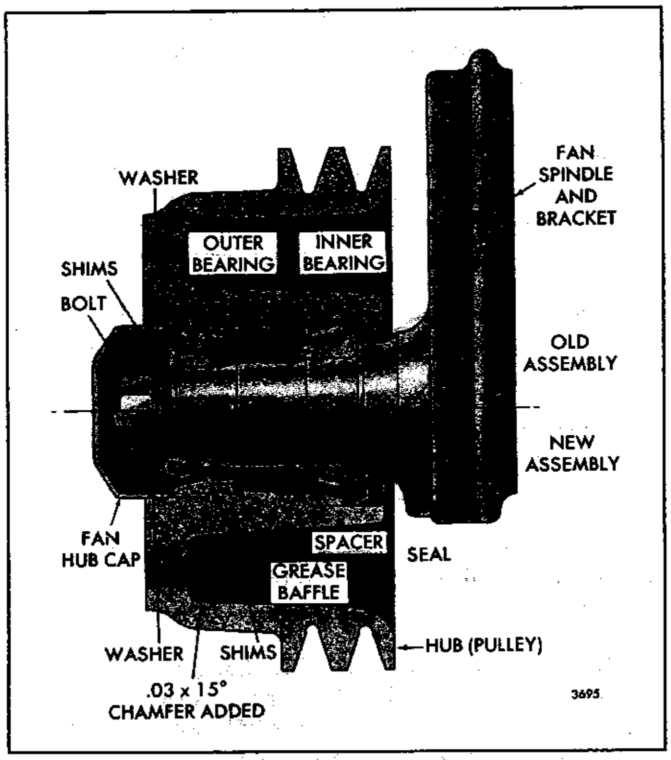


Fig. 7 – Spindle Type Fan Hub Assembly (6V and 8V Engine)

EXAMPLE: A former 1.800" thick spacer and cap assembly have been replaced by two .500" thick spacers, one .800" thick spacer and the new fan hub cap.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

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. 5. 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 1.000" to 1.260". A longer hub retaining bolt and a .320" 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.

Fan hubs equipped with roller bearings (except the sealed type in Fig. 3) may be modified by adding a grease fitting (refer to Section 5.0).

Assemble Hub and Adjusting Bracket

A new, heavy–duty shaft and bearing assembly is now used for high–mounted fan applications. This assembly incorporates both ball and roller bearings (Fig. 11). The former assembly contained two rows of ball bearings. The new shaft and bearing assembly can be identified by the designation "HR–803" stamped on the front of the shaft.

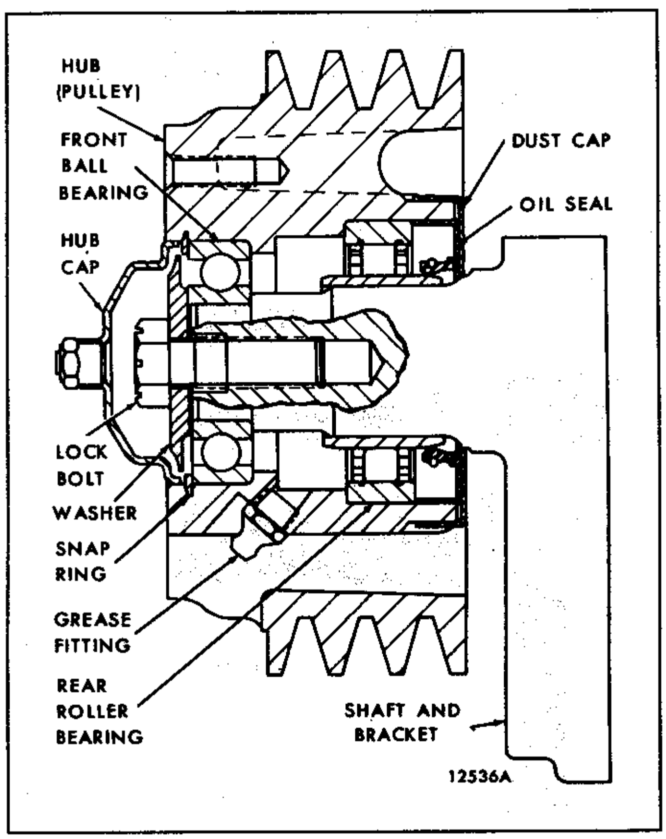


Fig. 8 – Shaft Type Fan Hub Assembly (4–53 and 6V–53 Engines)

