and opens the port. Oil from the accumulators passes through the pilot valve, forces the buffer piston to the left, and moves the power piston upward to give the engine more fuel. The compression of the left-hand buffer spring results in a higher pressure on the right-hand side of the buffer plunger and on the underside of the receiving compensating piston. This pressure moves the pilot valve plunger upward and stops the movement of the power piston when it has moved far enough to correct for the load change that started the action.

Oil leaking through the compensating needle valve gradually releases the force under the receiving compensating piston, allowing the buffer piston to return to center. This force is no longer needed to hold the pilot valve plunger in its central position, because during this time the engine speed has been returning to normal.

In the preceding description of operation, speed changes as a result of load changes have been considered. Similar governor movements occur when a difference between actual governor speed and governor speed setting is produced by changing speeder spring tension through the speed adjusting control used on the governor. With large speed changes the buffer piston travel is much greater, to the left or right, depending on increase or decrease in speed, opening a passage for the flow of oil to or from the power piston.

Under normal operation, the air pressure sensor assembly and rebalancing arrangement will automatically adjust itself to provide correct operation. However, if air box pressure or fuel demand is not normal during operation, the rebalancing and fuel limit arrangement, explained in the following pages, will automatically make an adjustment to compensate for the condition.

Every time a governor is installed on an engine the injector rack setting should be checked.

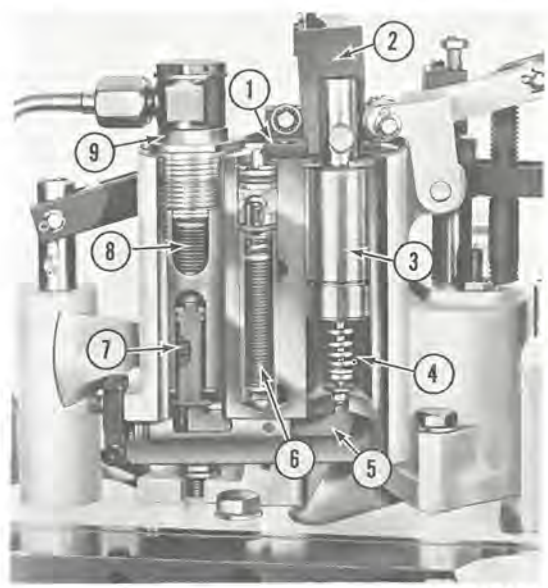
AIR PRESSURE SENSOR ASSEMBLY

DESCRIPTION

The air pressure sensor assembly, Fig. 11-4, should be adjusted before the engine speeds are set.

The purpose of the sensor assembly is to adjust the fuel limiter and pilot valve rebalancer arrangement in accordance with the absolute air pressure. The automatic positioning of these two controls is dependent upon engine air box pressure and atmospheric pressure.

As shown in Fig. 11-4, the sensor assembly consists of the bellows on the left, the orifice stack in the center, the sensor piston to the right, with the limiter cam



1. Cam Roller Block
2. Limiter Cam
3. Piston
4. Piston Spring
5. Rocker Lever
6. Orifice Stack
7. Lower Bellows
8. Upper Bellows
9. Bellows Adjusting Screw

Fig. 11-4 — Air Pressure Sensor Assembly mounted on the piston extension and the rocker lever balanced between the bellows and the piston. Clean governor oil is supplied to the sensor piston.

Governor pressure oil is admitted to the top shoulder of the piston. Oil at a lesser pressure, due to a drop passing through the orifice stack is admitted under the piston. Normally, oil is constantly flowing through the valve at the piston, passing out to the vertical passage in the housing and discharging at the top near the bellows locknut.

In operation the piston moves downward with an increase in engine air box pressure or atmospheric pressure. A partial vacuum has been produced in the lower bellows and the upper bellows is subjected to engine air box pressure.

If engine air box pressure increases in the upper bellows or atmospheric pressure is increased on the lower bellows, the bellows assembly will be extended downward. This downward movement will cause the rocker lever to increase the valve opening at the piston side. The oil flow will be less restricted and oil pressure under the piston will be lower. The oil force on the shoulder of the piston will move the piston downward. As the piston moves downward, spring tension on the valve will be increased until it will again balance the bellows, and the valve will resume its normal position. Increased oil pressure under the piston will result in a force equal to that above, and the piston will be stopped at a lower position.

If air box pressure or atmospheric pressure is decreased, the rocker lever will move upward at the bellows side, and spring pressure on the piston side will close the valve. Oil pressure then will build up under the piston, and due to the difference in area under pressure, a greater force will exist at the underside of the piston. The piston will move upward and valve spring tension will be reduced, until the rocker lever returns the valve to its normal position. The piston then will be held at its new position due to equal forces acting against each other. The limiter cam then will be at a higher rebalance position.

MAINTENANCE

The following governor adjustments should be made with the governor on a suitable test stand.

The air pressure sensor assembly bellows are adjusted as follows:

1. Place the governor at rest, that is with no air pressure on the bellows and no governor oil pressure. (Disconnect the air line to the bellows.)
2. Lift the rebalancer rocker arm off the piston stem and pull up on the limiter cam to make certain that the piston is at the top end of its travel. Measure the height of the limiter cam above the cam roller block to use as a reference measurement for subsequent use.
3. Operate the governor at idle speed and full governor accumulator oil pressure, but no air pressure on the bellows.

Again measure the height of the limiter cam above the cam roller block as done in Step 2.

The difference between the first and second measurements should correspond to the travel listed in Table A for the existing barometric pressure when the measurements are made. Table A will be found in the Service Data at the end of this section.

To decrease travel, loosen the locknut, Fig. 11-4, and turn the bellows adjustment counterclockwise, or turn clockwise to increase travel. Very little movement of the bellows adjustment is needed to effect a change.

Tighten the locknut, replace the air connection, and check the settings.

NOTE: If test stand is equipped with 60" absolute pressure manometer, read inches of mercury absolute directly from manometer. If test stand is equipped with 30" mercury column and a barometer, subtract barometric pressure from absolute pressures given in this instruction and establish pressure difference as inches of mercury on 30" mercury column.

If rocker lever below bellows and piston, Fig. 11-4, has been removed for any reason, it must be positioned and locked to give highest possible cam height with governor operating, before above adjustment can be made.

With 100 psi governor accumulator pressure, rapidly increase and decrease the air box pressure to the bellows. (This may be done by application of a vent valve between the mercury column and the governor air connection.) Observe the limiter cam motion. This should follow the pressure changes closely. If the limiter cam does not follow a decreasing air pressure, check the limiter oil supply filter and orifice stack, Fig. 11-4, for plugging.

ENGINE SPEED CONTROL

DESCRIPTION

Speed setting with the electro-hydraulic governor is accomplished in steps by energizing different combinations of the "A," "B," "C," and "D" solenoids, Fig. 11-5. Solenoids "A," "B" and "C" have plungers bearing on a triangular fulcrum plate at varying distances from a set fulcrum point. The triangular plate fulcrum bears on a lever which is connected to the speed control pilot valve inside a rotating

