SECTION IX

COOLING SYSTEM

A. GENERAL DESCRIPTION

The cooling system of the engine consists of engine driven centrifugal water pumps, replaceable inlet water manifolds with individual jumper line to each liner, cylinder head discharge elbows and outlet manifold, through which cooling water is circulated. The centrifugal water pumps are mounted on the accessory drive housing and driven by the governor drive gear.

Water temperature gauges, level gauges, connecting piping, and fill and drain lines complete the cooling system. A representative schematic of the cooling system is shown in Section 8.

The heated discharge water from the engine is cooled by either of two different methods depending on the individual installation.

1. Air Cooling

The engine discharge water is cooled in banks of tube and fin type radiators which are force ventilated by means of fans either driven mechanically by the engine or by separate electric motors. Water thus cooled leaves the radiators and flows through the lube oil cooler and then continues on to the water pump inlet where it is then recirculated through the engine.

Cooling air admission to the radiators is controlled by automatically operated shutters according to the water temperature. Electrically driven cooling fans also function automatically by thermostatic control, according to the water temperature. Some of the mechanically driven fans are constantly driven at speeds directly proportional to engine speeds while others use eddy-current coupling arrangements to vary the fan speed according to the engine water temperature.

2. Water Cooling

If a sufficient supply of raw water is available a heat exchanger may be used on applicable installations. Engine water temperature on these applications is controlled by an automatic thermostat valve arrangement.

B. DESCRIPTION

1. Pumps

The engine cooling water pumps are of the centrifugal type and rotate counter-clockwise. Two pumps are used on the 12 and 16 cylinder engines and only one pump on the 6 and 8 cylinder engines. The pumps are carried under two part numbers to identify the right or the left bank pumps. The difference in the bank designation is only because of the position of the impeller housing to enable line up to the pump discharge pipe. The impeller housing position on either pump may be changed to permit use on either engine bank.

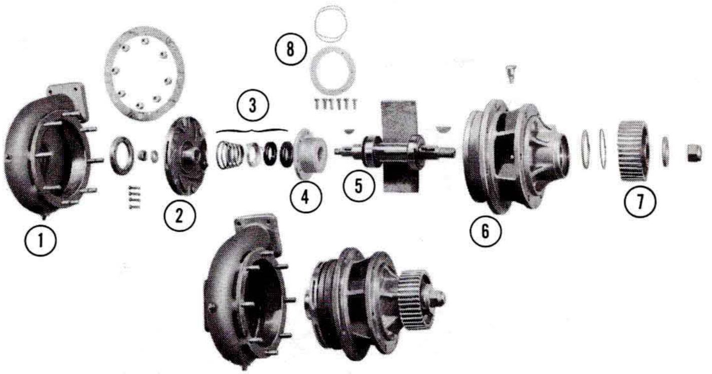
The various parts of the water pump are shown in Fig. 9-1. The main parts are: impeller, impeller housing, drive shaft, drive shaft housing, bearing, seal assemblies and drive gear. A cross-section of the pump is shown in Fig. 9-2.

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 abuts a water slinger 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 by a washer and nut on the shaft.

An integral seal assembly and thrust collar is used in the right hand pump, while a stationary bushing and separate seal assembly is used in the left hand pump. The seals, as assemblies, may be used in either water pump. The impeller is keyed to the pump shaft and is held by washer and nut. It is enclosed by the impeller housing, which is mounted by studs and nuts to the main pump housing. Plugged drain holes are provided in the impeller housing and a tell-tale drain is provided in the main pump housing to dispose of any water leak past the seal.

