LUBRICATING OIL COOLER

Engine oil coolers are provided for all engines with the exception of certain 2-cylinder models which do not include or require an oil cooler. The oil cooler is mounted on the side of the cylinder block at the lower front corner (Fig. 1).

To assure engine lubrication should the oil cooler become plugged, a by-pass valve located near the top of the lower engine front cover by-passes oil from the oil pump discharge port directly to the oil galleries in the cylinder block. The by-pass valve opens at approximately 52 psi (current In-line engines), 30 psi (former In-line engines) or 52 psi (6V and 8V engines). The valve components are the same as and serviced in the same manner as the oil pressure regulator valve in Section 4.1.1.

> **NOTE:** The by-pass valve opens at approximately 32 psi on 6V marine engines prior to engine number 6D-11074 and all 6V engines prior to engine number 6D-17960.

Cooling water circulated through the oil cooler completely surrounds the oil cooler core. Therefore, whenever an oil cooler is assembled, special care must be taken to have the proper gaskets in place and the retaining bolts tight to assure good sealing.

The oil cooler housing on an In-line engine is attached to an oil cooler adaptor which, in turn, is attached to the cylinder block. The flow of oil is from the oil pump through a passage in the oil cooler adaptor to the full flow oil filter, which is also mounted on the oil cooler adaptor, and then through the oil cooler core and the cylinder block oil galleries.

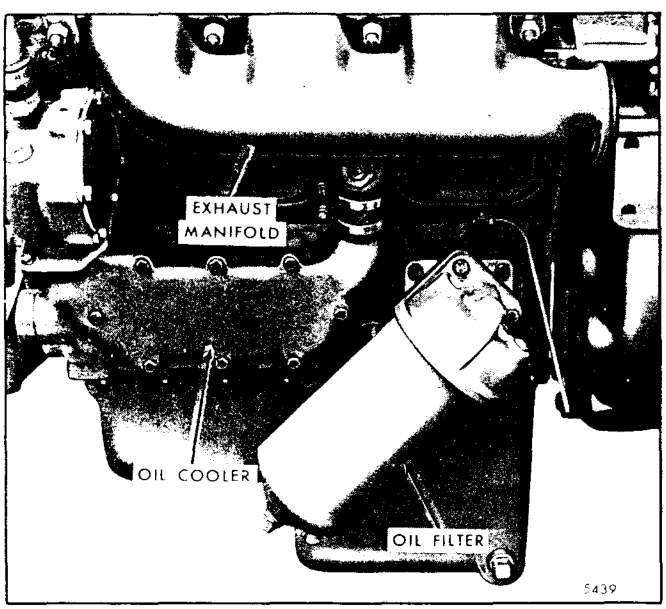

Fig. 1 - Typical Oil Cooler Mounting (6V-53 Engine Shown)

The oil cooler housing on a V-type engine is attached directly to the cylinder block.

Remove Oil Cooler Core

1. Drain the cooling system by opening the drain cock at the bottom of the oil cooler housing.

2. Remove any accessories or other equipment necessary to provide access to the cooler.

3. On In-Line or 6V engines, loosen and slide the clamps and hose back on the water inlet elbow on the cylinder block. On 8V engines, remove the bolt and lock washer attaching the water outlet flange and seal ring to the cylinder block.

4. Loosen and slide the clamps and hose back on the tube leading from the thermostat to the water pump.

5. Remove the bolts and lock washers which attach the water pump to the oil cooler housing.

6. Matchmark the end of the oil cooler housing, cooler core and adaptor with a punch or file so they can be reinstalled in the same position.

7. Remove the bolts and lock washers which attach the oil cooler housing to the adaptor or cylinder block and remove the housing and core as an assembly. Be careful when withdrawing the assembly not to drop or damage the cooler core.

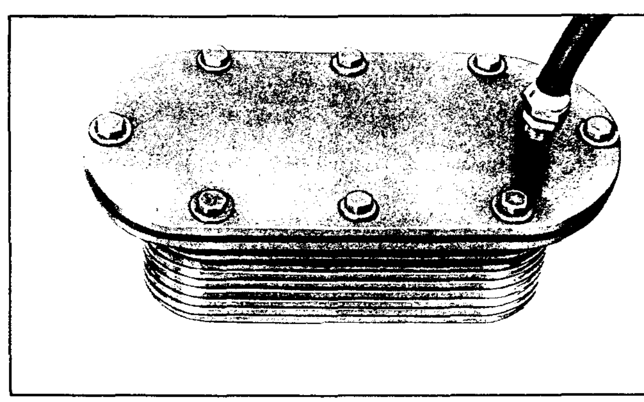

Fig. 2 - Preparing Oil Cooler Core for Pressure Test

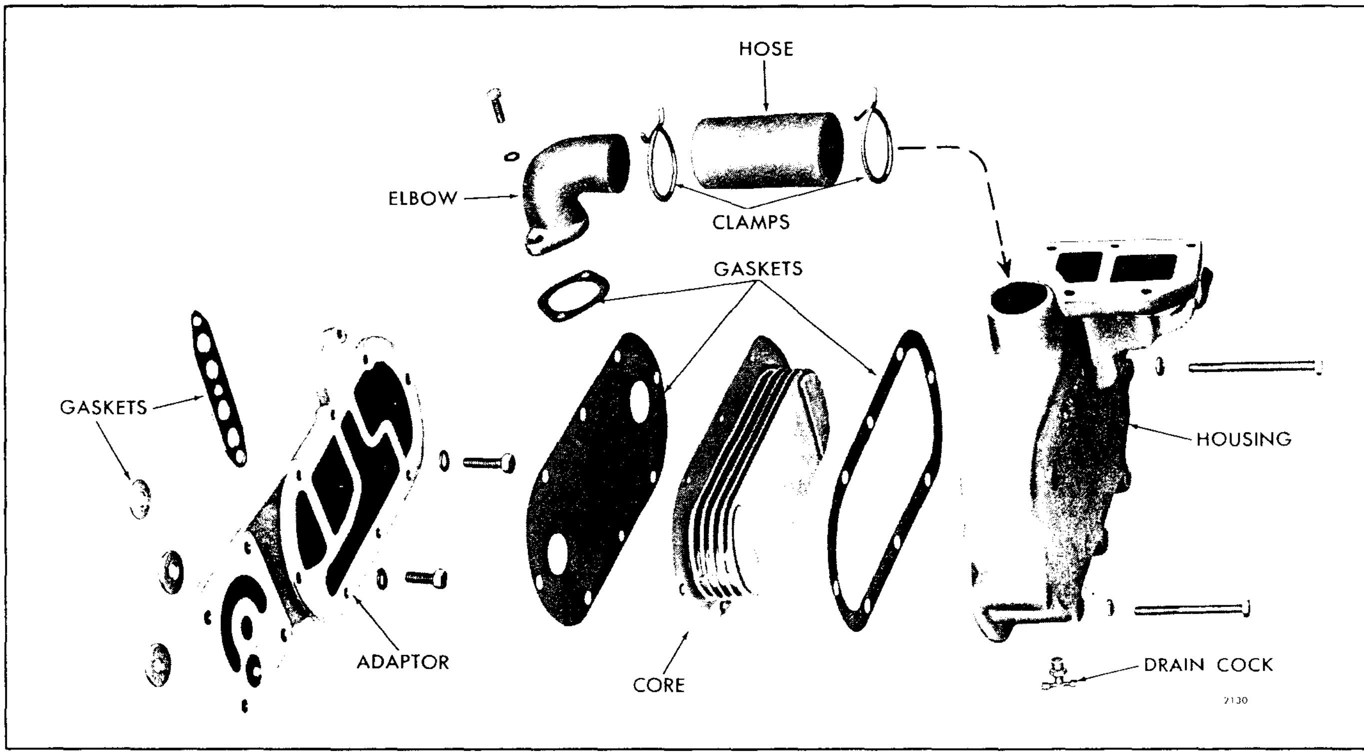

Fig. 3 - Oil Cooler Details and Relative Location of Parts (In-Line Engine)

8. If the adaptor (In-line engine) is to be removed, the oil filter must first be removed. Then remove the bolts and lock washers which attach the adaptor to the cylinder block. Withdraw the adaptor and gaskets.

9. Remove all traces of gasket material from the cylinder block and the oil cooler components.

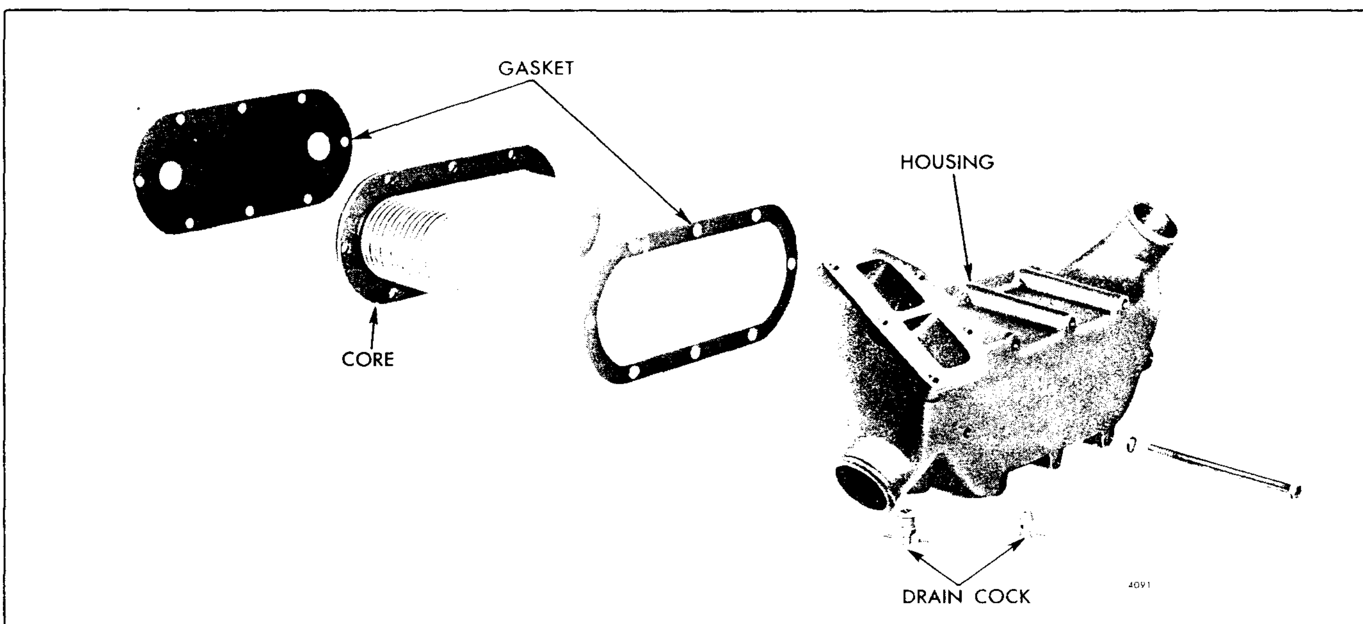

Fig. 4 - Oil Cooler Details and Relative Location of Parts (6V or 8V engine)

Clean Oil Cooler Core

1. *Clean oil side of Core* - Remove the core from the oil cooler. Circulate a solution of trichloroethylene through the core passages with a force pump to remove the carbon and sludge.

> **CAUTION:** This operation should be done in the open or in a well ventilated room when trichloroethylene or other toxic chemicals are used for cleaning.

Clean the core before the sludge hardens. If the oil passages are badly clogged, circulate an Oakite or alkaline solution through the core and flush thoroughly with clean, hot water.

2. *Clean water side of Cooler* - After cleaning the oil side of the core, immerse it in the following solution: Add one-half pound of oxalic acid to each two and one-half gallons of solution composed of one third muriatic acid and two-thirds water. The cleaning action is evidenced by bubbling and foaming.

Watch the process carefully and, when bubbling stops (this usually takes from 30 to 60 seconds), remove the core from the cleaning solution and thoroughly flush it with clean, hot water. After cleaning, dip the core in light oil.

> **NOTE:** Do not attempt to clean an oil cooler core when an engine failure occurs in which metal particles from worn or broken parts are released into the lubricating oil. Replace the oil cooler core.

Pressure Check Oil Cooler Core

After the oil cooler core has been cleaned, check for leaks as follows:

1. Make a suitable plate and attach it to the flanged side of the cooler core. Use a gasket made from rubber to assure a tight seal. Drill and tap the plate to permit an air hose fitting to be attached at the inlet side of the core (Fig. 2).

2. Attach an air hose, apply approximately 75-150 psi air pressure and submerge the oil cooler core and plate assembly in a container of water heated to 180 °F. Any leaks will be indicated by air bubbles in the water. If leaks are indicated, replace the core.

> **CAUTION:** When making this pressure test be sure that personnel are adequately protected against any stream of pressurized water from a leak or rupture of a fitting, hose or the oil cooler core.

3. After the pressure check is completed, remove the plate and air hose from the cooler core, then dry the core with compressed air.

> **NOTE:** In cases where a leaking oil cooler core has caused contamination of the engine, the engine must be immediately flushed to prevent serious damage (refer to Section 5).

Install Oil Cooler Core

1. If the oil cooler adaptor (In-Line engines) was removed from the cylinder block, remove the old gasket material from the bosses where the adaptor sets against the block. Affix new adaptor gaskets (Fig. 3), then secure the adaptor to the cylinder block with five bolts and lock washers.

2. Clean the old gasket material from both faces of the core flange and affix new gaskets to the inner and outer faces (Figs. 3 and 4). Insert the core into the cooler housing.

> **NOTE:** The inlet and outlet openings in the oil cooler core are stamped "IN" and "OUT". It is very important that the core be installed in the correct position to prevent any possibility of foreign particles and sludge, which may not have been removed in cleaning the fins of the core, entering and cirulating through the engine.

3. Align the matchmarks previously placed on the core and housing and install the oil cooler core in the oil cooler housing.

4. With the matchmarks in alignment, place the oil cooler housing and core against the oil cooler adaptor (In-Line engines) or cylinder block (6V or 8V engines). On 8V engines, slide the water outlet flange and a new seal ring over the outlet. Then secure the housing in place with bolts and lock washers. Tighten the bolts to 13-17 lb-ft torque. On 8V engines, secure the outlet flange in place with two bolts and lock washers.

5. Slide the hose and clamps in position between the cylinder block water inlet elbow and the oil cooler. Secure the clamps in place.

6. Place a new gasket between the fresh water pump and the cooler housing and secure the pump to the cooler housing.

7. Position the hose and clamps in place between the water pump and the tube to the thermostat housing. Secure the clamps.

8. Install all of the accessories or equipment it was necessary to remove.

9. Reinstall the oil filter (In-Line engine).

10. Make sure the draincock in the bottom of the cooler housing is closed. Then fill the cooling system to the proper level.

OIL LEVEL DIPSTICK

A steel ribbon type oil level dipstick is mounted in an adaptor on the side of the engine (Fig. 1) to check the amount of oil in the engine oil pan. The dipstick has markings to indicate the *Low* and *Full* oil level.

> **NOTE:** On 8V engines, effective with 8D-468, a new dipstick, adaptor and guide combination is employed to raise the full mark on the dipstick approximately two (2) quarts. When replacement of any part of the combination is required on an early engine, the complete new combination is necessary.

The engine should not be operated if the oil level is below the *Low* mark and no advantage is gained by having the oil quantity above the *Full* mark. Start and operate the engine for ten minutes to fill the oil filter, oil passages, etc., then stop the engine. After the engine has been stopped for a minimum of ten minutes, add oil as required to bring the oil level up to the *full* mark on the dipstick.

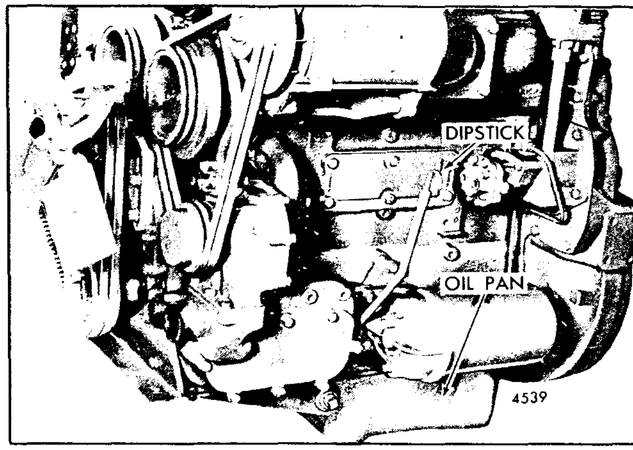

Fig. 1 - Typical Oil Dipstick Mounting

OIL PAN

The oil pan may be made of steel, cast iron or cast aluminum. A shallow or deep sump type oil pan is used, depending upon the particular engine application. A one-piece oil pan gasket is used with stamped steel pans. A four-piece gasket is used with the cast oil pans.

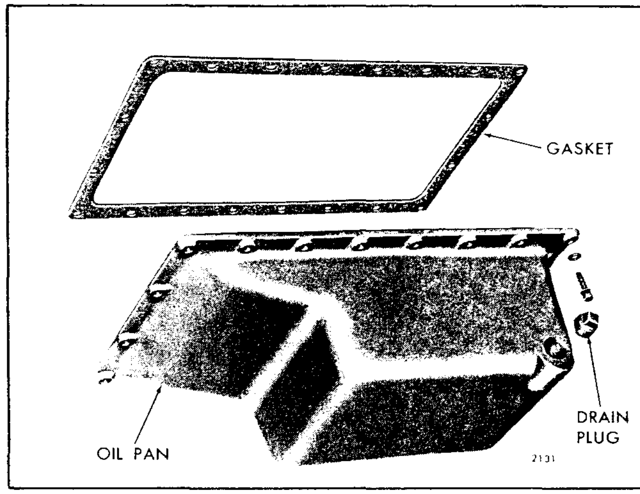

Fig. 1 - Typical Oil Pan

Removing and Installing Oil Pan

On some engine applications, it may be possible to remove the oil pan without removing the engine. It is recommended that if the engine is to be taken out of the unit, the oil pan be left in place until the engine is removed.

The procedure for removing the oil pan without taking the engine out and after taking the engine out of the unit will vary. However, the following will generally apply.

1. Remove the drain plug and drain the engine lubricating oil.

2. Detach the oil pan; take precautions to avoid damaging the oil pump inlet pipe and screen.

   NOTE: Stamped oil pans used on some marine engines have a layer of lead or cadmium beneath the paint to protect the pans against the salt water atmosphere encountered in some marine applications. If this coating is scuffed or broken unknowingly, corrosion or electrolysis may result. Electrolysis in the form of small holes will eat through the pan at the scuffed area. Therefore, do not rest, slide or rock the engine on its oil pan when removing it. Every precaution should be taken before installation to prevent nicks and scratches on stamped marine oil pans. Also exercise care when performing engine repairs to avoid scratching the outer surface of the oil pan.

3. Remove the oil pan gasket completely.

4. Clean the oil pan with a suitable solvent and dry it with compressed air.

5. Inspect a cast oil pan for porosity or cracks. Check a stamped oil pan for large dents or breaks in the metal which may necessitate its repair or replacement. Check for misaligned flanges or raised surfaces surrounding the bolt holes by placing the pan on a surface plate or other large flat surface.

6. When replacing the pan, use a new gasket and tighten the bolts evenly to avoid damaging the gasket or springing the pan.

7. On 8V engines, if the oil pan and flywheel housing include outriggers for the installation of reinforcement bolts, be sure the oil pan butts up against the flywheel housing before tightening the oil pan bolts. Install and tighten the 1/2" -13 reinforcement bolts.

8. Install and tighten the oil drain plug. Tighten the plug (with nylon washer) to 25-35 lb-ft torque. Replenish the lubricating oil supply and, after the engine is started, check for leaks.

VENTILATING SYSTEM

Harmful vapors which may be formed within the engine are removed from the crankcase, gear train and valve compartment by a continuous, pressurized ventilating system.

A slight pressure is maintained in the engine crankcase by the seepage of a small amount of air from the airbox past the piston rings. This air sweeps up through the engine and is drawn off through a crankcase breather.

In-line engines are equipped with a breather assembly attached to the valve rocker cover (Fig. 1) or a breather assembly mounted on the flywheel housing (Fig. 2).

On 6V engines, a breather assembly is mounted on the upper engine front cover (Fig. 3).

The 8V engines have a breather tube attached to the valve rocker cover and a breather (with a filter pad) mounted on the governor. However, the marine engines did not include a filter pad until engine serial number 8D-2701 (Fig. 4). Early 8V engines were equipped only with a breather assembly mounted on the governor housing.

Service

It is recommended that the breather tube be inspected and cleaned, if necessary, to eliminate the possibility of clogging. This can best be done by removing the tube from the engine, washing it with a suitable solvent and drying it with compressed air.

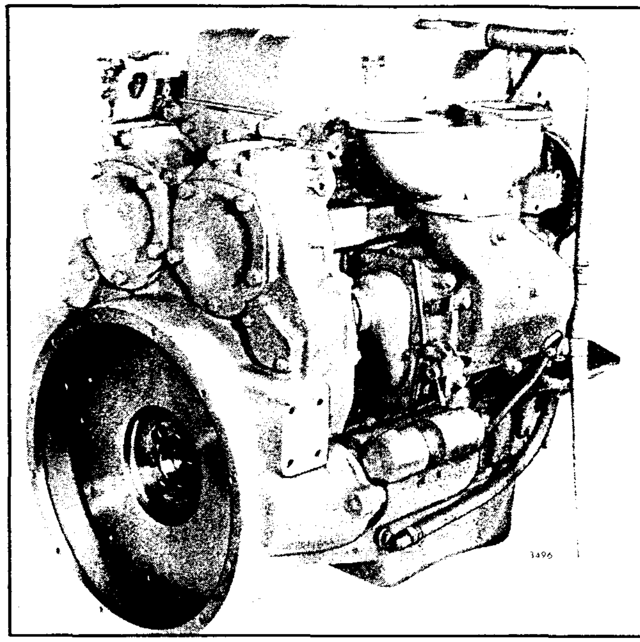

Fig. 1 - Typical Crankcase Breather Mounting (In-Line Engine)

The wire mesh pad (element) in the breather

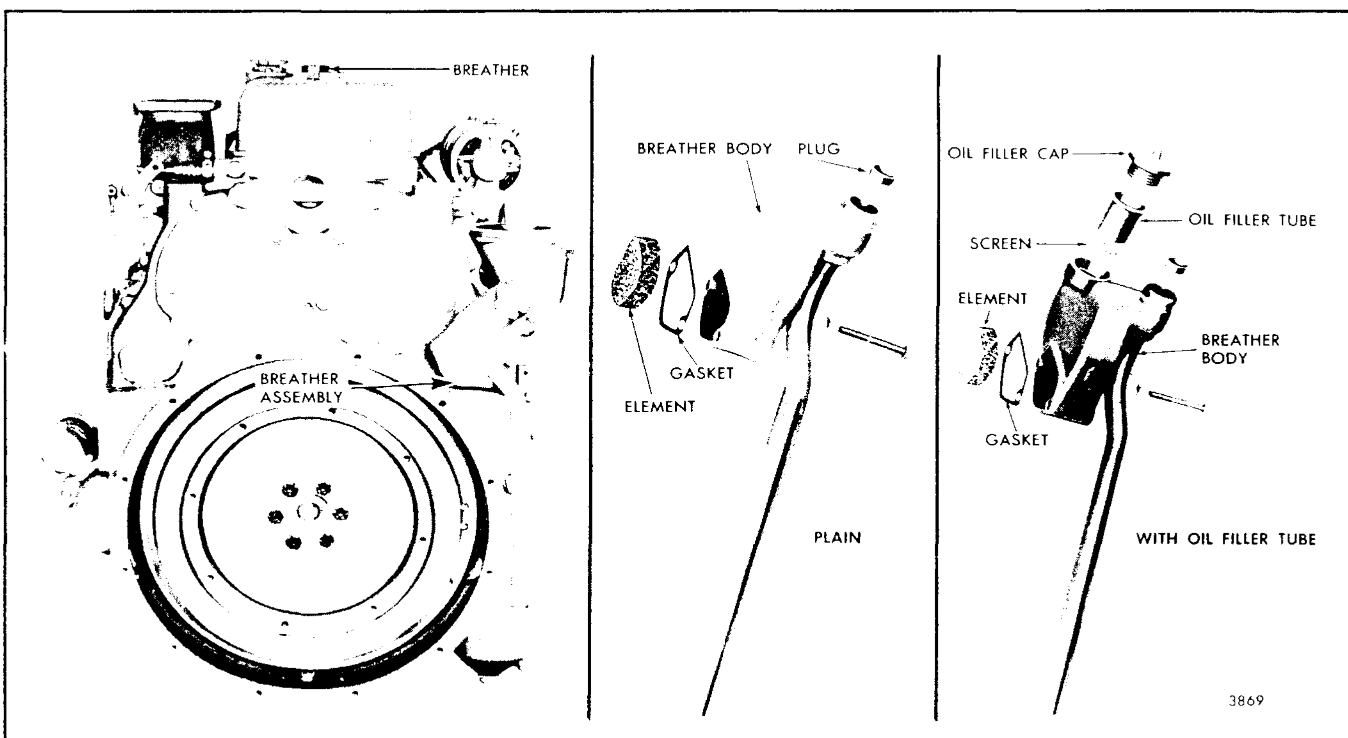

Fig. 2 - Crankcase Breather Mounting and Details (In-Line Engine)

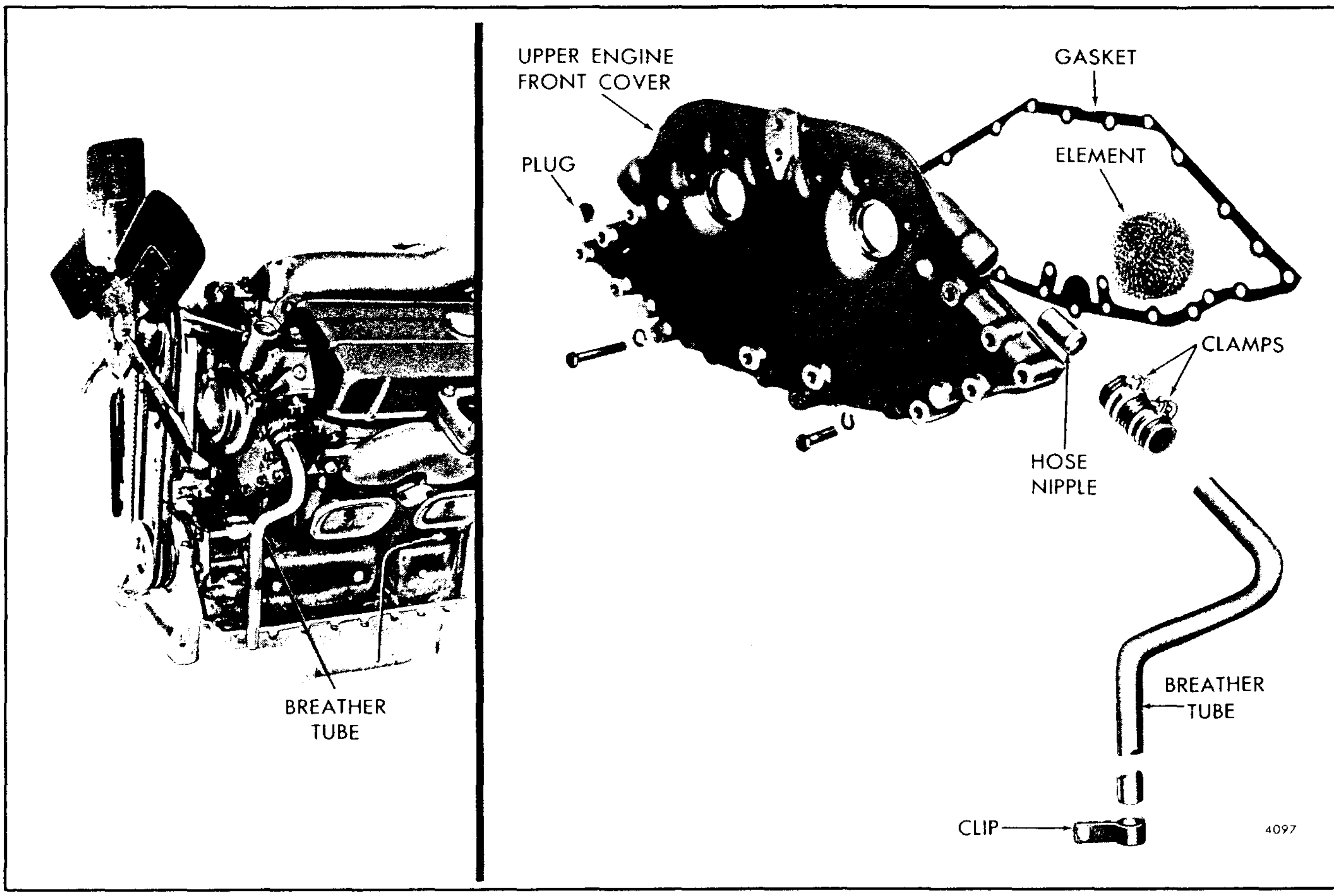

Fig. 3 - Typical Crankcase Breather Mounting and Details (6V-53 Engine)

assemblies should be cleaned if excessive crankcase pressure is observed.

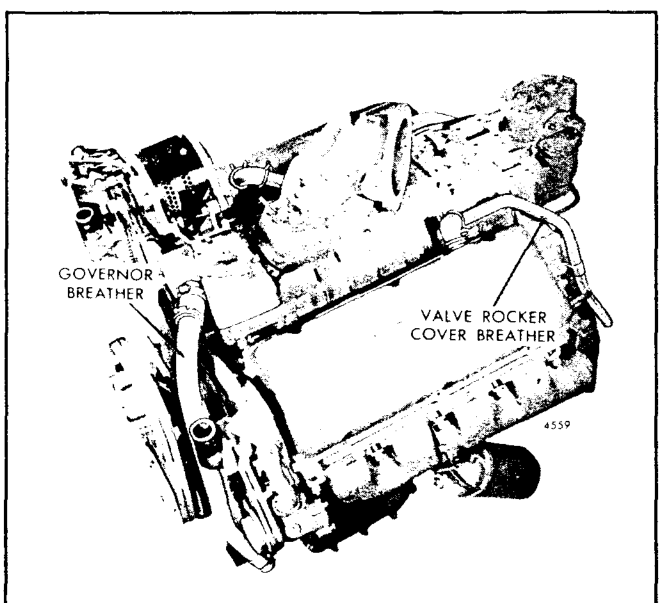

Fig. 4 - Typical Breather Mountings (8V-53 Engine)

If it is necessary to clean the element, remove the breather housing from the flywheel housing (In-line engines), or the upper front cover (6V engines), or the governor housing and/or valve rocker cover (8V engines).

Wash the element in fuel oil and dry it with compressed air.

Reinstall the element in the breather housing, the upper front cover or the governor housing and/or the valve rocker cover and install them by reversing the procedure for removal.

NOTE: When the limiting speed governor assembly or the governor housing is replaced on an early 8V engine, it will be necessary to include the current thicker breather element.

SHOP NOTES - SPECIFICATIONS - SERVICE TOOLS

SHOP NOTES

REWORK INSTRUCTIONS FOR 6V-53 OIL PUMP INLET TUBE SUPPORTS

When replacing the cylinder block or main bearing caps on an early engine, it will be necessary to either replace the oil inlet tube support or elongate the bolt holes in the support (Fig. 1) and use new support attaching parts.

In the old bearing caps, the holes were tapped 5/16" - 18 with 1.68" between centers. In the new bearing caps, the holes are tapped 3/8" - 16 with 2.24" between centers.

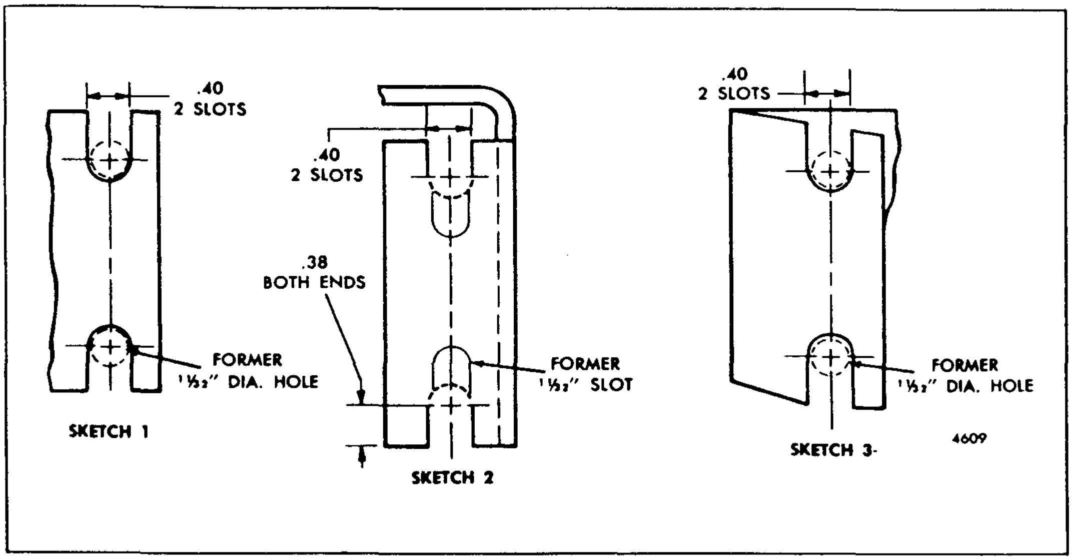

Fig. 1 - Oil Inlet Tube Supports

REWORKING 6V-53 CAST IRON OIL PAN FOR USE WITH CURRENT OIL PUMP INLET TUBE

When the seven hole upper main bearing shells (Section 1.3.4) are used in 6V marine engines prior to 6D-11074 and all 6V engines prior to 6D-17960, a 1-3/8" diameter lubricating oil pump inlet tube must be used rather than the former 1" diameter inlet tube. To conform with the increased diameter of the oil pump inlet tube, the cast iron oil pan must be reworked to provide installation clearance by reducing the height of the integral cast baffle approximately .44" (Fig. 2).

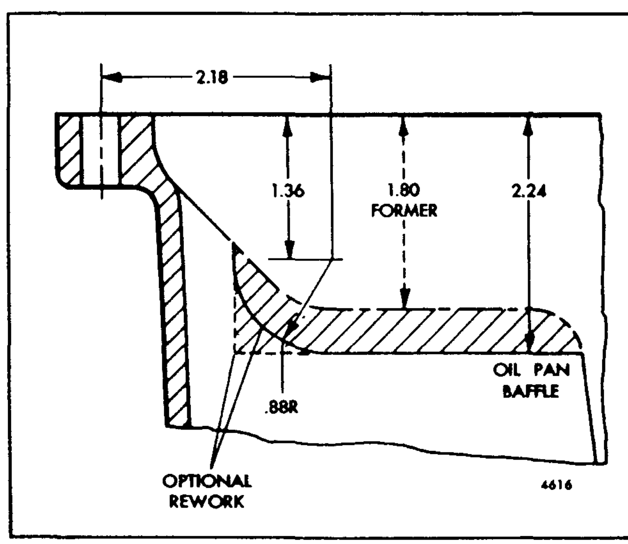

Fig. 2 - Rework Sketch for a Cast Iron Oil Pan

SPECIFICATIONS

STANDARD BOLT AND NUT TORQUE SPECIFICATIONS

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

EXCEPTIONS TO STANDARD BOLT AND NUT TORQUE SPECIFICATIONS

APPLICATION	TORQUE (lb-ft)
Oil filter center stud	40-50
Oil pan drain plug (Nylon washer) 18mm	25-35

SERVICE TOOLS

TOOL NAME	TOOL NO.
Crankshaft and oil pump gear puller	J 3051
Oil pump drive gear installer	J 8968-01
Oil pump drive gear adaptor	J 23126
Two-arm steel grip puller	J 8174

SECTION 5

COOLING SYSTEM

CONTENTS

Cooling System	5
Water Pump	5.1
Water Pump Idler Pulley Assembly	5.1.1
Thermostat	5.2.1
Radiator	5.3
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Raw Water Pump (Jabsco)	5.6
Coolant Filter and Conditioner	5.7
Specifications - Service Tools	5.0

COOLING SYSTEM

To effectively dissipate the heat generated by the engine, one of three different types of cooling systems is used on a Series 53 engine: radiator and fan, heat exchanger and raw water pump, or keel cooling. A centrifugal type water pump is used to circulate the engine coolant in each system. Each system incorporates thermostats to maintain a normal operating temperature of 160° - 185°F. Typical In-line and V-type engine cooling systems are shown in Figs. 1 and 2.