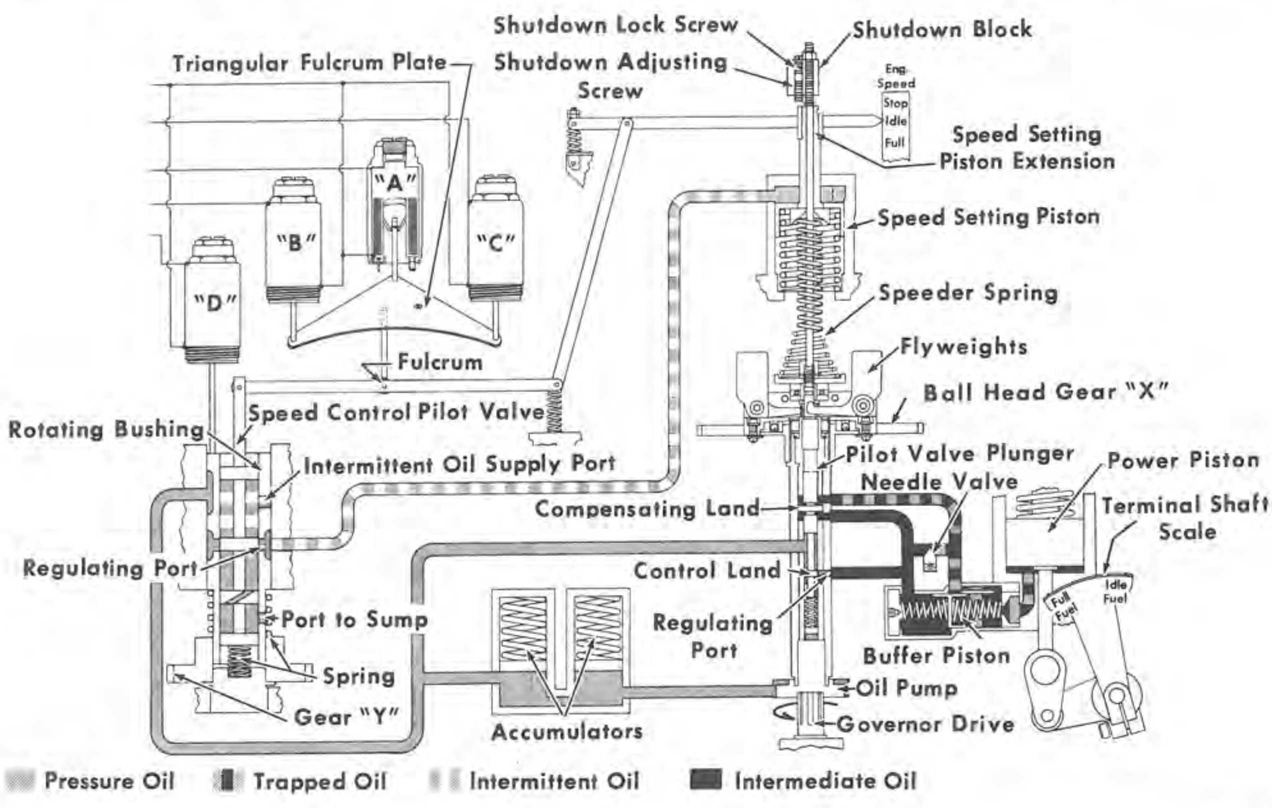


Fig. 11-5 — Speed Control, Adjustment Points bushing. The "D" solenoid plunger bears on the rotating bushing through its cap and bearing.

To increase engine speed, the speeder spring must be compressed; or compression lessened to decrease speed. The speed setting piston position must be changed to satisfy these conditions. This is accomplished by admitting or releasing governor oil above the speed setting piston. Admission or release of oil to or from the speed setting piston is controlled by the solenoids through the speed control pilot valve and rotating bushing.

When a solenoid or different combinations of "A," "B" or "C" solenoids are energized, the triangular fulcrum plate is forced down a distance depending on the solenoids energized. This causes the speed control pilot valve to go down. The regulating port in the rotating bushing is uncovered, permitting governor oil under pressure to force the speed setting piston down and compress the speeder spring. As the speed setting piston moves downward, the linkage raises the speed control pilot valve to again close the regulating port when the desired piston position has been reached.

Compression of the speeder spring forces the flyweights in, allowing the governor pilot valve plunger to lower and permit oil to raise the power piston to increase fuel to the engine. Unbalanced oil pressure on the compensating land of the pilot valve plunger closes the regulating port when the power piston has been raised enough for the desired speed. When the new engine speed is reached, the flyweights will return to balance position against speeder spring pressure.

When a solenoid or a combination of "A," "B" or "C" solenoids is de-energized, the triangular fulcrum plate will rise, and the speed control pilot valve will also be moved upward. Since the pilot valve is raised, oil above the speed setting piston drains through the regulating port to the oil sump. The speed setting piston is raised by its spring. As the piston moves up, the connecting linkage causes the speed control pilot valve to move down and close the regulating port when the desired position is reached.

Since the speed setting piston was raised, speeder spring compression is lessened. The flyweights will move outward under centrifugal force to lift the pilot valve plunger. Oil will then be released from under the power piston and it will move downward to decrease fuel supply and engine speed.

Energizing the "D" solenoid in combination with other solenoids lessens their effect on engine speed, since the "D" solenoid pushes down the rotating bushing and lowers the regulating port. When only the "D" solenoid is energized, it opens the regulating port in the rotating bushing to sump, permitting oil above the speed setting piston to be released. The piston then raises and the piston extension lifts the shutdown block, causing the governor to shut off the engine fuel supply.

Note that oil enters the speed control rotating bushing through an intermittent supply port. This port is of such size as to allow the speed setting piston to move a full stroke in a specified time. Consequently speed increase is controlled under all conditions of operation. Time of speed decrease is controlled by a slot in the lower land.

MAINTENANCE

It is recommended that a suitable test stand be used when making engine speed settings.

When setting engine speeds, the governor solenoids are adjusted to provide specified speeds at idle, intermediate, and full speed throttle positions.

For applicable speeds at each throttle setting refer to Table B in the Service Data at the end of this section.

In addition to the other information on the governor name plate, each name plate has an insert, Fig. 11-6, which shows the full speed of the engine and the full load injector rack length for the engine speed given in the insert. If the governor is removed from one engine and applied to another having either a different full load injector rack length or engine speed, a new insert should be applied having the correct information.

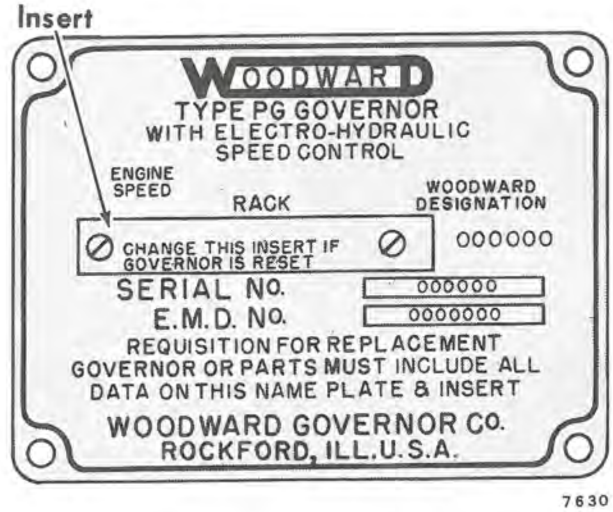


Fig. 11-6 — Governor Name Plate

Before attempting to set speeds, the governor should be operated with the heated test stand oil (180°-200° F.) for a sufficient length of time to allow the temperature to equalize.

To facilitate setting speeds, the solenoid adjustment wrench may be used. This tool provides a means for holding the solenoid case while making locknut and stop screw adjustments.

Establish pressure to bellows, as given in Table C. Adjust the solenoids to set engine speeds as follows.

1. Place the throttle in No. 6 position and bring speed to specified RPM by adjusting fulcrum nut, Fig. 11-7, at the end of the linkage. Raising the fulcrum nut increases speed.

2. Move the throttle to No. 8 position and set speed by adjusting the "D" solenoid stop screw. Back off stop screw to increase speed.

3. With the throttle in No. 5 position, adjust the "A" solenoid stop screw to set speed. Turn stop screw in to increase speed.

4. Place throttle in No. 3 position and set speed by adjusting "B" solenoid stop screw. Turning stop screw in, increases speed.

5. With throttle in No. 2 position adjust "C" solenoid to set speed. Turn screw in to increase speed.

6. Check idle speed setting. If idle speed is high, lower speed by adjusting the "A" solenoid stop screw. An adjustment made at this throttle position will result in slight variations in the speed in throttle positions 3, 5, and 7.