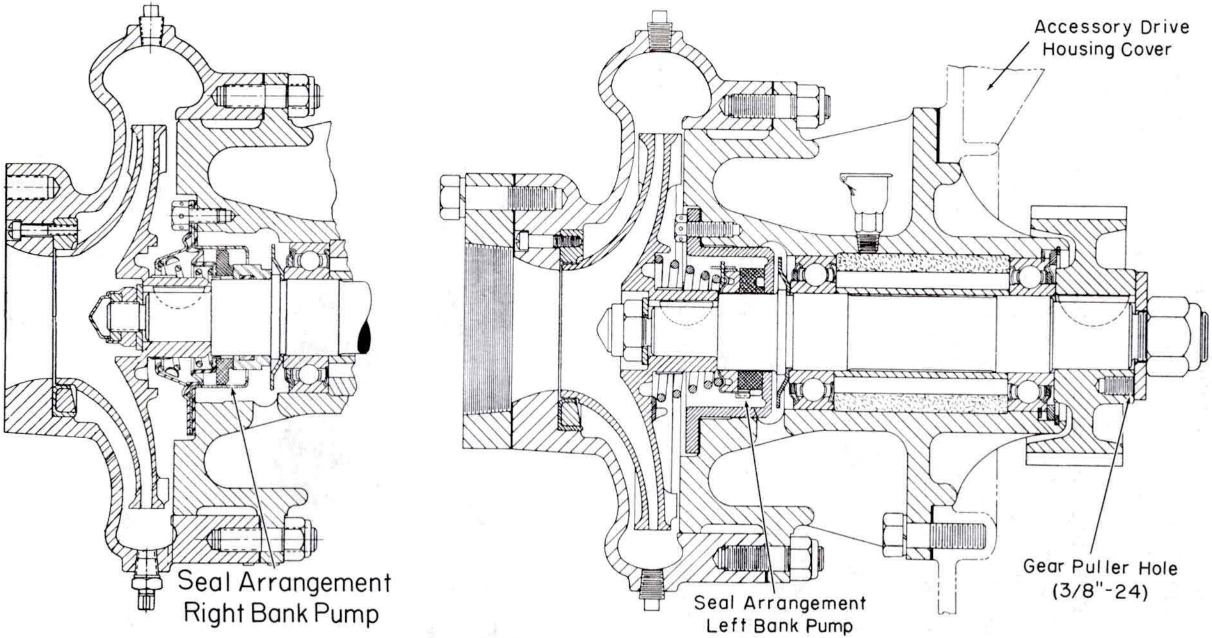
2. Engine Water Passages

Pump discharge elbows conduct water from the pumps to the removable water inlet manifolds, extending the length of the crankcase, located in each air box, Fig. 9-3. 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 is correctly



1. Impeller Housing
2. Impeller
3. Seal Assembly
4. Stationary Bushing
5. Drive Shaft Assembly
6. Drive Shaft Housing
7. Drive Gear
8. Gaskets

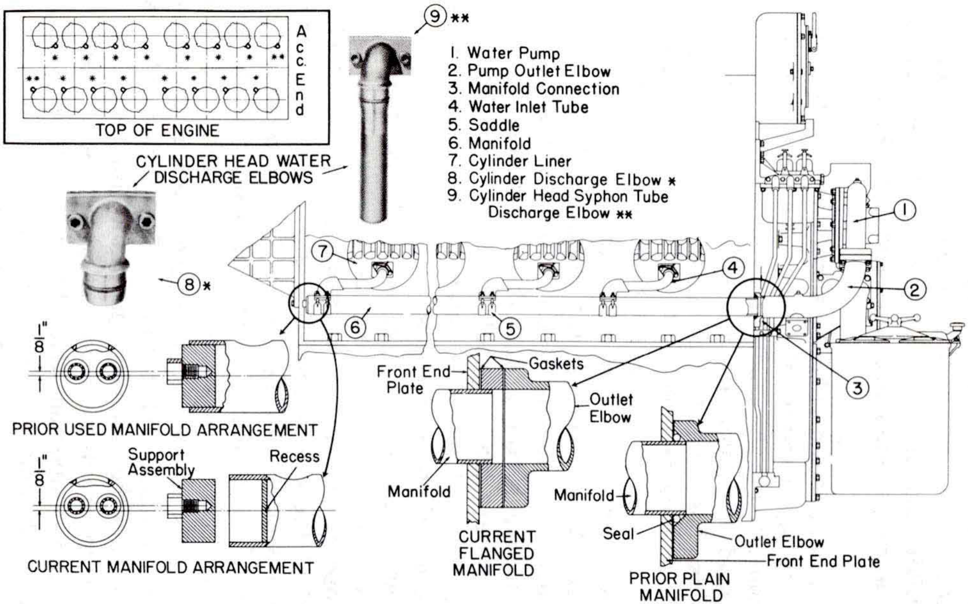
Water Pump — Exploded View
Fig. 9-1



Water Pump Cross-Section
Fig. 9-2

located at the rear end plate by dowels which fit into counterbores in the end plate and held in place by two cap screws through the end plate. A flange at the front end of the manifold faces the front end plate when the manifold is installed. A gasket is used between the manifold flange and end plate and the water inlet elbow flange. Earlier manifold arrangements are also shown in Fig. 9-3.