Radiator and Fan Cooling System

The engine coolant is drawn from the lower portion of the radiator by the water pump and is forced through the oil cooler and into the cylinder block.

From the cylinder block, the coolant passes up through the cylinder head(s) and, when the engine is at normal operating temperature, through the thermostat housing(s) and into the upper portion of the radiator. Then the coolant passes down a series of tubes where the coolant temperature is lowered by the air stream created by the revolving fan.

Upon starting a cold engine or when the coolant is below operating temperature, the coolant is restricted at the thermostat housing(s) and a by-pass provides water circulation within the engine during the warm-up period.

Heat Exchanger Cooling System

In the heat exchanger cooling system, the coolant is drawn by the fresh water pump from the lower portion of the expansion tank through the engine oil cooler, then through the engine the same as in the radiator and fan system. Upon leaving the thermostat housing, the coolant either passes through the heat exchanger core or by-passes the heat exchanger and flows directly to the water pump, depending on the coolant temperature.

While passing through the core of the heat exchanger, the coolant temperature is lowered by raw water, which is drawn by the raw water (sea water) pump from an outside supply. The raw water enters the heat exchanger at one side and is discharged at the opposite side.

To protect the heat exchanger element from electrolytic action, a zinc electrode is located in both

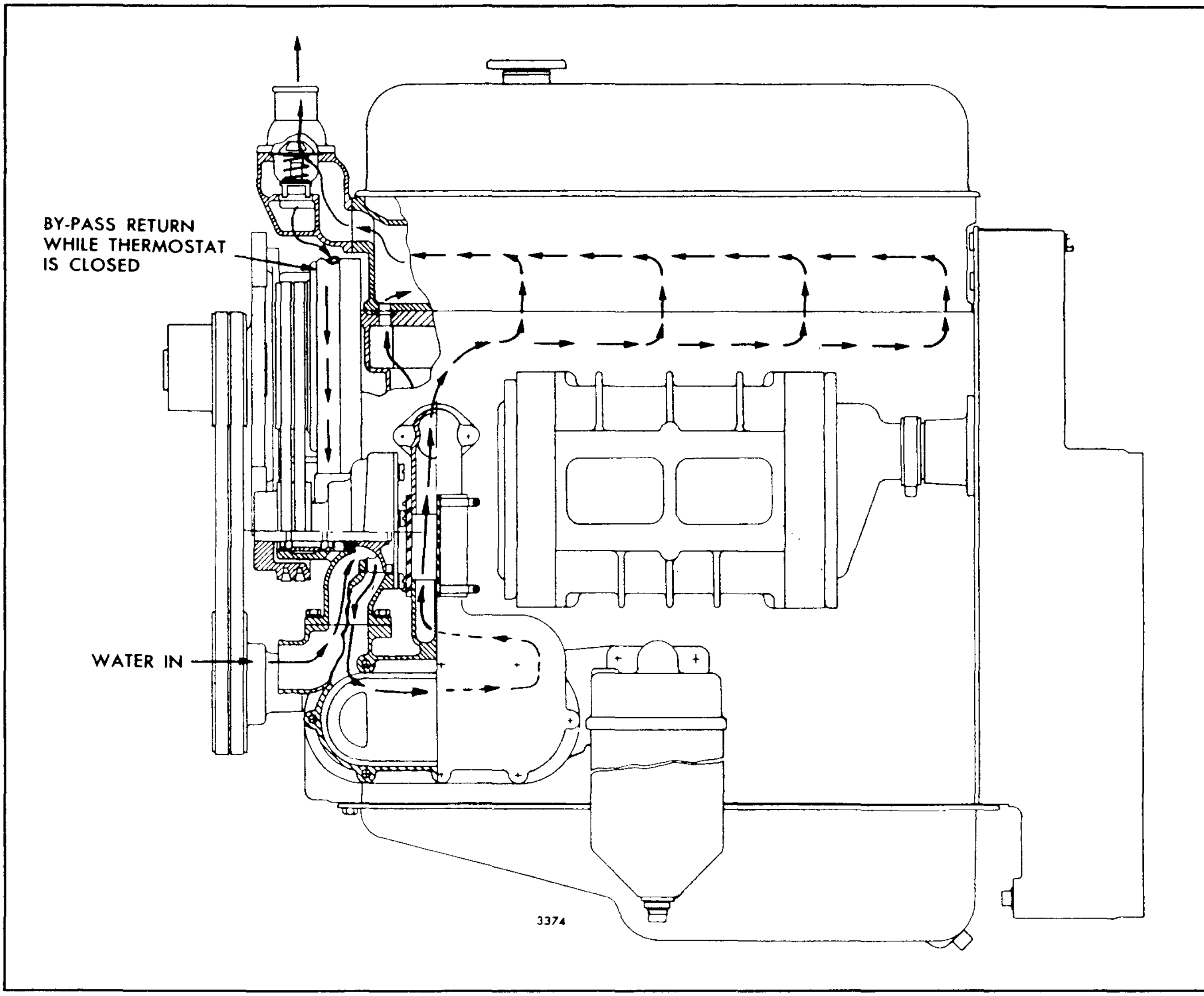

Fig. 1 - Typical Cooling System for an In-Line Engine

the heat exchanger inlet elbow and the raw water pump inlet elbow and extends into the raw water passage.

Keel Cooling System

The keel cooling system is similar to the heat exchanger system, except that the coolant temperature is reduced in the keel cooler. In this system the coolant is drawn by the fresh water pump from the lower portion of the expansion tank through the engine oil cooler. From the cooler the flow is the same as in the other systems. Upon leaving the thermostat housing, the coolant is by-passed directly to the lower portion of the expansion tank until the engine operating temperature, controlled by the thermostat, is reached. As the engine temperature increases, the coolant is directed to the keel cooler, where the temperature of the coolant is reduced before flowing back to the expansion tank.

ENGINE COOLING SYSTEM MAINTENANCE

Engine Coolant

The function of the engine coolant is to absorb the heat, developed as a result of the combustion process

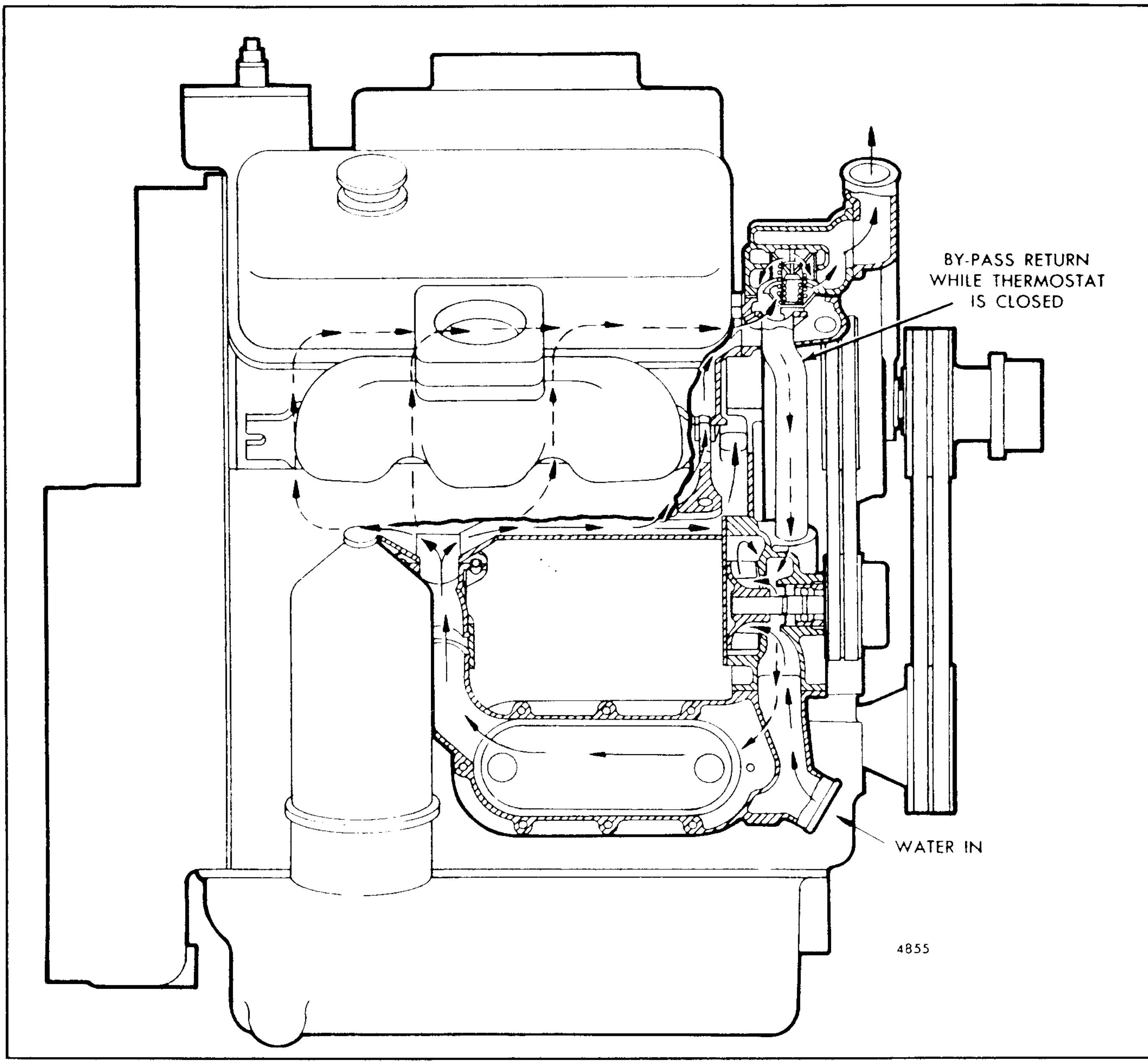

Fig. 2 - Coolant Flow Through a 6 or 8V Engine

in the cylinders, from component parts such as exhaust valves, cylinder liners and pistons which are surrounded by water jackets. In addition, the heat absorbed by the oil is also removed by the engine coolant when oil to water oil coolers are used. Refer to Section 13.3 for coolant recommendations.

Cooling System Capacity

The capacity of the basic engine cooling system (cylinder block, head, thermostat housing and oil cooler housing) is shown in the Table.

To obtain the complete amount of coolant in the cooling system of a unit, the additional capacity of the radiator, hoses, etc. must be added to the capacity of the basic engine. The capacity of the radiator and related equipment should be obtained from the equipment supplier, or the capacity of a particular cooling system may be determined by filling the system with water, then draining and measuring the amount required.

COOLING SYSTEM CAPACITY CHART (BASIC ENGINE)	
ENGINE	CAPACITY (Quarts)
2-53	6
3-53	8
4-53	9
6V-53	14
8V-53	20

Fill Cooling System

Before starting the engine, close all of the drain cocks and fill the cooling system with water. If the unit has a raw water pump, it should be primed, since operation without water may cause impeller failure. The use of clean, soft water will eliminate the need for de-scaling solutions to clean the cooling system. A hard mineral-laden water should be made soft by using water softener chemicals before it is poured into the cooling system. These water softeners modify the minerals in the water and greatly reduce or eliminate the formation of scale.

Start the engine and, after normal operating temperature has been reached, allowing the coolant to expand to its maximum, check the coolant level. The coolant level should be within 2 " of the filler neck.

Excessive amounts of air in the cooling system may hinder the flow of water due to pump cavitation or result in hot spots when air collects at low velocity points in the water passages. Therefore, whenever the cooling system is filled or make-up water is added, the air must be thoroughly vented from the system. The thermostat housing(s) on the Series 53 engines provides a vent hole to release the air to the atmosphere while the cooling system is being filled. In addition, the cooling system should be vented at the time normal operating temperature is reached after starting the engine and again after the engine has been in operation for 30 to 45 minutes.

Should a daily loss of coolant be observed, and there are no apparent leaks, there is a possibility of gases leaking past the cylinder head water seal rings into the cooling system. The presence of air or gases in the cooling system may be detected by connecting a rubber tube from the overflow pipe to a water container. Bubbles in the water in the container during engine operation will indicate this leakage. Another method for observing air in the cooling system is by inserting a transparent tube in the water outlet line.

COOLANT DRAIN VALVES		
Engine	Oil Cooler or Coolant Inlet Side of Block	Side of Block Opposite Oil Cooler or Coolant Inlet
2-53	Bottom of oil cooler or coolant inlet	*Water hole cover near front of block
3-53	Bottom of oil cooler and coolant inlet	Just forward of blower mounting pad
4-53	Bottom of oil cooler, coolant inlet, and behind blower drive or governor near rear of block	Behind blower drive or governor near rear of block
6V-53	Bottom of oil cooler, coolant inlet, and side of block near rear end	Water hole cover between hand hold covers and side of block near rear end
8V-53	Bottom of oil cooler, and side of block near rear end	Side of block near front end and below center of air box cover

*Most industrial units contain a 1/8" pipe plug at this location.

Drain Cooling System

Drain the cooling system by opening the cylinder block and radiator (or heat exchanger) drain cocks and removing the cooling system filler cap. Removal of the filler cap permits air to enter the cooling passages and the coolant to drain completely from the system.

Drain cocks are located as indicated in the coolant drain valve chart. Radiators that do not have a drain cock are drained through the oil cooler housing drain.

If freezing weather is anticipated and the engine is not protected by antifreeze, drain the cooling system completely when the engine is not in use. Leave all of the drain cocks open until the cooling system is refilled. Should any entrapped water in the cylinder block, radiator or other engine parts freeze, it will expand and may result in damage to the engine.

Marine engine exhaust manifolds are cooled by the same coolant used in the engine. Whenever the engine cooling system is drained, open the exhaust manifold drain cocks.

Raw water pumps are drained by loosening the cover attaching screws and tapping the cover gently to loosen it. After the water has drained, tighten the screws.

Flushing

If a coolant filter is used and properly maintained, the cooling system need not be flushed. Otherwise, the cooling system should be flushed each spring and fall. The flushing operation cleans the system of antifreeze solution in the spring and removes the summer rust inhibitor in the fall, cleaning the system for the next solution. The flushing operation should be performed as follows:

1. Drain the previous season's solution from the engine.

2. Refill with soft clean water.

> **CAUTION:** If the engine is hot, fill slowly to prevent rapid cooling and distortion of the engine castings.

3. Start the engine and operate it for 15 minutes to thoroughly circulate the water.

4. Drain the unit completely.

5. Refill with the solution required for the coming season.

Cooling System Cleaners

If the engine overheats, and the fan belt tension and water level have been found to be satisfactory, clean and flush the entire cooling system. Remove scale formation by using a reputable and safe descaling solvent. Immediately after using the de-scaling solvent, neutralize the system with the neutralizer. It is important that the directions printed on the container of the descaler be thoroughly read and followed.

After the solvent and neutralizer have been used, completely drain the engine and radiator and reverse-flush before filling the system.

Reverse-Flushing

After the engine and radiator have been thoroughly cleaned, they should be reverse-flushed. The water pump should be removed and the radiator and engine reverse-flushed separately to prevent dirt and scale deposits clogging the radiator tubes or being forced through the pump. Reverse-flushing is accomplished by hot water, under air pressure, being forced through the cooling system in a direction opposite to the normal flow of coolant, loosening and forcing scale deposits out.

The radiator is reverse-flushed as follows:

1. Remove the radiator inlet and outlet hoses and replace the radiator cap.

2. Attach a hose at the top of the radiator to lead water away from the engine.

3. Attach a hose to the bottom of the radiator and insert a flushing gun in the hose.

4. Connect the water hose of the gun to the water outlet and the air hose to the compressed air outlet.

5. Turn on the water and, when the radiator is full, turn on the air in short blasts, allowing the radiator to fill between air blasts.

> **CAUTION:** Apply air gradually. Do not exert more than 30 psi air pressure. Too great a pressure may rupture a radiator tube.

6. Continue flushing until only clean water is expelled from the radiator.

The cylinder block and cylinder head water passages are reverse-flushed as follows:

1. Remove the thermostats and the water pump.

2. Attach a hose to the water inlet of the cylinder block to drain the water away from the engine.

3. Attach a hose to the water outlet at the top of the cylinder block and insert the flushing gun in the hose.

4. Turn on the water and, when the water jackets are filled, turn on the air in short blasts, allowing the engine to fill with water between air blasts.

5. Continue flushing until the water from the engine runs clean.

If scale deposits in the radiator cannot be removed by chemical cleaners or reverse-flushing as outlined above, it may be necessary to remove the upper tank and rod out the individual radiator tubes with flat steel rods. Circulate water through the radiator core from the bottom to the top during this operation.

Miscellaneous Cooling System Checks

In addition to the above cleaning procedures, the other components of the cooling system should be checked periodically to keep the engine operating at peak efficiency. The cooling system hoses, thermostats and radiator pressure cap should be checked and replaced if found to be defective.

When water connection seals and hoses are installed, be sure the connecting parts are properly aligned and the seal or hose is in its proper position before tightening the clamps. All external leaks should be corrected as soon as detected.

The fan belt must be checked and adjusted, if necessary, to provide the proper tension and the fan shroud must be tight against the radiator core to prevent recirculation of air which may lower the cooling efficiency.

Contaminated Engines

When the engine cooling or lubricating system becomes contaminated, it should be flushed thoroughly to remove the contaminants before the engine is seriously damaged. One possible cause of such contamination, that is damaging to the engine if it is not corrected immediately, is a cracked oil cooler core. With a cracked oil cooler core, oil will be forced into the cooling system while the engine is operating, and when it is stopped, coolant will leak into the lubricating system.

Coolant contamination of the lubricating system is especially harmful to engines during the cold season when the cooling system is normally filled with an ethylene glycol antifreeze solution. If mixed with the oil in the crankcase, this antifreeze forms a varnish which quickly immobilizes moving engine parts.

To remove such contaminants from the engine, both the cooling system and the lubrication system must be thoroughly flushed as follows:

COOLING SYSTEM

If the engine has had a failure resulting in the contamination of the cooling system with lubricating oil, the following procedure is recommended.

1. Prepare a mixture of Calgon, or equivalent, and water at the rate of two ounces (dry measure) to one gallon of water.

2. Remove the engine thermostats to permit the Calgon and water mixture to circulate through the engine and the radiator or heat exchanger.

3. Fill the cooling system with the Calgon solution.

4. Run the engine for five minutes.

5. Drain the cooling system.

6. Repeat Steps 3 through 5.

7. Fill the cooling system with clean water.

8. Let the engine run five minutes.

9. Drain the cooling system completely.

10. Install the engine thermostats.

11. Close all of the drains and refill the engine with fresh coolant.

LUBRICATION SYSTEM

When the engine lubricating system has been contaminated by an ethylene glycol antifreeze solution or other soluble material, the following cleaning procedure, using Butyl Cellosolve, or equivalent, is recommended.

> **CAUTION:** Use extreme care in the handling of these chemicals to prevent serious injury to the person or damage to finished surfaces. Wash off spilled fluid immediately with clean water.

If the engine is still in running condition, proceed as follows:

1. Drain all of the lubricating oil.

2. Remove and discard the oil filter element. Clean and dry the filter shell and replace the element.

3. Mix two parts of Butyl Cellosolve, or equivalent, with one part SAE 10 engine oil. Fill the engine crankcase to the proper operating level with the mixture.

4. Start and run the engine at a fast idle (1,000 to 1,200 rpm) for 30 minutes to one hour. Check the oil pressure frequently.

5. After the specified time, stop the engine and immediately drain the crankcase and the filter. *Sufficient time must be allowed to drain all of the fluid.*

6. Refill the crankcase with SAE 10 oil after the drain plugs are replaced, and run the engine at the same fast idle for ten or fifteen minutes and again drain the oil thoroughly.

7. Remove and discard the oil filter element, clean the filter shell and install a new element.

8. Replace the drains and fill the crankcase to the proper level with the oil recommended for normal engine operation.

9. To test the effectiveness of the cleaning procedure, it is recommended that the engine be started and run at a fast idle (1,000 to 1,200 rpm) for approximately 30 minutes. Then stop and immediately restart the

engine. There is a possibility that the engine is not entirely free of contaminant deposits if the starting speed is slow.

10. If the procedures for cleaning the lubricating oil system were not successful, it will be necessary to disassemble the engine and to clean the affected parts thoroughly.

Make certain that the cause of the internal coolant leak has been corrected before returning the engine to service.

WATER PUMP

A centrifugal-type water pump (Fig. 1) is mounted on top of the engine oil cooler housing as shown in Fig. 2. It circulates the coolant through the oil cooler, cylinder block, cylinder head(s) and radiator.

The pump is belt driven by either the camshaft or balance shaft (In-line engines) or by one of the camshafts (V-type engine).

An impeller is pressed onto one end of the water pump shaft, and a water pump drive pulley is pressed onto the opposite end. The pump shaft is supported on a sealed double-row combination radial and thrust ball bearing. Coolant is prevented from creeping along the shaft toward the bearing by a seal. The shaft and bearing constitute an assembly, and are serviced as such, since the shaft serves as the inner race of the ball bearing.

The sealed water pump shaft ball bearing is filled with lubricant when assembled. No further lubrication is required.

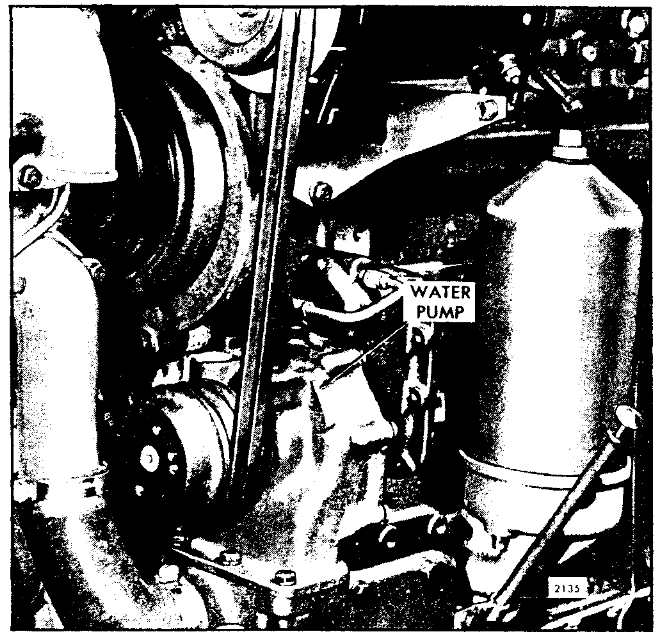

Fig. 2 - Typical Water Pump Mounting

NOTE: An idler pulley is used on some engines to adjust the water pump drive belt tension.

Remove Water Pump

1. Remove the radiator cap, open the block and radiator drain cocks, and drain the cooling system.

2. Loosen and remove the water pump belts.

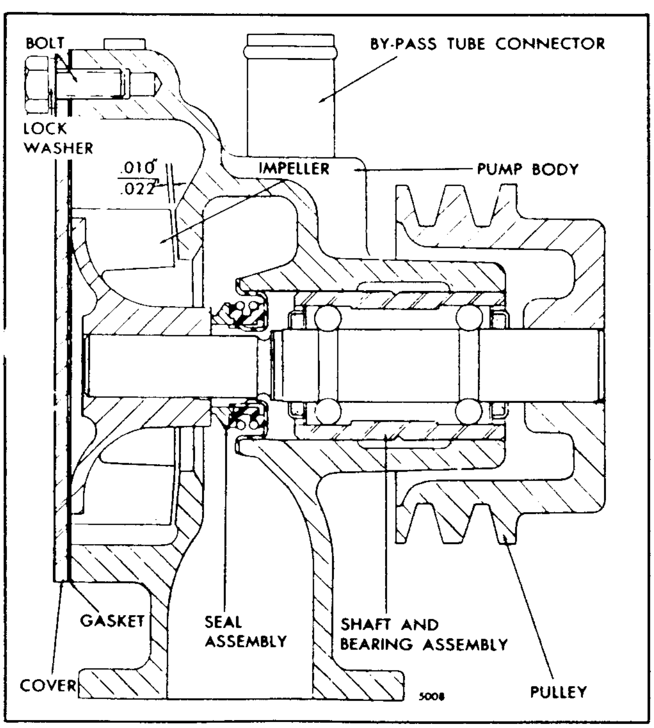

Fig. 1 - Water Pump Assembly

3. Loosen the hose clamps and slide the hose up on the water by-pass tube.

4. Remove the five bolts securing the water pump to the oil cooler housing and take off the pump.

Disassemble Pump

1. Note the position of the pulley on the shaft so that the pulley can be reinstalled in the same position when the pump is reassembled. Remove the water pump pulley as shown in Fig. 3.

2. Remove the pump cover and discard the gasket.

3. Press the shaft and bearing assembly, seal, and impeller out of the pump body as an assembly, by applying pressure on the bearing outer race with remover J 1930.

CAUTION: The bearing will be damaged if the pump is disassembled by pressing on the end of the pump shaft.

4. Press the end of the shaft out of the impeller as shown in Fig. 4, using plates J 8329 and holder J 358-1.

5. Remove the seal assembly from the pump shaft and discard it.

Inspection

Wash all of the pump parts, except the bearing and shaft assembly, in clean fuel oil and dry them with compressed air.

> **NOTE:** A permanently sealed and lubricated bearing is used in the bearing and shaft assembly and should not be washed. Wipe the bearing and shaft assembly with a clean lintless cloth.

Examine the impeller for damage and excessive wear on the impeller face which contacts the seal. Replace the impeller if it is worn or damaged.

Discard the bearing if it has a general feeling of roughness, is tight or has indications of damage.

Assemble Pump

1. Use installer J 1930 to apply pressure to the outer race of the bearing as shown in Fig. 5 and press the shaft and bearing assembly into the pump body until the outer race of the bearing is flush with the outer face of the body.

> **CAUTION:** The bearing will be damaged if the bearing and shaft assembly is installed by applying pressure on the end of the shaft.

2. Lightly coat the outside diameter of the new seal with sealing compound. Then, with the face of the body and the bearing outer race supported, install the seal by applying pressure on the seal outer flange only, until the flange contacts the body (Fig. 1). Wipe the face of the seal with a chamois to remove all dirt and metal particles.

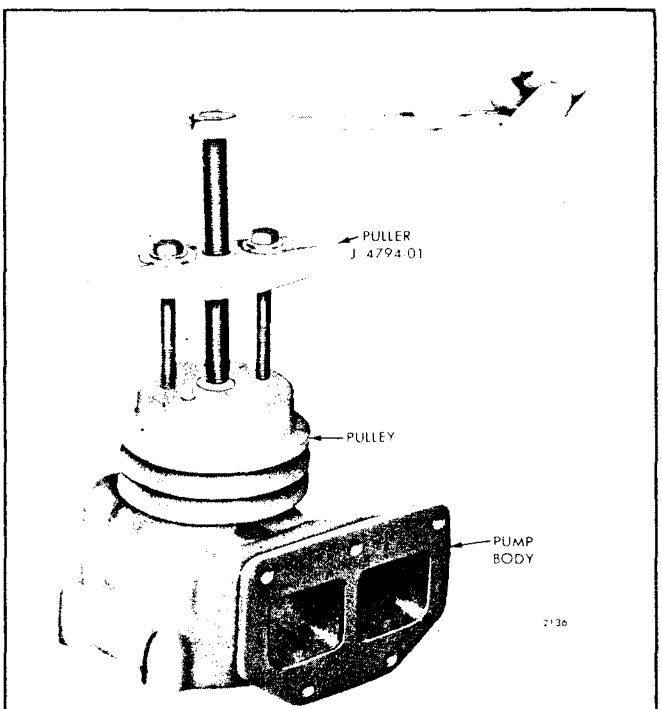

Fig. 3 - Removing Pulley

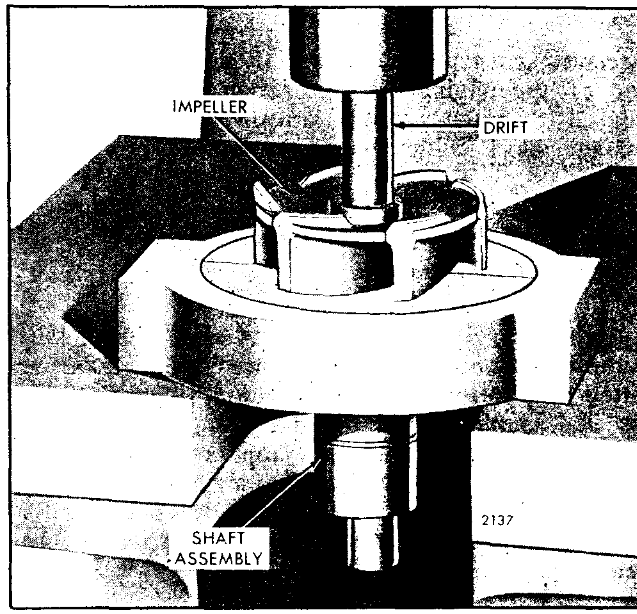

Fig. 4 - Removing Shaft from Impeller with Tools J 8329 and J 358-1

3. Support the pulley end of the shaft on the bed of an arbor press and press the impeller on the shaft until the impeller is flush with the large end of the body.

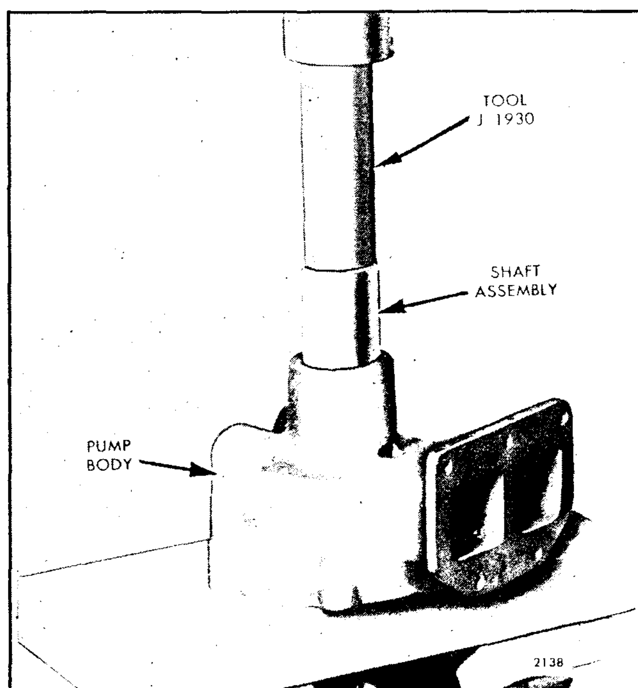

Fig. 5 - Pressing Shaft Assembly into Water Pump

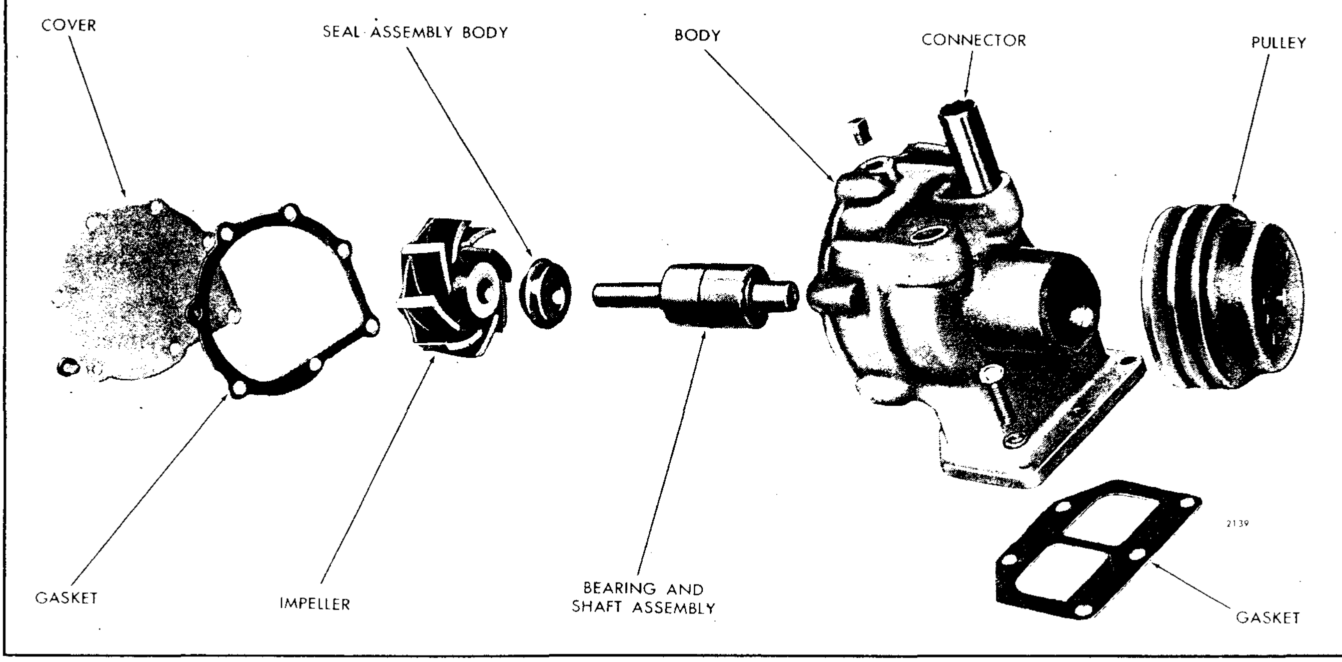

Fig. 6 - Fresh Water Pump Details and Relative Location of Parts

4. Place the pulley on the bed of an arbor press. Place a suitable rod between the ram of the press and the impeller end of the shaft, then press the shaft into the pulley until the pulley is in its original position on the shaft.

5. Install the cover and a new gasket on the pump body. Tighten the cover bolts to 6-7 lb-ft torque.

6. Run the pump dry at 1200 rpm for a minimum of 30 seconds, or as required, to assure satisfactory seating of the seal.

Install Water Pump

1. Affix a new gasket to the flange of the water pump body.

2. Secure the water pump to the oil cooler housing with the five bolts and lock washers.

3. Install the hose between the water pump and water by-pass tube and tighten the hose clamps.

4. Install and tighten the belts.

NOTE: An idler pulley is used on some engines to adjust the water pump drive belt tension.

5. Close all of the drain cocks and refill the cooling system.

6. Start the engine and check for leaks.

FRESH WATER PUMP WITH CERAMIC INSERT IN IMPELLER

Effective with engine serial numbers 2D-27598, 3D-64888, 4D-66635, 6D-66897 and 8D-3815, current water pump assemblies used on Series 53 engines include an impeller and ceramic insert combination (Figs. 7 and 8). Disassembly and assembly of the current water pump is the same as the former water pump except as follows:

When removing the impeller protect the ceramic insert from damage at all times during pump overhaul. Always lay the impeller on the bench with the ceramic insert up to prevent damage to the insert.