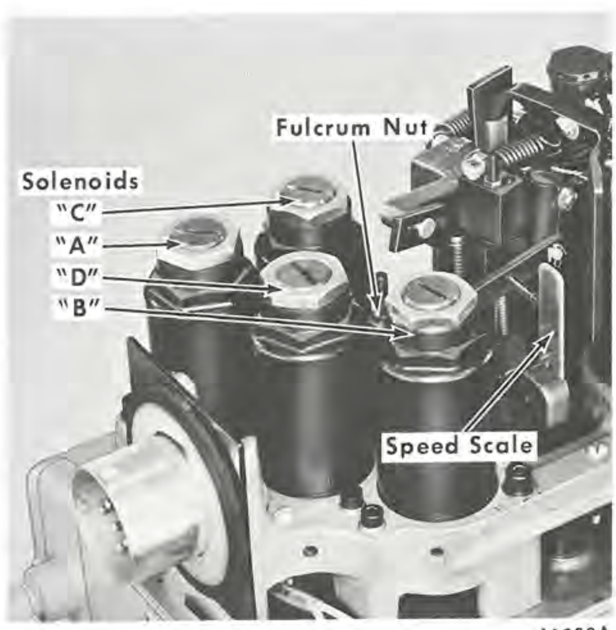


Fig. 11-7 — Speed Control, Adjustment Points

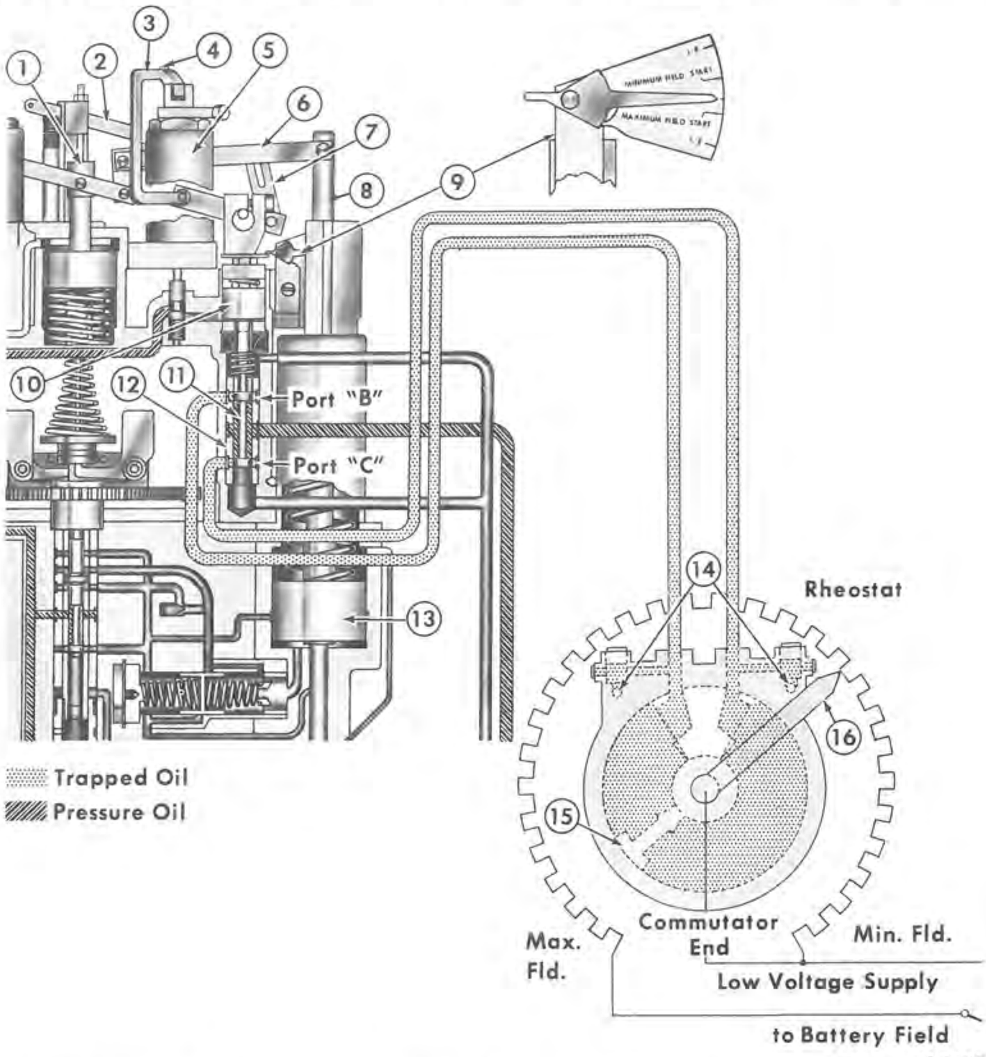
7. Check above settings and, if correct, all other speeds will be within limits, with all solenoids set. Check engine speed at all throttle positions. Speeds at intermediate throttle positions must be within limits shown in Table B.

8. The speed pointer should be observed to register at correct speed on the speed scale when setting speeds at idle and full speed. If not, scale must be relocated or remarked so pointer and scale correspond at idle and full speed.

LOAD REGULATOR PILOT VALVE AND ASSOCIATED LINKAGE

DESCRIPTION

The load regulator pilot valve, Fig. 11-8, is a device in the governor for controlling the oil to the vane motor of the load regulator. In addition to this, the load control is also made dependent upon absolute air pressure, since the rebalancer will vary the position of the load control pilot valve in response to variations in engine air box and barometric pressures.



1. Speed Setting Piston Extension
2. Limiting Lever
3. Rebalancer Rocker Arm
4. Rebalancer Rocker Arm Stop Screw
5. Overriding Solenoid
6. Floating Link
7. Slotted Link
8. Power Piston Tailrod
9. Pilot Valve Scale
10. Overriding Piston
11. Pilot Valve Plunger
12. Pilot Valve Bushing
13. Power Piston
14. Vane Motor Internal Check Valves
15. Vane
16. Brushholder And Arm

Fig. 11-8 — Pilot Valve and Load Regulator, Schematic Diagram

The pilot valve linkage, Fig. 11-9, consists of the rebalancer rocker arm, horizontal floating link, slotted link, eccentric adjustment, and clevis, the latter being threaded on the pilot valve plunger.

The pilot valve in conjunction with the load regulator requires the engine to assume a predetermined load for each throttle position by controlling the loading of the main generator through the battery field.

The action of the rebalancing linkage is such that a lower set of predetermined load values is established when the air box pressure falls below the minimum that has been established for full load operation.

Fig. 11-8 shows a partial governor section through the pilot valve and associated parts. When engine output is correct for a certain throttle position, the lands of the pilot valve plunger close ports "B" and "C" in the pilot valve bushing. In this plunger position no oil can flow through the ports to or from the load regulator vane motor. This position is the balanced position of the pilot valve. As shown, lubricating oil under pressure enters the valve at a point between the lands of the plunger and is trapped when the pilot valve is balanced.

When the horsepower demand on the engine is greater or less than the engine is adjusted to develop at a given throttle position, a change will be made in the position of the governor power piston to meet the changed horsepower demand. Since the throttle position has not changed, the pilot valve plunger will either be raised or lowered, through the movement of the power piston and linkage. This action unbalances the pilot valve and the oil thus permitted to flow causes the load regulator to adjust the generator load to the desired engine output.

If a more than proper load is placed on the engine the power piston will move upward to increase fuel. This action raises the pilot valve plunger, Fig. 11-8, opening port "B" with its upper land. Oil under pressure can then flow through port "B" to the vane motor of the load regulator. This causes the load regulator movement

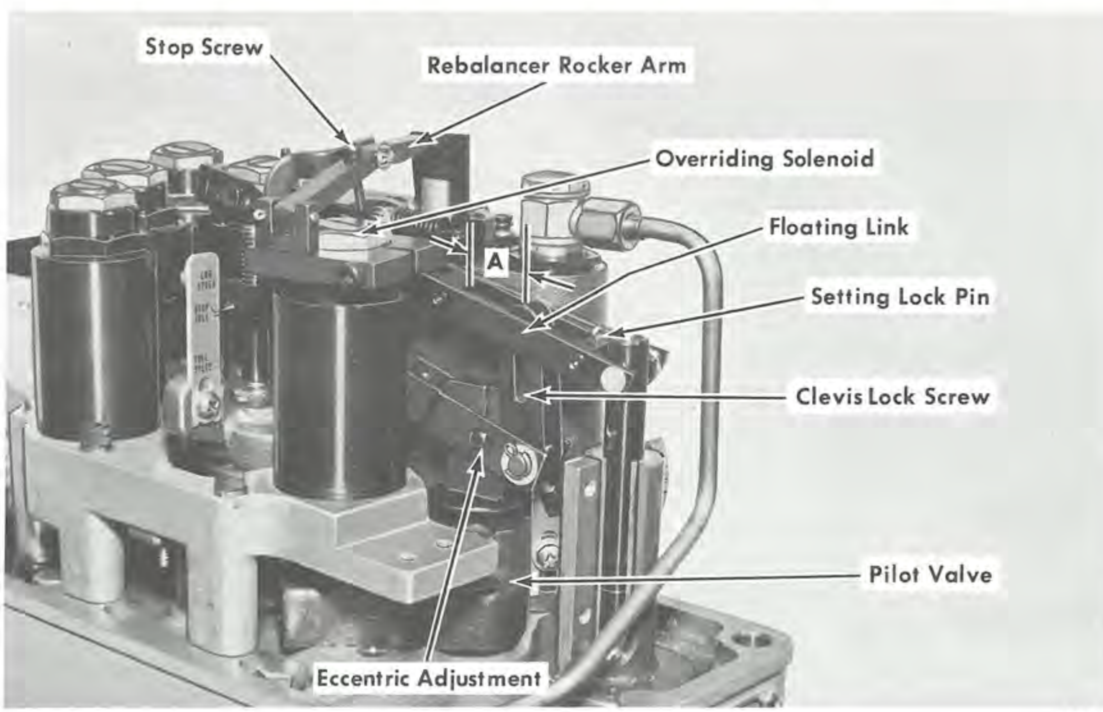


Fig. 11-9 — Pilot Valve Linkage

to reduce main generator output. As the vane rotates it pushes oil ahead of it through oil line port "C" of the pilot valve and then to the engine oil sump. As the load on the engine is reduced, the power piston and pilot valve plunger move down to normal position. The pilot valve plunger again closes both ports "B" and "C."