Both former and new shaft and bearing assemblies are completely interchangeable, and only the new will be available for service.

Apply Loctite "601" or equivalent to the bearing shaft and the bearing case when rebuilding the fan hub assembly.

IN-LINE ENGINES (Ball Bearing Type Hub):

Refer to Figs. 3 and 9 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.

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

IN-LINE ENGINES (Roller Bearing Type Hub):

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

1. Apply Texaco Premium RB grease or an equivalent Lithium base multi-purpose 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 (113-126 N·m) 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).

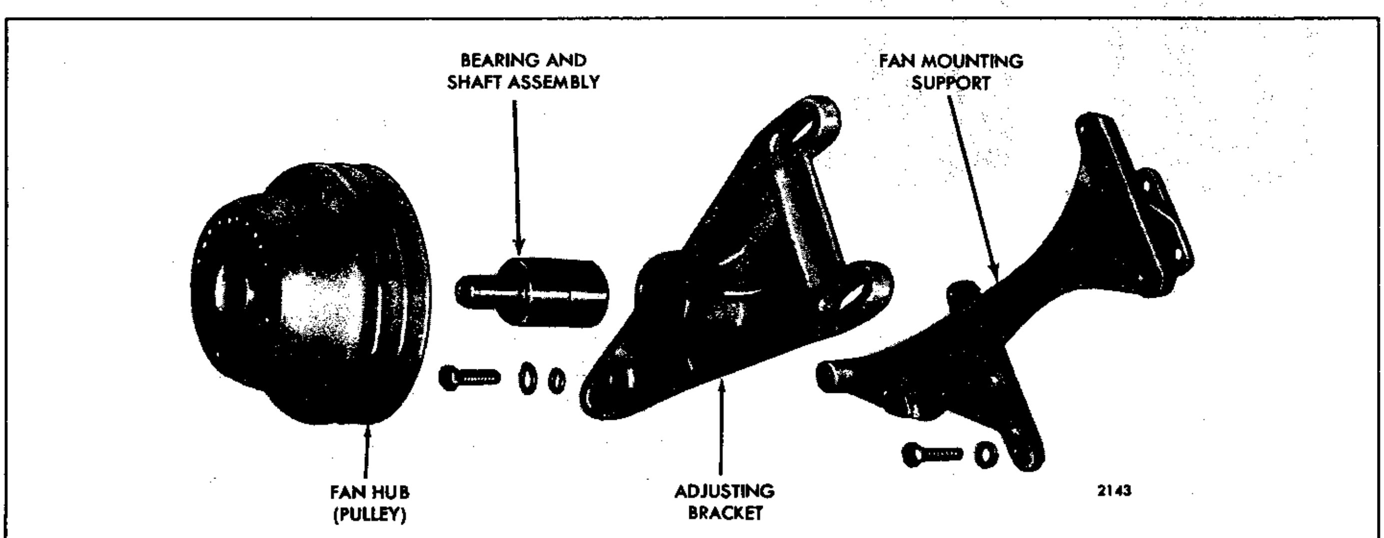


Fig. 9 – Typical Fan Hub and Adjusting Bracket Details and Relative Location of Parts (In-Line Engine)