Inspect the ceramic insert for cracks, scratches and bond to the impeller. If the insert is damaged, it may be replaced in the following manner:

1. Bake the used ceramic insert and impeller assembly at 500°F. for one hour to remove the ceramic insert. The ceramic insert can be removed easily from the counterbore while the adhesive is hot. Wire brush the impeller bond area to remove the old adhesive, oxide, scale, etc.

2. Wipe the impeller bond area and the grooved side of the new ceramic insert with a cloth soaked in a

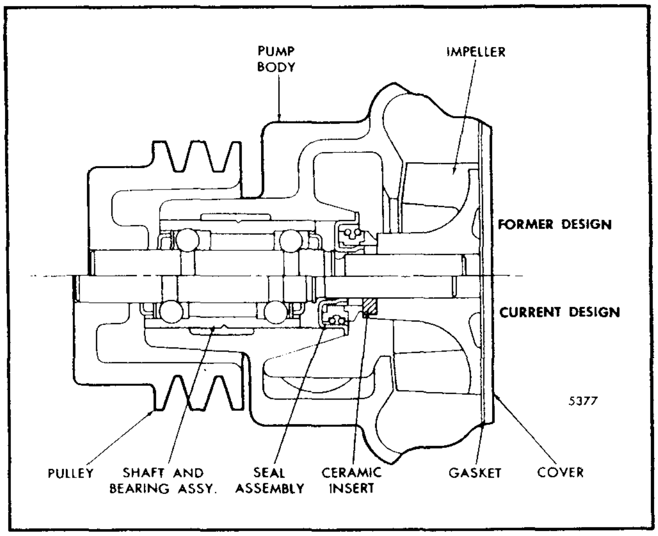

Fig. 7 · Comparison of Water Pumps

common solvent such as alcohol. Wipe clean with a dry cloth.

3. Place the adhesive washer in the impeller bond area with the ceramic insert on top. The polished face of the ceramic insert should be visible to the assembler. Clamp the ceramic insert and impeller together with a 3/8" bolt and nut and two smooth 1/8" thick washers. Tighten the bolt to 10 lb-ft torque.

CAUTION: Do not mar the polished surface of the ceramic insert.

4. Place the impeller assembly in a level position, with the ceramic insert up, in an oven preheated to 350°F. and bake it for one hour.

NOTE: The face of the ceramic insert must be square with the axis of the tapered bore within .004". The pump shaft may be used as a mandrel for inspection.

5. Remove the impeller from the oven and, after it has cooled to room temperature, install it in the pump. Do not loosen the clamping bolt until the assembly cools. Make sure the mating surfaces of the water seal and the ceramic insert are free of dirt, metal particles and oil film.

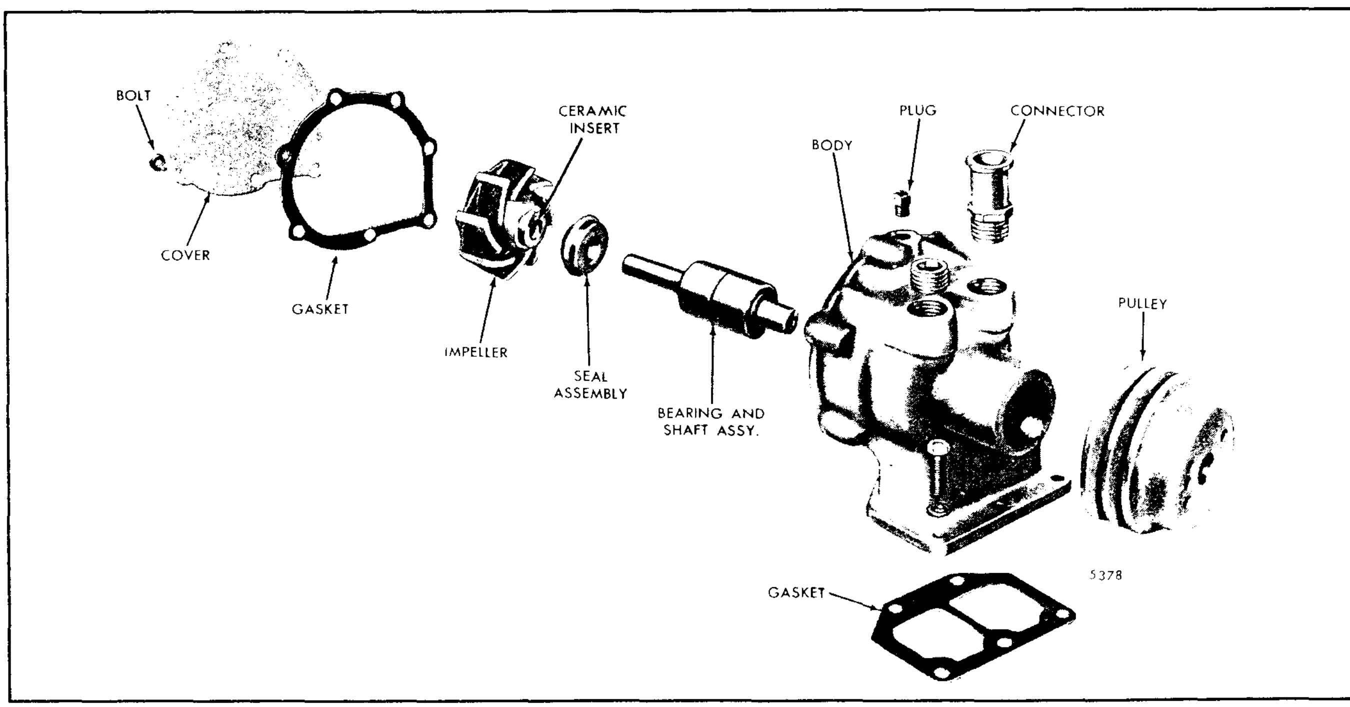

Fig. 8 · Details of Water Pump with Ceramic Seal

FRESH WATER PUMP IDLER PULLEY ASSEMBLY

The fresh water pump idler pulley assembly is mounted on the upper engine front cover (Fig. 1).

Remove Idler Pulley Assembly

Remove the two attaching bolts and lift the pulley assembly away from the front cover and drive belts.

Disassemble Idler Pulley Assembly

1. Support the pulley, then press the shaft and bearing assembly and bracket from the pulley by applying pressure to the outer race of the bearing (Fig. 2).

2. Support the bracket, then press the shaft and bearing assembly from the idler pulley bracket by applying pressure on the shaft only.

Inspection

Wash the idler pulley bracket and pulley in clean fuel oil and dry them with compressed air. The idler pulley shaft and bearing assembly must not be washed in fuel oil. If the bearing is immersed in cleaning fluid, dirt may be washed in and the fluid and dirt could not be entirely removed from the bearing.

Examine the bracket and pulley for excessive wear or cracks.

Revolve the shaft slowly in the bearing by hand. If rough or tight spots are detected, the bearing and shaft assembly must be replaced.

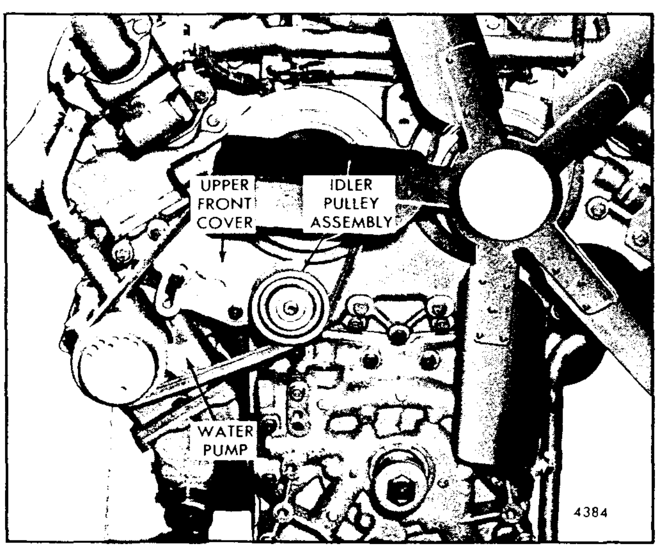

Fig. 1 - Typical Fresh Water Pump Idler Pulley Mounting

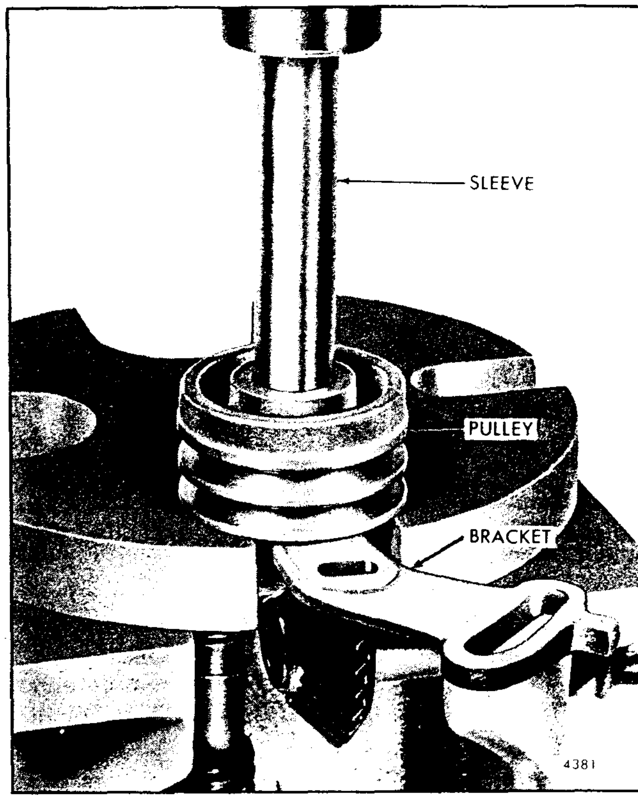

Fig. 2 - Removing Shaft and Bearing Assembly and Bracket from Idler Pulley

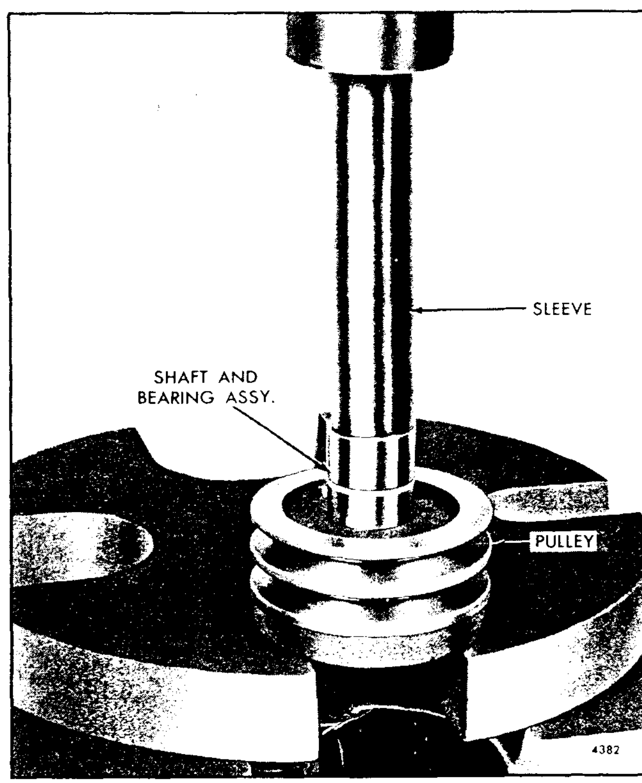

Fig. 3 - Installing Shaft and Bearing Assembly in Idler Pulley

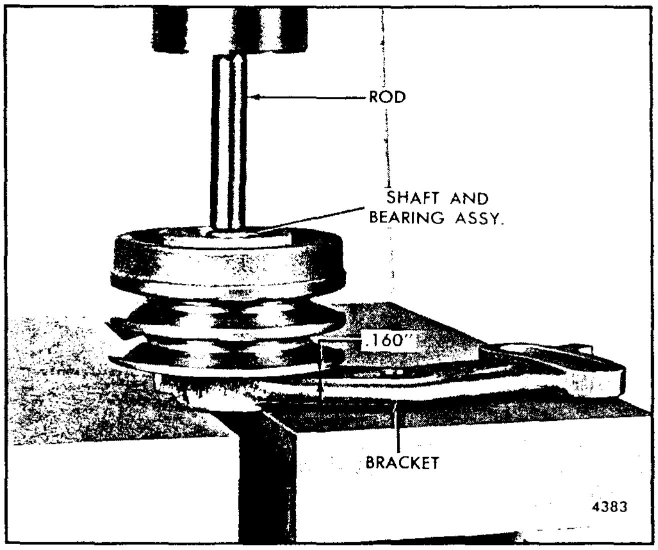

Fig. 4 - Installing Shaft and Bearing Assembly and Pulley in Bracket

On early engines, if the bracket or bearing assembly requires replacement, the complete idler pulley assembly must be replaced. The bearing bore diameter on the current bracket is .6237" -.6247". On the former bracket, the bearing bore diameter is .6242" - .6252".

Assemble Idler Pulley Assembly

1. Apply a minimum of 2500 lbs pressure only on the outer race of the bearing as shown in Fig. 3 and press the bearing and shaft assembly into the idler pulley until the outer race of the bearing is flush with the inside surface of the pulley.

2. With a short rod, apply pressure on the shaft only (Fig. 4) and press the shaft and bearing assembly with the pulley into the idler pulley bracket. The distance between the outer edge of the pulley and the bracket must be .160".

Install Idler Pulley Assembly

1. Attach the idler pulley assembly to the front cover with two bolts and lock washers.

2. Install the water pump drive belts.

3. Adjust the idler pulley assembly so that the drive belts have the proper tension and tighten the bolts.

THERMOSTAT

The temperature of the In-line engine coolant is controlled by a single choke type thermostat located in a housing attached to the water outlet end of the cylinder head. Two by-pass type thermostats are used in the V-type engines, one at each cylinder head.

The by-pass system on the V-type engine consists of a cross-over tube connecting the two thermostat housings and an outlet tube attached between one thermostat housing and the water pump (Fig. 1). On the In-line engines, a by-pass tube is attached between the thermostat housing and the water pump.

At coolant temperatures below approximately 170°F., the thermostat valve remains closed and blocks the flow of coolant through the radiator or heat exchanger. During this period, the coolant circulates through the cylinder block and head and then back to the suction side of the pump via the by-pass tube. As the coolant temperature rises, the thermostat valve begins to open, restricting the by-pass system and permits the coolant to circulate through the radiator or heat exchanger. When the valve is fully open, the by-pass system of the V-type engine is completely blocked off and all of the coolant circulates through the radiator. However, with the valve fully opened in the in-line engine, a very small portion of the coolant will continue to circulate through the by-pass tube, while the major portion will pass through the radiator.

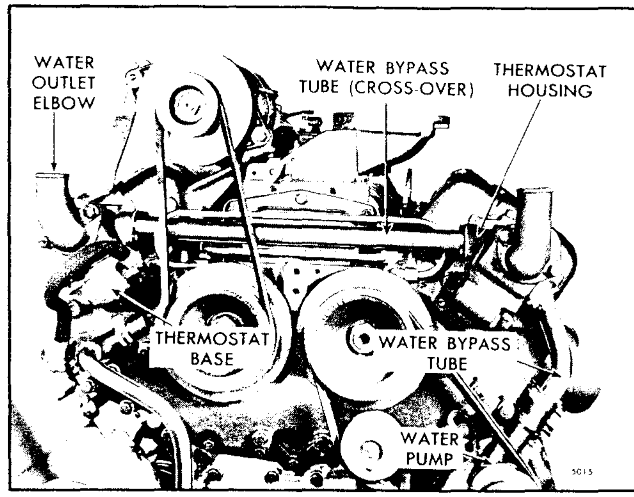

Fig. 1 -Thermostat Housings Mounted on a 6V Engine

A properly operating thermostat is essential for efficient operation of the engine. If the engine operating temperature deviates from the normal range of 160°F - 185°F., remove and check the thermostat(s).

Remove Thermostat

1. Drain the cooling system to the necessary level by opening the drain valves.

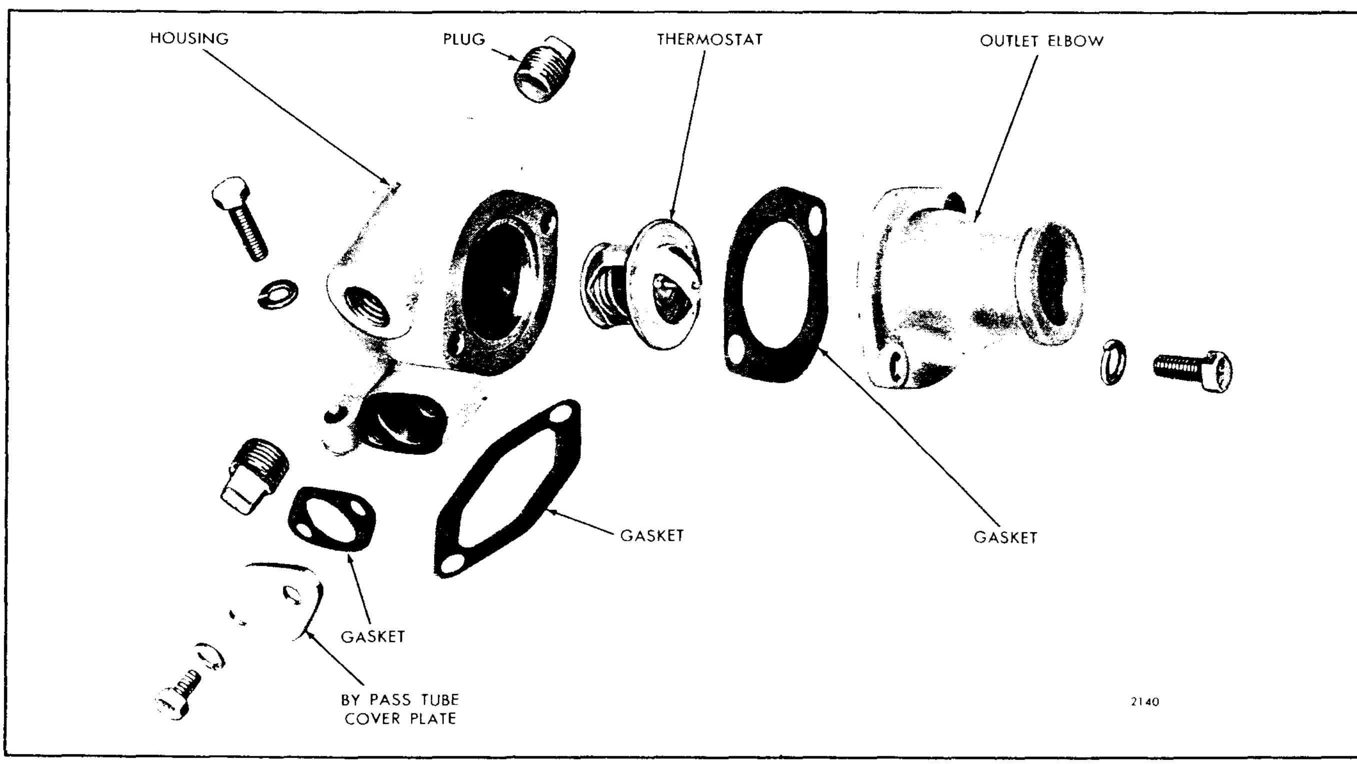

Fig. 2 - Thermostat Housing Details and Relative Location of Parts (In-Line Engine)

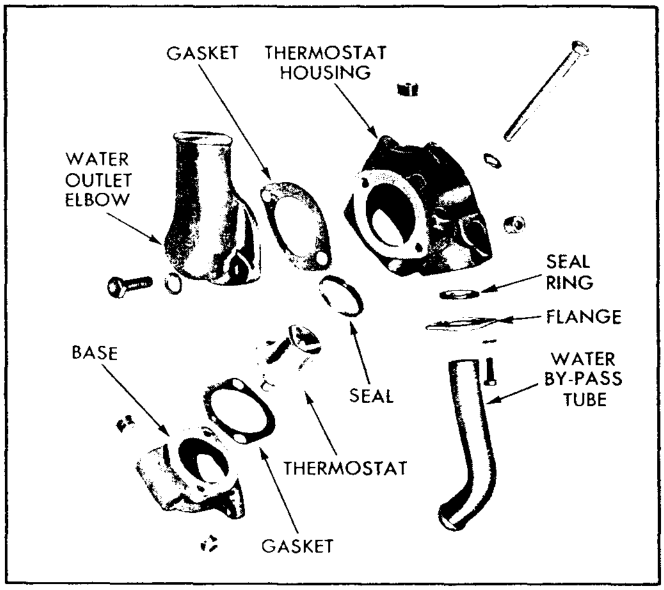

Fig. 3 - Thermostat Housing Details and Relative Location of Parts (V-Type Engine)

2. Remove the hose connections between the thermostat housing water outlet elbow and the radiator or heat exchanger.

3. Loosen the bolts and remove the water outlet elbow from the thermostat housing on the in-line engine (Fig. 2). Take out the thermostat.

4. On the V-type engine, remove the cross-over by-pass tube which is located between the thermostat housings. Also, disconnect the by-pass tube between the water pump and the thermostat housing (Fig. 3). Remove the gaskets. Then loosen the bolts and remove the thermostat housings from their bases. Remove the thermostats and remove and discard the thermostat seals.

Inspection

If the action of the thermostat has become impaired due to accumulated rust and corrosion from the engine coolant so that it remains closed, or only partially open, thereby restricting the flow of water, overheating of the engine will result. A thermostat which is stuck in a wide open position may not permit the engine to reach its normal operating temperature. The incomplete combustion of fuel due to cold operation will result in a build-up of carbon deposits on the pistons, rings and valves.

The operation of the thermostat may be checked by immersing it in a container of hot water (Fig. 4). Place a thermometer in the container, but do not allow it to touch the bottom. Agitate the water to maintain an even temperature throughout the container. As the water is heated, the thermostat valve should begin to open when the temperature reaches 167° - 172°F. (In-line engine) or 174° - 176°F. (V-engine). The opening temperature is usually stamped on the thermostat. The thermostat should be fully open at approximately 190° - 192°F.

Clean the thermostat seating surface in the thermostat housing and base or the water outlet elbow.

Check the bleed hole in the thermostat housing to be sure it is open (Fig. 5).

> **NOTE:** The early 6V-53 thermostat housing had three bleed holes. Current housings have one bleed hole. If an excessively long warm-up period is encountered with the former thermostat housing (three bleed holes), plug two of the bleed holes with No. 4 drive screws.

Drill a 3/32" diameter hole in the thermostat housing used on in-line industrial engines built prior to serial number 2D-603, 3D-011 or 4D-094 (refer to Fig. 6). This will provide a coolant drain hole for the by-pass cavity in the housing.

Install Thermostat

Refer to Figs. 2 and 3 and install the thermostat(s) as follows:

IN-LINE ENGINE:

1. Place a new gasket on the thermostat housing.

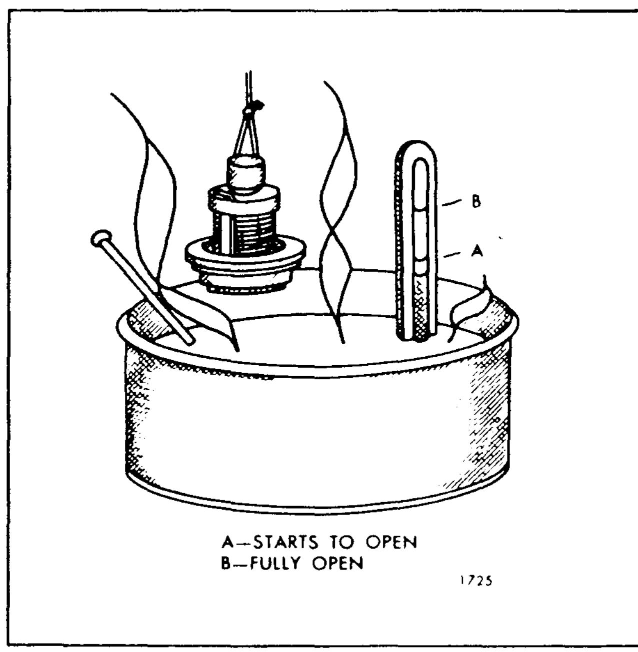

Fig. 4 - Method of Checking Thermostat Operation

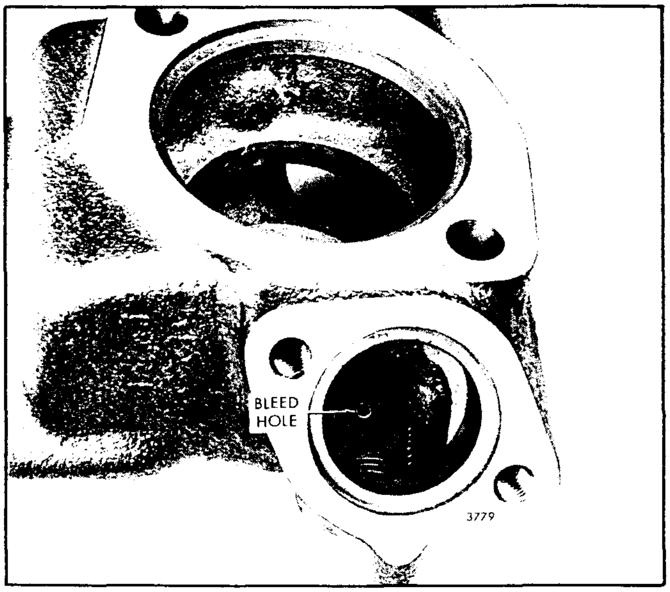

Fig. 5 - Bleed Hole in Thermostat Housing (V-Type Engine Housing Shown)

2. Insert the thermostat into the housing.

3. Install the water outlet elbow and secure it to the housing with two bolts and lock washers.

4. Connect the hose from the radiator or heat exchanger to the water outlet elbow, align and tighten the hose clamps.

V-TYPE ENGINE:

1. Install new seals in the thermostat housings. Position the seals so the lips face away from the thermostats. Press the seals in with seal installer J 22091 and handle J 7092-2.

2. Place a new gasket on each thermostat housing base.

3. Insert a thermostat in each base.

4. Install the thermostat housings and secure the housings with bolts and lock washers.

CAUTION: Exercise care to prevent damaging the thermostat seals.

5. Place new seals on the cross-over by-pass tube; then, reinstall the tube.

6. Use new gaskets and attach the water outlet elbows to the thermostat housings; secure them with bolts and lock washers.

7. Place a new seal ring on the upper end of the by-pass tube and install the tube between the thermostat housing and the water pump.

8. Install the hoses between the radiator or heat exchanger and the water outlet elbows and secure them with the hose clamps.

After the thermostats have been installed, close all of the drain cocks and fill the cooling system. Vent the system as outlined in Section 5. Then start the engine and check for leaks.

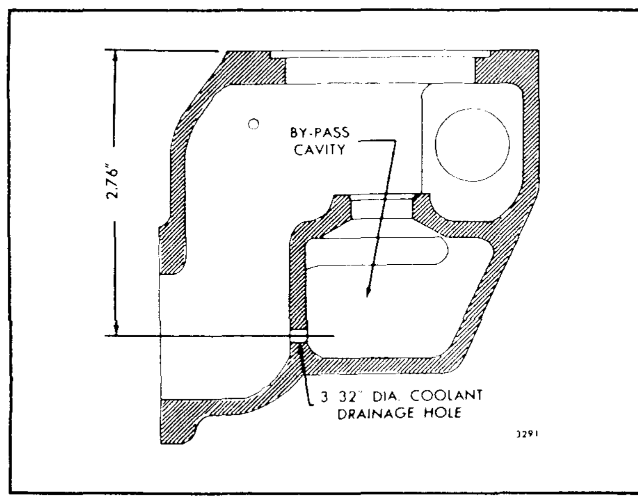

Fig. 6 - Cross-Section of Thermostat Housing (Early Industrial In-Line Engine)

RADIATOR

The temperature of the coolant circulating through the engine is lowered by the action of the radiator and the fan. The radiator is mounted in front of the engine so that the fan will draw air through it, thereby lowering and maintaining the coolant temperature to the degree necessary for efficient engine operation.

The life of the radiator will be considerably prolonged if the coolant used is limited to either clean, soft water and a rust inhibitor or a mixture of water and a high boiling point type antifreeze (refer to Section 13.3). The use of any other type of antifreeze is not recommended.

To increase the cooling efficiency of the radiator, a metal shroud is placed around the fan. The fan shroud must be fitted airtight against the radiator to prevent re-circulation of the hot air drawn through the radiator. Hot air which is permitted to pass around the sides or bottom of the radiator and is again drawn through the radiator will cause overheating of the engine.

Another cause of overheating is slippage of the fan drive belts which is caused by incorrect belt tension, worn belts or worn fan belt pulley grooves, or the use of fan belts of unequal length when two or more belts are used. The belt tension and condition of the belts should be checked periodically. Refer to *Preventive Maintenance*, Section 15.1.

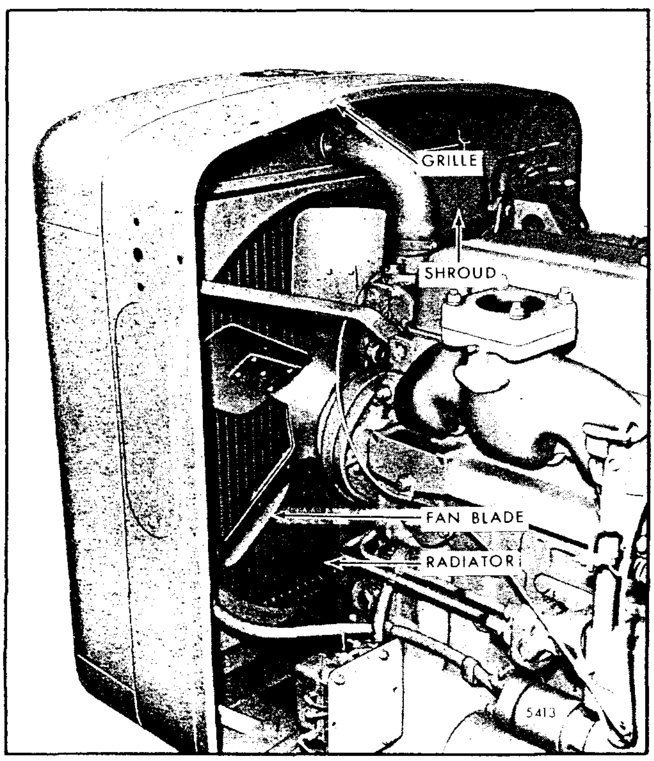

Fig. 1 - Typical Radiator Mounting (In-Line Engine)

A radiator that has a dirty, obstructed core or is leaking, a leak in the cooling system, or an inoperative thermostat will also cause the engine to overheat. The radiator must be cleaned, the leaks eliminated, and defective thermostats replaced immediately to prevent serious damage from overheating.

The external cleanliness of the radiator should be checked if the engine overheats and no other causes are apparent.

Cleaning Radiator

The radiator should be cleaned whenever the foreign deposits are sufficient to hinder the flow of air or the transfer of heat to the air. In a hot, dusty area, periodic cleaning of the radiator will prevent a decrease in efficiency and add life to the engine.

The fan shroud and grille should be removed, if possible, to facilitate the cleaning of the radiator core.

An air hose with a suitable nozzle is often sufficient to remove loose dust from the radiator core. Occasionally, however, oil may be present requiring the use of a solvent, such as oleum, to loosen the dirt. *The use of gasoline, kerosene, or fuel oil is not recommended as a solvent.* A spray gun is an effective means of applying the solvent to the radiator core. Use air to remove the remaining dirt. Repeat this process as many times as necessary, then rinse the radiator with clean water and dry it with air.

> **NOTE:** Provide adequate ventilation of the working area to avoid possible toxic effects of the cleaning spray.

Another method of cleaning the radiator is the use of steam or a steam cleaning device, if available. If the foreign deposits are hardened, it may be necessary to apply solvents.

The scale deposit inside the radiator is a result of using hard, high mineral content water in the cooling system. The effect of heat on the minerals in the water causes the formation of scale, or hard coating, on metal surfaces within the radiator, thereby reducing the transfer of heat. Some hard water, instead of forming scale, will produce a silt-like deposit which restricts the flow of water. This must be flushed out at least twice a year --- more often if necessary.

To remove the hardened scale, a direct chemical action is necessary. A flushing compound such as sal-ammoniac, at the specified rate of 1/4 pound per each gallon of radiator capacity, should be added to the coolant water in the form of a dissolved solution while the engine is running. Operate the engine for at least 15 minutes, then drain and flush the system with clean water.

Other flushing compounds are commercially available and should be procured from a reliable source. Most compounds attack metals and should not remain in the engine for more than a few minutes. A neutralizer should be used in the cooling system immediately after a de-scaling solvent is used.

For extremely hard, stubborn coatings, such as lime scale, it may be necessary to use a stronger solution. The corrosive action of a stronger solution will affect the thin metals of the radiator, thereby reducing its operating life. A complete flushing and rinsing is mandatory and must be accomplished skillfully.

After the solvent and neutralizer have been used and the cooling system is flushed, completely drain the entire system again and fill it with clean, soft water plus a rust inhibitor or high boiling point type antifreeze (refer to Section 13.3). After filling the cooling system, inspect the radiator and engine for water leaks.

NOTE: When draining or filling, the cooling system must be vented.

COOLANT PRESSURE CONTROL CAP

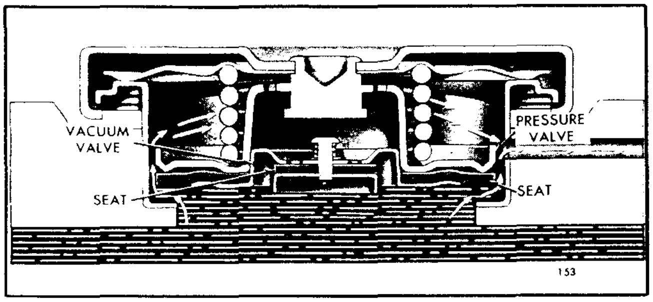

Fig. 1 - Pressure Control Cap (Pressure Valve Open)

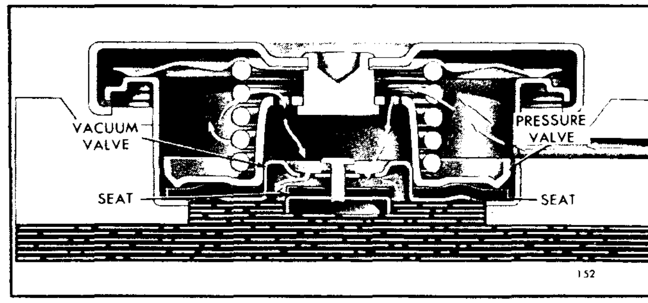

Fig. 2 - Pressure Control Cap (Vacuum Valve Open)

The radiator (or expansion tank) has a pressure control cap with a normally closed valve. The cap is designed to permit a pressure of approximately seven pounds in the system before the valve opens. This pressure raises the boiling point of the coolant and permits somewhat higher engine operating temperatures without loss of any coolant from boiling.

To prevent the collapse of hoses and other parts which are not internally supported, a second valve in the radiator cap opens under vacuum when the system cools.

CAUTION: Always remove the radiator cap *slowly and carefully* to avoid a possible flash of hot coolant.

To ensure against possible damage to the cooling system from either excessive pressure or vacuum, check both valves periodically for proper opening and closing pressure. If the pressure valve does not open between 6-1/4 to 7-1/2 psi or the vacuum valve is not open at 5/8 psi (maximum), replace the pressure control cap.

ENGINE COOLING FAN

The engine cooling fan is driven by a pair of V-drive belts from the crankshaft pulley (Fig. 1) or driven directly by the crankshaft (Fig. 2).