The operation of the pilot valve for less than proper load on the engine is opposite that given for an overload, again adjusting generator load to permit the engine to assume its proper load for a certain throttle position.

The movement or timing of the vane or brush holder of the load regulator is automatically controlled by orifices and slots in port "C", or lower port of the pilot valve bushings, as oil from the load regulator must return through port "C" when oil to the load regulator leaves through port "B" or when oil to regulator passes through port "C." The slot and orifices in the pilot valve bushing lower port are designed to provide for a definite load regulator movement or timing.

The pilot valve is set for maximum field start, but through the action of the overriding solenoid when energized, the pilot valve is placed in minimum field position. Immediately after de-energizing of the overriding solenoid, the pilot valve assumes the position as originally set, maximum field. See Overriding Solenoid. Provision is also made to allow oil to circulate through the system with the engine in idle. This keeps warm oil in the system, improving the operation of the mechanism.

MAINTENANCE

It is recommended that the governor be placed on a suitable test stand to perform the following maintenance.

SETTING PILOT VALVE LINKAGE

Preparation

Before setting the pilot valve, the speeds and the air pressure sensor assembly must be correctly set as previously outlined.

The engine speed scale must agree with the engine speed at idle and full speed, or the scale relocated or remarked so they agree.

The pilot valve scale must also show "0" or balance when the pilot valve plunger is in the position to prevent movement of the load regulator. If necessary, relocate the scale to show balance at the pilot valve position.

Once the pilot valve is properly set, it should not be changed to correct engine output until all other conditions are investigated.

Setting Procedure

1. Back off the rebalancer rocker arm stop screw, Fig. 11-9, several turns to ensure no interference during pilot valve adjustment.
2. Operate the governor on the test stand at full load rack length, engine speed, and absolute pressure on the sensor assembly as shown in Table C in Service Data at end of section.
3. Pointer on the pilot valve scale must show "0" or balance position with the settings as given in Step 2. If not, loosen the eccentric clevis lock screw and using a screwdriver, adjust the eccentric to bring the pilot valve to the balance position. Then tighten the clevis lock screw. The pilot valve must be at "0" balance at the proper full load injector rack length, full engine speed and the correct absolute pressure.

4. Operate the governor test stand to simulate idle engine speed, so that the terminal shaft pointer and the absolute pressure on the sensor assembly are as shown in Table C.

5. If the pilot valve scale pointer is below the MAXIMUM FIELD START position, dimension "A" should be lengthened. If above, dimension "A" should be shortened. On this correction, adjust dimension "A" 1/2 required, then return to the conditions to set "0" or balance as outlined under Step 2.

6. Recheck the settings to conform to conditions given in Steps 2, 3, 4, and 5 to obtain the correct adjustment for full speed conditions and idle speed conditions or readjust the linkage as outlined until correct positions are obtained.

SETTING REBALANCER ROCKER ARM STOP SCREW

DESCRIPTION

The rebalancer rocker arm, Fig. 11-9, adjusts the load to the air available for fuel. The setting of the rebalancer rocker arm stop screw determines the maximum balanced injector rack position at the minimum air box pressure required for full load. At air box pressures below that required for full load, the rebalancer rocker arm positions the pilot valve to limit the load in proportion to the available air pressure.

MAINTENANCE

It is recommended that the governor be placed on a suitable test stand to perform the following maintenance.

1. Back off on the rebalancer rocker arm stop screw, Fig. 11-10, to ensure no interference during loading of the governor on the test stand.

Fig. 11-10 — Rebalancing Stop Screw Adjustment

2. Bring the governor up to full injector rack length and full engine speed and at the absolute pressure as shown in Table C.

3. Using a .001-002" feeler gauge under the rebalancer rocker arm Allen type screw, Fig. 11-10, run the screw down until a drag is felt on the gauge as it is pulled from under the screw.

4. Check the above setting by increasing the absolute pressure on the sensor assembly bellows by 2" Hg. and observe that the injector rack setting remains the same.

FUEL LIMITER

DESCRIPTION

The purpose of the fuel limiter, Fig. 11-9, is to prevent supplying fuel to the engine in excess of that which can be properly consumed with the available air supply.

In response to a demand for fuel, the governor pilot valve is lowered to permit governor oil to raise the power piston. The power piston upon being raised will also lift the fuel limiter lever. Fig. 11-11.

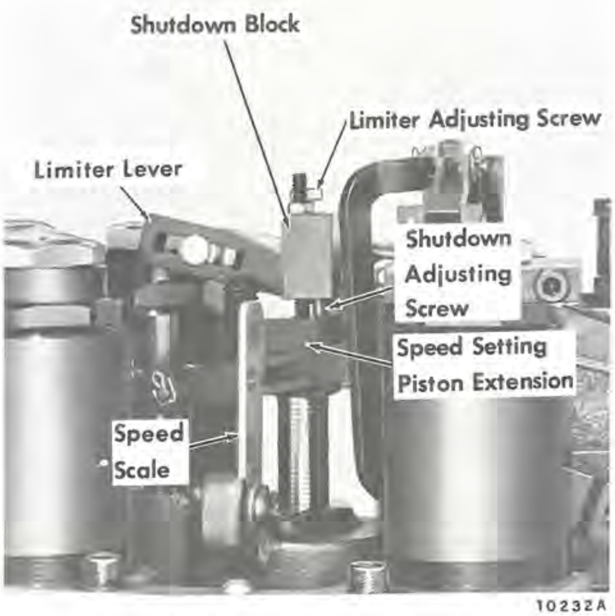


Fig. 11-11 — Shutdown Adjustment Location

If sufficient air is not available for proper combustion, the limiter lever will contact the limiter adjusting screw, which will raise the shutdown block and governor power piston pilot valve. The governor oil port to the power piston will then be closed and the upward or increase fuel movement of the power piston will be stopped.

Since the limiter lever has a movable fulcrum, the fulcrum position is automatically varied to correspond to air box pressure. This will adjust the limiter action in proportion to the available air box pressure.

MAINTENANCE

It is recommended that the governor be placed on a suitable test stand to perform the following maintenance.

1. Before setting the fuel limiter, check to be sure that the limiter lever has clearance in the shutdown block.

   Insert a .005" feeler gauge between the sides of the lever and the shutdown block. The gauge must pass freely between the lever and the block.

2. With the governor in operation at full engine speed, establish the absolute pressure to the sensor assembly bellows as specified in Table D in the Service Data at the end of the section. Adjust the test stand air valve linkage to position the power piston at about the fourth graduation on the terminal shaft scale below the limiting point.

3. Very slowly adjust test stand air valve linkage to the specified rack length, Table D. Under this condition a speed reduction of 15 RPM should be achieved.

   If the speed is not reduced, carefully adjust the fuel limit screw, Fig. 11-11, to obtain correct speed reduction.

ENGINE SHUTDOWN

DESCRIPTION

Engine shutdown can normally be accomplished by depressing the STOP button or placing the throttle in the STOP position. Either action will energize the "D" solenoid, Fig. 11-5. This action depresses the speed control rating bushing so its port is below the land of the speed control pilot valve. This allows the trapped oil above the governor speeder spring piston to drain. The spring under the piston forces the speeder spring piston upward and the piston extension contacts the shutdown adjusting screw in the shutdown block. Raising the shutdown block also lifts the power piston pilot valve. Oil will then be released from under the power piston, causing the power piston through the associated linkage to bring the injectors to the "no fuel" position.

MAINTENANCE

SOLENOID ADJUSTMENT

No additional adjustment is required on the governor solenoids. The "D" solenoid which causes engine shutdown is adjusted at the time of speed adjustment.

SHUTDOWN ADJUSTING SCREW

The shutdown adjusting screw location in the shutdown block is shown in Fig. 11-11.

The shutdown adjusting screw is set with the governor operating at idle engine speed. Remove the lock screw to gain access to the adjusting screw as they are both in the same hole in the shutdown block. Set the adjusting screw to provide 1/32" clearance between the bottom of the screw and the top of the speeder spring piston extension.

In addition to the normal engine shutdown provisions in the governor, an additional shutdown device is incorporated in this governor. This device operates on the basis of a low oil pressure or high oil pump suction condition in the engine. It operates a low oil pressure alarm switch and shuts down the engine after a lapse of preset time. The description and maintenance procedures are contained in Section 12 of this manual under the heading of Protective Devices.

SPEED SETTING PISTON STOP

DESCRIPTION

The speed setting piston stop, Fig. 11-4, is a piston travel limit (when the engine is shut down) to effect a reduction in cranking time when starting the engine and to prevent the piston from striking the top of the cylinder.