Each liner is individually supplied from the water manifold through a water inlet tube assembly. The inlet tube is connected to the manifold by saddle strap assemblies around the manifold and bolted to the liner. 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 (shown in Section 4), turning the water to prevent direct impingement on inner liner wall. Water enters the cylinder head through twelve discharge holes at the top of the liner. A counterbore around each hole accomodates a water seal ring. A single water discharge elbow, Fig. 9-3, 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 designs 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.



Engine Cooling System Details
Fig. 9-3

3. Engine Water Temperature

Temperature gauges are provided in the cooling system for visual indication of engine water temperature and as a guide to engine water operating temperature in the recommended range. The recommended operating range is a water discharge temperature between 160° F. and 180° F. The minimum water temperature at which the engine should be loaded is 120° F. Automatic engine water temperature controls (where used) are set to maintain the water discharge temperature within approximately the 150° F. - 180° F. range.

A hot engine alarm (where used) indicates dangerous water discharge temperature. Hot engine water would result due to improper water, faulty water cooling equipment or loss of water. Engine load should be removed and speed reduced, not stopped, to obtain normal temperature in event of a hot engine alarm. Before resuming operation, the cause of the hot engine water should be found and corrected.

For the applicable instruction covering hot engine and engine temperature control settings, refer to the specific Maintenance Instruction.

4. Engine Cooling Water

Proper coolant and attention to the cooling system cannot be too highly emphasized. In order to provide satisfactory cooling system operation, three requirements must be met by the coolant. 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 will result in increased maintenance, replacement and repair of parts and damage to the cooling system.

The water used in the cooling system should not exceed 10 grains per gallon in hardness and the chloride content should not exceed 10 grains per gallon. In addition, the coolant should be treated to prevent rust or corrosion of metal parts by a suitable inhibitor that is not detrimental to the engine cooling system. The pH value of the coolant should be in the range of 8.5 to 9.5.

Borate type water inhibitors are satisfactory for use in the engine cooling system, such as National Aluminate Corporation Nalco #39, solid or liquid type, or Dearborn Chemical Company, Dearborn #527, or their equivalent. It is recommended that 0.75 ounces of solid compound of these inhibitors or 2 fluid ounces of the liquid inhibitor should be added for each gallon of coolant in the cooling system.

Other types of inhibitors such as soluble oil or chromate type have disadvantages. Soluble oil is detrimental to cooling system seals. Chromate types lend themselves to personal safety risk through careless handling and/or negligent personal hygienic risks and in addition should not be used with ethylene glycol antifreeze solutions.

It is our recommendation 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 not to assume that a coolant operating satisfactorily in some other engine will be satisfactory for use in the 567 series engine. Difference in load factors, coolant velocities, temperature, 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. Likewise it should not be assumed if an antifreeze solution is used containing rust or corrosion inhibitor that it will provide adequate inhibitor protection for the coolant of the entire cooling system, since additional inhibitor may be required.

5. Engine Water Heating

To prevent freezing of the engine water during cold weather when the engine is temporarily inactive, some means of heating the water must be provided. Methods for this protection are live steam admission to the cooling system, separate small water heaters, either oil-burning or electric, or by running the engine at idle.

Each engine cooling system is equipped with a steam admission line with a check valve allowing steam supply from an external source or from a steam generator on units so equipped. If steam is supplied for heating, the pressure must not exceed 50 p.s.i. and any overflow valve in the cooling system should be opened to permit condensation to drain and maintain the desired water level. A disadvantage in steam heating the water is loss of inhibitor resulting in a weak solution.

Separate oil heaters or electric immersion type heaters may be applied to heat the engine water. The number and type of units, frequency of need for heat, availability of external heat supply and other factors, will influence the selection of equipment.

C. MAINTENANCE

1. Cooling System Piping Installation

All 567C engines now have a "flanged" water inlet manifold, as shown in Fig. 9-3, replacing the prior used plain manifold. In addition to the flange at the front of the manifold, the opposite end of the manifold is recessed to fit over a pipe support assembly at the rear end plate when the manifold is installed. The pipe support assembly is held to the rear end plate by two cap screws and is correctly located by two dowels which fit into counterbores in the end plate. The pipe support assembly is installed so that the small area above the dowels is at the top. To effectively seal the manifold, a gasket is applied between the flange and the front end plate and between the flange and the water pump outlet elbow flange.