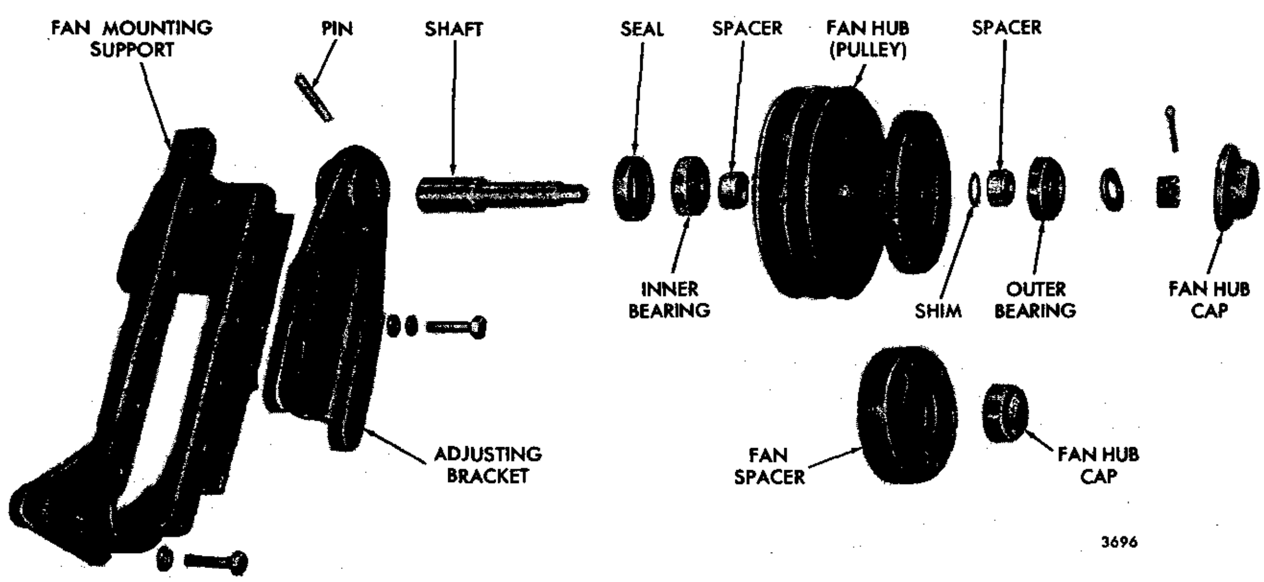


Fig. 10 – Typical Fan Hub, Shaft and Adjusting Bracket Details and Relative Location of Parts (6V Engine)

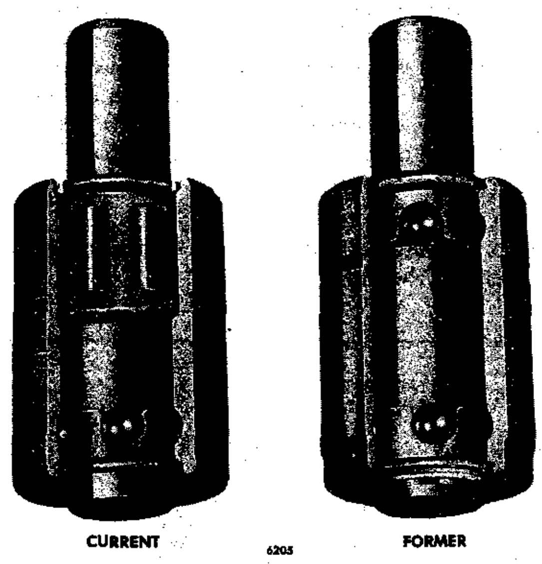


Fig. 11 – Heavy–Duty Shaft and Bearing Assembly

V–TYPE ENGINE:

Assemble the fan hub, shaft and adjusting bracket shown in Figs. 6 and 10 as follows:

1. Apply Texaco Premium RB grease or an equivalent Lithium base multi–purpose 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).

   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 (47–54 N·m) torque.

   NOTICE: 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).