MAINTENANCE

The speed setting piston stop adjustment is made with the Allen type setscrew shown in Fig. 11-4. With the governor operating at a speed corresponding to engine idle speed the setscrew is run down until it contacts the top of the speed setting piston and then is backed off 1-1/2 turns and locked.

GOVERNOR COMPENSATION

DESCRIPTION

The compensating mechanism prevents the engine from racing or hunting by arresting the movement of the power piston after it has traveled a sufficient amount to give the desired speed. The compensating mechanism includes the integral compensating receiving piston, buffer piston and springs, and compensating needle valve.

When the engine is started the first time or after installation of a new or reconditioned governor or one that has been drained and cleaned and new oil added, the governor will require compensation adjustment. This is necessary to purge the governor oil system of trapped air.

MAINTENANCE

COMPENSATION ADJUSTMENT

1. See that the governor oil is at the proper level in the sight glass. Then start the engine, operating at idle speed.
2. Open the compensating needle valve, Fig. 11-1, several turns. Loosen the vent plug, Fig. 11-1, several turns, but do not remove the plug.
3. The engine will hunt and surge, and air will bleed from the system at the vent plug. When oil only flows from the vent plug, the system is free of air, and the compensating needle valve should be closed slowly until the hunting condition stops or is lessened. Allow the engine to run until normal operating temperature is reached. Tighten the vent plug to prevent oil leakage, and add the oil necessary to obtain the proper level in the governor.
4. After normal temperature has been reached, again open the compensating needle valve and allow the engine to

hunt. Then close the needle valve until hunting stops. The needle valve will be open approximately one-quarter to three turns depending upon the engine characteristics.

5. Test the governor stability by manually changing the engine speed to observe governor recovery. If the engine returns to a steady speed, the compensating adjustment is satisfactory. If hunting is resumed, close the compensating needle valve slightly and test again.

6. Keep the compensating needle valve open as far as possible to prevent sluggishness and still maintain even engine operation. After compensation is made, it should not require another adjustment, unless a permanent temperature change effects the viscosity of the governor oil.

OVERRIDING SOLENOID

DESCRIPTION

The overriding solenoid "O" Fig. 11-9, is employed on the governor to position the load regulator in the minimum field position. The solenoid is energized by external circuits which may be determined by consulting the specific wiring diagram covering the particular governor application. When the overriding solenoid is energized, it moves a small cylindrical valve downward, permitting governor accumulator oil pressure to flow under the overriding cylinder piston. This piston moves up carrying the load regulator pilot valve plunger with it. When the solenoid is de-energized, a spring moves the pilot valve back to normal position.

MAINTENANCE

SOLENOID ADJUSTMENT

1. Loosen locknut on overriding solenoid and run the screw down until the load control pilot valve moves up.

2. Carefully back off the screw until pilot valve starts down, then back off screw a full quarter turn more, and lock it.

   Improper adjustment of the overriding solenoid may result in a loss of governor accumulator oil pressure. This is caused by the overriding solenoid adjusting screw being backed off too far, allowing its valve to open the supply port, permitting governor oil pressure to be bypassed directly back or the governor oil sump.

   In cases where the engine dies in the lower throttle positions, the adjustment of the overriding solenoid should be one of the checks made.

EXTERNAL OIL FILTER

DESCRIPTION

The external oil filter Fig. 11-12, is used on the governor to protect the servo bellows assembly screen and orifice stack. The filter element is approximately 5/8" in diameter, and 3-1/2" long having filter openings of .006". As shown, the filter is contained in a housing that is mounted on the side plate containing the lube oil suction diaphragm cover plate.

MAINTENANCE

The design of this filter is such that under normal service it is expected to stay in service without cleaning or other attention. Maintenance may be done at the annual inspection with other governor work. However, if the sensor assembly bellows operation does not follow air pressure changes closely, the filter should be checked for cleanliness. If required, the filter may be cleaned by washing in solvent.

FLUSHING GOVERNOR

Governor flushing is not recommended as a regular maintenance item. Instead, the governor should be disassembled and

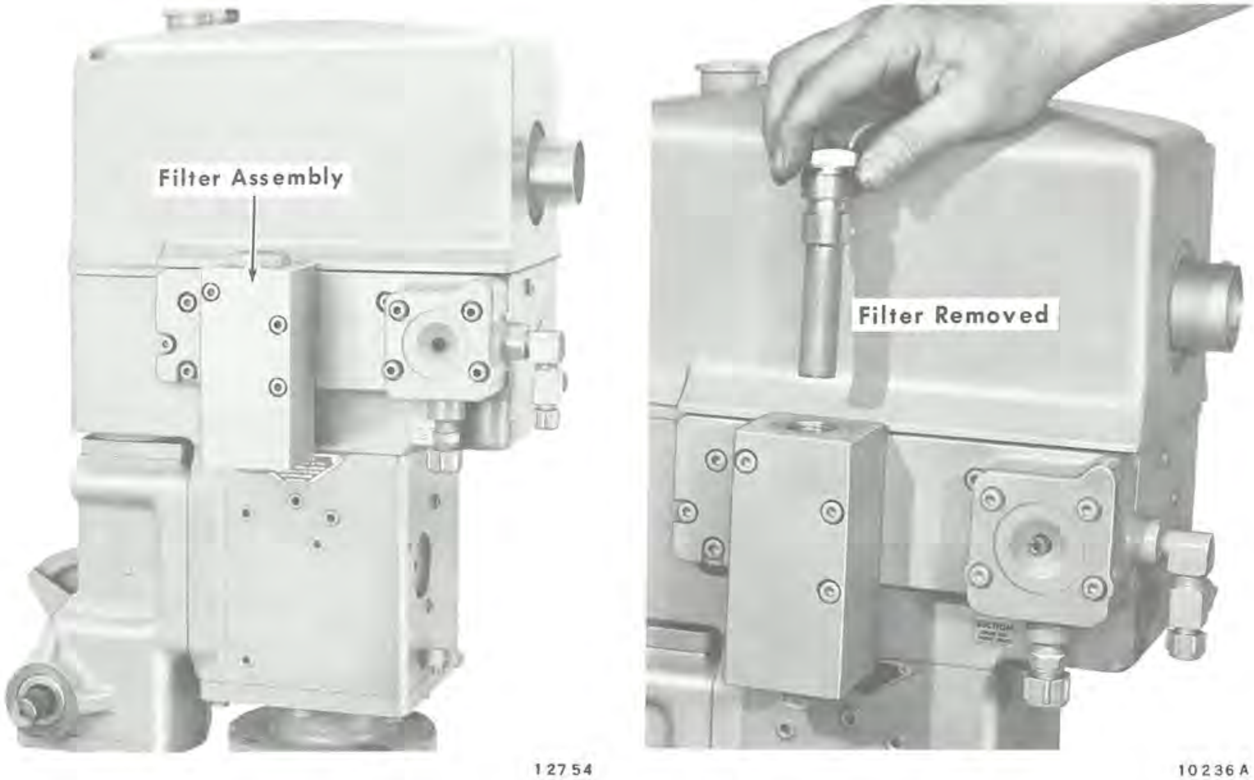


Fig. 11-12 — External Oil Filter

cleaned if operation is impaired due to dirt or other foreign particles in the governor.

In cases of necessity where the governor is suspected of being dirty and it would not be practical to remove the governor from the engine, it may be flushed on the engine as follows:

1. The engine should be shut down and the drain plug removed from the governor case, or petcock opened. Close valve or replace plug and add two pints of filtered kerosene to governor and start engine. Using the layshaft lever, vary the speed of the engine from 400 to 500 RPM, for about five minutes. Shut the engine down and drain kerosene from the governor. Repeat this operation several times until the kerosene drained from the governor appears clean.

2. Add two pints of recommended oil to the governor and repeat the above procedure and drain. This will remove any kerosene trapped in the governor.

3. Fill the governor with recommended oil to the proper level and start the engine. Adjust the governor compensation as previously described. The oil level should then be checked and oil added, if necessary.

GOVERNOR OIL SUPPLY

The oil capacity of the governor is three pints. Use new oil which will meet the specifications for governor oil listed in M.I. 1752 or an air compressor type oil having rust and oxidation protection, as specified in M.I. 1756. The oil level should be maintained between the marks on the sight glass. The vent at the top of the sight glass must be open to ensure correct readings. If the air compressor type oil is used, the governor oil need only be changed once a year, using care that the oil and its container are clean.

GOVERNOR STORAGE

In the event the governor is to be stored for a considerable length of time, it should be protected against rust. Governors using air compressor type oil having rust and oxidation protection require no further protection. However, if other oil lacking these properties is used, the oil should be drained and the governor flushed with kerosene and drained. The governor should then be filled with oil providing protection against rust. After filling with this oil, the governor should be run several minutes if possible. When the governor is again put in service the recommended governor oil should be used.