To replace the plain type manifold with the flange type, it is necessary to replace the pump outlet elbows and flange bolts and add the pipe support assembly as well as using the flange type manifold.

The prior used plain type manifold, Fig. 9-3, has the rear end plate locating dowels as a part of the manifold. The front end of the manifold extends through the front end plate, fitting into a counterbore in the pump outlet elbow flange, when it is installed. A round seal is used over the end of the pipe at the front end plate. A chamfer at the inside diameter of the pump outlet flange compresses this seal against the flange, manifold and end plate to prevent leakage, when the water pump outlet elbow is applied.

Before application of the water inlet tube assemblies, the cylinder head and liner assemblies must be properly installed. The water manifold also must be correctly located. The flange type manifold must have the flange to end plate gasket applied and the flange tightened to the end plate and the recessed end fitting over the applied pipe support at the rear end plate. (The manifold may be temporarily secured as given in the preceding until the water tubes are applied, which will then hold the manifold, to aid in engine assembly if the blower supports or water pump outlet elbows are not yet applied.) The plain manifold should have the rear end dowels in place and held securely.

Application of the water inlet tube assemblies to the manifold and liner is the same for either type manifold. Apply the liner water inlet tube seal (this seal is also used at the cylinder head discharge elbow) and apply tube to liner, leaving cap screws loose. Apply the saddle strap, and tighten strap nuts finger tight, leaving sufficient space between the pipe and saddle for the gasket. Bend the gasket slightly to conform to pipe and place the gasket under the saddle with the long side across the pipe. Then tighten the liner cap screws to 30 foot-pounds torque and saddle strap nuts to 15 foot-pounds.

As shown in Fig. 9-3, it is important that the last cylinder head of the right bank and the first cylinder head of the left bank, be equipped with a cylinder head siphon tube discharge elbow to permit draining of the water discharge manifold when the engine is drained. All the other cylinder heads have the discharge elbows without siphon tubes.

2. Pumps

a. Removing Pump

(1) Drain cooling system.
(2) Remove water pump inlet flexible connections.
(3) Disconnect pump discharge flange connection.
(4) Remove pump mounting capscrews allowing pump to be removed from the engine.

b. Removing Impeller

(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 hoist or other means, impeller end down, and by tapping on the housing with a rawhide or wooden mallet.
(2) Remove impeller shaft nut and washer and apply impeller puller #8067245 to remove the impeller as shown in Fig. 9-4. The thrust

Removing Impeller
Fig. 9-4

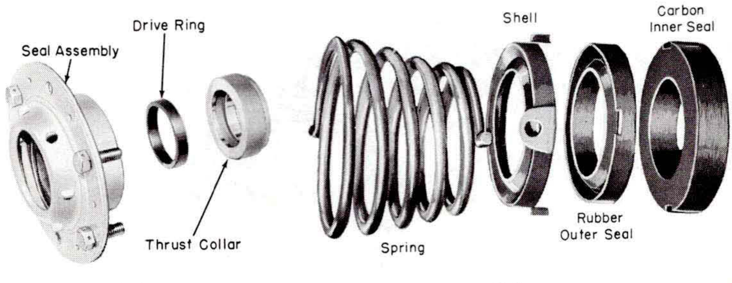
cup which is part of the puller is placed over the end of the shaft to protect the shaft threads. Remove holding key.

c. Removal and Application of Pump Seals

The seal assemblies used in the water pumps are shown in Figs. 9-2 and 9-5. Seal assembly (a) is used in the right bank water pump and seal (b) is used in the left bank water pump. Either seal, however, as a complete assembly can be used in either pump. A stationary bushing, as shown in Fig. 9-7, is required with the seal assembly (b) while a thrust collar and drive ring is used with the seal assembly (a). Application of the seals is shown in Fig. 9-2.