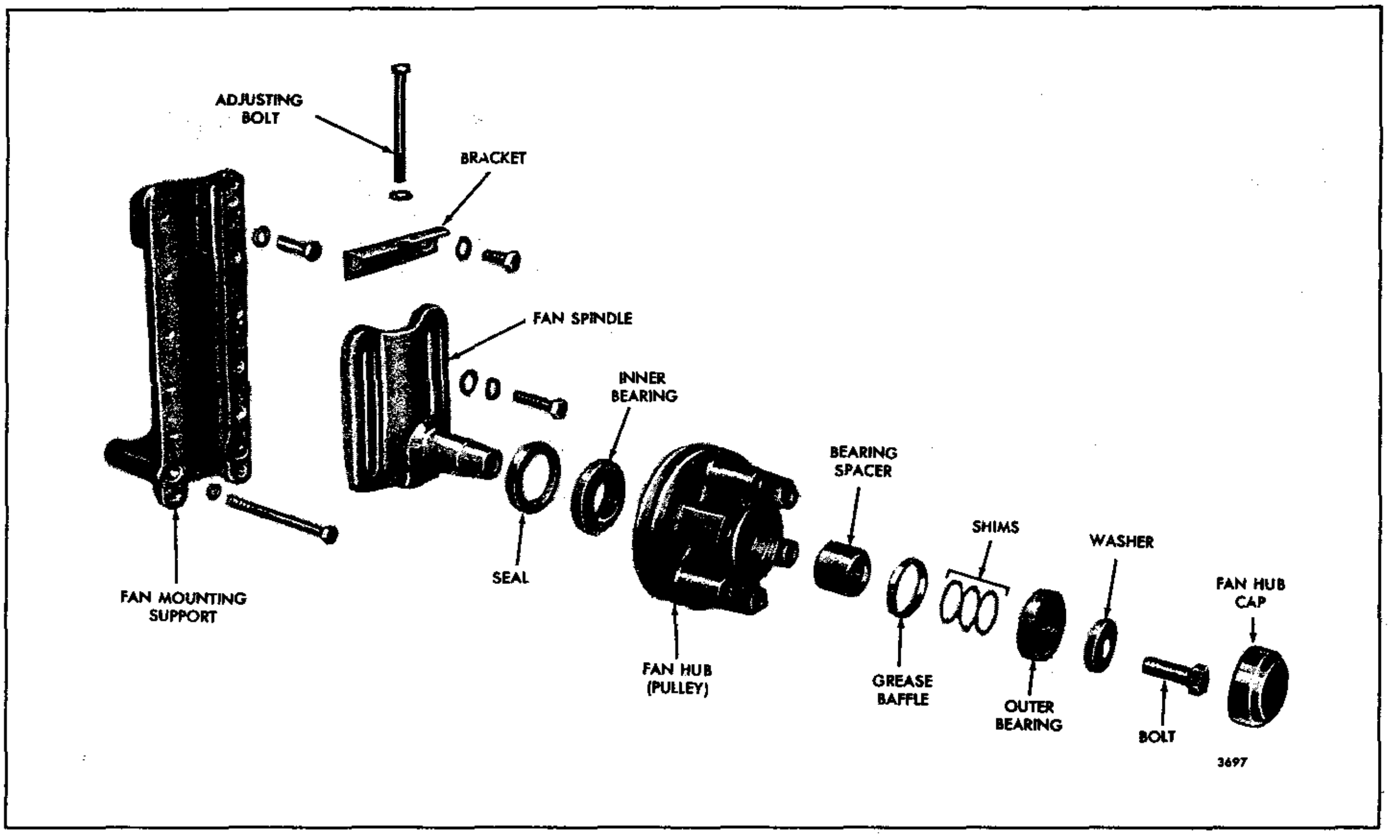


Fig. 12 – Typical Fan Hub and Spindle Details and Relative Location of Parts (6V and 8V Engine)

Assemble the fan hub and spindle shown in Figs. 7 and 12 as follows:

1. Apply Texaco Premium RB grease or an equivalent Lithium base multi–purpose 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 (113–126 N·m) 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).