GOVERNOR DRIVE ASSEMBLY

DESCRIPTION

The governor drive assembly, Fig. 11-13, is mounted at the front of the engine on the accessory drive cover adjacent to the water pumps. The governor is mounted on the housing and driven through the 90° bevel gear drive. The serrated end of the drive shaft is mated into a drive plate on the governor drive gear in the accessory gear train. Lubrication of the governor drive bearings and gears is provided through drilled passages in the drive housing.

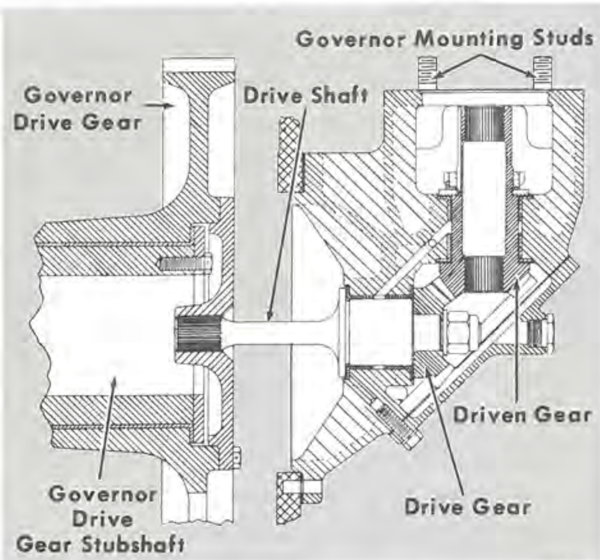


Fig. 11-13 — Governor Drive Application

MAINTENANCE

The governor drive assembly normally does not require servicing except at the time of general engine overhaul or reconditioning. At this time or when conditions warrant, the governor drive assembly should be removed and the parts inspected and checked. After removal of the governor, the governor drive assembly can be easily removed. A mounting dowel correctly positions the governor drive housing on the accessory drive cover.

After the governor drive assembly has been removed and disassembled, visually inspect the bushing bores and thrust faces for flaking, imbedded dirt, chipping or scoring. Bushings that are chipped or flaked or have large quantities of imbedded dirt should be replaced with new bushings. Check oil passages in the housing to be sure they are free of restrictions. Inspect bevel gears for nicks, pitting or visible wear on the loaded tooth faces. Nicks, burrs or any high spots should be stoned out or the gears replaced. If it is necessary to replace a gear, it is recommended that both gears be replaced as a set. Check individual parts and assembly to be sure dimensions are within limits given in Service Data at the end of this section.

SERVICE DATA

GOVERNOR

SETTING AND ADJUSTMENT TABLES

AIR PRESSURE SENSOR ASSEMBLY

TABLE A

Barometric Pressure (Not corrected to sea level)	Cam Travel	Cam Height (Based on reference height of 1-24/64")
31.3" to 30.7"	17/64"	1-7/64"
30.6" to 30.1"	16/64"	1-8/64"
30.0" to 29.5"	15/64"	1-9/64"
29.4" to 28.8"	14/64"	1-10/64"
28.7" to 28.2"	13/64"	1-11/64"
28.1" to 27.5"	12/64"	1-12/64"
27.4" to 26.9"	11/64"	1-13/64"
26.8" to 26.3"	10/64"	1-14/64"
26.2" to 25.6"	9/64"	1-15/64"
25.5" to 25.0"	8/64"	1-16/64"
24.9" to 24.4"	7/64"	1-17/64"
24.3" to 23.7"	6/64"	1-18/64"

ENGINE SPEED

TABLE B

ENGINE GOVERNOR SPEED SETTINGS

Throttle Position	Engine Speed RPM Min	Max	Solenoid Energized A	B	C	D	Solenoid Adjustment Sequence
Stop						*	
Idle	307	323					(see text) 6
1	307	323					
2	390	398	*				"C" 5
3	475	483			*		"B" 4
4	545	575	*		*		
5	645	653		*	*	*	"A" 3
6	730	738	*	*	*	*	Fulcrum Nut 1
7	800	830		*	*		
8	900	908	*	*	*		"D" 2

PILOT VALVE

TABLE C

Governor	Engine Speed	Injector Rack Length	Throttle Position	Pilot Valve Position	Absolute Pressure
8333343	900 307-323	.96" 1.75"	8 Idle	Balance Max. Fld.	55" Hg. 30" Hg.

The approximate "A" dimension for these settings in 24/32".

NOTE: The full load injector rack length is based on the use of .845 specific gravity fuel oil. Railroads using fuel substantially heavier or lighter may find it necessary to adopt different full load rack length settings to maintain engine horsepower within the specified limits.

FUEL LIMITER

TABLE D

Governor	Throttle Position	Engine Speed	Absolute Pressure	Limiting Point
8333343	8	900-908	48" Hg.	.99"

SPECIFICATIONS

Bushing bore diameter (as assembled in housing) - Max.	1.8795"
Distance between bushing thrust faces - Min.	1.867"
Diameter of drive shaft journal - Min.	1.8715"
Governor drive shaft thrust face to shoulder - Max.	1.879"
Driven gear thrust face to shoulder - Max.	1.881"
Diameter of driven shaft journal - Min.	1.8715"
Bevel gear backlash - Max.	.013"
Thrust clearance	Limit is governed by gear backlash

EQUIPMENT LIST

	Part No.
Hand tachometer	8107967
Tachometer drive adapter	8210556
Rotary shaft bearing remover - installer	8225658
Rotary shaft oil seal driving rod	8225659
Rotary shaft oil seal remover	8225660
Solenoid adjustment wrench	8343447

PROTECTIVE DEVICES

GENERAL

This section contains the description and maintenance information for engine protective devices. These devices are designed to, in most instances, shut down the engine in the event of a malfunction occurring during engine operation.

LOW OIL PRESSURE AND HIGH LUBE OIL SUCTION SHUTDOWN

DESCRIPTION

Although the low oil pressure and high lube oil suction shutdown device, Fig. 12-1, is not considered an assessory to the engine, but rather as a component of the governor. It is covered in this section due to its function as an engine protective device.

Engines equipped with electro-hydraulic speed control governors have the low oil pressure and high lube oil suction shutdown device as an integral part of the governor. Under either a low oil pressure or high oil suction condition, the governor will act to shut down the engine.

A time delay of approximately 40 seconds at idle engine speed is provided after the alarm switch has been tripped and prior to shutting the engine down, to allow operating pressures to be reached after starting engine, and to provide time to locate trouble spot in the event of malfunction. Repeated engine starting to locate cause of shutdown should not be attempted. The time delay is voided at engine speed of 425 RPM and over, and shutdown will occur in approximately two seconds.

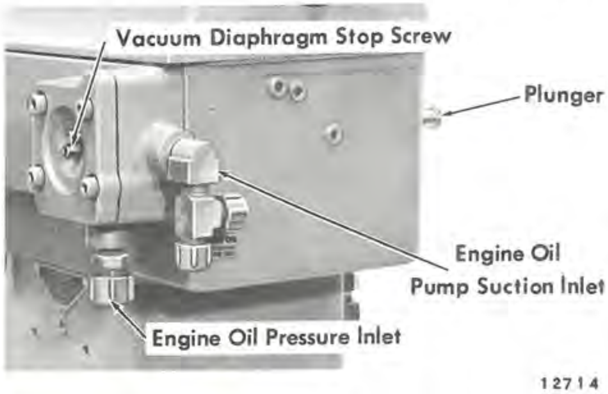
Since oil pressure is the lowest at the rear of the engine, an oil line runs from this point to the shutdown device in the governor.

The shutdown device in the governor, Fig. 12-1, consists of an oil pump vacuum diaphragm with stop screw, oil failure diaphragm and plunger, oil failure piston, two ball valves, shutdown rod, and an alarm switch.

Engine pressure oil is admitted to the left of the oil failure diaphragm. A spring also exerts pressure on the left side of the diaphragm. Pressure oil from the governor speed setting piston pushes against the right side of the oil failure diaphragm. The pressure of the oil from the speed setting piston varies with engine speed. The highest pressure is at full engine speed and the lowest is at idle engine speed. If engine oil pressure is reduced below a safe level, the speed setting piston oil pressure will become greater than engine oil pressure and move the oil failure diaphragm and shutdown plunger to the left. Movement of the plunger releases the trapped oil above the speed setting piston allowing the piston to travel upward. When the piston extension contacts and lifts the shutdown block on the governor pilot valve extension, resultant movement of other governor components places the terminal shaft, layshaft lever, and the injector racks in a no fuel position and the engine will shut down.