Effective with engine serial numbers 2D-28185, 3D-66957 and 4D-68816 new fan hub assemblies are being used on the In-line engines. The new assemblies are similar to the integral cast shaft and bracket design, with tapered roller bearings, currently used on the V-type engines (Fig. 5).

The belt-driven fan is bolted to a combination fan hub and pulley which turns on a sealed ball bearing assembly (former In-line engines) or two tapered roller bearings (V-type and current In-line engines). The crankshaft driven fan is bolted to the crankshaft pulley.

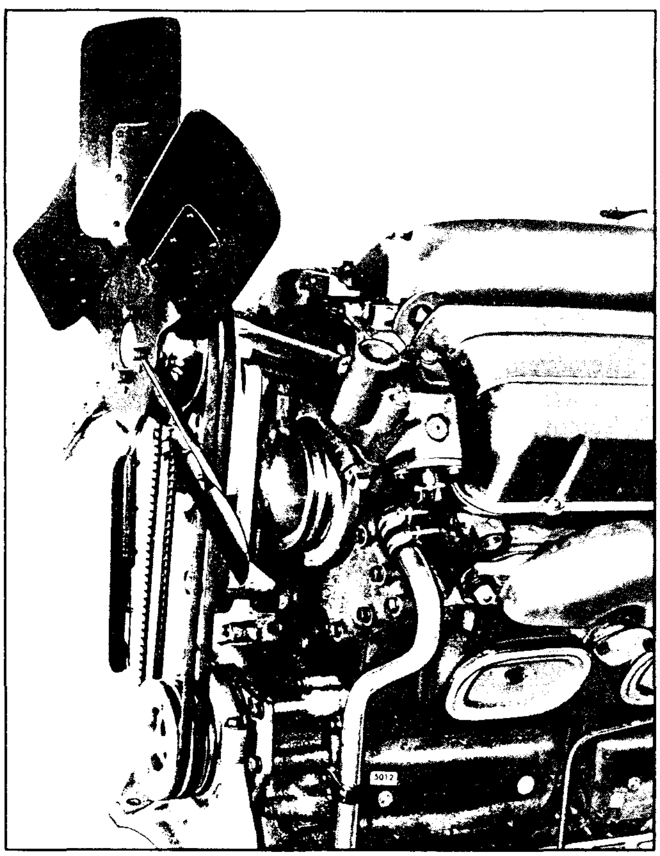

Fig. 1 - Belt-Driven Fan Mounting (V-Type Engine)

Lubrication

The sealed ball bearings, used in the fan hub assembly on the former In-line engines, is pre-lubricated and requires no further lubrication.

The tapered roller bearings, used in the fan hub on V-type and current In-line engines, are pressure lubricated prior to assembly. The cavity between the bearings is packed with Chevron BRB No. 2 grease or an equivalent performance grease at the time the hub is assembled. Also the fan hub cap is packed approximately 75% full of grease. Repack the fan hub assembly as outlined in the assembly procedure. The hub cap at the front and a seal at the rear of the hub prevents leakage of the lubricant.

Remove Fan, Hub and Adjusting Bracket

The fan blades must rotate in a vertical plane parallel with and a sufficient distance from the radiator core.

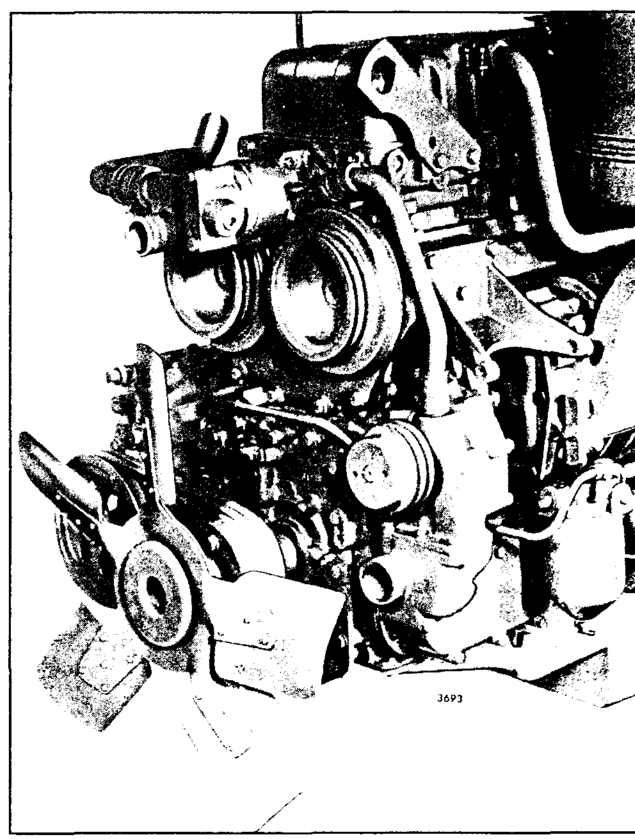

Fig. 2 - Crankshaft-Driven Fan Mounting (In-Line Engine)

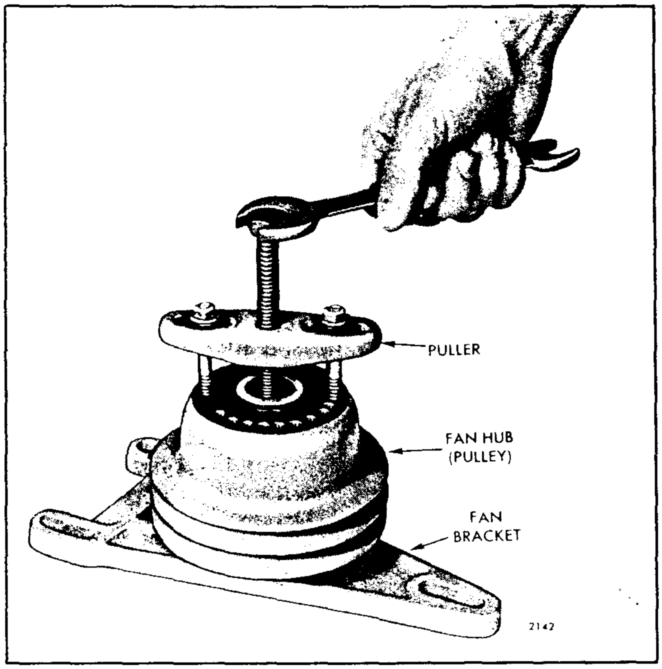

Fig. 3 - Removing Fan Hub (Pulley)

Bent fan blades reduce the efficiency of the cooling system, may throw the fan out of balance, and are apt to damage the radiator core. Before removing the fan blades, check the blades for alignment. Do not rotate the fan by pulling on the fan blades.

1. Remove the attaching bolts and lock washers and remove the fan and spacer (if used).

2. Loosen the fan hub adjusting bracket bolts and remove the drive belts. Then withdraw the bolts and washers and remove the hub and bracket assembly from the engine.

Disassemble Hub and Adjusting Bracket

IN-LINE ENGINES (FORMER):

1. Measure the distance between the rear face of the rim on the pulley and rear face (machined) of the fan adjusting bracket. Record this measurement for reassembly purposes.

2. Remove the fan hub from the shaft with a puller as shown in Fig. 3.

3. Place the bracket assembly in an arbor press. Then place a suitable sleeve over the shaft and against the outer race of the bearing and press the bearing and shaft assembly from the bracket.

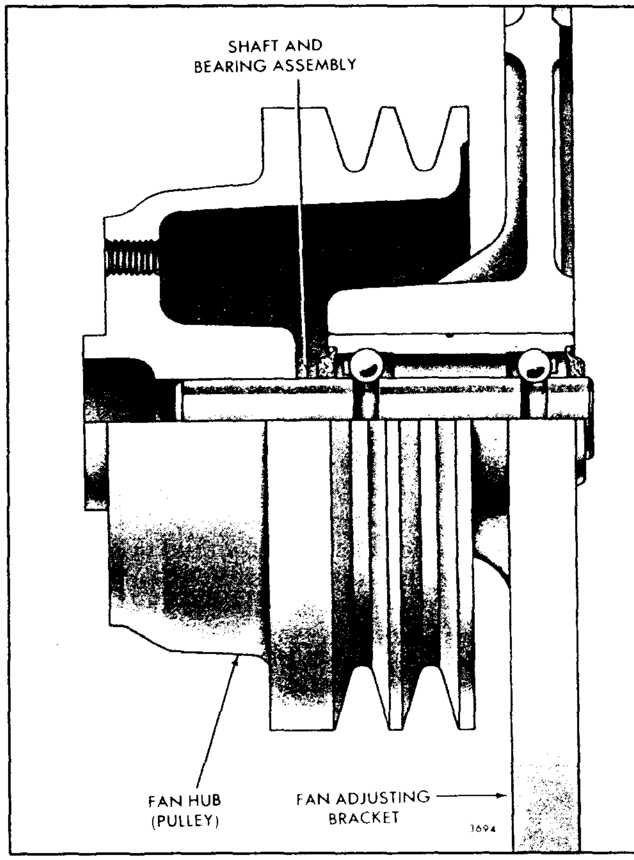

Fig. 4 - Former Fan Hub Assembly (In-Line Engine)

CAUTION: Damage to the bearing will result if force is applied to the shaft.

IN-LINE ENGINES (CURRENT):

1. Remove the fan hub cap.

2. Remove the hub bolt and washer.

3. Withdraw the hub and bearing assembly from the shaft. It may be necessary to tap the end of the shaft with a soft hammer to loosen the hub assembly.

4. Remove the oil seal and bearing from the fan hub.

5. Remove the bearing spacer, shims and grease retainer.

V-TYPE ENGINES:

1. Remove the fan hub cap (if a spacer and cap assembly were not used).

2. Remove the hub retaining cotter pin, nut and washer (Fig. 6) or the bolt and special washer

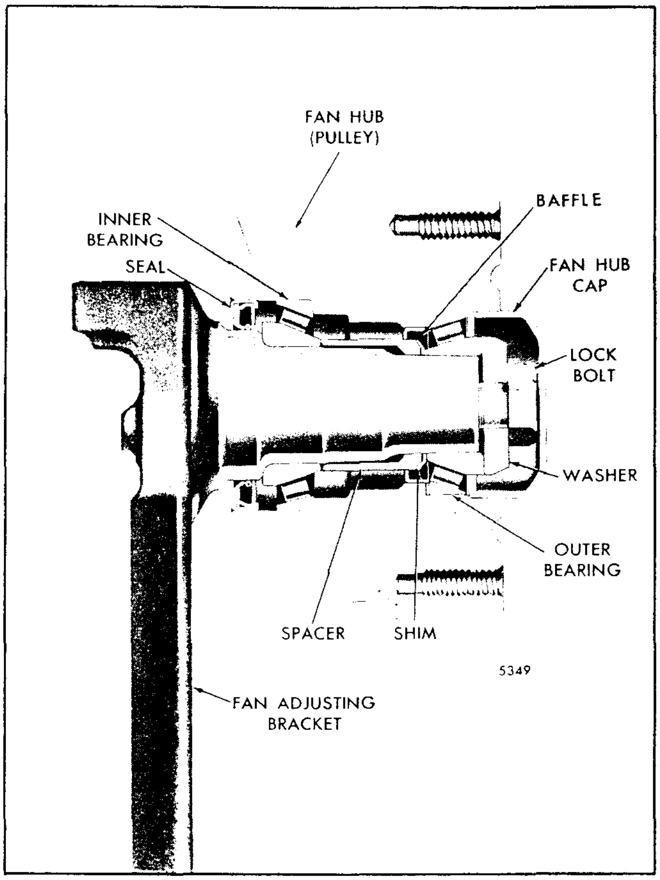

Fig. 5 - Current Fan Hub Assembly (In-Line Engine)

(Fig. 7). Also remove the shims if the former type fan hub assembly illustrated in Fig. 7 is used.

3. Withdraw the hub and bearing assembly from the shaft. It may be necessary to tap the end of the shaft with a soft hammer to loosen the hub assembly.

4. Remove the seal and bearings from the fan hub.

5. Remove the bearing spacer (Fig. 7) and shims (if the current type hub assembly is used).

Inspection

Wash the fan and fan hub parts thoroughly with fuel oil, dry them with compressed air and inspect them for wear or damage.

> **NOTE:** Do not wash the permanently sealed bearing which is used in the In-line engine hub assembly. Wipe the bearing and shaft assembly with a clean lintless cloth.

Hold the inner race (shaft of sealed ball bearing

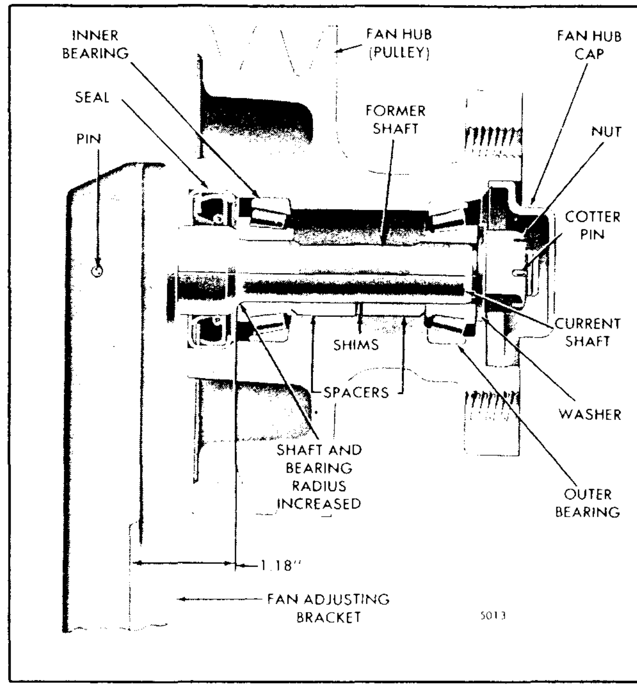

Fig. 6 - Shaft Type Fan Hub Assembly (6V Engine)

assembly) and revolve the outer race of each bearing

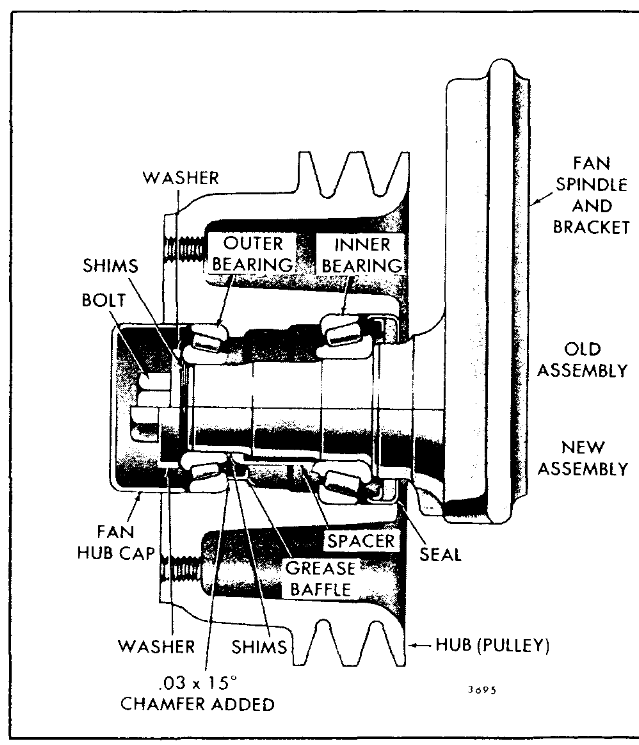

Fig. 7 - Spindle Type Fan Hub Assembly (6V and 8V Engine)

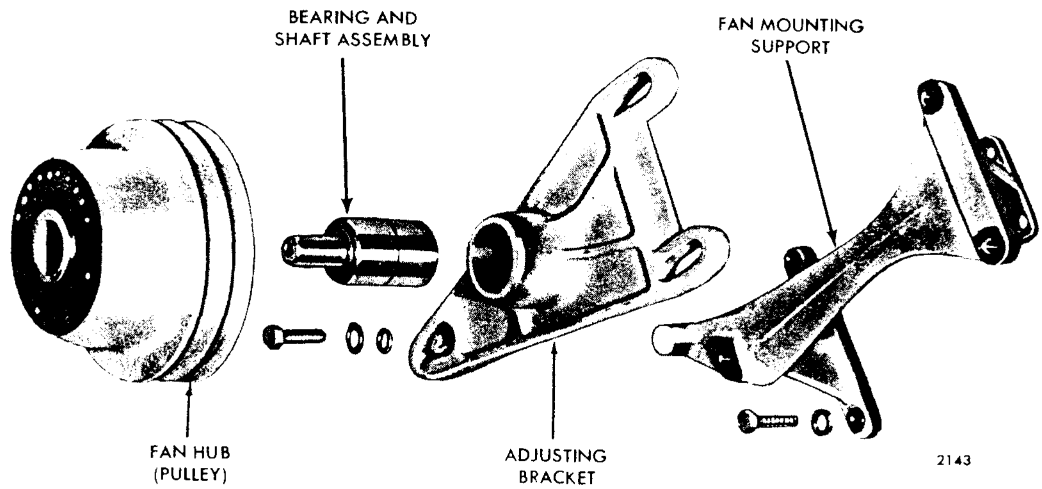

Fig. 8 - Typical Fan Hub and Adjusting Bracket Details and Relative Location of Parts (In-Line Engine)

slowly by hand. If rough or tight spots are detected, replace the bearing.

Examine the fan blades for cracks. Replace the fan if the blades are badly bent, since straightening may weaken the blades, particularly in the hub area.

Remove any rust or rough spots in the grooves of the fan pulley and crankshaft pulley. If the grooves are damaged or severly worn, replace the pulleys.

The fan hub assembly illustrated in Fig. 6 has been revised. The revisions consist of an increase in the bearing inner race and shaft bearing radii, a hardened hub retaining nut and washer and the addition of spacers and shims on the shaft between the bearings. This type fan hub assembly should be rebuilt with the current parts, especially where the former undercut shaft is used. The current spacers and shims cannot be used with the former shaft.

To replace the shaft, remove the groove pin and press the shaft from the adjusting bracket. Press the new shaft in the bracket to the dimension shown in Fig. 6. Then drill the shaft, using the hole in the bracket as a guide, and install a groove pin.

The spindle-type fan hub assembly illustrated in Fig. 7 has also been revised. A bearing spacer has been added and a new outer bearing, which provides a closer fit on the shaft, replaces the old. A baffle has also been added to retain the grease and assure lubrication at the outer bearing. To facilitate installation of the grease baffle, a .030 " by 15 ° chamfer has been added to the bore in the pulley.

The tapped hole in the end of the shaft has been counterbored and increased in depth from 1.00 " to 1.26 ". A longer hub retaining bolt and a .32 " thick washer replaces the former bolt and 1/8 " thick washer.

New shims, assembled between the bearing spacer and the inner race of the outer bearing, provide .001 " to .006 " end play. The former shims, which were assembled between the hub retaining washer and the end of the shaft, provide .002 " to .004 " end play.

When service is required on the spindle-type shaft, it should be rebuilt with the new components.

Assemble Hub and Adjusting Bracket

IN-LINE ENGINES (FORMER):

Refer to Figs. 4 and 8 and assemble the fan hub and adjusting bracket as follows:

1. Press the shaft and bearing assembly into the adjusting bracket by applying pressure on the outer race of the bearing, using a suitable sleeve, until the bearing is flush with the pulley end of the bracket.

2. Measure the shaft diameter and the pulley bore. It is important that a .001 " - .002 " press fit be maintained. Then support the bearing end of the shaft and press the fan hub (pulley) on the shaft to the original dimensions taken during disassembly. This will assure proper alignment and clearance of the parts.

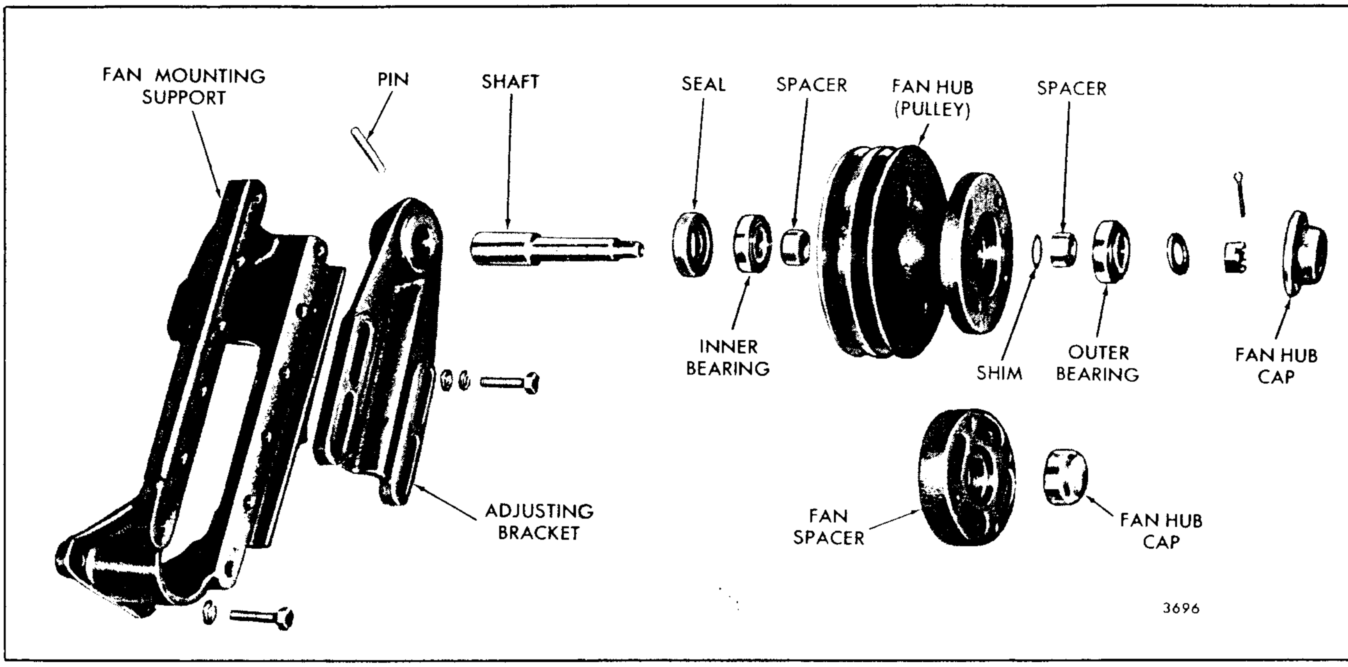

Fig. 9 - Typical Fan Hub, Shaft and Adjusting Bracket Details and Relative Location of Parts (6V Engine)

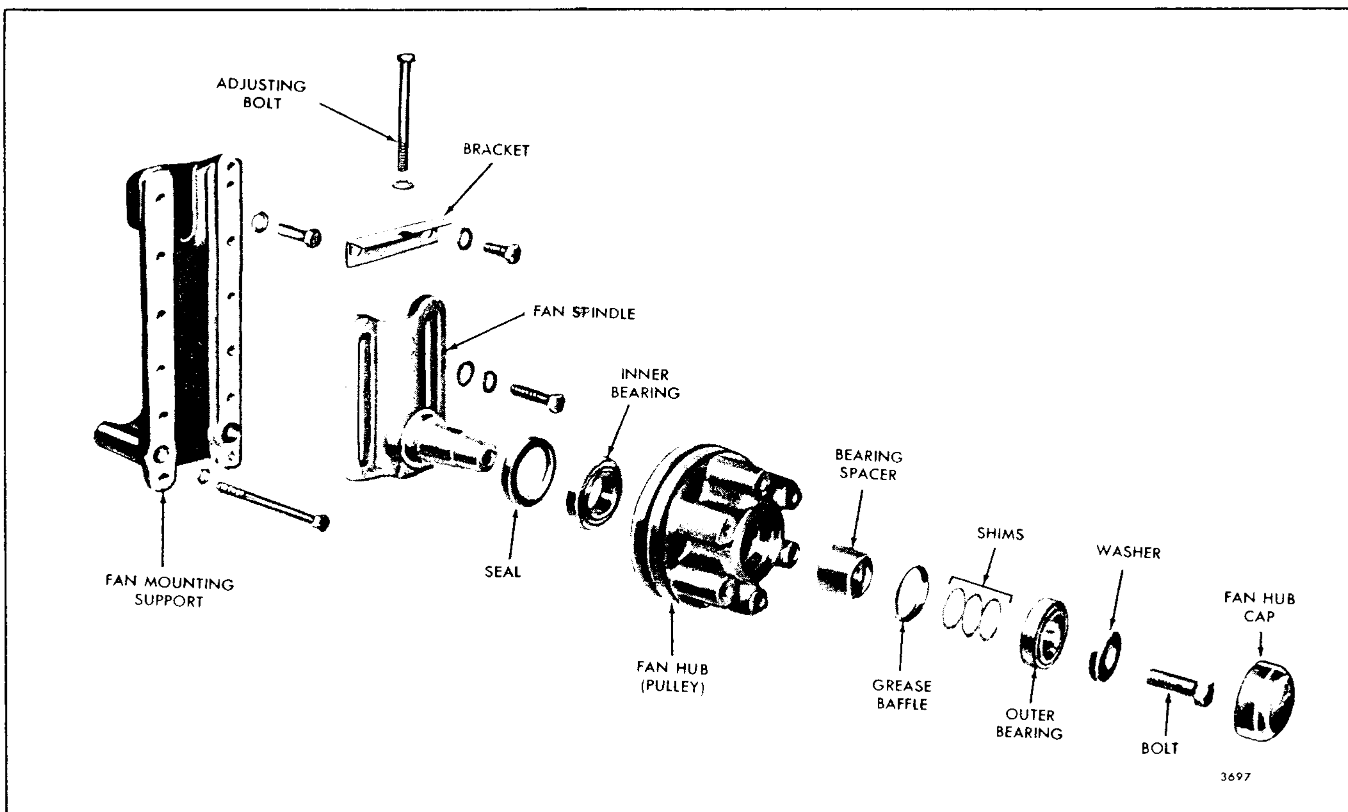

Fig. 10 - Typical Fan Hub and Spindle Details and Relative Location of Parts (6V and 8V Engine)

The shaft and bearing assembly are permanently sealed and require no lubrication.

IN-LINE ENGINES (CURRENT):

Assemble the fan hub and spindle shown in Fig. 5 as follows:

1. Apply Chevron BRB No. 2 grease or an equivalent performance grease to the rollers of both bearings before installing them in the fan hub (pulley).

2. Install the inner bearing with the protruding face of the inner race facing outward from the hub.

3. Install a new seal with the felt-side flush with the outer edge of the hub.

4. Place the hub over the spindle and install the bearing spacer.

5. Pack the cavity approximately 1/4 full with grease and install the grease baffle.

6. Place the shims against the bearing spacer. Then install the outer bearing with the protruding face of the inner race facing outward from the hub.

7. Place the retaining washer with the breakout side toward the bearing. Install and tighten the bolt to 83-93 lb-ft torque while rotating the pulley.

8. Check the end play in the assembly with the spindle (shaft) in a horizontal position. The end play must be within .001 " to .006 ". If necessary, remove the bolt, washer and outer bearing and adjust the number and thickness of shims to obtain the required end play. Shims are available in .015 ", .020 " and .025 " thickness. Then reassemble the fan hub and check the end play.

9. Fill a new fan hub cap 3/4 full of grease and install it in the end of the fan hub (pulley).

V-TYPE ENGINE:

Assemble the fan hub, shaft and adjusting bracket shown in Figs. 6 and 9 as follows:

1. Apply Chevron BRB No. 2 grease or an equivalent performance grease to the rollers of both bearings before installing them in the fan hub (pulley).

2. Install the inner bearing with the protruding face of the inner race facing outward from the hub.

3. Install a new seal with the lip of the seal facing toward the bearing. Coat the lip of the seal lightly with grease.

4. Slide the spacers and shims on the shaft (Fig. 6).

NOTE: It may be necessary to install as many as three .005 " and three .010 " shims between the spacers on a current shaft incorporated in a former fan hub to achieve the required .001 " to .005 " end play.

5. Place the hub over the shaft and pack the cavity approximately 1/2 full with grease. Then install the outer bearing with the protruding face of the inner race facing outward from the hub.

6. Secure the hub assembly with the washer and 1/2 "-20 nut. Tighten the nut to 35-40 lb-ft torque.

CAUTION: Enough shims must be provided to avoid loading directly through the bearing rollers when the nut is torqued. The pulley must turn freely after the nut is tight.

7. Check the bearing end play. If the end play is not within the specified limits (.001 " to .005 "), remove the hub, add or remove shims and repeat Steps 5 and 6.

8. Fill a new fan hub cap 1/2 full of grease and install it in the end of the fan hub (pulley).

Assemble the fan hub and spindle shown in Figs. 7 and 10 as follows:

1. Apply Chevron BRB No. 2 grease or an equivalent performance grease to the rollers of both bearings before installing them in the fan hub (pulley).

2. Install the inner bearing with the protruding face of the inner race facing outward from the hub.

3. Install a new seal with the felt-side flush with the outer edge of the hub.

4. Place the hub over the spindle and install the bearing spacer.

5. Pack the cavity approximately 1/4 full with grease and install the grease baffle.

6. Place the shims against the bearing spacer. Then install the outer bearing with the protruding face of the inner race facing outward from the hub.

7. Secure the hub with the retaining washer and bolt. Tighten the 1/2 "-20 bolt to 83-93 lb-ft torque while rotating the pulley.

8. Check the end play in the assembly with the spindle (shaft) in a horizontal position. The end play must be within .001 " to .006 ". If necessary, remove the bolt, washer and outer bearing and adjust the number and thickness of shims to obtain the required end play. Shims are available in .015 ", .020 " and .025 "

thickness. Then reassemble the fan hub and check the end play.

9. Fill a new fan hub cap 3/4 full of grease and install it in the end of the fan hub (pulley).

Install Fan, Hub and Adjusting Bracket

New .500 " thick and .800 " thick fan hub spacers and a new fan hub cap replaces the former spacer and cap assemblies to provide spacers compatible with the six bolt hole mounting fan hub assemblies. The spacers (individually or in combination) also provide a means for setting the different clearances between the back of the fan blades and front groove of the crankshaft pulley.

The new spacers have a flange on one side that serves as a pilot for the fan as well as a spacer pilot for the second spacer when two or more spacers are used together.

> **EXAMPLE:** A former 1.800 " thick spacer and cap assembly have been replaced by two .500 " thick spacers, one .800 " thick spacer and the new fan hub cap.

When replacing the former fan hub spacer be sure and include the new cap.

1. Attach the fan hub and adjusting bracket assembly to the bracket support on the engine with bolts, lock washers and plain washers. Do not tighten the bolts.

2. Install the drive belts and adjust the belt tension as outlined in Section 15.1. If used, install the adjusting bracket, bolt and plain washer shown in Fig. 10.

3. Install the fan (and fan spacer and cap, if used) on the hub and secure it with the 5/16 "-18 bolts and lock washers.

HEAT EXCHANGER

The heat exchanger core is mounted inside of the water expansion tank and is sealed at the inlet and outlet ends to prevent the engine coolant from mixing with the raw cooling water.

The heat exchanger core consists of a series of cells through which the engine coolant passes and is cooled by the raw water which is forced between the cells by the raw water pump. However, the core used in the two-cylinder engine models consists of a series of flat tubes through which the raw water passes and cools the engine coolant flowing between the tubes.

To protect the heat exchanger core from the electrolytic action of the raw water, a zinc electrode is located in both the heat exchanger inlet tube and the raw water pump inlet elbow (the two-cylinder engines use only one electrode--at the raw water pump).

That portion of the tank located above the heat exchanger provides a means of filling the engine coolant system as well as space for expansion of the coolant as the temperature rises. An overflow pipe near the top of the water tank vents the tank to the atmosphere.

The length of time a heat exchanger will function satisfactorily before cleaning will be governed largely by the kind of cooling liquid used in the engine and the kind of raw water used.

Clean soft water plus a good commercial rust inhibitor or antifreeze should be used as the engine coolant (refer to Section 13.3) to prevent lime deposits in the heat exchanger core as well as in the engine.

Enough coolant should be maintained in the engine to fill the cylinder block and head and to partially fill the water tank. Allow air space above the coolant in the tank for the increase in volume as the temperature of the coolant rises.

Whenever the heat exchanger fails to cool the engine properly, and the raw water pump is circulating a normal amount of cooling water around the heat exchanger core, the core should be examined for foreign deposits.

Clean Heat Exchanger Core

When foreign deposits accumulate in the heat exchanger to the extent that cooling efficiency is impaired, remove the heat exchanger core and clean it as follows:

Immerse the heat exchanger core in a scale solvent consisting of one-third muriatic acid and two-thirds water to which one-half pound of oxalic acid has been added to each two and one-half gallons of solution. Remove the core when foaming and bubbling stops. This usually takes from thirty to sixty seconds. Flush the core thoroughly with clean hot water under pressure.

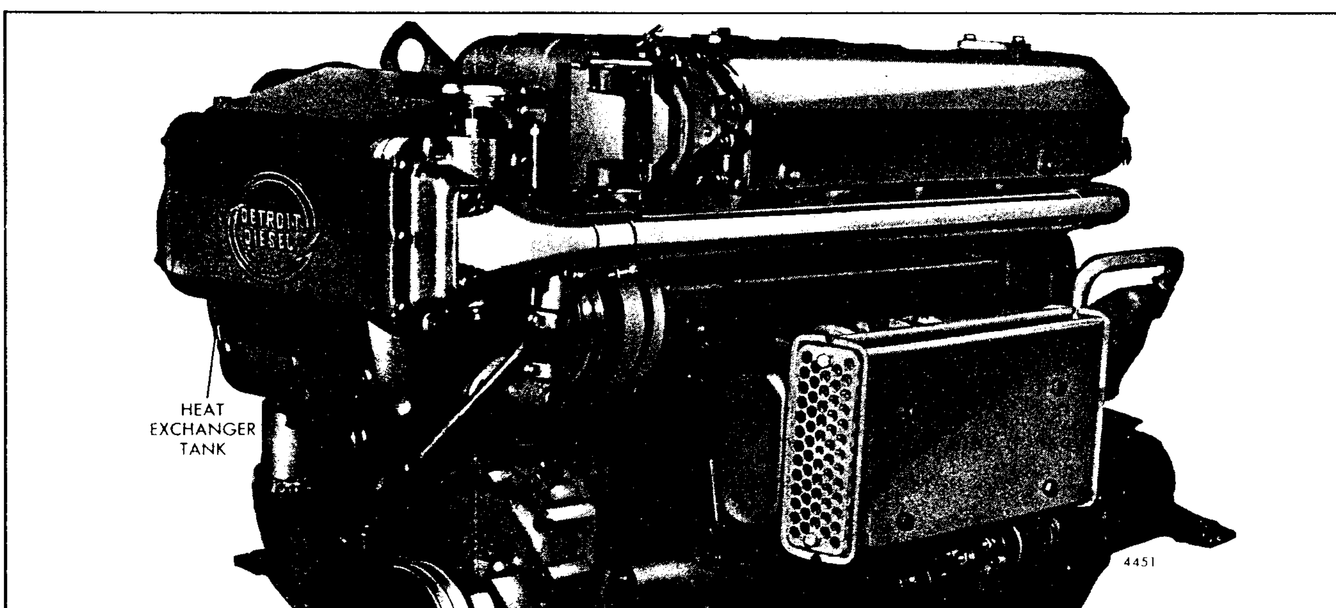

Fig. 1 - Typical Heat Exchanger Mounting In-Line Engine

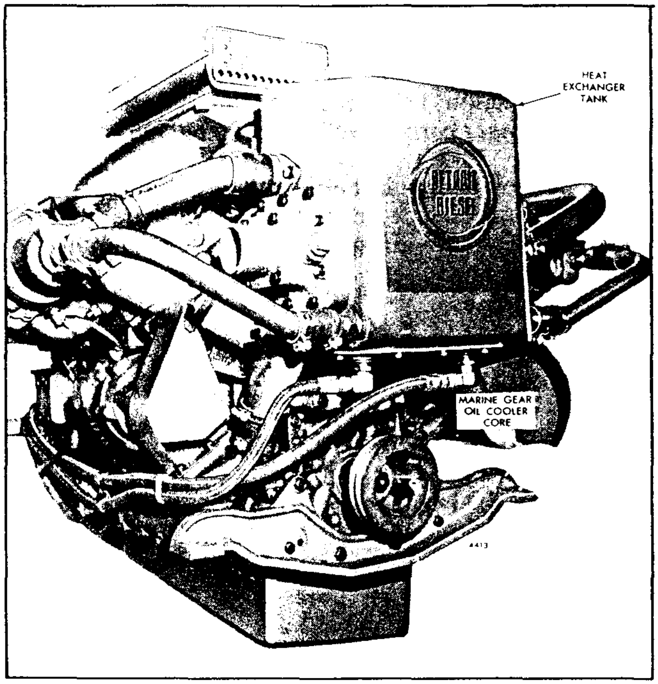

Fig. 2 - Typical Heat Exchanger Mounting
V-Type Engine

To prevent drying and hardening of accumulated foreign substances, the heat exchanger core must be cleaned as soon as possible after removing it from service.