Seal (a), Fig. 9-5

(1) Removal
  (a) Remove the impeller housing and impeller as outlined in preceding Item b.
  (b) Remove brass lockwire and six cap screws holding the seal assembly and remove the seal assembly.
  (c) The thrust collar and its drive ring are removed from the pump shaft, using collar remover 8220578, Fig. 9-6. The jaws of the remover grasp the thrust collar at the



(a) (b)

Water Pump Seal Assemblies — Exploded
Fig. 9-5

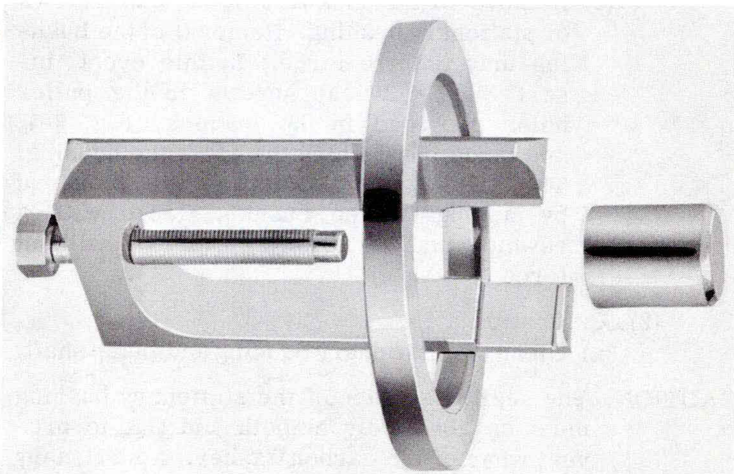
reduced diameter and are held together by the steel ring. The guard cup contacts the thread end of the shaft, serving as a pressure point for the remover bolt.

(2) Application

Since a new thrust collar or carbon seal may not function properly if mated with a worn seal face, a complete seal kit should be used if any part of the seal needs to be replaced.

(a) Clean the pump shaft in the area of thrust collar application. Apply a small amount of clean light oil to the shaft at the collar area.

(b) Thrust collar guide 8143316 is used to aid in thrust collar application. Place the rubber drive ring in place in the thrust collar and apply the thrust collar assembly to the shaft against the shoulder on the shaft. The narrow diameter of the collar should be next to the water slinger, as shown in Fig. 9-2.



Thrust Collar Removing Tool
Fig. 9-6

(c) Make sure the mounting surface for the seal is clean and smooth. Apply the seal gasket and seal assembly. Apply the six brass cap screws which hold the seal, but do not final tighten them until the seal has been centered around the shaft within 1/64". Cap screws used with this seal are 1/8" shorter than the cap screws used with the stationary bushing. Torque the cap screws to 6 foot-pounds and apply brass lockwire.

Seal (b), Fig. 9-5

(1) Removal

(a) Remove impeller as outlined in Item b.

(b) Remove seal spring and seal assembly. 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.

(c) Remove brass lockwire from cap screws of stationary bushing. Removal of the bushing may require force. In this event, insert 3/8" × 2" cap screws in the puller holes provided in the bushing, Fig. 9-7, and force the bushing out from the housing. The bushing may sometimes be loosened by tapping on the bushing flange with a rawhide mallet, allowing removal without force.

(2) Application

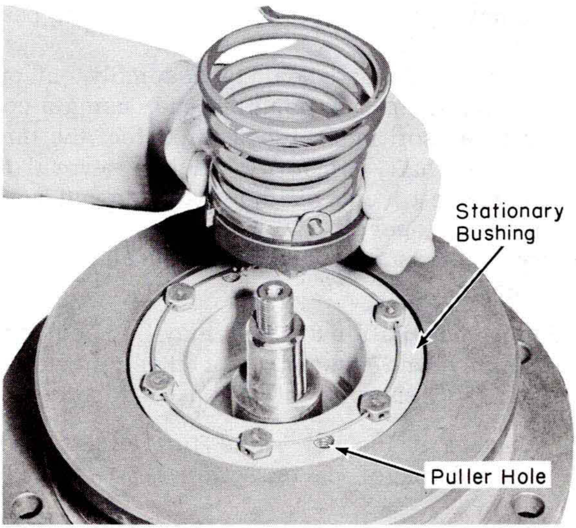
(a) Clean the stationary bushing and pump shaft.

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.

(b) Before applying the stationary bushing, be sure the bushing and mounting surfaces are clean. Any foreign material would 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 cap screws evenly and lockwire using brass lockwire. Torque value of the cap screws is 6 foot-pounds.

After applying the stationary bushing, check runout of the carbon seal surface using an indicator mounted on the end of the pump shaft. Runout should not exceed .001" total indicator reading. If .001" is exceeded, reposition bushing 180° and/or scrape off foreign material in area of high reading, on mounting surface.