When the shutdown plunger moves out, an alarm switch is actuated and a colored band is visible on the plunger indicating that the device has been tripped. After being tripped, the plunger must be manually reset to permit the governor to control engine operation. If conditions warrant the engine being shut down, the action will occur even though the plunger were to be held in manually. When the oil failure piston moves to the right, it contacts the valve pin and unseats ball valve No. 2, releasing speed piston oil pressure through the ball valve.

The time delay feature of the device is controlled by engine speed. When engine speed is below 460 RPM, governor pressure oil must pass through a bypass valve assembly before reaching the oil failure



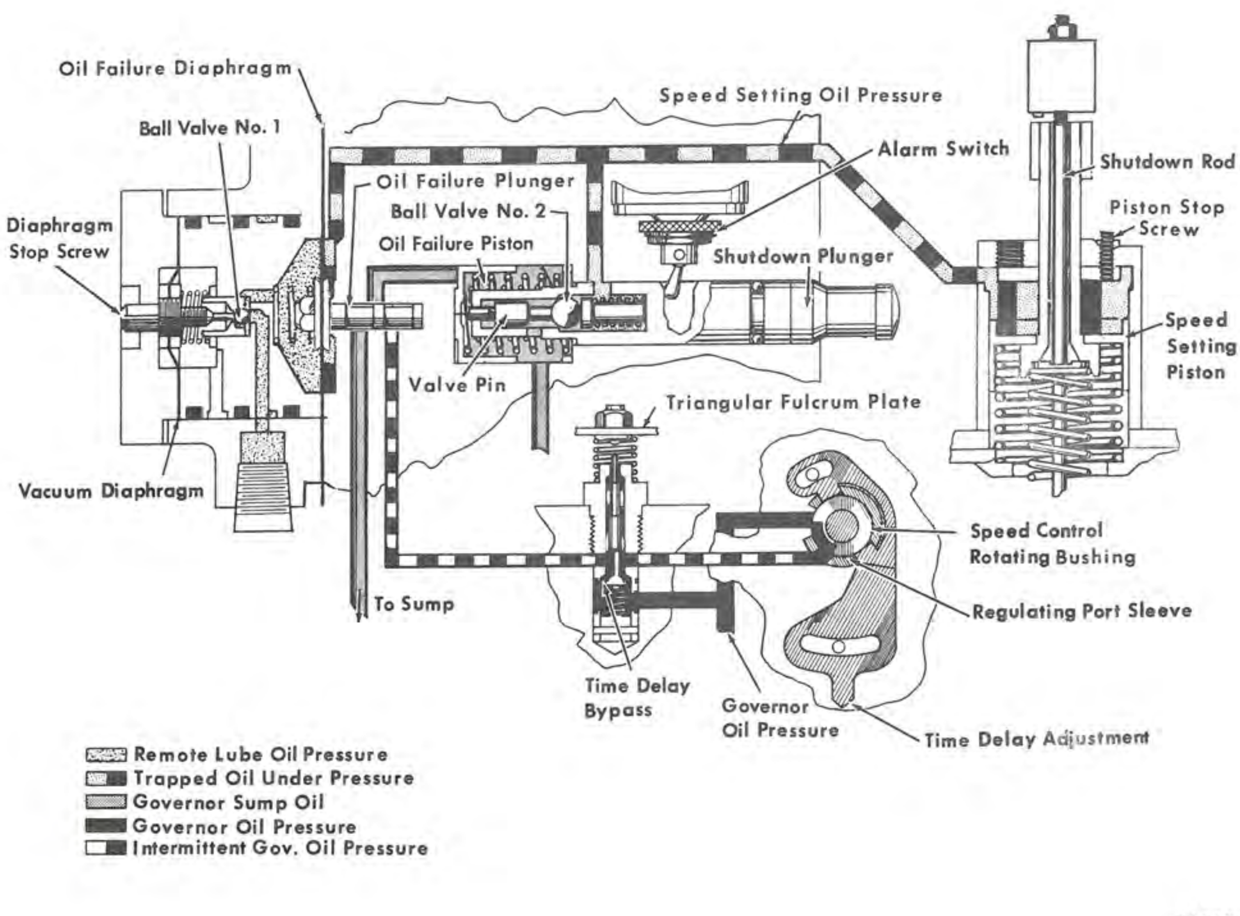


Fig. 12-1 — Low Oil Pressure And High Lube Oil Suction Shutdown Device piston. The time delay is brought about by the governor oil passing through an intermittent flow orifice toward the top of the speed control rotating bushing. At each revolution of the bushing, a slot in the bushing aligns with the oil line to the oil failure piston. The amount of oil discharged through the slot is regulated by adjusting the port sleeve. The amount of oil discharged determines the time required to admit a sufficient amount of oil to operate the oil failure piston. At engine speeds of 460 RPM and above, the speed solenoids bearing on the triangular fulcrum plate of the governor, open the time delay bypass. When the bypass is open, governor oil goes directly to the oil failure piston, and shutdown will occur in about two seconds.

The vacuum portion of the shutdown device, Fig. 12-1, is located to the left of the low oil pressure components and is separated from them by ball valve No. 1. The vacuum area to the right of the vacuum diaphragm is connected to the suction line of the engine lube oil pump. In the center of the diaphragm, there is a stop screw which unseats ball valve No. 1 when diaphragm moves inward. Under normal operation, ball valve No. 1 is held in the seat by engine pressure oil. If the vacuum in the oil pump suction line becomes high due to a restriction, such as dirty oil strainers, the vacuum diaphragm will be moved inward. The stop screw in the diaphragm will unseat ball valve No. 1 and reseat it in engine pressure oil line, shutting off the pressure oil to the oil failure diaphragm. This creates a low oil pressure condition and engine will be shut down as previously described for the low oil pressure device.

MAINTENANCE

LOW OIL PRESSURE SHUTDOWN

Setting Time Delay

Check the low oil pressure time delay with the engine at idle speed. Push in the stop screw, Fig. 12-1, in the vacuum diaphragm shutting off the oil supply to the oil failure diaphragm. Regulate the time delay adjustment located under the "A" and "C" solenoids. Movement of the adjustment in a counterclockwise direction increases the time delay.

Setting Time Delay Bypass

The correct setting of the time delay bypass is determined by the clearance between the setscrew and the time delay plunger. The setscrew is located between the "A", "C", and "D" solenoids and screws into the triangular fulcrum plate.

The clearance at idle engine speed should be .010" to .015". The setting is made by backing off several turns on the screw; running the engine in No. 3 throttle; and then turning the screw in until pressing the vacuum diaphragm causes the engine to shut down in approximately two seconds. Then turn the screw in another 1/4 turn.

HIGH SUCTION SHUTDOWN

Because of the differences in locomotive lube oil operating pressures, it is recommended that the governor be placed on a test stand to adjust the high suction shutdown device, Fig. 12-1. The high suction shutdown should operate at a vacuum of 16 to 20 inches of mercury.

The suction tripping pressure may be set by disconnecting the suction line at the governor and attaching a device capable of creating a vacuum of 16 to 20 inches of mercury in the diaphragm chamber, and adjusting the diaphragm stop screw to unseat ball valve No. 1 at this suction. Increase vacuum slowly to ensure accurate setting. Turning the stop screw in decreases the amount of suction required to reposition the diaphragm and initiate engine shutdown.

A suitable instrument for this purpose can be manufactured from information in

Maintenance Instruction 5522 which provides construction details, using standard available parts.

Operation of the high suction device may be checked manually by pressing in the vacuum diaphragm stop screw. With the engine running in the No. 3 throttle position, or higher, the engine should shut down in about two seconds when the stop screw is pushed in.

Check the diaphragm for leaks under a maximum of 10 psi external oil pressure. A broken diaphragm will result in a small amount of air entering the lube oil system.

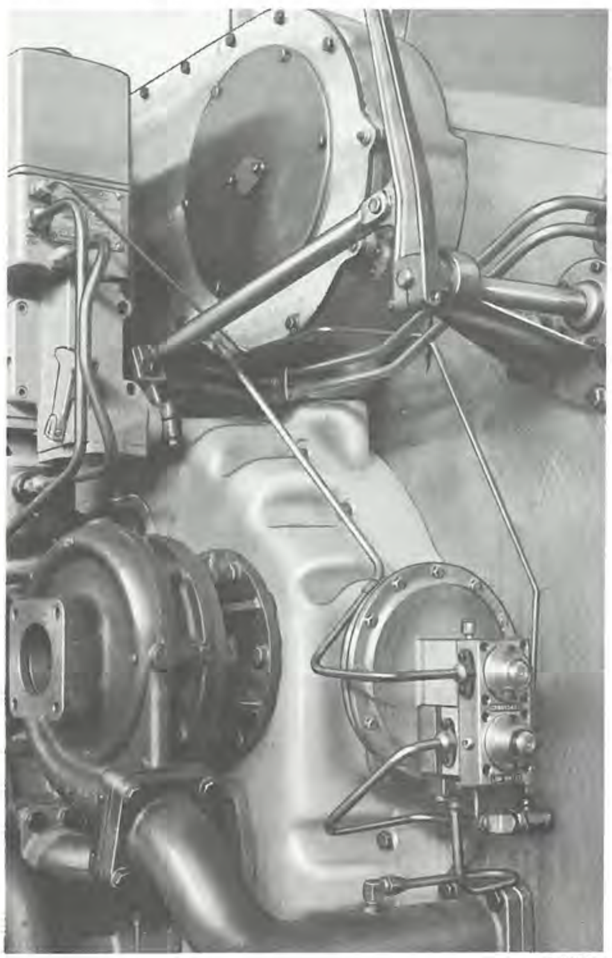
When pressure testing, seepage of air around the vacuum diaphragm stop screw should not be confused as a broken diaphragm as there is no seal around the stop screw, and a small leakage of air is not harmful.