Inspect Zinc Electrode

The zinc electrodes should be examined thirty days after installation. Under normal operating conditions, the electrode will last much longer and need only be examined periodically and replaced when necessary.

Remove Heat Exchanger Core

Remove the heat exchanger core for cleaning and inspection as follows:

1. Drain the engine coolant and raw water system.

2. Remove the heat exchanger core from the two-cylinder engine as follows:

   a. Remove the bolts holding the inlet and outlet covers to the expansion tank and raise the inlet tube away from the tank.

   b. Remove the seal rings from the covers.

   c. Withdraw the heat exchanger core and gasket from the tank.

3. Remove the heat exchanger core from 3, 4, 6, and 8 cylinder engines as follows:

   a. Remove four bolts that hold the inlet tube to the inlet cover. Lower the inlet tube and remove the gasket from the inlet tube flange.

   b. Remove the bolts that hold the inlet cover and heat exchanger core to the tank.

   c. Remove the bolts that hold the outlet elbow to the outlet cover. Lower the outlet elbow and remove the gasket from the flange of the elbow.

   d. Remove the bolts that secure the outlet cover to the tank.

   e. Remove the outlet cover, together with the seals and the seal gland, from the tank.

   f. Withdraw the heat exchanger core and gaskets from the tank.

Install Heat Exchanger Core

After the heat exchanger core has been cleaned and inspected, install it by reversing the sequence of operations given for removal, using new gaskets and seals.

> **NOTE:** To minimize electrolytic action of the raw water, brass pipe plugs are used in the raw water system components wherever pipe plugs are required. Replace any steel plugs that may be found on earlier units with brass plugs.

> **CAUTION:** When installing the heat exchanger core in a two-cylinder engine, the flat sides of the tubes MUST BE in a vertical position to permit uninterrupted flow of engine coolant between the tubes.

Refill the engine coolant fresh and raw water systems. The cooling system must be vented when filling (see Section 5).

Prime the raw water pump, if necessary, then start the engine and check for leaks.

RAW WATER PUMP (Jabsco)

Raw water for lowering the temperature of the engine coolant is circulated through the heat exchanger by a positive displacement pump (Figs. 1 and 2). The pump is attached to an adaptor which is, in turn, bolted to the flywheel housing. The pump is driven by a gear which meshes with the accessory drive plate mounted on the camshaft gear.

The pump drive shaft is supported by a pre-lubricated, shielded double-row ball bearing. An oil seal prevents oil leakage from the bearing compartment and a rotary type seal prevents water leakage along the shaft.

The current face-type water seal used in In-line engine pumps rides on its own mating surface. The former lip type seal rides on the shaft (Fig. 1).

An impeller splined to the end of the drive shaft is self-lubricated by the water pumped and should not be run dry longer than normally required for the pump to prime itself.

A wear plate in the impeller compartment prevents pump housing wear. This plate may be reversed if wear on the impeller side becomes excessive.

The raw water pump has been revised with the use of a new cam and wear plate assembly to improve the pump priming capabilities. The wear plate is round and conforms with the inside contour of the housing. A slot in the periphery of the wear plate registers with a dowel pin in the end of the cam, which assures a good fit and prevents the rotation of the wear plate with the pump shaft.

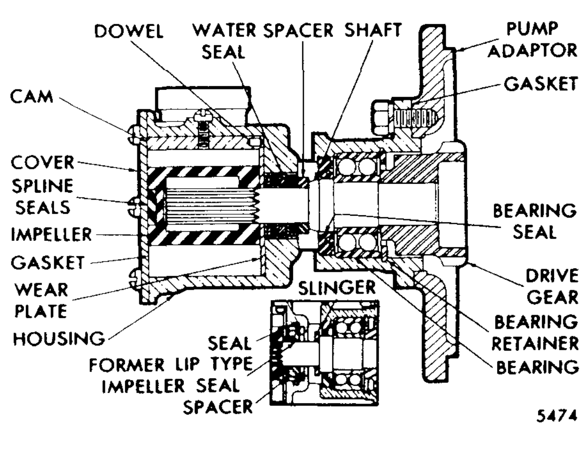

Fig. 1 - Raw Water Pump used on In-Line Engine

The top of the former wear plate was contoured to fit under the cam to prevent its rotation with the shaft.

The current cam and wear plate assembly is interchangeable with the former cam and wear plate and only the current cam and wear plate assembly is serviced.

The pump can be operated in a clockwise or counterclockwise direction. Raw water is drawn into the pump through the inlet opening and discharged through the outlet opening. Both openings are located on the top of the pump housing.

Replace Pump Seal

The impeller, cam and wear plate assembly and water seal assembly (Fig. 3) may be serviced without removing the pump from the engine as outlined below:

1. Remove the cover and gasket (Figs. 1 and 2).

2. Note the position of the impeller blades to aid in the reassembly. Then grasp a blade on each side of the impeller with pliers and pull the impeller off of the shaft.

The neoprene spline seal(s) can be removed from the impeller by pushing a screw driver through the impeller from the open end.

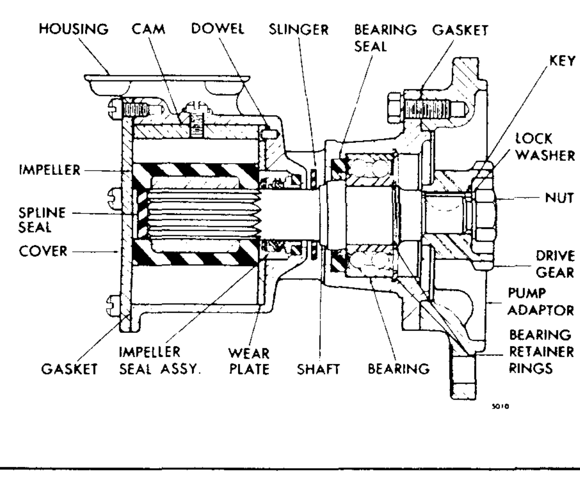

Fig. 2 - Raw Water Pump used on V-Type Engine

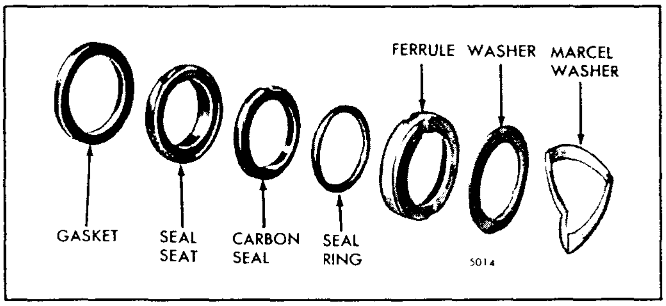

Fig. 3 - V-Type Engine Impeller Seal Detail

CAUTION: If the impeller is reuseable, exercise care to prevent damage to the splined surfaces.

3. Remove the cam retaining screw and withdraw the cam and wear plate assembly.

4. Remove the seal assembly (Fig. 3) from the pump used on the V-type engine by inserting two wires with hooked ends between the pump housing and the seal, with the hooks over the edge of the carbon seal. Remove the seal seat and gasket in the same way.

The seal may be removed from the pump used on the In-line engine by drilling two holes in the seal case and placing metal screws in the holes so that they may be grasped and pulled with pliers. Then remove the rubber seal ring from the groove in the former pump housing.

5. Clean and inspect the impeller, cam and wear plate assembly and water seal. The impeller must have a good bond between the neoprene and the metal. If the impeller blades are damaged, worn or have taken a permanent set, replace the impeller. Reverse the wear plate if it is worn excessively and remove any burrs. Replace the seal, if necessary.

6. Install the seal assembly in the pump used on the V-type engine as follows:

a. If the seal seat and gasket were removed, place the gasket and seal seat over the shaft and press them into position in the seal cavity.

b. Place the seal ring securely in the ferrule and, with the carbon seal and washer correctly positioned against the ferrule, slide the ferrule over the shaft and against the seal seat. Use care to ensure the seal ring is contained within the ferrule so that it grips the shaft.

c. Install the flat washer and then the marcel washer.

Install the face-type water seal and spacer over the shaft in the impeller end of the current pump housing. Push the seal against the spacer. The seal is a snug fit on the shaft.

A lip type seal may be installed in the former pump used on the In-line engine by placing the rubber seal ring in the groove, starting the seal with the lip facing the impeller cavity over the shaft and tapping it into place against the seal spacer.

7. Install the cam and wear plate assembly.

NOTE: Formerly the wear plate was installed separately with the contoured surface fitting under the cam. Currently the wear plate is round and is doweled to the cam. The wear plate must be installed with the cam in the pump housing as an assembly.

8. Apply a non-hardening sealant to the cam retaining screw and the hole in the pump body to prevent any leakage. Then hold the cam with the tapped hole aligned and secure it with the screw.

9. Compress the impeller blades to clear the offset cam and press the impeller on the splined shaft.

10. Install the neoprene spline seal(s) in the bore of the impeller.

11. Turn the impeller several revolutions in the normal direction of rotation to position the blades.

12. Affix a new gasket and install the pump cover.

Remove Pump from Engine

If complete disassembly or replacement of the pump is necessary, it may be removed from the engine as follows:

1. Drain the raw water system.

2. Remove the water inlet and outlet elbows and discard the gaskets.

3. Remove the bolts that secure the pump adaptor to the flywheel housing.

4. Tap the edge of the adaptor with a plastic hammer to loosen the pump.

5. Pull the pump straight out from the flywheel housing so the drive gear will disengage the coupling.

6. Cover the pump opening in the flywheel housing with a clean cloth to prevent the entrance of foreign matter.

Disassemble Pump

Follow the procedure outlined under *Replace Pump Seal* for the removal of the impeller, cam and wear plate assembly and water seal assembly and then proceed as follows:

1. Mark the pump housing and adaptor to aid in reassembly. Then remove the bolts and separate the housing and adaptor.

2. Clamp the V-type engine pump drive gear and housing assembly in a vise with soft jaws and remove the drive gear retaining nut. Take out the Woodruff key and remove the assembly from the vise.

Use puller J 4794-01 to remove the drive gear from the in-line engine pump.

3. Remove the bearing retainer ring from the groove in the housing.

4. Support the pump body in an arbor press with the splined end of the pump drive shaft under the ram of the press. Place a brass rod on the end of the shaft. Then press the shaft and bearing assembly out of the pump housing.

5. Remove the slinger from the opening in the top of the pump housing, then remove the bearing seal from the inside of the housing.

> **NOTE:** Remove the bearing retainer ring from the groove in the pump shaft on the V-type engine pump.

6. Place a suitable sleeve over the shoulder on the pump drive shaft and against the inner race of the bearing. Place the sleeve, shaft and bearing assembly on the bed of an arbor press with the threaded end of the shaft up. Hold a brass rod on the end of the shaft and under the ram of the press. Then press the bearing off of the shaft.

Inspect Pump Parts

After disassembling the pump, clean all of the parts, except the bearing, and dry them with air. Wipe the bearing with a clean cloth. *The shielded bearing must not be dipped or washed in fluid.*

Hold the bearing inner race and revolve the outer race slowly. Replace the bearing if it has rough spots, corrosion, is worn or does not roll freely.

On the V-type engine pump, inspect the carbon seal components. Replace worn or damaged parts as necessary.

Check the pump drive shaft seal contact surfaces for wear. Remove any scratches with crocus cloth wet with fuel oil.

Refer to Item 5 under *Replace Pump Seal* for the inspection of the remaining parts.

Assemble Pump

Only the current In-line engine pump housing is serviced. When replacing a former housing, it is necessary to include the new face-type water seal and spacer.

> **NOTE:** Stamp the former cover to identify that the pump now has a new housing and water seal.

Use new parts where necessary and assemble the pump as follows:

1. Lubricate the inside diameter of the drive shaft bearing with engine oil and start it, numbered side up, straight on the drive gear end of the shaft. Place a suitable sleeve over the shaft and against the inner race of the bearing. Support the sleeve, bearing and shaft on the bed of an arbor press and press the shaft into the bearing until the shoulder on the shaft is tight against the bearing inner race.

> **NOTE:** On the V-type engine pump, install the bearing retainer ring in the groove on the shaft.

2. Coat the lip of the seal lightly with grease and place it in position in the pump housing with the lip of the seal facing away from the bearing cavity.

3. Start the splined end of the drive shaft into and just through the inner bearing seal in the center of the pump housing from the drive flange end. Place the slinger in the opening in the top of the housing and over the end of the shaft. Carefully push the shaft straight into the housing until the bearing starts into the bearing bore. Use caution to prevent damage to the slinger.

4. Support the impeller end of the housing on the bed of an arbor press. Place a suitable sleeve on the outer race of the bearing and under the ram of the press and press the bearing straight into the bearing cavity in the pump housing.

5. Install the bearing retainer ring in the groove in the housing.

6. Lubricate the bore of the drive gear and start it on the shaft.

NOTE: A Woodruff key is used with the shaft in the V-type engine pump.

7. Support the in-line engine pump housing and drive shaft assembly on the bed of an arbor press with the splined end of the drive shaft resting on a steel block and the drive gear under the ram of the press. Press the gear on the shaft until it is tight against the shoulder.

Clamp the V-type engine pump drive gear and housing assembly in a vise with soft jaws and install the gear retaining nut and lock washer. Tighten the nut to 25-30 lb-ft torque. Then remove the pump assembly from the vise.

CAUTION: Exceeding the specified torque may cause a pump drive shaft failure.

8. Place a new gasket on the pump adaptor, align the match marks and install the pump housing on the adaptor with the bolts and lock washers. Tighten the bolts to 30-35 lb-ft torque.

9. Follow the procedure outlined under *Replace Pump Seal* for the installation of the impeller, cam and wear plate assembly and water seal assembly.

Install Pump

The raw water pump may be installed on the engine by reversing the procedure for removal.

The pump end cover is marked to indicate the outlet port for a RH rotation and the outlet port for a LH rotation pump installation. These markings are an aid to prevent any difficulty with regard to water flow direction.

After the pump has been installed, prime it before starting the engine.

Draining Pump

The raw water pump is not provided with a drain valve. If freezing temperatures are anticipated and the engine is not going to be operated or the engine is being placed in storage, it is recommended that the raw water pump impeller housing be drained in addition to draining the engine cooling system.

Drain the raw water pump impeller housing by carefully pulling the pump cover away from the housing after loosening the screws. If the gasket is damaged, the cover will have to be removed and the gasket replaced.

After the pump has been drained, replace the cover and tighten the screws.

WATER FILTER AND CONDITIONER

The engine cooling system water filter and conditioner (Fig. 1) is a compact by-pass type unit with a replaceable element.

A correctly installed and properly maintained water filter and conditioner provides a cleaner engine cooling system, greater heat dissipation, increased engine efficiency through improved heat conductivity, and contributes to longer life of engine parts.

The filter provides mechanical filtration by means of a closely packed element through which the water passes. Any impurities such as sand and rust particles suspended in the cooling system will be removed by the straining action of the element. The removal of these impurities will contribute to longer water pump life and proper operation of the thermostat.

The filter also serves to condition the coolant by softening the water to minimize scale deposits, maintain an acid-free condition and act as a rust preventive.

Corrosion inhibitors are placed in the element and dissolve into the water, forming a protective rust-proof film on all of the metal surfaces of the cooling system (refer to Section 13.3). The other components of the element perform the function of cleaning and preparing the cooling passages while the corrosion inhibitors protect them.

Filter Installation

If a water filter and conditioner is to be installed on an engine which has been in service, drain and flush the cooling system prior to installation of the filter.

Filter Maintenance

Replace the chemically activated element periodically and buff the lower corrosion resistor plate on the former filter each time (discard the plate if excessive metal loss or pitting is evident) to ensure effective protection of the cooling system.

If the water filter is installed on an engine which has previously been in service, it may be necessary to change the filter element two or three times at intervals of 6,000 miles or less to clean up accumulations of scale and rust in the cooling system. It is advisable to drain and flush the system during these initial change intervals.

Change the filter element periodically as outlined in Section 15.1.

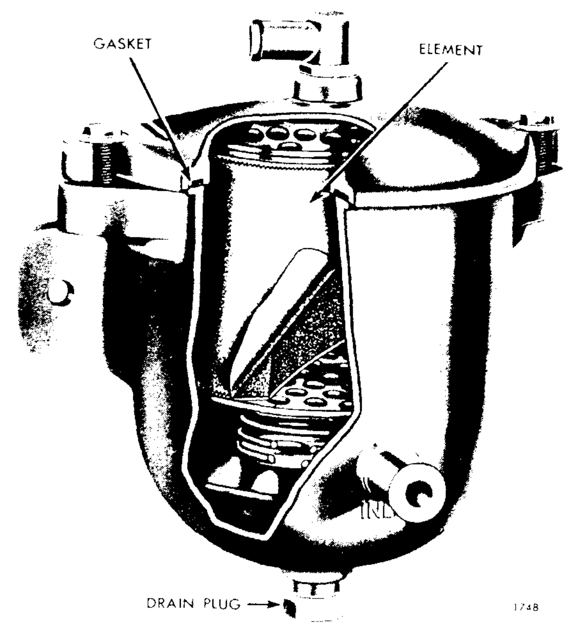

Fig. 1 - Water Filter and Conditioner

Make-up water up to approximately 40% of the total capacity of the cooling system may safely be added before a filter element change is required.

NOTE: Sea water must never be used for make-up water in a marine engine, except under emergency conditions. If it is necessary to use sea water, the cooling system must be completely drained and flushed with fresh water upon reaching port. The water filter element must be changed and on the former type filter the resistor plates inspected for pitting. Presence of salt in the coolant results in rapid pitting of the resistor plates.

If it is necessary for any reason to drain the cooling system before an element change, the treated water should be saved and re-used. If the treated water is discarded, a new filter element must be installed since the protective agents in the used filter will have been partially consumed in treating the discarded water.

Service

Whenever the water filter is removed and reinstalled, the filter must have metal-to-metal contact (grounded), either directly with the mounting surface or through the mounting bolts.

The current water filter includes a non-chromate type element. This element can be used in place of either of the former water filter elements (permanent type anti-freeze or plain water type) and thus provides year around cooling system protection. The current and the former water filter elements are completely interchangeable in the former filter can (refer to Section 13.3).

Replace the element and service the water filter and conditioner as follows:

1. Close the water filter inlet and outlet shut-off valves. If shut-off valves are not provided, vise grip pliers can be used to clamp each hose closed during the filter change.

2. Remove the filter cover-to-filter body bolts.

3. Remove and discard the element.

4. Remove and discard the corrosion resistor plates, if the former type filter is used.

5. Remove the sludge and sediment and wash the sump and filter body. Dry it thoroughly with compressed air.

6. Replace the drain plug, if removed, in the bottom of the filter.

7. Insert the new element.

8. Use a new filter cover gasket, install the filter cover, and tighten the bolts evenly.

9. Open the inlet and outlet lines by opening the shut-off valves or removing the vise grip plier clamps.

10. Operate the engine and check for leaks. The top of the filter and the outlet line should feel warm to the touch with the rise in coolant temperature. If not, disconnect the filter outlet line at the end opposite the filter connection to bleed the air from the system and reconnect the line. Use caution to minimize coolant loss.

SHOP NOTES - SPECIFICATIONS - SERVICE TOOLS

SHOP NOTES

The Jabsco raw water pump is equipped with a synthetic rubber impeller. Since synthetic rubber loses its elasticity at low temperatures, impellers made of natural rubber should be installed when it is necessary to pump raw water that has a temperature below 40°F.

The synthetic rubber impeller must be used when the pump operates with water over 40°F.

The natural rubber impeller can be identified by a stripe of green paint between two of the impeller blades.

EXCEPTIONS TO STANDARD BOLT AND NUT TORQUE SPECIFICATIONS

APPLICATION	THREAD SIZE	TORQUE (lb-ft)
Water pump cover bolt	5/16-18	6-7
Fan hub retaining nut (6V engines)	1/2 -20	35-40
Fan shaft bolt (V-type engines)	1/2 -20	83-93
Raw water pump drive gear retaining nut	5/8 -18	30-35

SERVICE TOOLS

TOOL NAME	TOOL NO.
Holder	J 358-1
Remover and installer	J 1930
Installer	J 22091
Puller	J 4794-01
Handle	J 7092-2
Plates	J 8329

SPECIFICATIONS

STANDARD BOLT AND NUT TORQUE SPECIFICATIONS

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

SECTION 6

EXHAUST SYSTEM

CONTENTS

Exhaust System 6

Exhaust Manifold (Air-Cooled) 6.1
Exhaust Manifold (Water-Cooled) 6.1.1

EXHAUST SYSTEM

Fan and radiator cooled engines are equipped with an air-cooled exhaust manifold. A water-cooled exhaust manifold is provided for engines incorporating a heat exchanger or keel cooling system.

The outlet flange may be located at the end or at the mid-section of the exhaust manifold, depending upon the installation requirements. A flexible exhaust connection or a muffler may be attached to the outlet flange.

The exhaust manifold is attached to studs located between the exhaust ports and the outer side of the two end ports in the cylinder head. Special washers and nuts secure the manifold to the cylinder head.

EXHAUST MANIFOLD (AIR COOLED)

Two types of exhaust manifolds are used. One type has an outlet to accommodate a square exhaust outlet flange (Fig. 1) and the other has a circular outlet which is connected to the exhaust pipe with a Marmon-type clamp (Fig. 2). Current manifolds, flanges (square) and flange gaskets have SAE standard dimensions.

On engines equipped with a mechanical automatic shut-down system, the exhaust manifold is provided with two 5/16"-18 tapped bolt holes and a 7/8" drilled hole to permit installation of the temperature shut-down valve adaptor and plug assembly.

Remove Exhaust Manifold

1. Disconnect the exhaust pipe or muffler from the exhaust manifold flange.

2. If the engine is equipped with a mechanical automatic shut-down system, remove the two bolts and lock washers and withdraw the shut-down valve adaptor and plug assembly from the exhaust manifold.

3. Loosen, but do not remove, one of the center exhaust manifold nuts. Remove the other nuts and washers.

4. Support the manifold and remove the center nut and washer.

5. Remove the manifold and gasket from the cylinder head.

Inspection

Remove any loose scale and carbon that may have accumulated on the internal walls of the exhaust manifold. Clean the manifold and check for cracks, especially in the holding lug areas.

Clean all traces of gasket material from the cylinder head.

Examine the exhaust manifold studs. Replace damaged studs. Apply sealant to the threads and drive new studs to 25-40 lb-ft torque (1.40" to 1.50" height).

Install Exhaust Manifold

1. Place a new gasket over the studs and against the cylinder head.

2. Position the exhaust manifold over the studs and hold it against the cylinder head.

3. Install the washers and nuts on the studs. If beveled (dished) washers are used, position them so that the crown side faces the nut. On some engines, crabs are used in place of washers at the end positions (Fig. 2).

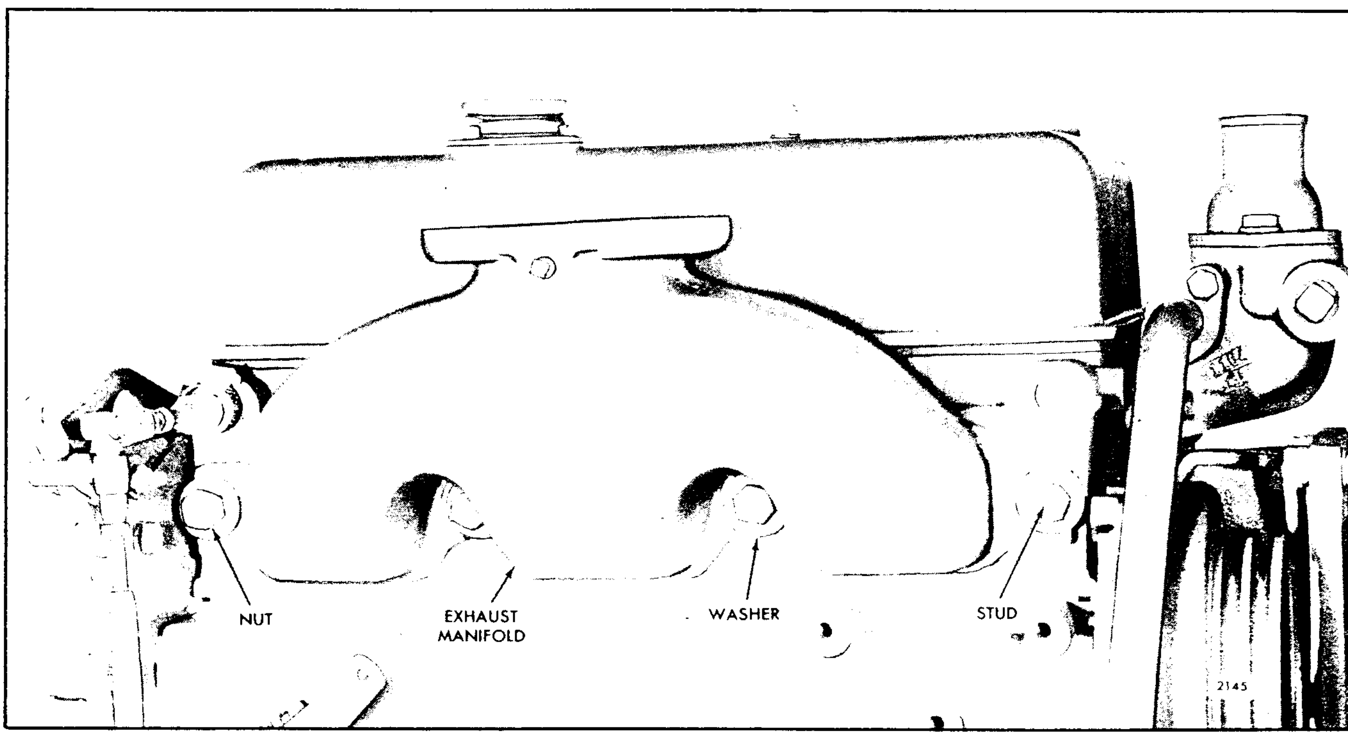

Fig. 1 - Typical Air-Cooled Exhaust Manifold (Square Flange) Mounting

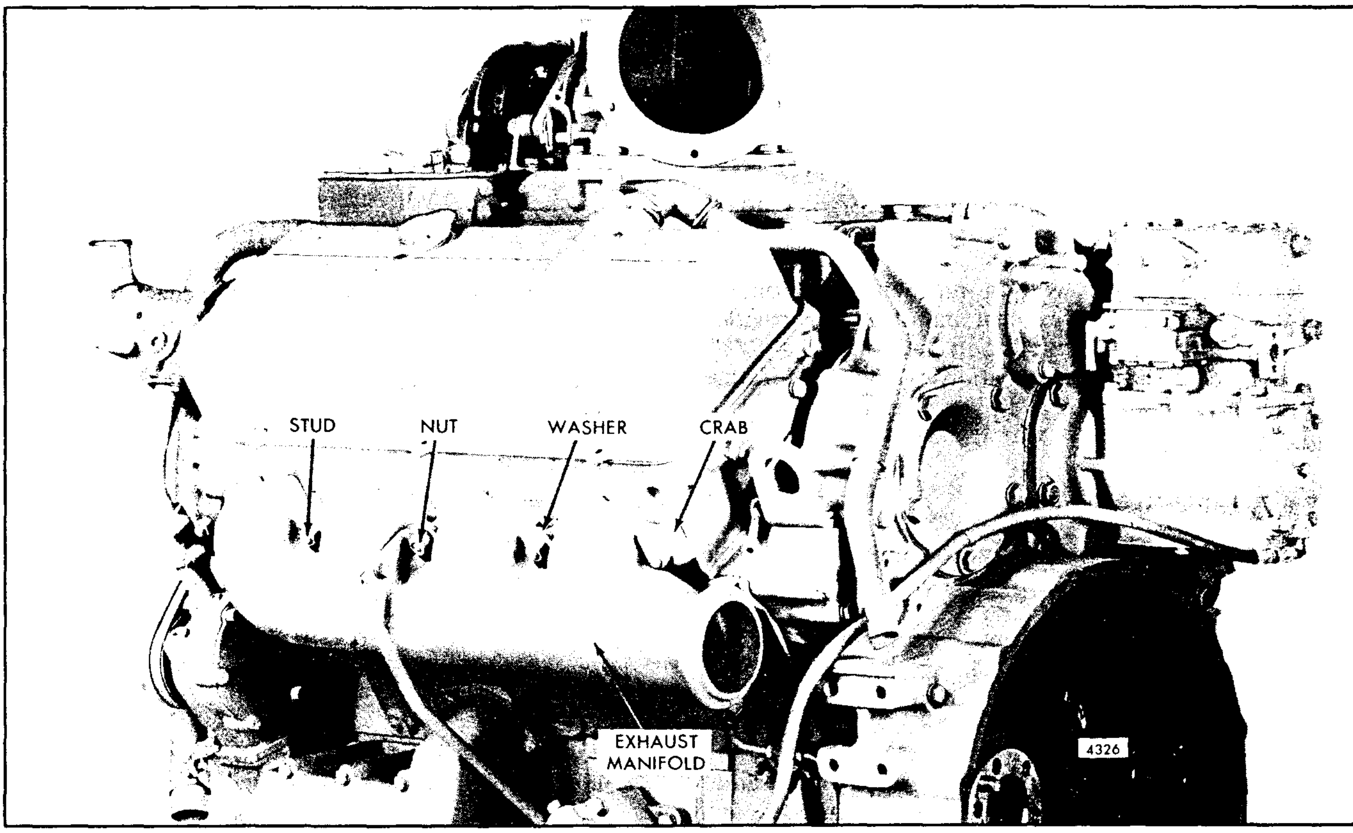

Fig. 2 - Exhaust Manifold with Marmon Flange

Beginning with one of the center stud nuts and working alternately toward each end of the manifold, tighten the nuts to 30-35 lb-ft torque.

4. If the engine is equipped with a mechanical automatic shut-down assembly, install the shut-down valve adaptor and plug assembly in the exhaust manifold and secure it with two bolts and lock washers.

5. Connect the exhaust pipe or muffler to the exhaust manifold flange.

EXHAUST MANIFOLD (Water Cooled)

A water jacket surrounds the exhaust chamber in the cast iron water-cooled exhaust manifold illustrated in Fig. 1. The engine coolant flows from the rear of the cylinder head through the water jacket around the exhaust manifold and through the thermostat housing and the water by-pass tube to the water tank.

Remove Exhaust Manifold

1. Remove the water tank filler cap and open the vent valve at the front end of the exhaust manifold.

2. Drain the cooling system.

3. Disconnect the exhaust pipe from the exhaust manifold flange.

4. Loosen the hose clamps and slide the hose back on the water inlet connector attached to the rear end of the cylinder head. On some engines, the connector is a formed hose which can be removed.

5. Disconnect the water tank vent tube, if used, at the exhaust manifold.

6. Loosen the hose clamps and slide the hoses back on the water by-pass tube and the heat exchanger water inlet tube or the thermostat housing.

7. If a water filter is used, disconnect the filter hose to the exhaust manifold.

8. Loosen the hose clamps at each end of the raw water pump outlet intermediate tube and slide the hose back on the tube at the curved end, then slide the tube out of the hose at the heat exchanger end.

9. Support the manifold and remove the nuts and washers which secure it to the cylinder head.

10. Remove the manifold and manifold gasket.

11. If necessary, remove the exhaust manifold flange at the rear of the manifold and the water outlet flange at the front.

Inspection

Remove the loose scale and carbon that may have accumulated on the internal walls of the exhaust manifold.

Clean all traces of gasket material from the cylinder head.

Examine the exhaust manifold studs for damage. If necessary, replace the studs. Apply sealant to the threads and drive new studs in to a height of 1.40" to 1.50" or to 25-40 lb-ft torque.