Installing Pump Seal Assembly
Fig. 9-7

(c) Install new seal assembly, shown in Fig. 9-7. Apply carbon washer (inner seal), narrow end contacting the stationary bushing. Check carbon face for cleanliness. Apply outer seal (synthetic rubber) to shell, and apply to carbon washer so ears of shell fit into the slots in the carbon washer. 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.

d. Removing Pump Shaft And Bearings

(1) Remove impeller housing, impeller, shaft seal, and stationary bushing, as outlined in Items "b" and "c."
(2) Remove nut and gear retaining washer from drive gear end of pump shaft.
(3) Remove gear using puller 8219744.
(4) Remove bearing retainer snap ring and bearing retainer ring.
(5) Press shaft and bearing assembly out of the housing from the impeller end, using a copper or other soft metal block to protect the threads of the shaft. Unscrew oil cup several turns to assure tip end will not protrude and restrict pressing operation.
(6) Press bearing assembly off the shaft from the gear end.

NOTE: Pump shaft puller 8219743 may be used for disassembly and assembly of these parts. File print #536 shows application of this tool.

(7) Clean and inspect parts for defects and replace damaged parts.

Bearings with seals or shields on both sides should not be washed but wiped clean. Inspect bearings for excessive end play, roughness, seizing, galled, worn or abraded surfaces, broken or bent seals or shields, fractured ring or rusted or discolored balls and raceways.

Pump shaft seal contact surfaces must be smooth.

See Specifications for condemning limits.

e. Pump 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 retaining ring to the outside. These parts are assembled, 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. 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.

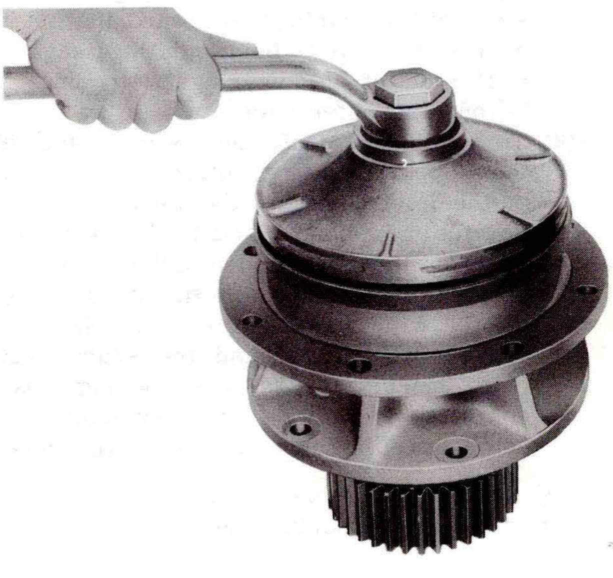
(4) First apply the bearing retainer and then the snap ring back of the rear bearing.

(5) Apply drive gear to shaft, puller taps outside. Check shaft key and way fit. Pump shaft diameter to gear bore fit is, .001" loose, maximum. Inspect gear nut insert, that it is free of tears or disintegration. Nuts may be re-used if fibre collar torque is 92 inch pounds. Gear nut (1"-14) torque is 265 foot pounds.

(6) Apply stationary bushing and gasket to housing and replace seal assembly as given in Item "c."

f. Installing Impeller

(1) Fig. 9-8 shows the impeller pressing on tool #8052959 in use. The threaded bushing of the tool is screwed on pump shaft threads. Then



Installing Pump Impeller
Fig. 9-8

by turning outer portion of 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 (if used) is in the spring slot under the impeller. Then continue to carefully 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 fibre collar torque is 32 inch-pounds. Apply the impeller retaining washer and nut. Torque value of the impeller nut is 80 foot-pounds.

g. Installing Impeller Housing

Before installation of the housing, 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.

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. 9-9.

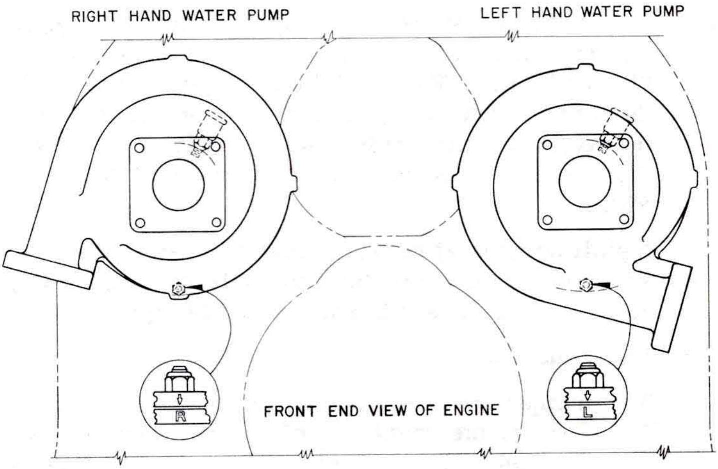
Install housing at correct location, using new gasket between the impeller and shaft housing. Apply housing nuts to studs and carefully tighten.

h. Installing Pump

The pumps are installed in the position shown in Fig. 9-9 for the right or left bank. Torque value for the pump to accessory cover mounting bolts is 65 foot-pounds.