4–53 and 6V–53 ENGINES (Front Ball and Rear Roller Bearing):

Assemble the new pulley hub as follows (Fig. 8).

1. Apply Texaco Premium RB grease or an eqivalent Lithium base multipurpose grease to the front ball bearings and the rollers of the rear bearing, before installing them in the pulley hub. *Do not overgrease.*

2. Install the front ball bearing against the shoulder counterbore in the pulley hub. Then, install the snap ring in the pulley hub.

3. Install the rear roller bearing outer ring and roller assembly against the shoulder in the counterbore of the pulley hub.

4. Install a new oil seal with rubber side flush with the outer edge of the hub.
5. Install the dust cap (if used) over the oil seal in the hub.
6. Place the shaft and bracket on wood blocks setting on the bed of an arbor press. Then, press the rear bearing inner ring or race onto the fan shaft.
7. Pack the cavity 3/4 full with Texaco Premium RB grease.
8. Install the partially assembled fan hub over the rear bearing inner ring on the shaft and against the shoulder on the pully hub shaft.
9. Secure the hub with the washer and 1/2"–20 lock bolt. Tighten the bolt to 83–93 lb–ft (113–126 N·m) torque while rotating the pulley hub.
10. Fill a new fan hub cap 3/4 full of grease and install it in the end of the pulley hub.

Install Fan, Hub and Adjusting Bracket

1. Attach the fan hub and adjusting bracket assembly to the support bracket on the engine with bolts, lock washers and plain washers. Do not tighten the bolts until the fan belts are installed.
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. 12.
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 (see Section 5.0).

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.

- A properly inhibited antifreeze solution should be used year–round for freeze and boilover protection (refer to Section 13.3).

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.

- **CAUTION: Use extreme care when removing a coolant pressure control cap. The sudden release of pressure from a heated cooling system can result in loss of coolant and possible personal injury (scalding) from the hot liquid.**

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.

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.