Install Exhaust Manifold

1. If removed, install the exhaust flange and water outlet flange on the exhaust manifold.

2. Place a new gasket over the studs and against the cylinder head.

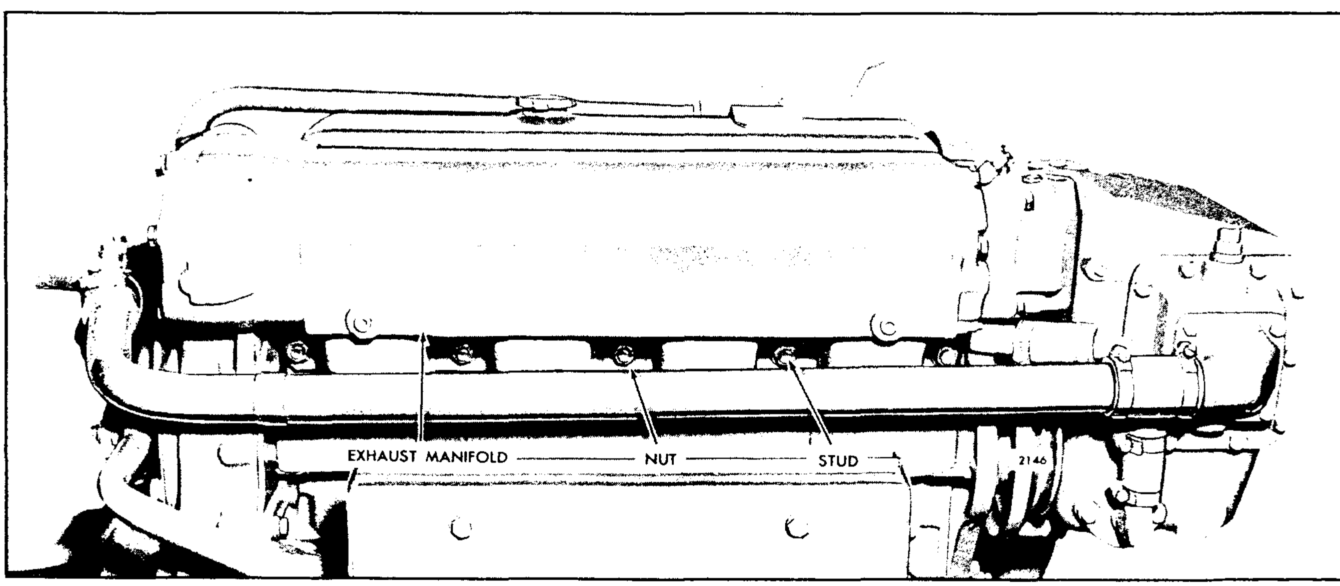

Fig. 1 - Typical Water-Cooled Exhaust Manifold Mounting (In-Line Engine)

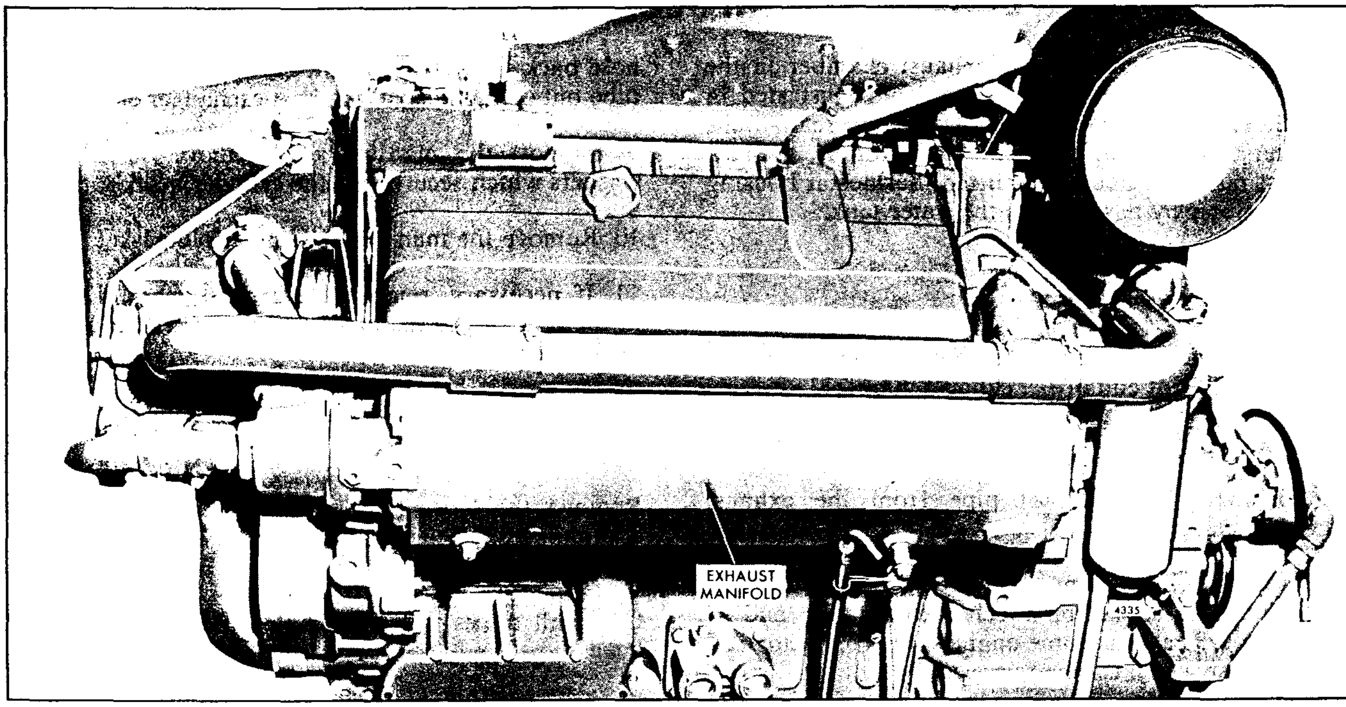

Fig. 2 - Typical Water-Cooled Exhaust Manifold Mounting (8V Engine)

3. Position the exhaust manifold over the studs and hold it against the cylinder head.

4. Install the washers and nuts on the studs. Beginning with one of the center stud nuts and working alternately toward each end of the manifold, tighten the nuts to 30-35 lb-ft torque.

5. Slide the hoses in place on the water by-pass tube and the heat exchanger water inlet tube or the thermostat housing and tighten the hose clamps.

6. Install the formed hose or slide the hose in place on the water inlet connector attached to the rear of the cylinder head. Tighten the hose clamps.

7. If used, connect the water tank vent tube to the exhaust manifold.

8. If the engine is equipped with a water filter, connect the filter hose to the exhaust manifold.

9. Install the raw water pump outlet intermediate tube, slide the hoses in place and tighten the hose clamps.

10. Connect the exhaust pipe to the exhaust manifold flange.

11. Close the drain valves and fill the cooling system.

12. Close the vent valve at the front end of the exhaust manifold and install the water tank filler cap.

13. Start the engine and check for leaks in the cooling system.

SECTION 7

ELECTRICAL EQUIPMENT, INSTRUMENTS AND PROTECTIVE SYSTEMS

CONTENTS

Electrical System	7
Battery-Charging Generator	7.1
Battery-Charging Generator Regulator	7.1.1
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ELECTRICAL SYSTEM

A typical engine electrical system generally consists of a starting motor, a battery-charging generator (alternator), a transistor combination voltage regulator, current regulator and cutout relay to protect the electrical system, a storage battery and the necessary wiring.

Additional equipment such as an engine protective system may also be included.

Detailed information on maintenance and repair of the specific types of electrical equipment can be found in the service manuals and bulletins issued by the equipment manufacturer. Information regarding equipment manufactured by the Delco-Remy Division of General Motors Corporation may be obtained from their electrical equipment operation and maintenance manuals. The manuals may be obtained from United Delco Division, or from the Technical Literature Section, Delco-Remy Division of General Motors Corporation, Anderson, Indiana.

In most instances, repairs and overhaul work on electrical equipment should be referred to an authorized repair station of the manufacturer of the equipment. Replacement parts for electrical equipment should be ordered through the equipment manufacturer's outlets, since these parts are not normally stocked by Detroit Diesel Allison. For electrical equipment manufactured by Delco-Remy Division, repair service and parts are available through United Delco Division branches and repair stations.

BATTERY-CHARGING GENERATOR (D.C. and A.C.)

The battery-charging circuit consists of a generator (alternator), regulator, battery and the wiring. The battery-charging generator is introduced into the electrical system to provide a source of electrical current for maintaining the storage battery in a charged condition and to supply sufficient current to carry any other electrical load requirements up to the rated capacity of the generator.

Direct current generators (Fig. 1) are manufactured in a wide range of sizes and types, but the basic design of all D.C. generators is the same. The size and type of generator applied to a particular engine depends on many factors, including maximum electrical load, type of service, percentage of engine idling to running time, type of drive, drive ratio (engine speed to generator speed), generator mounting and environmental conditions.

The alternating current self-rectifying generator (alternator), Figs. 2 and 3, is especially beneficial on an engine with extra electrical accessories and one that has to operate for extended periods at idle speeds. Diodes, built into the slip ring end frame, rectify the three phase A.C. voltage to provide D.C. voltage at the battery terminal of the generator, thereby eliminating the need for an external rectifier. The alternator is also available in a variety of sizes and types.

The proper selection of a generator which will meet the needs of the battery-charging circuit on the particular engine is mandatory. This, together with adherence to the recommended maintenance procedures, will reduce generator troubles to a minimum. Since most generators adhere to the same basic design, the maintenance, removal and installation procedures for all are similar.

Generator Maintenance

1. Maintain the proper drive belt tension. Replace worn or frayed belts. Belts should be replaced as a set when there is more than one belt on the generator drive.

2. Lubricate the generator bearings as outlined in the *Lubrication and Preventive Maintenance Chart* in Section 15.1.

Remove Generator

1. Disconnect all of the leads from the generator and tag each one to ensure correct re-installation.

2. Loosen the generator mounting bolts and nuts and the adjusting strap bolt. Then, remove the generator drive belts.

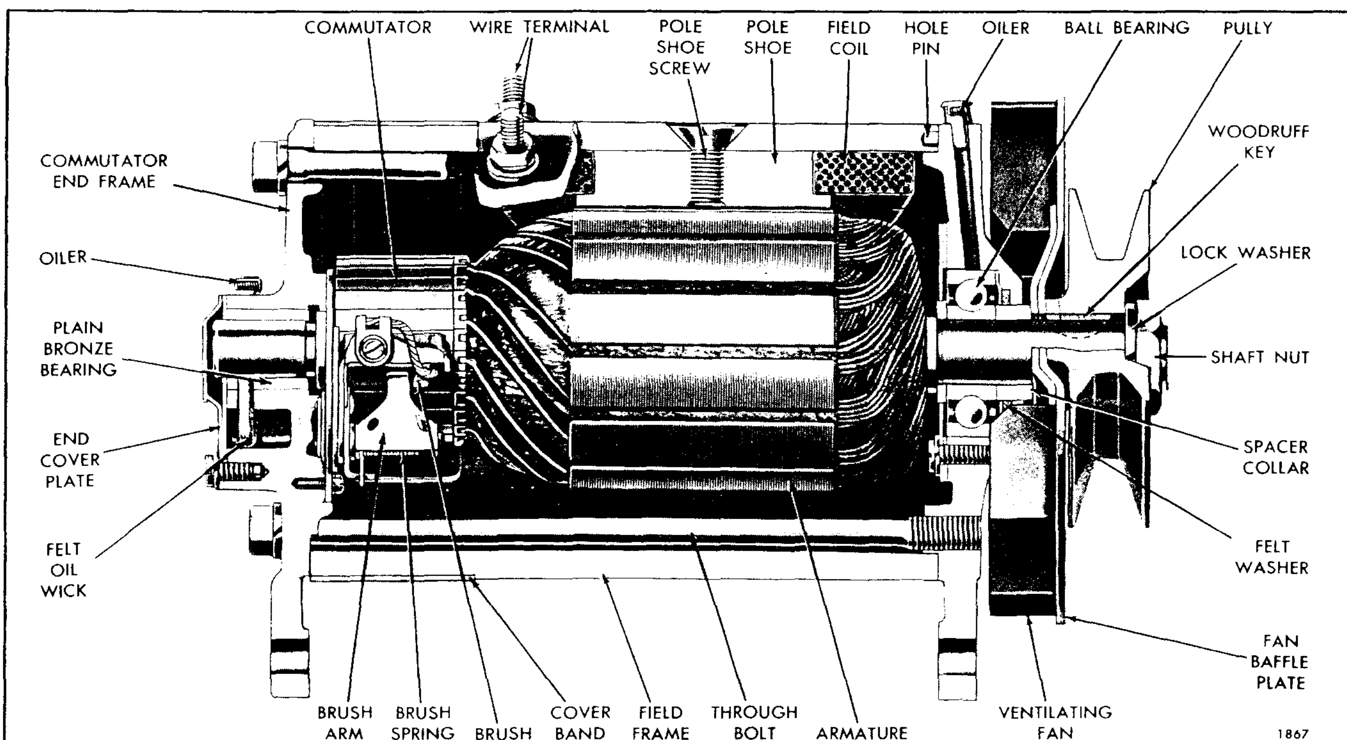

Fig. 1 - Typical Direct Current Generator

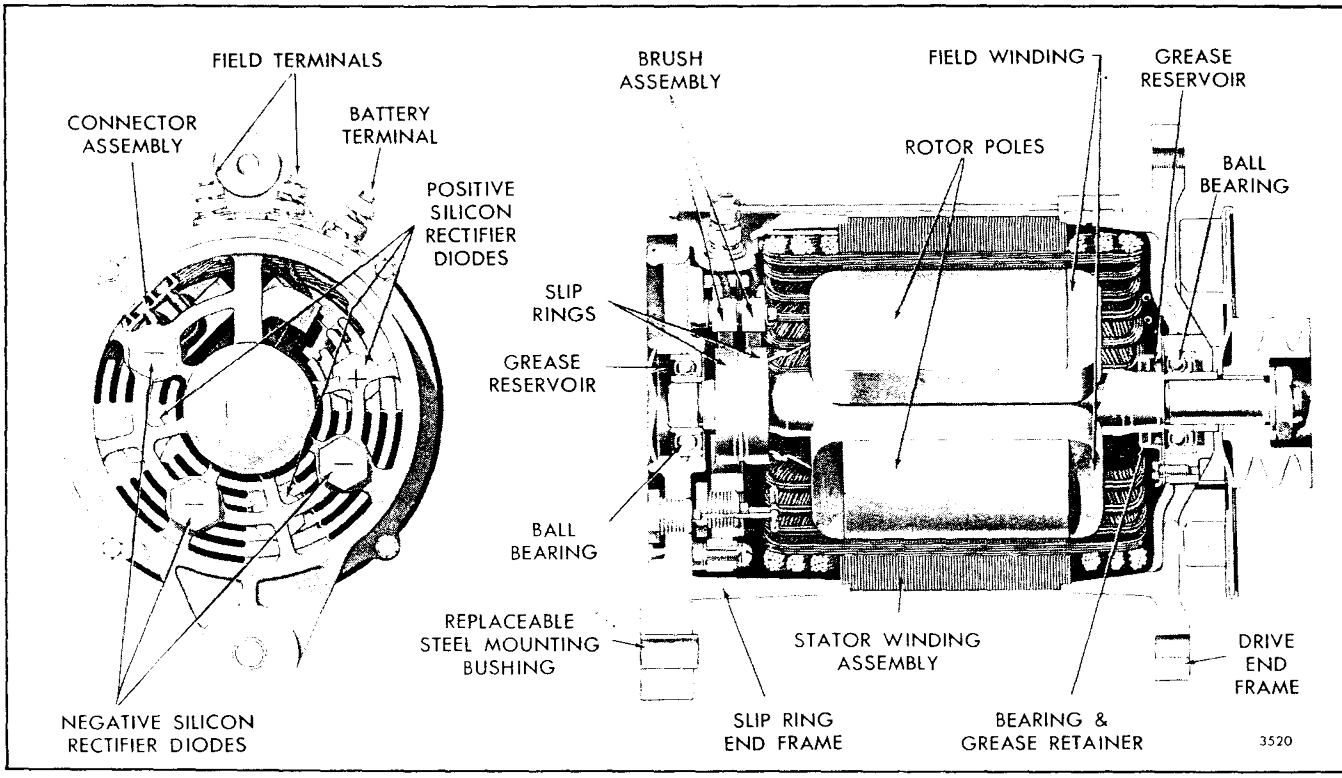

Fig. 2 - 30 DN Type 100 A.C. Self-Rectifying Generator (Alternator)

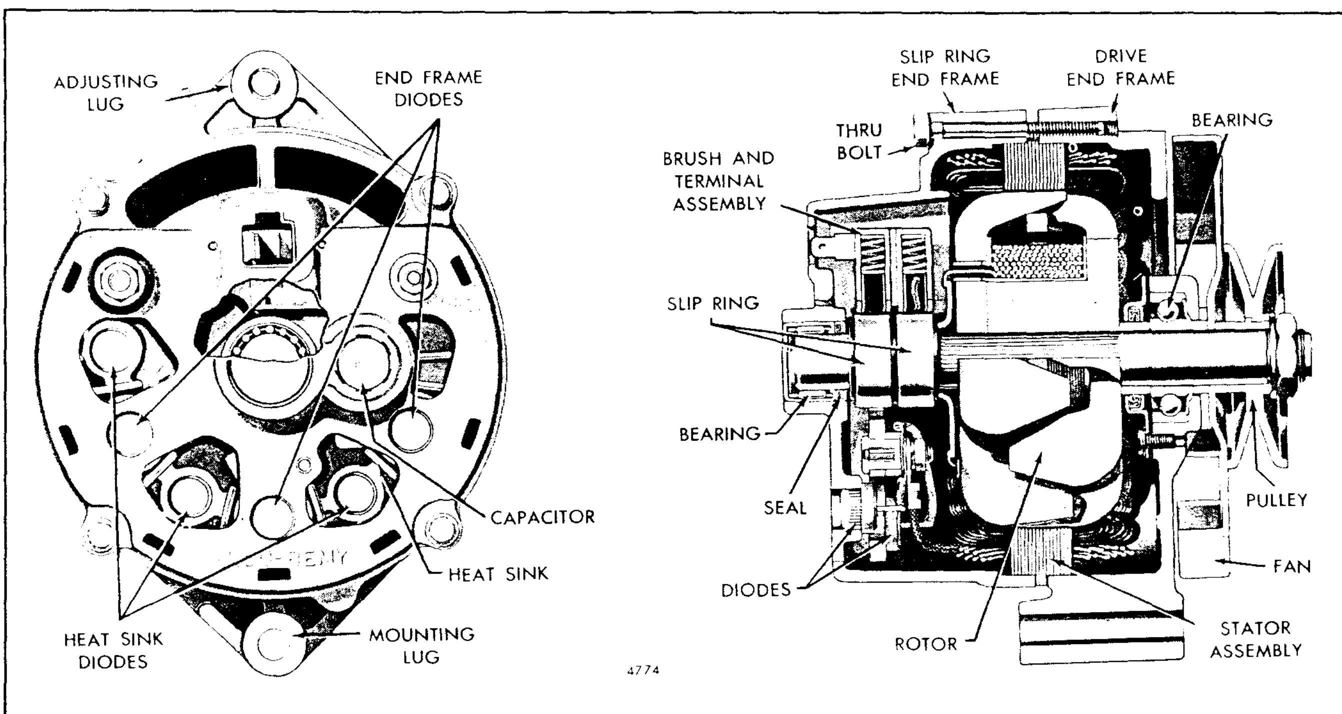

Fig. 3 - 10 DN Type 112 A.C. Self-Rectifying Generator (Alternator)

3. While supporting the generator, remove the adjusting strap bolt and washers and the mounting bolts, washers and nuts. Then remove the generator.

4. Remove the pulley assembly if the generator is to be replaced.

Install Generator

1. Install the generator drive pulley, if it was removed. Tighten the pulley retaining nut to 60 lb-ft torque.

NOTE: If the pulley was not removed, check the retaining nut for proper torque.

2. Position the generator on the mounting brackets and start the bolts, with lock washers, through the bolt holes in the generator end frames. If nuts are used, insert the bolts through the bolt holes and then install the lock washers and nuts.

3. Align the threaded hole in the extension ear of the drive end frame with the slot in the adjusting strap. Start the bolt, with the lock washer and plain washer, through the slot of the adjusting strap and into the threaded hole in the generator end frame.

4. Place the drive belts in the grooves of the pulleys.

5. Adjust the generator belt tension as outlined in Section 15.1.

6. Attach the wires and cables. Be sure that each one is correctly installed in accordance with its previous location on the generator. Keep all connections clean and tight.

Polarizing D. C. Generator

After each check or adjustment of the voltage regulator or generator, particularly after the leads have been disconnected and then reconnected, it is necessary to polarize the D.C. generator before starting the engine. This is to ensure correct polarity with respect to the battery.

CAUTION: Never attempt to polarize an alternator.

Failure to polarize a D.C. generator will result in burned or stuck cutout relay contact points in the regulator, a rundown battery and damage to the generator.

The procedure for correctly polarizing a generator will vary with the type of electrical equipment installed and upon the generator regulator wiring circuit. If the generator field is grounded through the regulator, it is an "A" circuit; if it is internally grounded, it is a "B" circuit.

If Delco-Remy electrical equipment is installed, reference can be made to the Delco-Remy "Electrical Equipment Manual" and "Test Specifications" (refer to Section 7) to determine the type of circuit applicable to the regulator being used. Since it is possible to have either an "A" or "B" circuit regulator with any given generator, the polarizing procedures must be carefully adhered to. Use of the wrong polarizing procedure or neglecting to polarize will result in reversed generator polarity and serious damage to electrical components.

After ascertaining the correct circuit used, polarize the generator as outlined below:

1. "A" Circuit:

   Connect a jumper lead momentarily between the "BAT" and "GEN" terminals of the regulator.

2. "B" Circuit:

   Remove the "F" lead from the regulator and momentarily connect it to the "BAT" terminal of the regulator.

A momentary surge of current to the generator correctly polarizes it with respect to the battery.

Alternator Precautions

Precautions must be taken when working on or around alternators. The diodes and transistors in the alternator circuit are very sensitive and can be easily destroyed.

Avoid grounding or shorting the output wires or the field wires between the generator and the regulator.

Grounding an A.C. generator's output wire or terminals, which are always "hot" regardless of whether or not the engine is running, or accidental reversing of the battery polarity will destroy the diodes. Grounding the field circuit will also result in the destruction of the diodes. Some voltage regulators provide protection against some of these circumstances. However, it is recommended that extreme caution be used.

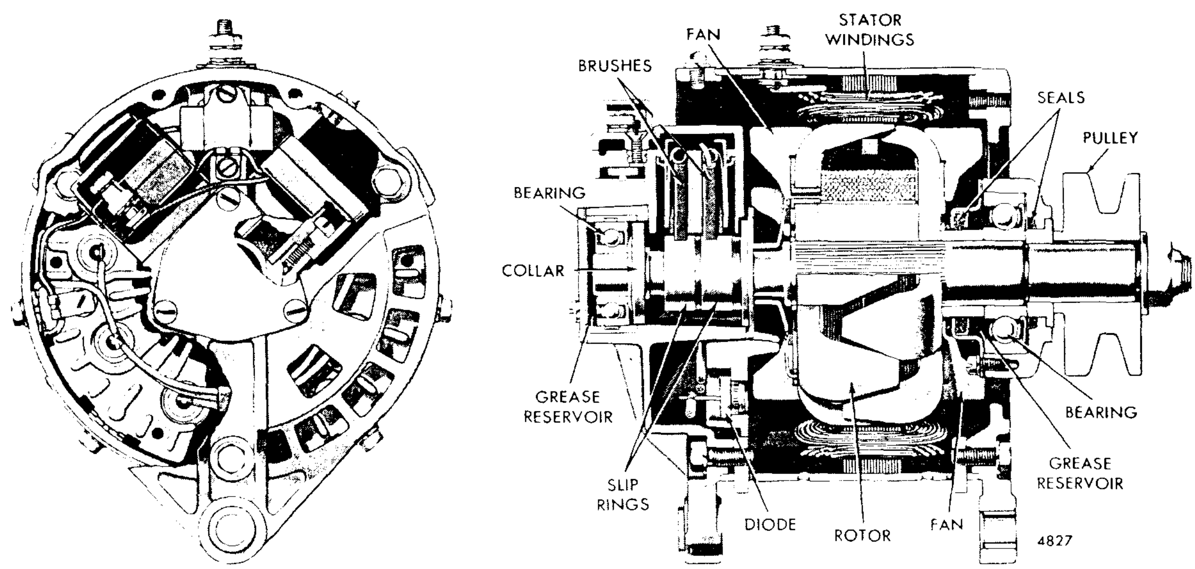

Fig. 4 - 20 DN Type 250 A.C. Self-Rectifying Generator (Alternator)

Accidentally reversing the battery connections must be avoided.

Never disconnect the battery while an alternator is in operation. Disconnecting the battery may result in damage to the generator diodes due to the momentary high voltage and current generated by the rapid collapse of the magnetic field surrounding the field windings.

In marine applications which have two sets of batteries, switching from one set of batteries to the other while the engine is running will momentarily disconnect the batteries and result in damage to the generator diodes unless the field circuit is opened first.

If a booster battery is to be used, the batteries must be connected correctly (negative to negative and positive to positive).

Never use a fast charger with the battery connected or as a booster for battery output.

Never attempt to polarize the alternator.

The alternator diodes are also sensitive to heat and care must be exercised to prevent damage to them from soldering irons, etc.

If faulty operation of an alternator occurs on an engine equipped with an insulated starting motor, check to be sure that a ground strap is present and is correctly installed.

BATTERY-CHARGING GENERATOR REGULATOR

D.C. CHARGING CIRCUIT

To regulate the voltage and current output of the battery-charging generator and to maintain a fully charged storage battery, several protective devices are employed, depending on the type of electrical system. The most representative of these devices is the "three-unit" regulator (Fig. 1).

These regulators are identified as:

a. A "Circuit A" unit in which the generator field circuit is connected to ground within the regulator and is used only with generators having an externally grounded field circuit.

b. A "Circuit B" unit in which the generator field circuit passes through the regulator and returns to ground inside the generator itself. This regulator must be used only with "Circuit B" generators in which the field is internally grounded.

The regulators are dust and moisture-proofed. On most applications, it is necessary to use shock mounts which insulate the regulator against vibration but necessitates the installation of a ground lead.

The three-unit regulator consists of a cutout relay, a voltage regulator and a current regulator mounted in a single assembly as shown in Fig. 1. These three units are basic and generally apply to most regulators in a D.C. generator system.

CUTOUT RELAY

The cutout relay (Fig. 2) has two windings assembled on one core; a series winding of a few turns of heavy wire and a shunt winding of many turns of fine wire. The relay core and windings are assembled into a frame. A flat steel armature is attached to the frame by a hinge so it is centered just above the center of the core. The armature has two or more contact points which are located just above a similar number of stationary contact points.

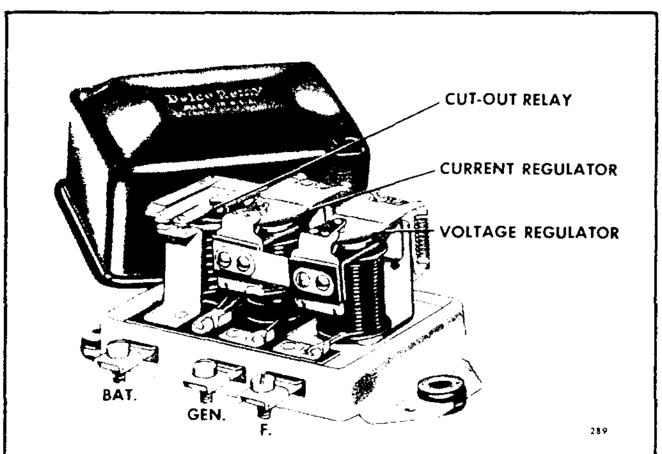

Fig. 1 - Typical Regulator Assembly

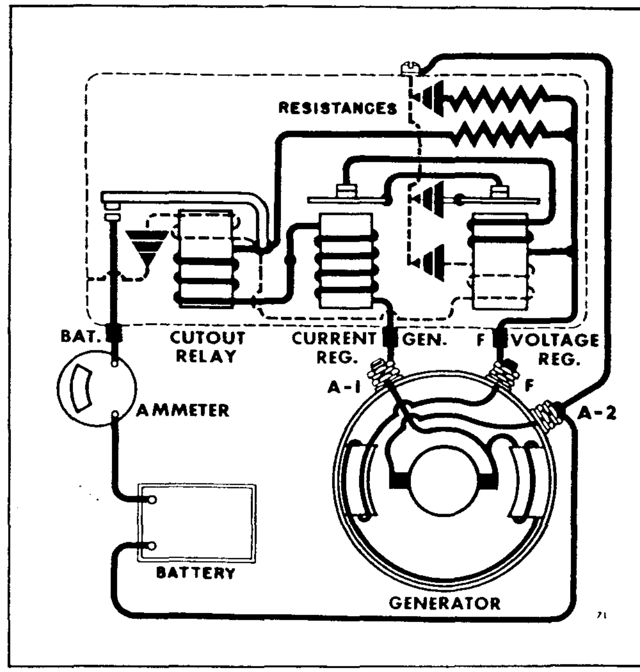

Fig. 2 - Wiring Circuit of Typical Three-Unit Regulator

Operation

When the engine is not running, the armature contact points of the relay are held away from the stationary points by tension of a leaf spring.

As the engine starts and the generator speed increases, the current flowing through the shunt winding builds up until it reaches the value for which the relay has been set. At this point, sufficient magnetism overcomes the armature spring tension, the contact points close and the current flows to the battery. Then the current which flows through the series winding is in the right direction to add to the magnetic force holding the armature down and the points closed.

When the engine is slowed down or stopped, current will begin to flow from the battery to the generator. This reverses the direction of current flow through the series winding, causing a reversal of the series winding magnetic field. The magnetic field of the shunt winding does not reverse. Therefore, the two windings now oppose each other magnetically and the resultant magnetic field is not strong enough to hold the armature down. The leaf spring pulls the armature away from the core and the points separate, opening the circuit between the generator and the battery.

CAUTION: The regulator cutout relay contact points must never be closed by hand with the battery connected. This would cause a high current flow through the units and damage them.

VOLTAGE REGULATOR

The voltage regulator (Fig. 2) has two windings on a single core. One is a shunt winding consisting of many turns of fine wire which, in series with a resistor, is shunted across the generator at all times. The second winding is a field current winding which is connected between the generator field circuit and ground whenever the regulator contact points are closed. In addition to the core frame, armature and contact points, the unit has a spiral spring which holds the armature away from the core so the two contact points are touching when the voltage regulator is not operating.

Operation

When the generator voltage reaches the value for which the voltage regulator is adjusted, the combined magnetic field produced by the shunt winding and the field current winding overcomes the armature spring tension, pulls the armature down and separates the voltage regulator contact points. This introduces resistance into the generator field circuit so the generator field current and generator voltage are reduced. The lowering of the output of the generator causes the points to close again, thereby removing the resistance and increasing the generator output. The complete cycle of opening and closing the points and the alternate inserting and removing of the resistance in the generator field circuit is done rapidly, thus limiting the the generator voltage to a predetermined maximum value. With the generator voltage limited, the generator supplies varying amounts of current to meet the requirements of varying states of battery charge and electrical loads.

CURRENT REGULATOR

The current regulator (Fig. 2) contains two windings assembled on one core; a series winding and a field current winding. The series winding, consisting of a few turns of heavy wire, is connected into the charging circuit so that the full output of the generator passes through it. The field current winding is connected in series with the generator field circuit so that the field current flows through the field winding when the regulator contact points are closed.

The outward appearance of the current regulator is similar to that of the voltage regulator.

Operation

The magnetism produced by current flowing through the series winding overcomes the armature spring tension and the contact points open when the current reaches the value for which the current regulator is adjusted. This inserts a resistance into the generator field circuit, resulting in a drop in generator output. Immediately, the magnetic field of the series winding is weakened, the contact points close, the generator output starts to increase and the cycle is repeated. This action prevents the generator from exceeding its rated output.

Therefore, when the load demand is heavy, generator output will increase until it reaches the current value for which the current regulator is set; then the current regulator will begin to operate and pre-regulate the current output from the generator.

After any check or adjustment of the voltage regulator, it is necessary to polarize the generator before starting the engine to assure correct polarity with respect to the battery (refer to Section 7.1).

BATTERY-CHARGING GENERATOR REGULATOR

A.C. CHARGING CIRCUIT

The alternating current generator regulator is similar in outward appearance to the regulator used with the D.C. generator. The D.C. and A.C. regulators are NOT interchangeable.

The internal wiring circuits of all standard A.C. generator regulators are similar, but the internal connections vary somewhat according to the method used to control the circuit breaker relay.

There are two and three unit standard A.C. generator regulators; the two unit regulators have a circuit breaker relay controlled by a relay rectifier or by an oil pressure switch and the three-unit regulators have a circuit breaker relay controlled by a built-in control relay.

The generator field circuit is insulated in the generator and grounded in the regulator. This type of connection is designated as Circuit "A".

> **NOTE:** Each type of regulator is used with a certain circuit. Do not attempt to interchange regulators.

The two unit A.C. generator regulator has a circuit breaker relay and a voltage regulator unit while the three unit regulator is also equipped with a control relay in addition to the other two units.

CIRCUIT BREAKER RELAY

The circuit breaker relay has a core with the winding made up of many turns of fine wire. This core and winding are assembled into a frame. A flat steel armature is attached to the frame by a hinge and is centered above the core. Two contact points, supported by two flat springs on the armature, are located above two stationary contact points. The upper and lower contact points are held apart by the tension of a flat spring riveted to the top side of the armature.

Operation

When the D.C. voltage reaches the value for which the circuit breaker relay is adjusted, the magnetism induced in the core by current flow in the winding is sufficient to overcome the armature spring tension and the relay points close. Closing of the contact points connects the D.C. side of the power rectifier to the battery so that current will flow to the battery whenever the generator is driven at sufficient speed.

The relay contact points remain closed as long as the D.C. voltage is enough to hold the relay armature against the core. They open when the voltage decreases to a value at which the magnetic pull of the core can no longer overcome the armature spring tension.

VOLTAGE REGULATOR

The voltage regulator unit has a core with a single shunt winding. This winding also consists of fine wire and is connected across the D.C. side of the power rectifier. The assembly and parts are similar to the circuit breaker relay. The matching upper contact point is supported by a detachable contact support insulated from the frame.

Operation

If the voltage regulator unit is not operating, the generator field circuit is completed to ground through the contact points which are held closed by the tension of a spiral spring acting on the armature.

When the D.C. voltage of the A.C. - D.C. system reaches the value for which the voltage regulator is adjusted, the magnetic field produced by the shunt winding overcomes the armature spring tension and pulls the armature down, causing the contact points to separate. When the contact points separate, resistance is introduced into the field circuit. The resistance decreases the field current causing a corresponding decrease in generator voltage and magnetic pull on the regulator armature. This allows the armature spring tension to re-close the contact points. When the voltage again reaches the value for which the voltage regulator is adjusted, this cycle repeats and continues to repeat many times a second, thus limiting the voltage to the value for which the regulator is set.

With the voltage limited in this manner, the generator supplies varying amounts of current to meet the various states of battery charge and electrical load.

Voltage regulators are compensated for variations in temperature by means of a bi-metal thermostatic hinge on the armature. The effect of this hinge causes the regulator to adjust at a higher voltage when cold, which partly compensates for the fact that a high voltage is required to charge a cold battery.

acts to prevent oxidation of the voltage regulator contacts. Regulators incorporating the choke coil are identified by a spot of green paint on the regulator base, next to the single mounting bolt hole.

CAUTION: A capacitor must not be installed unless the transistorized regulator incorporates the choke coil.

Operation

When the engine starting switch is closed, the field relay winding is energized and causes the contacts to close. Current then flows from the battery through the relay contacts to the regulator "F2" terminal. From this point, the current flows through the generator field winding and then through the transistor and voltage contact points to ground.

As the generator speed increases, the increased voltage from the generator "BAT" terminal is impressed through the field relay contacts across the regulator shunt winding. The magnetism created in the winding causes the voltage contacts to open, thus causing the transistor to shut off the field current. The generator voltage then decreases and the voltage contacts re-close. This cycle repeats many times per second, thereby limiting the generator voltage to the value for which the regulator is set.

The magnetism produced in an accelerator winding, when the voltage contacts are closed, aids the shunt winding in opening the contacts. When the contacts are open, the absence of the magnetism in the accelerator winding allows the spring to immediately re-close the contacts. This action speeds up the vibration of the contacts.

CAUTION: Do not short across or ground any of the terminals on the regulator or the generator and *do not* attempt to polarize the generator.

TRANSISTOR REGULATOR

The transistor regulator is composed principally of transistors, diodes, capacitors and resistors to form a completely static electrical unit containing no moving parts.

The transistor is an electrical device which limits the generator voltage to a pre-set value by controlling the generator field current. The diodes, capacitors and resistors act together to aid the transistor in performing this function, which is the only function that the regulator performs in the charging circuit.

The voltage at which the generator operates is determined by the regulator adjustment. Once adjusted, the generator voltage remains almost constant, since the regulator is unaffected by length of service, changes in temperature or changes in generator output and speed.

A separately mounted field relay connects the regulator "POS" terminal and the generator field windings to the battery when the engine starting switch is closed.