When installing the water pump, care should be taken during application of the flexible water inlet connections.

Flexible connections consisting of a sleeve, synthetic rubber seals, steel rings and bolted clamps, should be checked that the pipes joined should not exceed 6° misalignment. Pipes to be joined should be checked to see that they are clean, without deep cuts, burrs or sharp edges for a distance from the end of the pipe equal to the length of the assembled coupling. Minimum engagement on both ends are to be such that the pipe protrudes through the seal into the coupling body by at least 1/4". Gap between the ends of pipes to be a minimum of 1/4" to allow for expansion and freedom of movement. Care should be taken to tighten the bolts enough to provide a tight seal, but not to a point where it would retard resilience of the seal and defeat the purpose of the flexible connection.



Position Of Impeller Housing
Fig. 9-9

Metallic bellows type flexible connections must not be compressed beyond 1/16", and should not be expanded more than 3/16". Parallel misalignment of the two flanges must not exceed 3/16" in any direction. Angular misalignment between flanges of the hose assembly should not exceed 2° maximum. The flexible hose should be checked for nicks and deep scratches which would lead to rupture of the hose.

3. Water Leaks

If loss of water in the cooling system is noticed, check for leaks in piping, pump seals, jumper tube connections, cylinder head outlet elbow, junction head to liner, or possible cracked liner or cylinder head.

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 on the head or liner surfaces requires their removal. Inspect cylinder interior through liner ports.

The only place where water might leak and enter the lube oil is at the cylinder head outlet elbow seals. These seals can be replaced without disturbing the cylinder head after a crab nut and crab are removed. Lubricating oil contamination by water will necessitate draining the oil and flushing the system, as outlined in Maintenance Instruction 1757, before the oil is renewed.

Lube oil contamination is best determined by laboratory analysis, but in the absence of such means, a method of checking for water in the oil is as follows: Draw or dip a gallon of lube oil from the bottom of the engine lube oil sump. Let it stand for about ten (10) minutes, then spill about three-fourths (3/4) of the oil from the container. Place the remaining one-fourth (1/4) in a glass bottle and allow sample to stand another ten minutes. If any water is indicated in the bottom of the bottle, it is suggested that the lube oil system be drained and flushed. Replace with new oil after source of contamination is eliminated.

4. Additional Cooling System Information

Due to prohibitive length required to cover completely all details of the cooling system, separate maintenance instructions have been written covering the various components of the cooling system.

D. SPECIFICATIONS

Water pump speed

(800 RPM Engine Speed)	2440 RPM
(835 RPM Engine Speed)	2546 RPM

Pump Capacity:

Actual pump capacity is 240 g.p.m. with 26 p.s.i. discharge pressure. The resistance of the various cooling systems affect the capacity and are varied.

Pump drive gear backlash — New .008" - .016" - Limit .030"

Dimensional Limits

	Diametric Condemning Limit	
	Min.	Max.
Bearing bores in support housing may be oversize or bearing outer diameter undersize. Fit must be	.0001" tight to .0025" loose	
Pump shaft, bearing mounting diameters to bearing bore. No wear allowed. Fit must be	.0009" tight to .0001" loose	

Dimensional Limits (Cont'd)

	Diametric Condemning Limit Min.	Max.
Pump shaft, drive gear mounting diameters to gear bore. Fit must be	.0005" tight to	.001" loose
Pump shaft impeller mounting diameters to impeller	.0005" tight to	.0025" tight

E. EQUIPMENT LIST

Name	Part No.
Impeller puller	8067245
Impeller pressing-on tool	8052959
Water pump collar puller	8220578
Water pump shaft and gear puller assembly	8219743
Water pump gear puller assembly	8219744
Engine cooling system water test (schematic piping diagram)	File 292

For additional tools see Tool Catalog 91B.