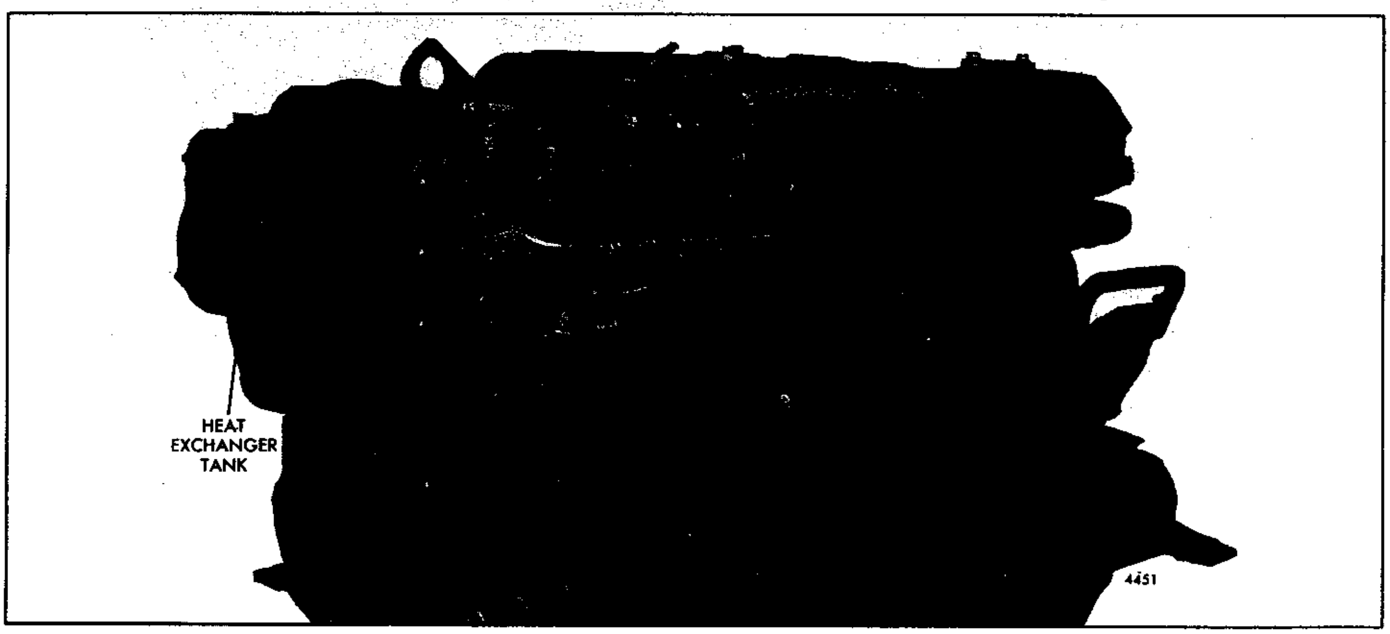


Fig. 1 – Typical Heat Exchanger Mounting In–Line Engine

• Inspect Zinc Electrodes

Remove the zinc electrodes from the inlet side of the raw water pump and the heat exchanger. Clean the electrodes with a wire brush or, if worn excessively, replace with new electrodes. To determine the condition of a used electrode, strike it sharply against a hard surface; a weakened electrode will break.

Remove Heat Exchanger Core

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

1. Drain the engine coolant and raw water system.

   - **CAUTION: To avoid being burned by the hot liquid, allow the engine to cool before draining the coolant.**

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.

NOTICE: 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.

NOTICE: 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.

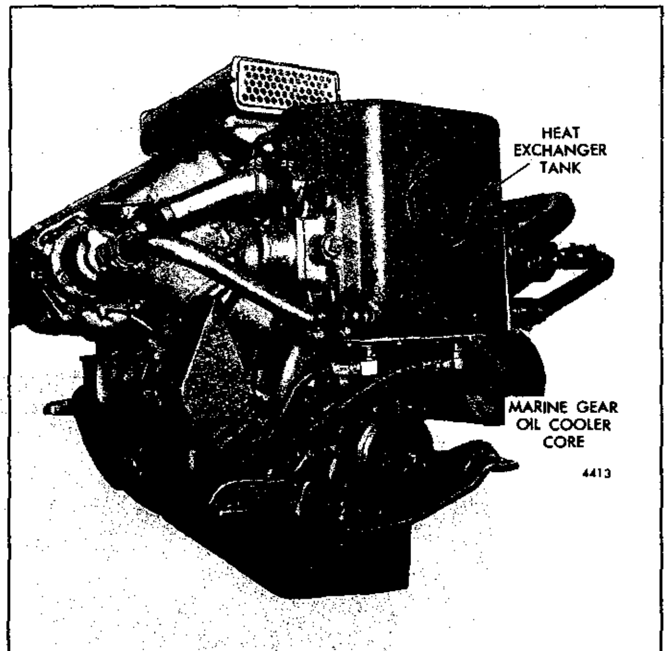


Fig. 2 – Typical Heat Exchanger Mounting V–Type Engine

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.

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

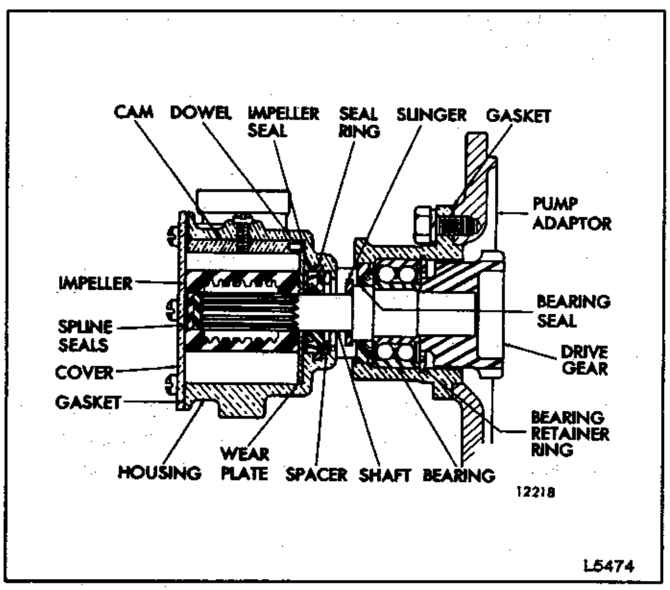


Fig. 1 – Raw Water Pump Used on In–line Engine

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.