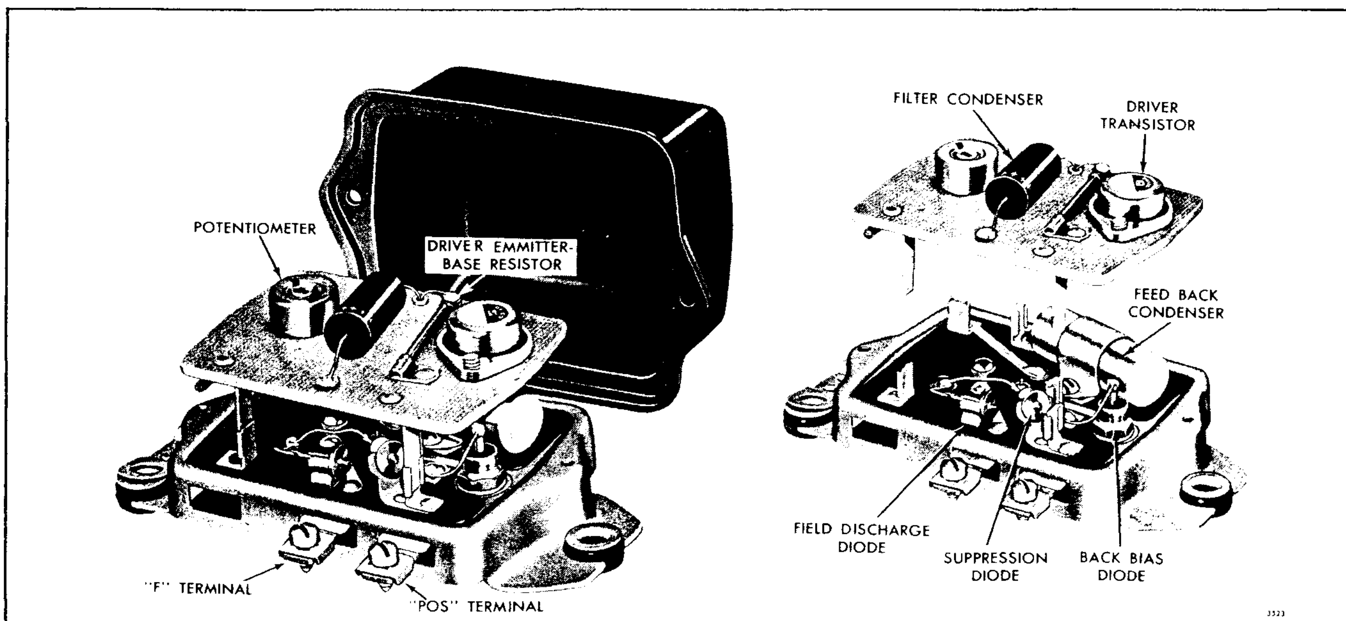

Fig. 4 - Transistor Regulator (Negative Ground Circuits Only)

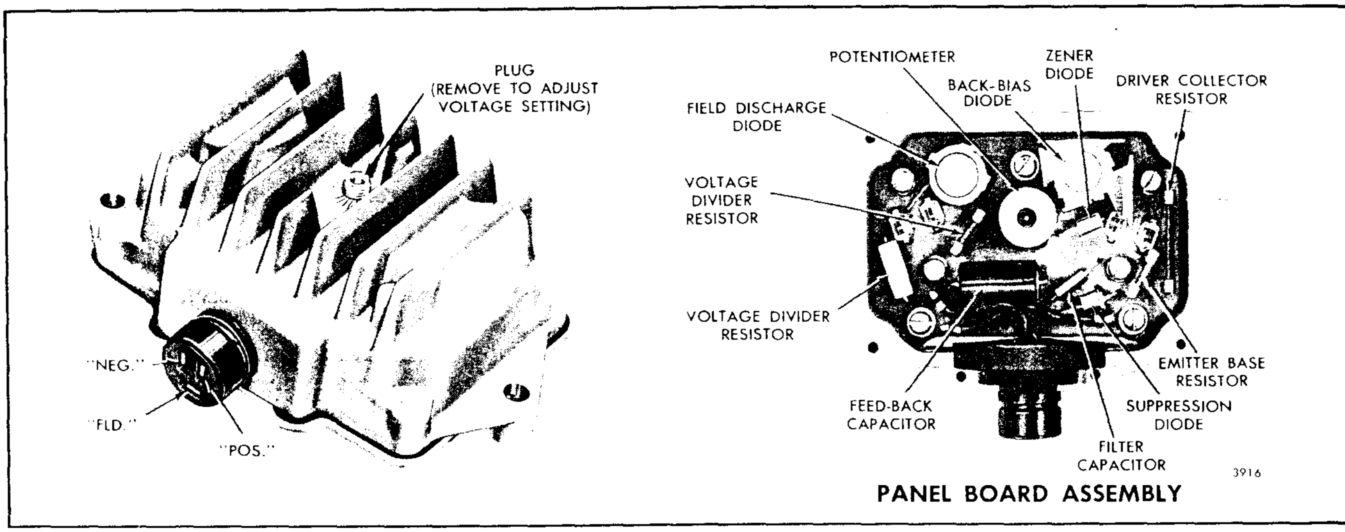

Fig. 5 - Transistor Regulator with Plug-In Connections

The voltage regulator illustrated in Fig. 4 is designed for negative ground battery-charging circuits only. It has two exposed terminals. The voltage setting may be adjusted by relocating a screw in the base of the regulator.

The voltage regulator shown in Fig. 5 has shielded plug-in connections and requires a cable and plug assembly to connect the regulator into the battery-charging circuit. This type of regulator may be used in negative ground, positive ground and insulated charging circuits. The voltage setting may be adjusted by removing a plug in the cover and turning a slotted adjusting button inside the regulator.

Operation

When the engine starting switch is closed, the field relay winding is energized, which causes the relay contacts to close.

In the **negative ground circuit** with the field relay contacts closed and the engine not running, generator field current can be traced from the battery through the relay contacts to the regulator "POS" terminal. Current then continues through the back-bias diode (D-1) and power transistor (TR-1) to the regulator "FLD" terminal, and then through the generator field winding to ground, completing the circuit back to the battery.

When the generator begins to operate, A.C. voltages are induced in the stator windings. These voltages are changed, or rectified, to a D.C. voltage which appears at the output, or "BAT", terminal on the generator. The generator then supplies current to charge the battery and operate vehicle accessories.

As generator speed increases, the voltage reaches the pre-set value and the components in the regulator cause transistor TR-1 to alternately "turn off" and "turn on" the generator field voltage. The regulator thus operates to limit the generator output voltage to the pre-set value.

In the **positive ground circuit**, when the switch is closed and the engine is not running, the field current can be traced from the battery positive ground to generator ground, and then to the regulator "POS" terminal. The current continues through diode D-1 and transistor TR-1 to the regulator "FLD" terminal, and then through the field winding and field relay contacts back to the battery, thus completing the circuit. Except for this primary difference, this circuit operates in the same manner as that described for the negative ground circuit.

REGULATOR PRECAUTIONS

Never short or ground the regulator terminals: *do not attempt to polarize the circuit.*

Make sure all connections in the charging circuit are tight to minimize resistance.

Refer to "A.C. Generator Precautions" in Section 7.1.

STORAGE BATTERY

The lead-acid storage battery is an electro-chemical device for converting chemical energy into electrical energy.

Function of Battery

The battery has three major functions:

1. It provides a source of current for starting the engine.

2. It acts as a stabilizer to the voltage in the electrical system.

3. It can, for a limited time, furnish current when the electrical demands exceed the output of the generator.

Types of Batteries

There are two types of batteries in use today.

1. The *dry charge* battery contains fully charged positive plates and negative plates separated by separators. The battery contains no electrolyte until it is activated for service in the field and therefore leaves the factory dry. Consequently, it is called a *dry charge* battery.

2. If the battery has been manufactured as a *wet* battery, it will contain fully charged positive and negative plates plus an electrolyte. This type of battery will not maintain its charged condition during storage and must be charged periodically to keep it ready for service.

BATTERY RECOMMENDATION

Engine	Batt. Volt.	Cap. 20 Hr. Rate	No. of Batt. (12 Volt)	Connect In
2-53 3-53 4-53 6V-53	12 24	150 150	1 2	Single Series
8V-53	12* 24	410 205	2 2	Parallel Series

*On highway vehicle - use high performance starter.

NOTE: In the selection of a replacement battery, it is always good practice to select one of an "electrical size" at least equal to the battery originally engineered for the particular equipment by the manufacturer.

Install Battery

While the battery is built to satisfactorily withstand the conditions under which it will normally operate, excessive mechanical abuse leads to early failure.

1. Be sure the battery carrier is clean and that the battery rests level when installed.

2. Tighten the hold-down clamps evenly until snug. However, do not draw them down too tight or the battery case will become distorted or will crack.

3. Attach the cable clamps after making sure the cables and terminal clamps are clean and in good condition. To make the cable connections as corrosion resistant as possible, place a felt washer at the base of each terminal, beneath the cable clamps. Coat the entire connection with a heavy general-purpose grease. Be sure the ground cable is clean and tight at the engine block or frame.

4. Check the polarity to be sure the battery is not reversed with respect to the generating system.

5. Connect the *grounded* terminal of the battery last to avoid short circuits which will damage the battery.

Servicing the Battery

A battery is a perishable item which requires periodic servicing. Only when the battery is properly cared for as described below can long and trouble-free service be expected.

1. Check the level of the electrolyte regularly. Add water if necessary, but do not overfill. Overfilling can cause poor performance or early failure.

2. Keep the top of the battery clean. When necessary, wash with a baking soda solution and rinse with fresh water. Do not allow the soda solution to enter the cells.

3. Inspect the cables, clamps and hold-down bracket regularly. Clean and re-apply a coat of grease when needed. Replace corroded or damaged parts.

4. Use the standard battery test as the regular service test to check the condition of the battery.

5. Check the electrical system if the battery becomes discharged repeatedly.

Many electrical troubles caused by battery failures can be prevented by systematic battery service. In general, the care and maintenance recommendations for storage batteries are the same today as they have always been.

Battery Safety Precautions

When batteries are being charged, an explosive gas mixture forms beneath the cover of each cell. Part of this gas escapes through the holes in the vent plugs and may form an explosive atmosphere around the battery itself if ventilation is poor. *This explosive gas may remain in or around the battery for several hours after it has been charged. Sparks or flames can ignite this gas causing an internal explosion which could shatter the battery.*

STARTING MOTOR

The starting motor (Fig. 1) has a shift lever and solenoid plunger that are totally enclosed to protect them from dirt.

The starting motor is equipped with a Sprag overrunning clutch drive (Figs. 2 and 3). An important feature of the Sprag type drive is that once the solenoid has moved the starter pinion in mesh with the ring gear on the flywheel, it will not disengage during intermittent engine firing, which prevents damage to the pinion and the ring gear teeth. The pinion remains engaged until starting is assured and the solenoid circuit is interrupted.

The solenoid switch, mounted on the starting motor housing, operates the overrunning clutch drive by means of linkage and a shift lever. When the starting switch is engaged, the solenoid is energized, shifting the starting motor pinion in mesh with the engine flywheel ring gear and closing the main contacts within the solenoid. Battery current is then directed to the motor causing the armature to turn. Cranking torque is transmitted by the Sprag clutch from the starting motor armature to the engine flywheel ring gear. To protect the armature from excessive speed as the engine starts, the clutch "overruns", or turns faster than the armature, which permits the pinion to disengage.

The Sprag overrunning clutch drive type starting motor is used with an engine flywheel ring gear which has either no chamfer or a Bendix chamfer. It cannot be used with a ring gear which has a Dyer chamfer. When installing a service replacement starting motor, make sure the correct flywheel ring gear is also used.

Under normal operating conditions, no maintenance will be required on the starting motor between engine overhaul periods.

Adjustable Nose Housing

The nose housing on the Sprag clutch type starting motor can be rotated to obtain a number of different solenoid positions with respect to the mounting flange. When repositioning of the solenoid is required on a service replacement starting motor, proceed as follows:

STARTER WITH INTERMEDIATE DUTY CLUTCH

The lever housing and the commutator end frame are held to the field frame by bolts extending from the end frame to threaded holes in the lever housing. The nose housing is held to the lever housing by internal attaching bolts extending from the lever housing to threaded holes in the nose housing (Fig. 2). With this arrangement, it is necessary to partially disassemble the motor to provide access to the nose housing attaching bolts. Relocate the nose housing as follows:

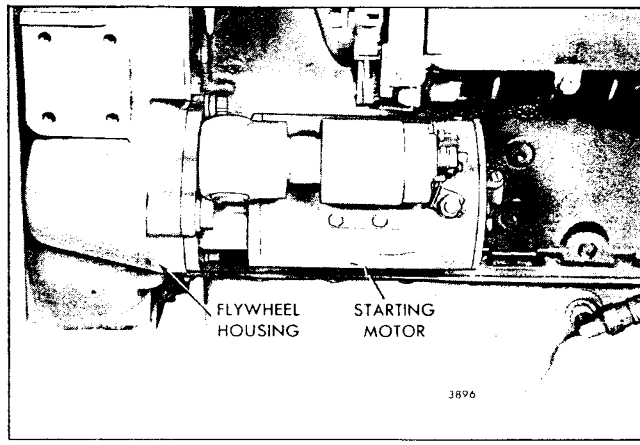

Fig. 1 - Typical Starting Motor Mounting

1. Remove the electrical connector and the screws attaching the solenoid assembly to the field frame; then, remove the bolts from the commutator end frame.

2. Separate the field frame from the remaining assembly and pull the armature away from the lever housing until the pinion stop rests against the clutch pinion; this will provide access to the nose housing attaching bolts.

3. Remove the nose housing attaching bolts with a box wrench or open end wrench.

4. Turn the nose housing to the required position.

   NOTE: The solenoid must never be located below the centerline of the starter or dust, oil, moisture and foreign material can collect and cause solenoid failures.

5. Reinstall the nose housing attaching bolts and tighten them to 11-15 lb-ft torque.

6. Reassemble the motor.

STARTER WITH HEAVY-DUTY CLUTCH

The nose housing, on starters equipped with the heavy-duty clutch, is attached to the lever housing by six bolts located around the outside of the housing (Fig. 3). Relocate the nose housing as follows:

1. Remove the six socket head screws (1 short and 5

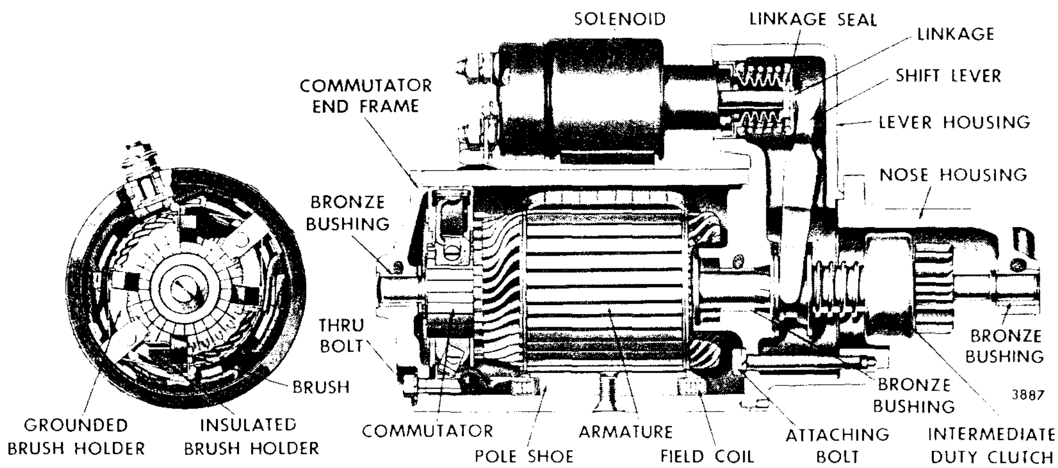

Fig. 2 - Cross-sectional View of Motor with Sprag Intermediate Duty Clutch

long) and six neoprene plugs from the unused holes if a 12 hole starter mounting flange is used.

2. Turn the nose housing to the required position.

NOTE: The solenoid must never be located below the centerline of the starter or dust, oil, moisture and foreign material can collect and cause solenoid failures.

3. Install the six socket head screws, with the short screw in the shallow hole nearest the solenoid. Install six neoprene plugs in the unused holes if a 12 hole starter mounting flange is used.

4. Tighten the screws to 13-17 lb-ft torque.

High-Output Starting Motor

A high-output 12-volt starting motor, with a Sprag overrunning clutch type drive, is provided for certain vehicle applications which require the equivalent of 24-volts for starting the engine and 12-volts for lighting and operation of electrical accessories. The same total battery capacity recommended for use with a 24-volt starter (two 205 ampere-hour batteries) must be retained and connected in parallel for the high-output 12-volt starter.

Lubrication of Starting Motors

The starting motor bearings (bushings) are lubricated by oil saturated wicks which project through each

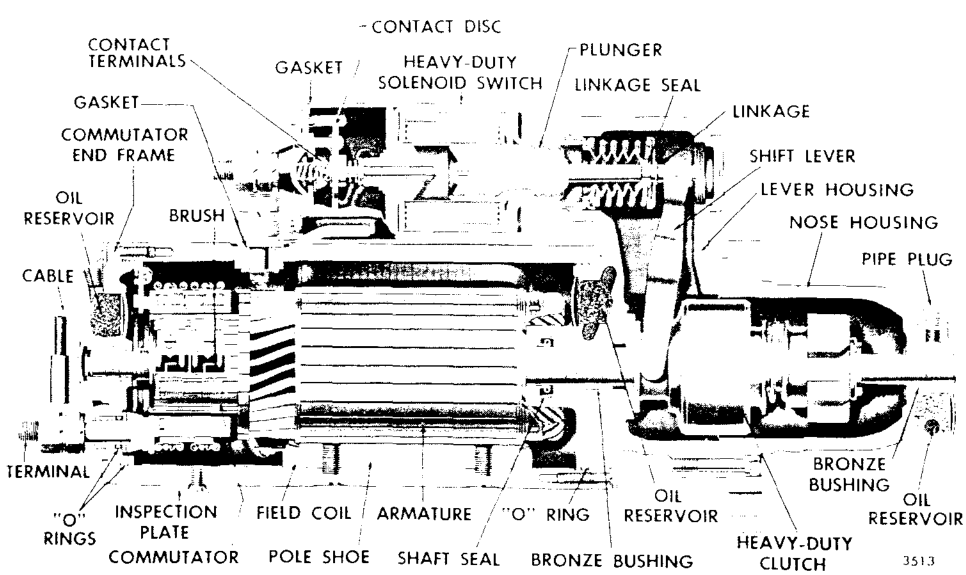

Fig. 3 - Cross-sectional View of Motor with Sprag Heavy Duty Clutch

bronze bushing (one at each end and one at the center) and contact the armature shaft. Oil can be added to each wick by removing a pipe plug which is accessible on the outside of the motor.

Remove Starting Motor

1. Remove the ground strap or cable from the battery or the cable from the starting motor solenoid. Tape the end of the cable to prevent discharging the battery from a direct short.

2. Disconnect all of the wires from the starting motor solenoid terminals. Tag the wires to insure correct reinstallation.

3. Support the motor and remove the three bolts and lock washers which secure it to the flywheel housing. Then pull the motor forward to remove it from the flywheel housing.

Check the starting motor, if required, in accordance with the Delco-Remy "Cranking Circuit" maintenance handbook.

Install Starting Motor

To install the starting motor, reverse the procedure outlined for removal. Tighten the 5/8"-11 mounting bolts to 137-147 lb-ft torque.

Keep all of the electrical connections clean and tight.

When installing wiring terminal leads to the starting motor and the solenoid switch, tighten the No. 10-32 connections to 16-30 **lb-in** torque and the 1/2" x 13 connections to 20-25 lb-ft torque.

INSTRUMENT PANEL AND INSTRUMENTS

The instruments (Fig. 1) generally required in the operation of a diesel engine consist of an oil pressure gage, water temperature gage, an ammeter and a mechanical tachometer. Instruments with slotted cases are available for use with lighted dashes. Also, closely related and usually installed in the general vicinity of these instruments are certain controls consisting of an engine stop knob, an emergency stop knob, and an engine starting switch.

All Torqmatic converters are equipped with an oil pressure gage and, in some instances, with an oil temperature gage. These instruments are mounted on a separate panel.

Instruments, throttle control and engine starting and stopping controls are mounted in various locations depending upon the particular use of the unit.

Marine propulsion units are provided with an instrument panel which usually includes an engine oil pressure gage, reverse gear oil pressure gage, water temperature gage, ammeter and a tachometer. The instrument panels are generally mounted some distance from the engine. Illuminated instrument panels are provided for marine applications which require night operations.

All illuminated instrument panels are wired for a 12 volt lighting circuit. Therefore, when marine propulsion units incorporate either a 24 or 32 volt electrical system, a 12 volt tap-off from the battery may be made, or resistors (see table) may be installed in the circuit to protect the instrument panel bulbs.

Resistor Specifications

Volts	Ohms	Watts
24	50	10
32	100	10

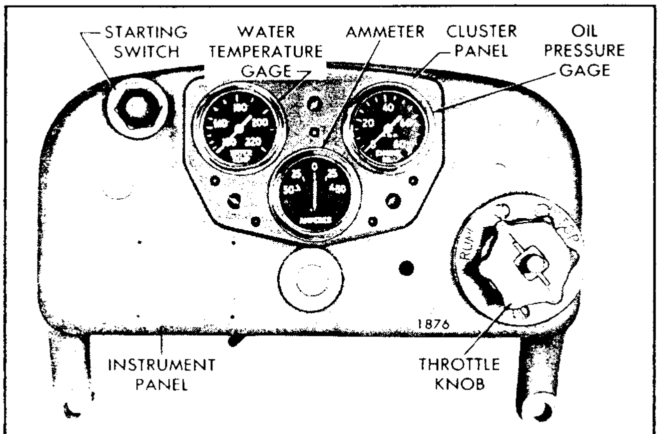

Fig. 1 - Typical Instrument Panel

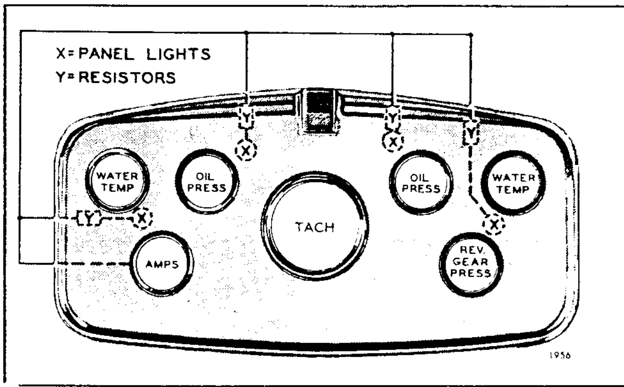

Fig. 2 - Installation of Resistors in Illuminated Instrument Panel

As indicated in Fig. 2, one resistor is used in the lead for each instrument panel bulb.

Whenever performing service or preventive maintenance procedures on marine propulsion engine units which include a 24 or 32 volt electrical system, the lighting circuit of the instrument panels should be checked to determine if either a 12 volt tap-off from the battery or resistors have been installed in the lighting circuit to protect the instrument panel bulbs.

Anti-Vibration Instrument Mountings

Anti-Vibration mountings (Lord mounts) are used in many places to absorb engine vibration in the mounting of instruments, drop relays, tachometers, etc. When it may become necessary to service a part secured by Lord mounts, care should be exercised, during the removal and installation of the part, to avoid twisting the rubber diaphragm of the mounts. At the time the part is removed from the engine for service, the mounts should be inspected for damage and replaced, if necessary.

The attaching screw, through the center of the mount, must be held from turning during final tightening of the nut. If this screw turns, it will pre-load the rubber diaphragm in torsion and considerably shorten the life of the mount.

Oil Pressure Gage

The oil pressure gage registers the pressure of the lubricating oil in the engine. As soon as the engine is started, the oil pressure gage should start to register. If the oil pressure gage does not register at least the minimum pressure listed in the *Operating Conditions* in Section 13.2, the engine should be stopped and the

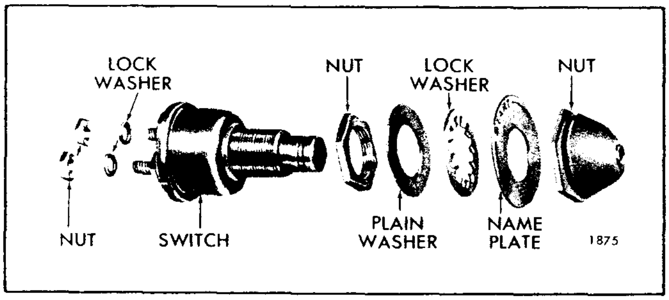

Fig. 3 - Typical Engine Starting Motor Switch

cause of the low oil pressure determined and corrected before the engine is started again.

Water Temperature Gage

The engine coolant temperature in the water manifold is registered on the water temperature gage.

Incorrect water temperature readings will be registered if the gage assembly is incorrectly installed or the capillary tube is damaged.

To prevent damage to the gage assembly from vibration, the capillary tube must be securely fastened to the engine the full length with suitable clips at intervals of 10 inches or less. Sharp bends in the tube must be avoided, particularly at the gage or bulb connection areas. Where the tube must be bent around any object, the bend must not be less than 1 inch radius.

Any extra length can be taken up by coiling, the diameter of which should not be less than two inches. The coils must be located so that they may be securely fastened to prevent vibrating.

Ammeter

The ammeter is wired into the electrical circuit to show the current flow to and from the battery. After starting the engine, the ammeter should register a high charge rate at rated engine speed. This is the rate of charge received by the battery to replenish the current used to start the engine. As the engine continues to operate, the ammeter should show a decline in the charge rate to the battery. The ammeter will not show zero charge rate since the regulator voltage is set higher than the battery voltage. The small current registered prevents rapid brush wear in the battery-charging generator. If lights or other electrical equipment are connected into the circuit, then the ammeter will show discharge when these items are operating and the engine speed is reduced.

Tachometer

The tachometer, driven by the engine, registers the speed of the engine in revolutions per minute (rpm).

Tachometer Drive

The tachometer drive shaft is pressed into the end of the camshaft, balance shaft or governor drive shaft. On V-type engines, it is pressed into the end of either camshaft, the blower drive shaft or the accessory drive gear.

Remove Tachometer Drive Shaft

If threads (5/16" -24 or 3/8" -24) are provided on the outer end of the tachometer drive shaft to accommodate a removing tool, thread remover J 5901-3 on the shaft; then, attach slide hammer J 5901-1 to the remover. A few sharp blows of the weight against the slide hammer rod will remove the tachometer drive shaft.

If threads are not provided on the outer end of the tachometer drive shaft, or if the end of the shaft is broken off, drill and tap the shaft. Then thread a stud into the shaft and remove the shaft with the remover and slide hammer.

CAUTION: Use adequate protective measures to prevent the metal particles from falling into the gear train and oil pan.

When installing a tachometer drive cover assembly or a drive adaptor, it is important they be aligned properly with the tachometer drive shaft as noted in Section 7.0.

Throttle Control

The engine throttle is connected to the governor control shaft through linkage. Movement of the speed control shaft changes the speed setting of the governor and thus the engine speed.

Engine Starting Switch

To start the engine, a switch (Fig. 3) is used to energize the starting motor. Release the switch immediately after the engine starts.

Engine Stop Knob

A stop knob is used to shut the engine down. When stopping an engine, the engine speed should be reduced to idle. The engine should be allowed to operate at idle for a few minutes to permit the coolant to reduce the temperature of the engine's moving parts and then the stop knob pulled and held until the engine stops. Pulling on the stop knob manually places the injector racks in the no-fuel position. The stop knob should be returned to its original position after the engine stops.

Emergency Stop Knob

In an emergency, or if the engine continues to operate after pulling the stop knob, the emergency stop knob may be used to stop the engine. When the emergency stop knob is pulled, the air shut-off valve, located between the air intake and the blower, will trip and shut off the air supply to the engine. Shutting off the supply of air to the engine will prevent further combustion of the fuel and stop the engine.

The emergency stop knob must be pushed back in after the engine is stopped, and the air shut-off valve must be re-set manually. The cause of the malfunction should be determined before the engine is started again.

ENGINE PROTECTIVE SYSTEMS

MANUAL SHUT-DOWN

A manually operated emergency engine shut-down device enables the engine operator to stop the engine in the event an abnormal condition should arise. If the engine continues to run after the engine throttle is placed in the no-fuel position, or if combustible liquids or gases are accidentally introduced into the combustion chamber causing overspeeding of the engine, the shut-down device will prevent damage to the engine by cutting off the air supply and thus stopping the engine. The shut-down device consists of an air shut-off valve mounted in the air inlet housing and a suitable operating mechanism.

Operation

The manually operated shut-down device is operated by a knob located on the instrument panel and connected to the air shut-off valve shaft lever by a control wire. Pulling the knob all the way out will stop the engine. Push the knob all the way in and manually reset the air shut-off valve before starting the engine again.

Service

For disassembly and assembly of the shut-down device, refer to Section 3.3.

AUTOMATIC MECHANICAL SHUT-DOWN

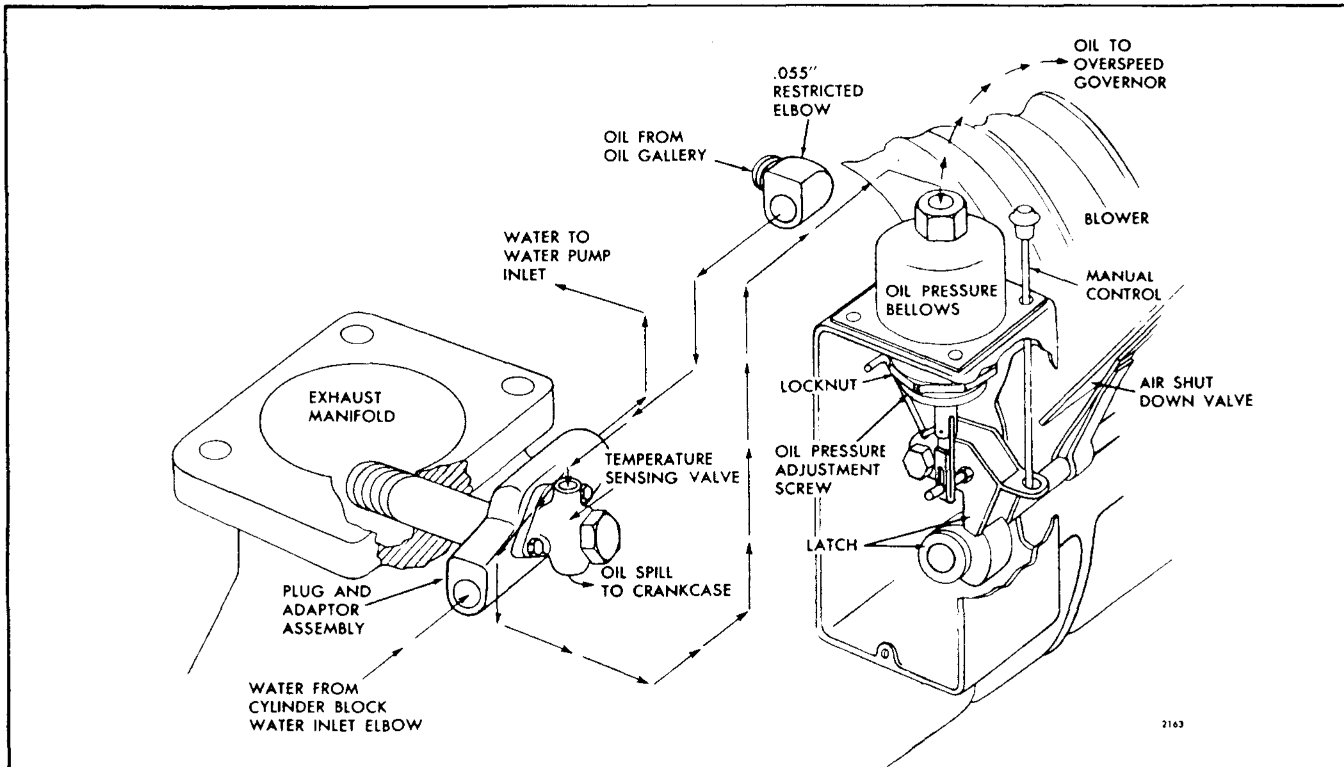

Fig. 1 - Mechanical Shut-Down System Schematically Illustrated

The automatic mechanical shut-down system is designed to stop the engine if an abnormal condition such as high engine coolant temperature, low engine oil pressure or engine over-speeding arises. The components of the shut-down system are schematically illustrated in Fig. 1.

A coolant temperature-sensing valve adaptor and plug assembly is mounted on the exhaust manifold with the plug extending into the manifold. Coolant from the engine is directed through the adaptor assembly, in which the bulb of the temperature-sensing valve assembly is located, to the suction side of the water pump.

Oil under pressure from the engine is directed through a restricted fitting to a "T" connection. One line from the "T" is connected to the temperature-sensing valve assembly and the other line leads to the oil pressure bellows. A line attached to the discharge side of the temperature valve directs any oil that passes through the valve to the engine crankcase. Oil under pressure entering the oil pressure bellows, works through the bellows against a spring, overcomes the spring tension and permits the latch to retain the air shut-off valve assembly in the open position. Should the oil pressure drop below a predetermined value, the spring in the oil pressure bellows will release the latch permitting the air shut-off valve to close, stopping the engine. The oil pressure bellows can be adjusted to release the latch at pressures ranging from approximately 5 to 25 psi.

The overspeed governor, used in some engine applications, consists of a small plunger and valve actuated by a set of spring-loaded weights. The plunger and valve are located in the oil line connecting the oil pressure bellows to the main oil gallery. An outlet in the valve is connected to the engine oil sump. Whenever engine speed exceeds the over-speed governor setting, the valve plunger (actuated by the governor weights) is lifted from its seat and permits oil in the line to flow to the engine sump. This results in a drop of oil pressure to the oil pressure bellows, thus actuating the shut-down mechanism and stopping the engine.

Operation

When starting the engine, it is necessary to first manually open the air shut-off valve and then press the engine starting switch, cranking the engine. As soon as the engine starts, the engine starting switch may be released, but the air shut-off valve must be retained in the open position until the engine oil pressure exceeds the setting of the pressure sensitive device and permits the latch to retain the air shut-off valve in the open position.

During operation, if the oil pressure drops below the setting of the pressure sensitive bellows, the spring within the bellows will release the latch and permit the air shut-off valve to close, stopping the engine.

If the engine coolant overheats during operation, the high temperature will cause the temperature-sensing valve to open and permit the oil to flow to the engine crankcase. The opening of the temperature-sensing valve lowers the oil pressure on the discharge side of the restricted fitting. The spring in the pressure sensitive bellows will release the latch and permit the air shut-off valve to close, stopping the engine.

Should the engine loose its coolant during operation, the copper plug extending into the exhaust manifold will heat up and radiate heat to the temperature-sensing valve which will operate and shut the engine down.

Whenever the engine speed exceeds the over-speed governor setting, the oil in the line flows to the sump, resulting in a decrease in oil pressure. The oil pressure bellows will then release the latch and permit the air shut-off valve to close, stopping the engine.

After the engine has been stopped due to the action of a protective device, it cannot be restarted until the particular device which actuates the shut-down has returned to its normal position. The abnormal condition which stopped the engine must be corrected before attempting to start the engine again.

Adjustment

The only adjustments necessary in the automatic mechanical shut-down system are the low oil pressure setting of the bellows and the overspeed setting of the overspeed governor. Replace the temperature-sensing valve when operation is unsatisfactory.

To adjust the low oil pressure setting of the bellows, run the engine until normal operating temperature (160°-186°F.) has been reached and the oil pressure has stabilized. Then reduce the engine speed slowly until the bellows disengages the latch on the air shut-off valve and stops the engine. Note the oil pressure at which the shut-down occurred. For units having a minimum idle speed of 1000 rpm, the recommended oil shut-down pressure is 18 psi; for units having a minimum idle speed of 500 rpm it is 10 psi. If adjustment is necessary, loosen the lock nut on the bellows and turn the adjusting screw clockwise to increase the oil pressure setting or counterclockwise to decrease the setting. Hold the adjusting screw and tighten the lock nut when the proper setting has been obtained.

Check the operation of the high coolant temperature-sensing valve by placing a cover over the radiator while the engine is operating at 1800 rpm under load. Observe the coolant temperature on a thermometer inserted at the radiator filler hole. An engine shut-down should occur when the coolant is 200°F. to 210°F. If shut-down does not occur, replace the coolant temperature-sensing valve assembly. If shut-down occurs below 200°F., check the coolant flow through the plug and adaptor assembly. If circulation is satisfactory and shut-down occurs below 200°F., replace the coolant temperature-sensing valve assembly. The coolant temperature-sensing valve cannot be adjusted.