LOW WATER AND CRANKCASE PRESSURE DETECTOR ASSEMBLY

DESCRIPTION

The low water and crankcase pressure detector assembly, Fig. 12-2, is a compact device for detecting loss or lack of engine cooling water as well as any change in the normal negative crankcase pressure to a positive pressure. If either of these conditions exists, the device will cause the engine to be shut down.

The low water pressure portion balances water pressure into the engine against the air box pressure plus a light spring to hold an oil relief valve in a latched position. In the event water pressure into the engine falls below the pressure in the air box plus the force of the light spring, the oil relief valve is released and lube oil pressure to the engine governor is



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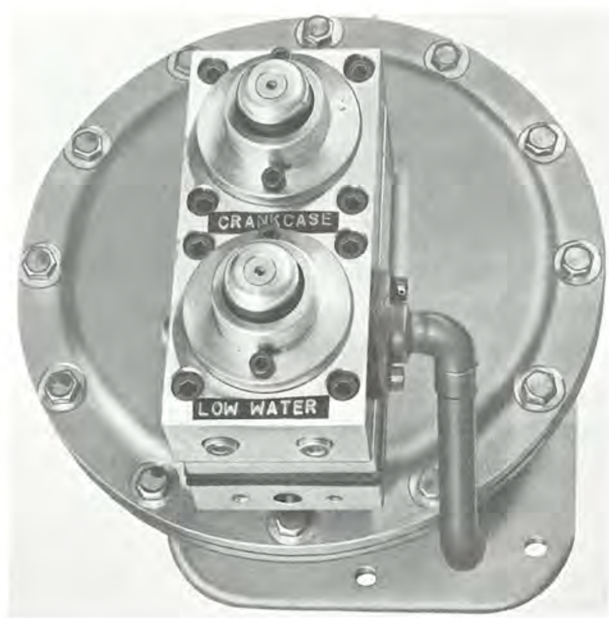

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Fig. 12-2 — Low Water And Crankcase Pressure Detector Assembly

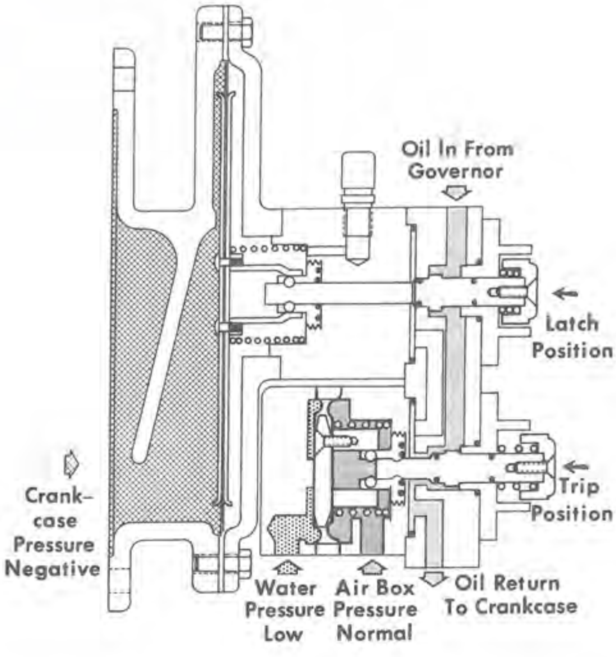

Fig. 12-3 — Low Water Pressure Condition

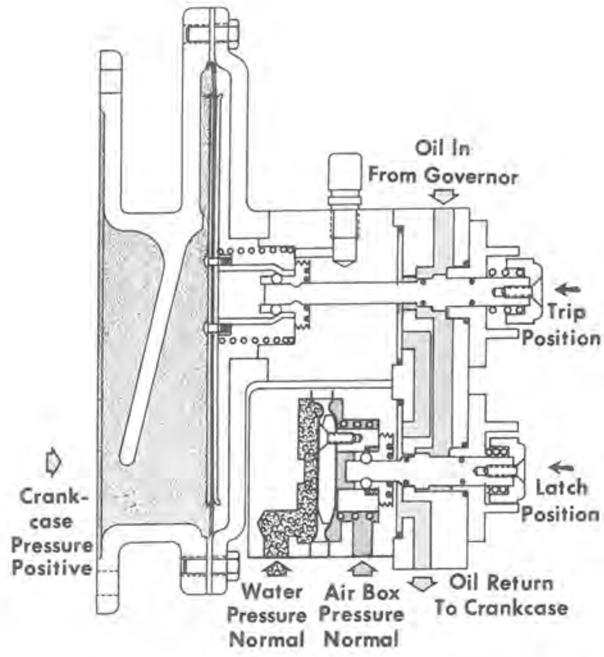

Fig. 12-4 — Positive Crankcase Pressure Condition

relieved, Fig. 12-3. The governor senses low oil pressure and initiates engine shutdown. The low water pressure portion of the device will trip whenever the cooling system is drained. Tripping should occur if water pressure does not exceed air box pressure by 0 to 14 inches of water pressure.

The crankcase pressure portion of the device consists of an oil relief valve, comparable to the one in the low water portion, held in a latched position until a positive pressure is built up in the crankcase. The oil relief valve is released and lube oil pressure to the engine governor is relieved, Fig. 12-4. As in the low water portion, the governor senses low oil pressure and initiates engine shutdown.

When a shutdown occurs, the reset button, Fig. 12-2, for that portion of the device responsible for the shutdown must be manually reset. The shutdown plunger on the engine governor must also be reset before starting the engine.

A 1/8" bleed hole is provided in the space between the water pressure and crankcase diaphragms to visually indicate a leaking diaphragm.

MAINTENANCE

The low water and crankcase pressure detector should be tested periodically to ensure proper operation.

The low water portion of the device is tested by placing the test cock handle at the bottom of the device in a horizontal position, Fig. 12-5. This shuts off water pressure to the device causing the low water pressure oil relief valve to be tripped. Test cock handle must be returned to vertical position, Fig. 12-5, and button must be manually reset before starting engine.

Without starting the engine the crankcase pressure portion of the device can be tested by removing the vent cap at the top of the device and creating a suction on the fitting, using a hydrometer bulb. Tripping pressure should be .04 to .05 psi.

If tests prove unsatisfactory, disassemble the device and thoroughly clean all of the parts.

CAUTION: Do not use a wirebrush or abrasives on oil valve shafts or machined surfaces engaging "O" rings or diaphragms.

Inspect oil valve shafts, retainer balls, and retainer cups for grooving due to engagement with balls, and replace if grooved.

Inspect diaphragms and replace if cracked or show signs of deterioration. It is also recommended that diaphragms be replaced if they are three years old.

Assemble diaphragm to mating parts with a new gasket on each side of each diaphragm. Apply gaskets and diaphragms without oil, grease, or gasket cement.

Using new "O" rings lubricated with light engine oil, assemble low water and air box diaphragms to oil valve block, including oil valve shafts.

Install steel balls in retainer with lubriplate to hold them in position. Holding valve in latched position and the diaphragms in the normal position of water pressure exceeding air box pressure, install bolts and torque to 5 ft-lbs. Install crankcase pressure valve shaft with new "O" rings lubricated with light engine oil. Coat steel balls with lubriplate and position in retainer. Assemble oil block, spacer, and crankcase diaphragm cover, install bolts and torque to 5 ft-lbs.

Holding crankcase valve in the latched position, seat balls in shaft groove and install diaphragm with new gaskets and ball retainer over the valve shaft.

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TEST POSITION

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NORMAL POSITION

Fig. 12-5 — Test Cock Positions

Hold diaphragm in position through the drilled passage in the mounting plate and assemble the mounting plate to the cover. Apply bolts and tighten finger tight, then torque uniformly to 5 ft-lbs.