Operation

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.

- **NOTICE:** Always prime the raw water pump before starting the engine. Since water acts as a lubricant for the impeller, failure to prime the pump (or at least wet the impeller vanes to induce a self–priming suction) can result in severe impeller damage when the engine is started. Insufficient raw water flow into the heat exchanger caused by a damaged impeller can lead to overheating and subsequent engine damage. To prime the pump: a) remove the pipe plug from the water inlet elbow: b) pour in at least a pint of water: c) replace the plug.

•Lubrication

The shielded type double–row ball bearing is filled with lubricant when assembled. No further lubrication is required.

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).

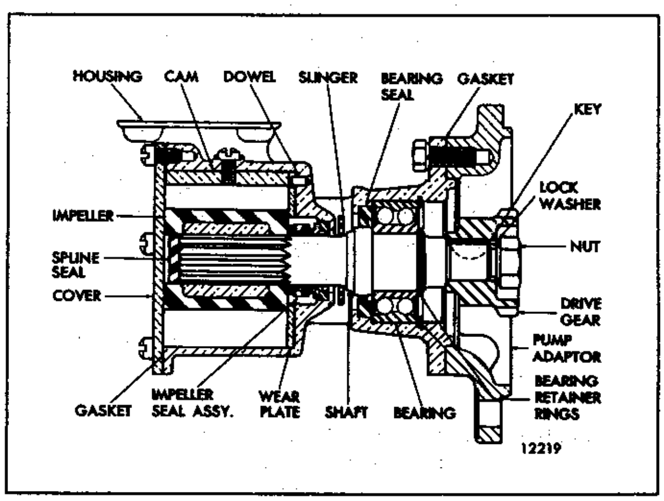


Fig. 2 – Raw Water Pump Used on V–Type Engine

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 screwdriver through the impeller from the open end. 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. The former wear plate was installed separately with the contoured surface fitting under the cam. The current 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.

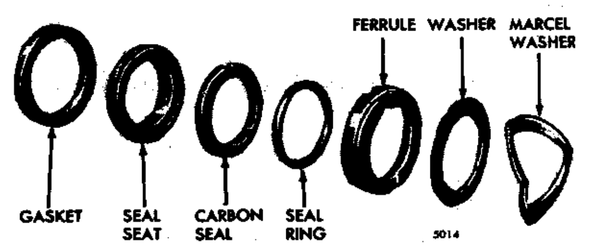


Fig. 3 – V–Type Engine Impeller Seal Detail

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 24420 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. 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 press the bearing off of the shaft.

Inspect Pump Parts

After disassembling the pump, clean all of the parts thoroughly, except the bearing.

- **NOTICE:** The shielded bearing must not be washed; dirt may be washed in and the cleaning fluid may not be entirely removed from the bearing.

Wipe the bearing clean on the outside and then inspect it. Hold the inner race and revolve the outer race slowly to detect possible wear or rough spots. Replace the bearing if it is worn or does not roll freely.

Examine the components of the seal assembly and discard any parts that have been worn or otherwise damaged.

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

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. 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 care 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. 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 (27–41 N·m) torque. Then remove the pump assembly from the vise.

- **NOTICE:** Exceeding the specified torque may cause pump drive shaft damage.

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 (41–47 N·m) 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.

Drain Pump in Freezing Temperatures

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.