NOTE: When removing the temperature-sensing valve or water temperature switch, examine the plunger in the current type copper plug (Fig. 2). If the plunger is not free in the plug and adaptor, install a new plunger, spring, plug and adaptor. Deposits from the engine coolant building up between the plunger, spring and copper plug can cause the plunger to stick. On the former type copper plug, replace the former plug with the new plug, plunger, spring and adaptor when the water holes become plugged with calcium deposits.

When required, the coolant temperature-sensing valve can be bench tested. This can be accomplished by attaching an air hose (40 psi) to the oil pressure hole and attaching a tube from the spill hole to a can of water. The bulb of the temperature-sensing valve and a thermometer should be emersed in a container of water that is heated and agitated. The valve opening will be indicated by the flow of air when the valve opens (195-206°F.

Overspeed Shut-Down Adjustment

1. Start the engine and bring it up to operating temperature.

2. Increase the engine speed to the specified over-speed shut-down speed. At this speed the bellow should disengage the air shut-down latch and stop the engine.

3. Adjust the overspeed governor setting, if necessary, by loosening the governor adjusting screw lock nut (on the overspeed governor cap), then turning the adjusting screw clockwise to increase the speed at which the air shut-down mechanism is tripped or counterclockwise to decrease the speed at which the latch will trip. Always tighten the lock nut after each adjustment.

4. Stop the engine and replace the control shut-down housing cover.

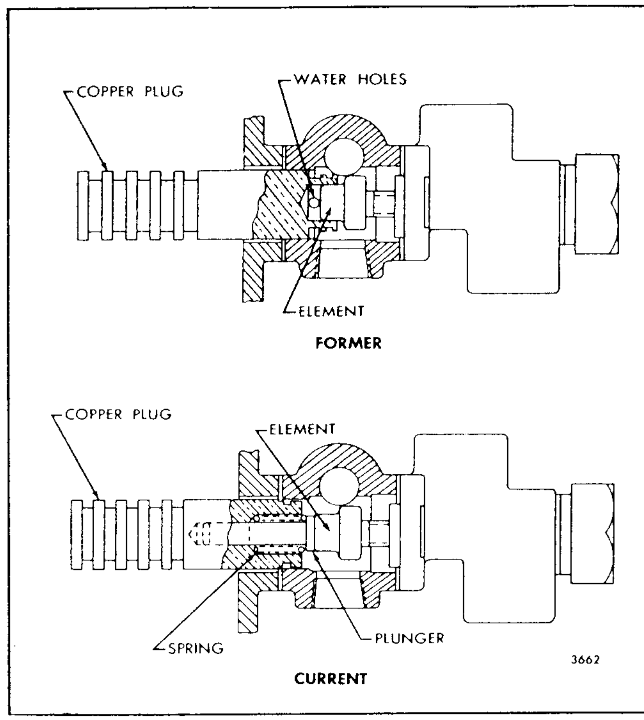

Fig. 2 - Comparison of New and Old Copper Plug

AUTOMATIC ELECTRICAL SHUT-DOWN

The automatic electrical shut-down system (Fig. 3) protects the engine against a loss of coolant, overheating of the coolant, loss of oil pressure or overspeeding. In the event one of the foregoing conditions arises, a switch will close the electrical circuit and energize the solenoid switch, causing the shut-down solenoid to release the air shut-down latch and stop the engine.

Operation

The electrical circuit is de-energized under normal operating conditions. When the engine is started, the oil pressure switch opens when the oil pressure reaches approximately 10 psi and the fuel oil pressure switch closes at approximately 20 psi fuel pressure. The water temperature switch remains open.

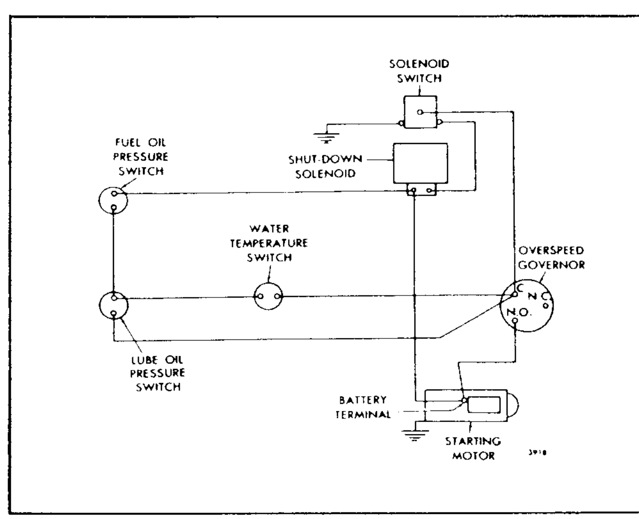

Fig. 3 - Automatic Electrical Shut-Down System Diagram

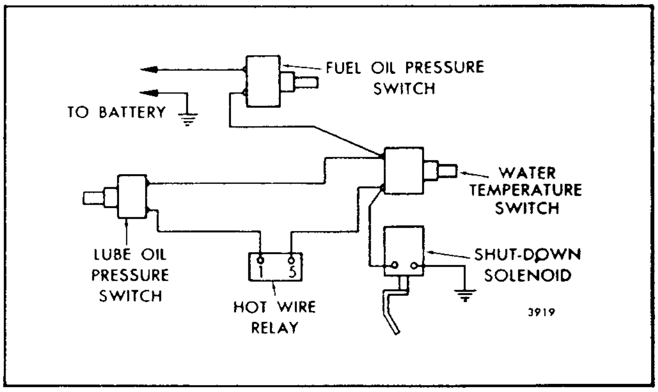

Fig. 4 - Automatic Electrical Shut-Down System Incorporating Hot Wire Relay

If the oil pressure drops below 10 psi, the oil pressure switch will close the circuit and energize the shut-down solenoid. This will activate the shut-down mechanism and stop the engine.

A loss of coolant or an increase in coolant temperature to approximately 203°F. will close the contacts in the water temperature switch, thus closing the electrical circuit and activating the shut-down mechanism.

The water temperature swtich consists of a temperature-sensing valve and a micro-switch. The valve contacts a copper plug (heat probe) which extends into the exhaust manifold outlet. Engine water is directed over the power element of the valve and should the water temperature exceed approximately 203°F., the valve will close the contacts in the micro-switch and energize the shut-down circuit. If a loss of water occurs, the heat of the exhaust gases will be transmitted through the copper plug to the temperature-sensing valve and cause the shut-down circuit to be activated.

If the engine speed exceeds the high speed setting of the overspeed governor, the governor switch will close and activate the shut-down mechanism.

When the engine is shut-down, the decrease in speed will open the governor switch and the decrease in oil and fuel pressures will close the oil pressure switch and open the fuel pressure switch, thus de-energizing the circuit.

The cause of the abnormal conditions must then be determined and corrected before the engine is started again. Also, the air shut-off valve must be manually reset in the open position before the engine can be started.

Some engines are equipped with an electrically operated automatic shut-down system which incorporates a hot wire relay (Fig. 4).

Since the fuel pressure builds up rapidly, the fuel oil pressure switch could close before the lubricating oil pressure switch opens, thereby effecting a shut-down of the engine. The hot wire relay, however, delays the closing of the fuel oil pressure switch for 3 to 10 seconds to enable the lubricating oil pressure to build-up and open the oil pressure switch contacts.

When the lubricating oil pressure falls below 10 ± 2 psi, the contacts in the oil pressure switch used in this system will close and current will flow to the hot wire relay. The few seconds required to heat the hot wire relay provides sufficient delay to avoid an engine shut-down when low oil pressure is caused by a temporary condition such as an air bubble or a temporary overlap in the operation of the oil pressure switch and the fuel oil pressure switch when starting or stopping the engine.

The high water temperature switch is installed in the side of the thermostat housing. The switch contacts close when the water temperature reaches approximately 205°F.

ALARM SYSTEM

The alarm system is similar in many respects to the automatic shut-down system, but does not include the automatic shut-down feature incorporating the electrical solenoid or the flap valve in the air shut-down housing which is operated by the solenoid. A bell is substituted for the solenoid in the alarm system. The alarm may be substituted for the shut-down solenoid, or it may be added to the automatic shut-down system. In either case, the alarm notifies the operator of a dangerous condition in the engine.

The voltage used through the alarm bell, however, must not exceed 12 volts.

Note that the cranking motor performs no essential function in the circuit.

An oil pressure switch, introduced into the engine oil gallery, is closed when the engine is not running, but opens after starting and remains open while the engine is running. This switch will close only in case of lowered oil pressure, thus causing the alarm to operate, or it will close if the engine is stopped by the operator. A water temperature switch, mounted in the water manifold, always remains open except in case of high water temperature when it closes and operates the alarm.

An automatic fuel oil switch closes after the engine is started and normal fuel oil pressure has been attained.

An optional overspeed switch is sometimes introduced into the system.

The water temperature switch and the oil pressure switch are similar to the same switches used in the automatic shut-down device.

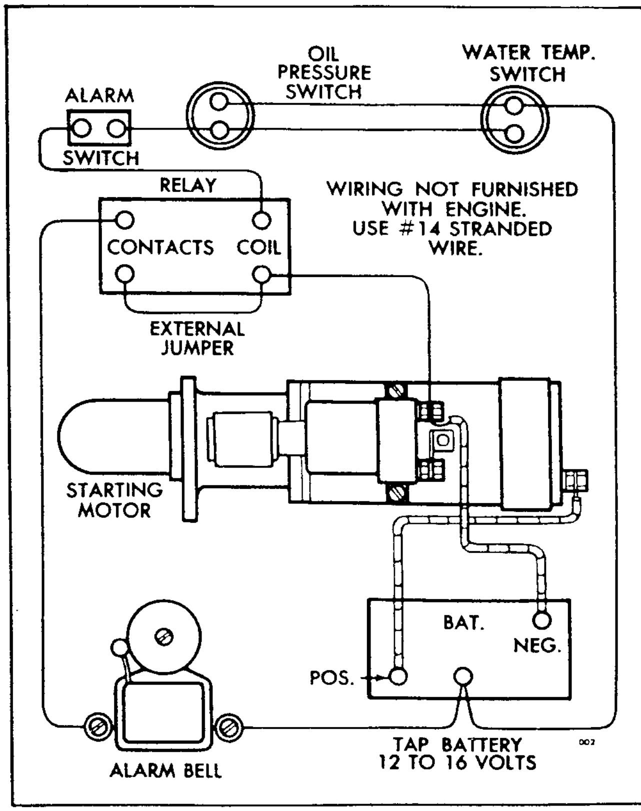

Fig. 1 - Alarm System Wiring Diagram

Service of the alarm system is usually limited to replacement of the alarm bell.

OVERSPEED GOVERNORS

ELECTRIC (Two Switch)

The series GY-2 Snychro-Start overspeed governor (Fig. 1) contains two separate snap action switches with single-pole double-throw contacts which operate at two different speeds. The governor is adjusted by the manufacturer to trip at the speeds required as indicated on the name plate. Unless otherwise specified, the name plate indicates trip points on increasing speed. The contacts will return to normal when the speed is decreased approximately 100 rpm below the trip speed, except on the high speed switch of those models having a manual reset button. The letter "M" after any model number indicates the high speed switch must be reset manually.

Service

1. The snap action switches may be replaced as follows:

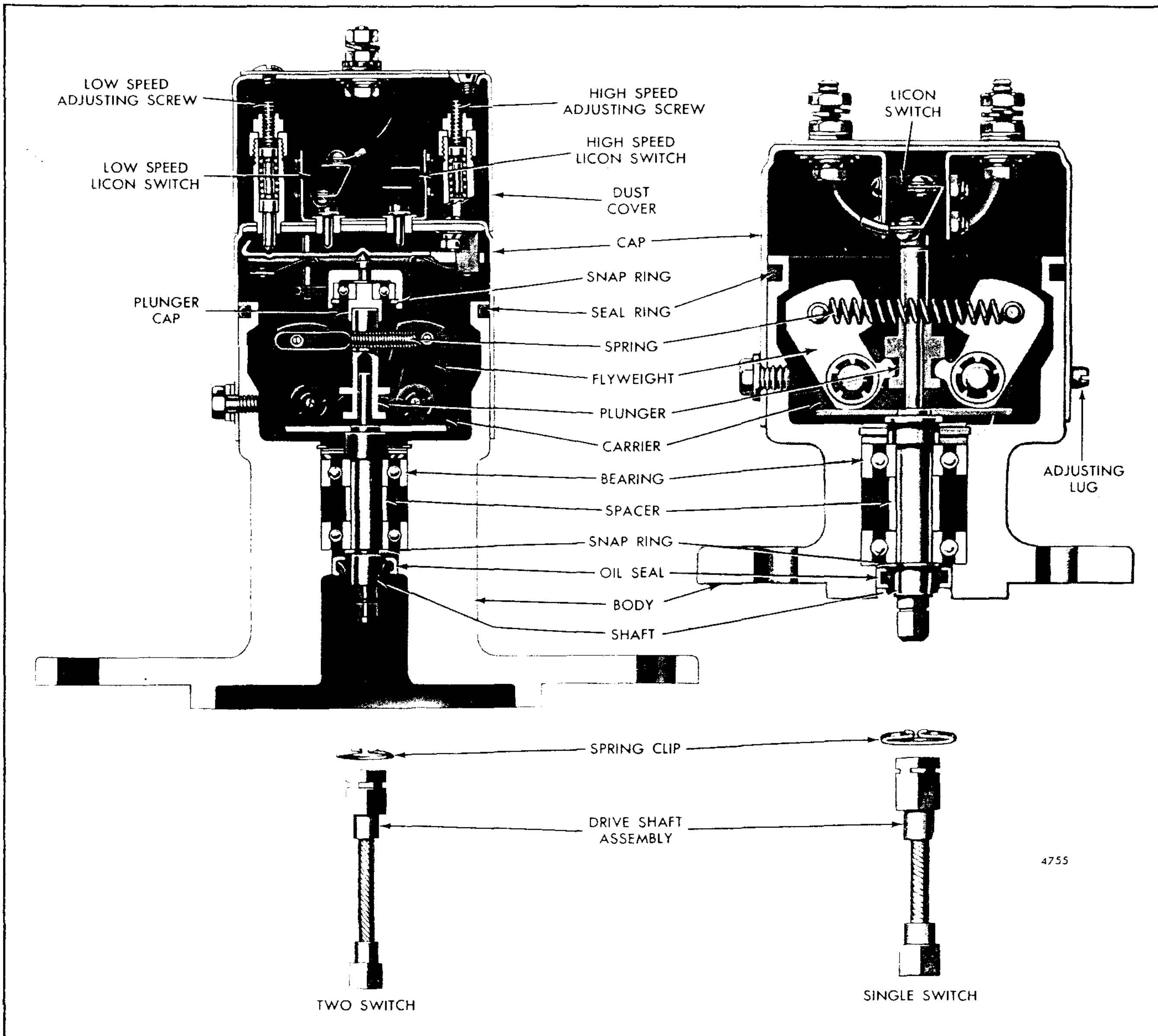

Fig. 1 - Electric Overspeed Governors

a. Mark the position of the dust cover and remove both hold-down screws.

b. Observe the position of the switches. Usually they are positioned with 1/64" clearance between the switch button and the lifters. If the lifters are replaced, make certain that the long lifter is placed beneath the low speed switch and the short lifter is placed beneath the high speed switch.

c. Install the new switches by reversing the above procedure.

CAUTION: When replacing the dust cover on a governor with a manual reset, make certain the switch wiring does not interfere with the reset mechanism.

d. Adjust the speed as outlined under *Speed Adjustment*.

2. Remove the governor cap as follows:

a. Observe the marking on the cap and the body and remove the three holding screws.

b. Remove the cap assembly, being careful not to damage the seal ring.

c. Replace any internal parts as required and reassemble and return the cap to the original position. A light coat of grease will facilitate assembly of the seal ring to the body.

NOTE: The position of the cap is very critical on governors in which the difference in trip points between the two switches is more than 1000 rpm and the trip point of the high speed switch is above 2100 rpm. These governors use elongated loop flyweight springs. If, after assembly, the No. 1 switch trips at a far higher point than normal, lower the cap position slightly. If the No. 2 switch trips at a very low speed, raise the cap position slightly. If difficulty arises, refer to Step 5 below.

d. Adjust the speed as outlined under *Speed Adjustment*.

3. Replace the speed adjusting springs as follows:

a. Hold the speed adjusting stud with a 5/16" open end wrench and loosen the adjusting stud nut with a 3/8" open end wrench.

b. After the above nut is removed, the adjusting spring and related parts may be removed and replaced as necessary. Exercise care to prevent particles of dirt from accumulating on the parts.

4. Replace the flexible drive shaft as follows:

a. Insert a sharp pointed instrument in the loop of the spring clip and pull it from the shaft as far as possible and remove the shaft assembly.

b. Upon reassembly, first install the spring clip in the groove of the fitting on the end of the governor shaft.

c. Push the shaft assembly into the square end of the governor shaft and the spring clip will snap in place.

NOTE: Check the position of the spring clip. If the clip has sprung out of position, use a small screw driver to push it into place.

5. Adjust the governor cap (with the dust cover in place):

a. Turn the low speed adjusting screw out for minimum speed adjustment. In this position, the top of the adjusting screw is approximately 1/8" from the top of the dust cover.

b. Turn the high speed adjusting screw in for almost maximum speed adjustment. In this position, the top of the adjusting screw is approximately 5/16" from the top of the dust cover.

c. With partial tension on the cap holding screws, turn the governor cap to the maximum extended position.

d. Operate the governor at 200 rpm above the trip point of the low speed switch.

e. Rotate the cap slowly in a clockwise direction until the low speed switch trips, mark the cap position and stop the engine. Then turn the cap another 1/16" and lock the holding screws securely.

f. Complete the operation as outlined under *Speed Adjustment*. Generally, the trip point of the low speed switch will have to be increased and the high speed switch decreased.

Maintenance

Grease the governor shaft ball bearings every 10,000 hours (every 5,000 hours if the governor speed is above 2500 rpm) as follows:

1. Remove the governor cap.

2. Remove the flexible drive shaft.

3. Remove the retaining ring from the groove in the housing. Then remove the weight and shaft assembly.

4. Inspect the oil seal and, if necessary, replace it as follows:

   a. Place the governor body in an arbor press, with the mounting flange toward the bottom, and use a 9/16" diameter rod to press the oil seal out.

   b. Press a new seal in place 3/64" from the bottom of the bearing cavity.

5. Fill the grease reservoir between the bearings *only 3/4 full* with Texaco "Unitemp" grease, or equivalent.

6. Reassemble the governor by reversing the procedure for disassembly and adjust the trip speeds as outlined below:

Speed Adjustment

Both switches may be individually adjusted. The dust cover screw marked "1" covers the low speed adjuster; the screw marked "2" covers the high speed adjuster. Proceed as follows:

1. Remove the appropriate dust cover screw. Then insert a 1/16" Allen wrench into the adjusting screw.

2. Turn the screw clockwise to increase the trip speed or counterclockwise to decrease the speed.

> **CAUTION:** If the adjusting screws are turned in too far, the switch will no longer operate. Do not attempt to use the slots in the cap for normal speed adjustments. This position is set and marked by the manufacturer for operation in the speed range required.

ELECTRIC (Single Switch)

Series GWA, GYA and GAA Synchro-Start overspeed governors (Fig. 1) are calibrated by the manufacturer to open or close the switch contacts at the particular speed required. The switch contacts will reset automatically when the speed is reduced approximately 100 rpm below the trip speed.

Service

Grease the governor shaft ball bearings every 10,000 hours (every 5000 hours if the governor speed is above 2500 rpm) as follows:

1. Remove the adjusting screw and the adjusting stud, then remove the governor cap.

2. Insert a sharp pointed instrument in the loop of the spring clip and pull the clip from the flexible shaft as far as possible. Then remove the shaft assembly.

3. Remove the retaining ring from the groove in the housing.

4. Remove the weight and shaft assembly.

5. Inspect the oil seal and, if necessary, replace the seal as follows:

   a. Place the governor body in an arbor press with the mounting flange facing down and use a 9/16" diameter rod to press the oil seal out of the body.

   b. Press the new oil seal in place, 3/64" from the bottom of the bearing cavity.

6. Fill the grease reservoir between the bearings *only 3/4 full* with Texaco "Unitemp" grease, or equivalent.

7. Reassemble the governor by reversing the procedure for disassembly and adjust the trip speed as outlined below.

Speed Adjustment

Loosen the cap adjusting lock screw and turn the cap until the desired trip speed is reached. Clockwise rotation of the cap lowers the trip speed and counterclockwise rotation increases the trip speed. The total range of adjustment of the particular governor is indicated on the governor name plate. The governor should not be adjusted to trip below 100 rpm above the normal running speed of the governor. Make sure the governor cap locking screw is tightened after the adjustment has been completed.

CAUTION: Under no circumstances should the governor switch be by-passed to prevent engine shut-down in the event of overspeed, otherwise serious damage to not only the engine, but also to the governor may be incurred since the governor is not designed to operate above its tripping speed.

HYDRAULIC

The hydraulic overspeed governor which contains a set of spring-loaded weights prevents excessive engine speeds.

Figure 2 illustrates the old and new hydraulic overspeed governors. The new governor differs from the old governor in the use of a new housing, cover and speed adjusting screw. The new housing is shorter and the new cover is longer than the old cover. The new adjusting screw differs from the former screw in the width of the seal ring groove which is wider on the new screw.

The overspeed governor is mounted in an adaptor which is mounted on the rear of the flywheel housing. A seal ring in the adpator end of the governor housing prevents oil seepage from the flywheel housing. The governor is driven by a flexible drive assembly from the blower drive shaft. Oil under pressure is supplied to the governor by a tube which is connected to the oil gallery in the cylinder block.

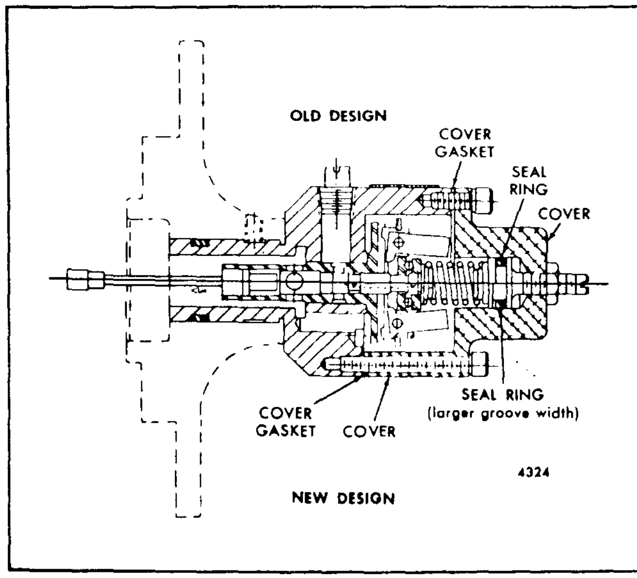

Fig. 2 - Hydraulic Overspeed Governor

Operation

When the engine speed reaches the value for which the overspeed governor is set, the centrifugal force of the weights in the overspeed governor overcomes the spring tension and opens a pilot valve in the governor. The pilot valve dumps oil from the oil tube, lowering the pressure at the engine oil pressure switch, thus closing the switch and energizing the shut-down solenoid and closing the shut-down valve.

Lubrication

The overspeed governor is lubricated by oil from the engine crankcase.

Adjustment

The engine shut-down speed is determined by the position of the adjusting screw in the overspeed governor cover. To change the setting, loosen the lock nut and turn the adjusting screw in to increase the speed or out to decrease the speed. When the proper setting is obtained, tighten the adjusting screw lock nut.

POWER GENERATOR AND CONTROLS

Detailed information on the maintenance and repair of power generators, control cabinets and component assemblies such as voltage regulators can be found in the service manuals and bulletins issued by the equipment manufacturers.

In many instances, repairs and overhaul work on electrical equipment may be referred to an authorized repair station of the manufacturer of the equipment.

Replacement parts for electrical equipment should be ordered through the equipment manufacturers outlets since these parts are not normally stocked by Detroit Diesel Allison.

For service information regarding Delco Products equipment, direct all requests to the Service Department, Delco Products Division, General Motors Corporation, Dayton, Ohio 45401.

Remove Power Generator From Engine

If required, remove the power generator (Fig. 1) from the engine as follows:

1. If the generator bearing is lubricated by oil, remove the drain plug from the end frame or the bottom of the sight gage and drain the oil.

2. Remove the terminal box cover plate and remove all of the external power leads.

> **CAUTION:** Tag each power lead before disconnecting to ensure correct connections when the generator is reinstalled.

3. If the unit is equipped with a control cabinet, disconnect all of the generator-to-control cabinet power leads at the cabinet. Also, disconnect all engine instruments, throttle control linkage, electrical wiring harness or engine shutdown mechanism at the control cabinet.

> **CAUTION:** Tag all electrical leads before disconnecting to ensure correct connections when the unit is reassembled.

4. Remove the control cabinet from the engine base.

5. Loosen the front engine-to-base mounting bolts. Also, loosen the upper hose clamps at the radiator to prevent hose distortion when the flywheel end of the engine is raised.

6. Remove the generator foot-to-engine base mounting bolts and spacers (if used).

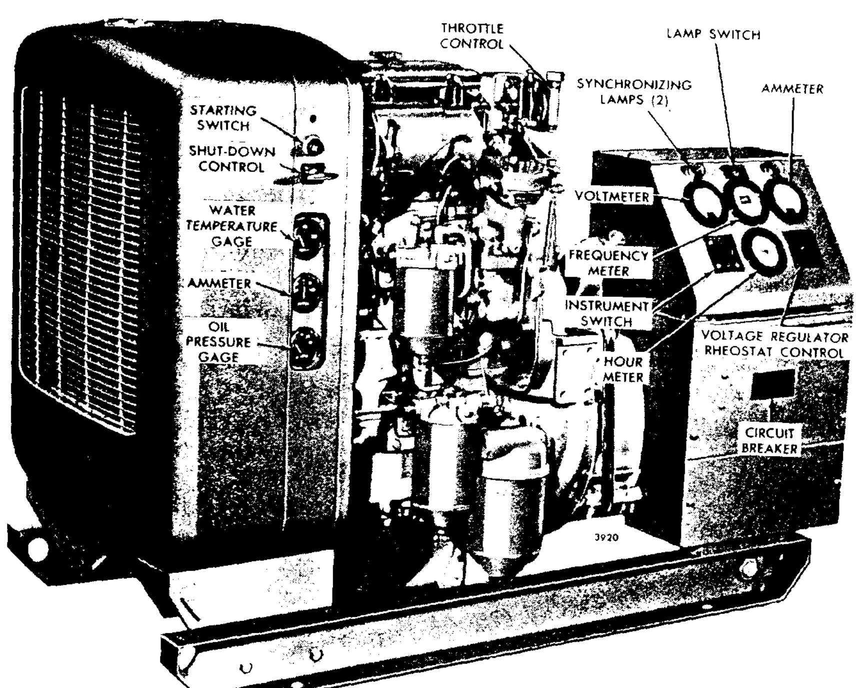

Fig. 1 - Location of Controls on Power Generator Unit

7. Attach a chain hoist to the generator eyebolt or lifting ears and raise the generator just enough to allow it to clear the engine base.

8. Place a suitable support under the flywheel housing to support the rear end of the engine before the generator is detached.

9. Remove the generator fan cover retaining bolts and remove the covers.

10. Remove the generator driving disc-to-engine flywheel mounting bolts.

11. With the chain hoist drawn taut, remove the generator frame flange-to-engine flywheel housing mounting bolts.

12. Apply pry bars at opposite sides of the generator to loosen it from the engine flywheel housing.

> **NOTE:** The tenon on the generator frame flange pilots inside of the engine flywheel housing; therefore, the generator must be withdrawn straight back from the engine.

Install Power Generator on Engine

Before installing the generator, the front engine-to-base mounting bolts must be loose and the flywheel end of the engine must be raised and suitably supported.

1. Use a chain hoist to swing the generator in place square against the engine flywheel housing so the pilot of the generator frame enters the flywheel housing.

> **NOTE:** The generator driving disc pilots inside of the engine flywheel with a close tolerance. The driving disc must set flat against the flywheel face when in place, otherwise the generator will be subjected to excessive vibration when placed in service.

2. Align the bolt holes in the generator driving disc with the mating holes in the engine flywheel. Then install the disc retaining bolts and tighten them.

3. Install the generator frame-to-engine flywheel housing bolts and tighten them.

4. Install the generator fan covers.

5. Install the generator foot-to-engine base mounting bolts and spacers (if used). Tighten the bolts.

6. Tighten the front engine-to-base mounting bolts.

7. Position the upper radiator hose and tighten the clamps.

8. Install the control cabinet.

9. Reconnect all power leads.

10. Install the generator terminal box cover plate.

11. Install the oil drain plug and fill the generator bearing oil reservoir, with the same grade of oil as specified for the engine, to the line on the sight gage. Do not overfill.

12. Reinstall and connect all other equipment which was removed during disassembly.

Balance Engine

If proper care is taken in attaching the generator to the engine, the unit should operate smoothly. However, if the unit runs rough (excessive vibration), it must be balanced as follows:

1. Loosen the generator driving disc-to-engine flywheel bolts approximately four turns.

2. Start the engine and run it at a speed not exceeding 600 rpm for approximately one minute. At this speed, the generator armature will tend to center itself with respect to the center line of the engine crankshaft.

3. Stop the engine and tighten the generator driving disc retaining bolts uniformly.

4. Normally, the above procedure will bring the unit into balance for smooth operation. However, if excessive vibration still exists, it may be corrected as follows:

   a. Remove the generator driving disc retaining bolts and rotate the engine flywheel 180°.

   b. Install the driving disc bolts finger tight.

   c. Repeat Steps 2 and 3 above.

SHOP NOTES - TROUBLE SHOOTING - SPECIFICATIONS - SERVICE TOOLS

SHOP NOTES

SERVICING ANTI-VIBRATION INSTRUMENT MOUNTINGS

Anti-vibration mountings (LORD mounts) are used in many places to absorb engine vibration in the mounting of instruments, drop relays, tachometers, etc. When it becomes necessary to service a part secured by Lord Mounts, care should be exercised during removal and installation of the part to avoid twisting the rubber diaphragm of the mounts. At the time the part is removed from the engine for service, the mounts should be inspected for tears and replaced, if necessary.

The attaching screw through the center of the mount must be held from turning during final tightening of the nut. If this screw turns, it will pre-load the rubber diaphragm in torsion and considerably shorten the life of the mount.

CHECK ENGINE STARTING SWITCH

If difficulty in starting motor engagement has been experienced in a vehicle which has been repowered by a diesel engine, check to see if the key-type starting switch on the instrument panel has been retained.

Key-type starting switches are usually not capable of carrying the current required for heavy-duty diesel engine starter solenoids. The excessive voltage drop in the solenoid circuit restricts the solenoid pull and results in failure of the starter to engage and crank. When tooth abutment occurs and the switch is turned off and on several times, breaking of the solenoid current causes burning or welding of the switch contacts.

Install a push button type starting switch which is capable of making, breaking and carrying the solenoid current without damage (refer to *Engine Starting Motor Switch* in Section 7.4). Otherwise, a heavy-duty magnetic switch should be used in the solenoid control circuit in addition to the key-type switch. The magnetic switch must be capable of making and breaking at least 90 amperes in a 12-volt system; the key switch would then carry no more than one ampere, which is sufficient to operate the magnetic switch.

ALIGNMENT TOOLS FOR TACHOMETER DRIVE COVERS AND ADAPTORS

Whenever a tachometer drive cover assembly or a tachometer drive adaptor is installed on an engine, it is important that the cover assembly or adaptor be aligned properly with the tachometer drive shaft.

Misalignment of a tachometer drive shaft can impose a side load on a tachometer drive cable adaptor resulting in possible gear seizure and damage to other related components.

To establish proper alignment, use one of the three tools in set J 23068. Because of the many different combinations of tachometer drive shafts, covers and adaptors, it is not practical to itemize specific usages for each tool. When confronted with an alignment job, test fit each tool to determine which provides the best fit and proceed to make the alignment with that tool as shown in Fig. 1.

Correct alignment is established when there is no tachometer drive shaft bind on the inside diameter of the tool when one complete hand rotation of the engine is made.

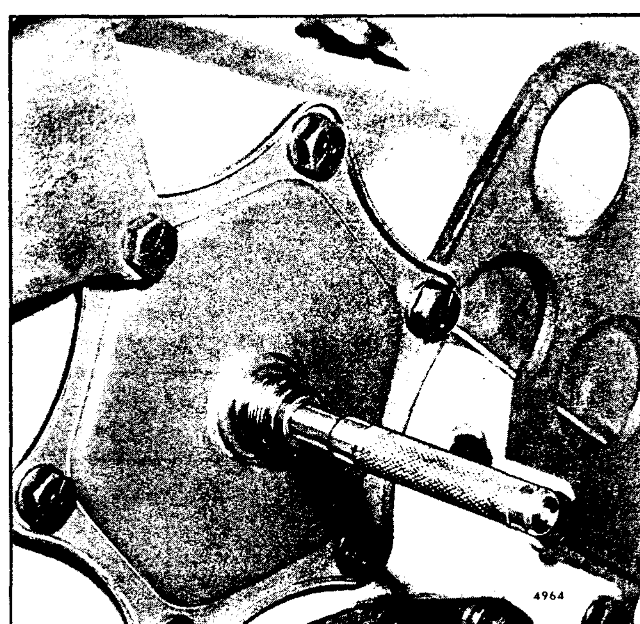

Fig. 1 - Checking Tachometer Drive Shaft Alignment

TROUBLE SHOOTING

CHECKING ENGINE ELECTRICAL GENERATING SYSTEM

In analyzing generator-regulator operation, check for one of the five following conditions.

1. A *fully charged battery* and *low charging rate* -- this indicates normal generator-regulator operation.

2. *Low battery* and *high charging rate*--indicates normal generator-regulator operation.

3. A *fully charged battery* and a *high charging rate*--this indicates the voltage regulator is not reducing the generator output as it should and will damage the battery--and may be caused by improper voltage regulator setting, defective regulator unit, short circuit or poor connections in the generator or regulator wiring or high battery temperature.

4. *Low battery* and *low or no charging rate*--indicates improper or no regulator operation--and may be due to loose connectons, damaged wires, low voltage or current regulator setting, oxidized contact points or a defective generator.

5. *Excessive arcing at contact points*--may be due to oxidized or misaligned contact points, defective regulator winding, poor cable connections or other causes.

If one of the latter three conditions exists, refer to the "Delco-Remy" electrical equipment operation and maintenance handbooks DR 324, DR 324A and DR 324S for correction of the problems. These manuals may be obtained from United Motors Service.

SPECIFICATIONS

STANDARD BOLT AND NUT TORQUE SPECIFICATIONS

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

EXCEPTIONS TO STANDARD BOLT AND NUT TORQUE SPECIFICATIONS

APPLICATION	THREAD SIZE	TORQUE (lb-ft)
Tachometer drive cover bolt	7/16 -14	30-35
Tachometer drive cover bolt	1/2 -13	30-35
Tachometer drive shaft (blower)	1/2 -20	55-65

SERVICE TOOLS

TOOL NAME	TOOL NO.
Puller set	J 5901
Slide hammer	J 5901-1
Tachometer drive shaft remover	J 5901-3
Tachometer drive alignment tool set	J 23068
Tool No. 1 (.310")	J 23068-1
Tool No. 2 (.313")	J 23068-2
Tool No. 3 (.375")	J 23068-3