COOLANT FILTER AND CONDITIONER

The engine cooling system filter and conditioner is a compact bypass type unit with a replaceable canister type element (Fig. 1), a spin–on type element (Fig. 2) or a clamp–on type element (Fig. 3).

A correctly installed and properly maintained coolant 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 coolant 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 coolant, forming a protective rustproof 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.

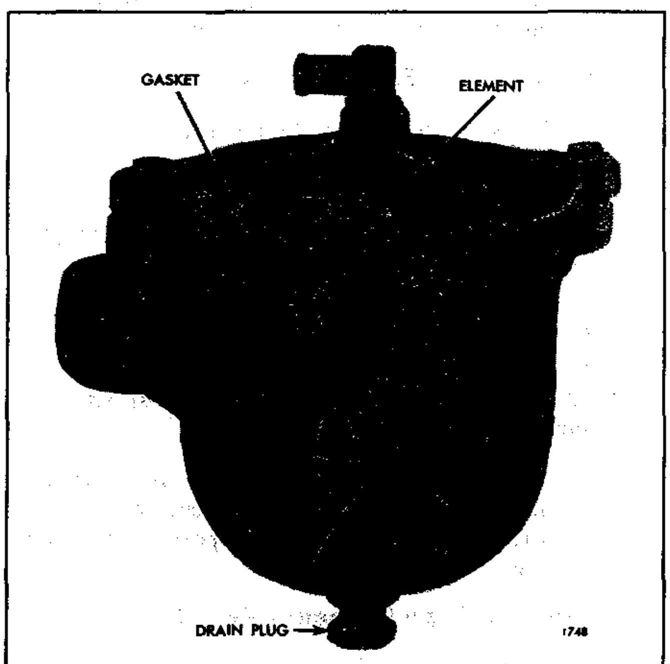


Fig. 1 – Coolant Filter and Conditioner (Canister Type)

Filter Installation

If a coolant 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, following the manufacturer's recommended change periods (refer to Section 15.1). The lower corrosion resistor plate (if used) must be buffed each time (discard the plate, if excessive metal loss or pitting is evident) to ensure effective protection of the cooling system.

If the 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 approximately 200 hours or 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.

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.

> **NOTICE:** 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 filter element must be changed. Filters with resistor plates must be 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 reused. 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

The coolant filter may be grounded at the option of the user.

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

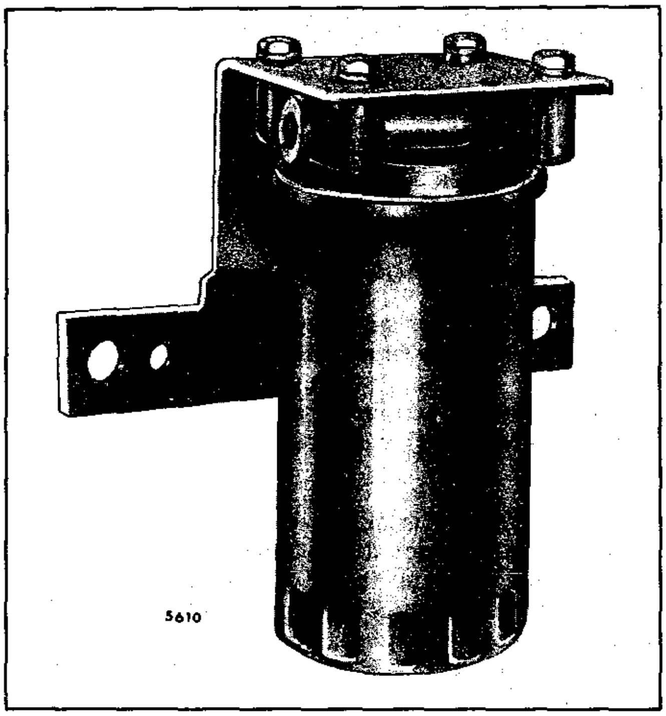


Fig 2. – Coolant Filter and Conditioner (Spin–On Type)

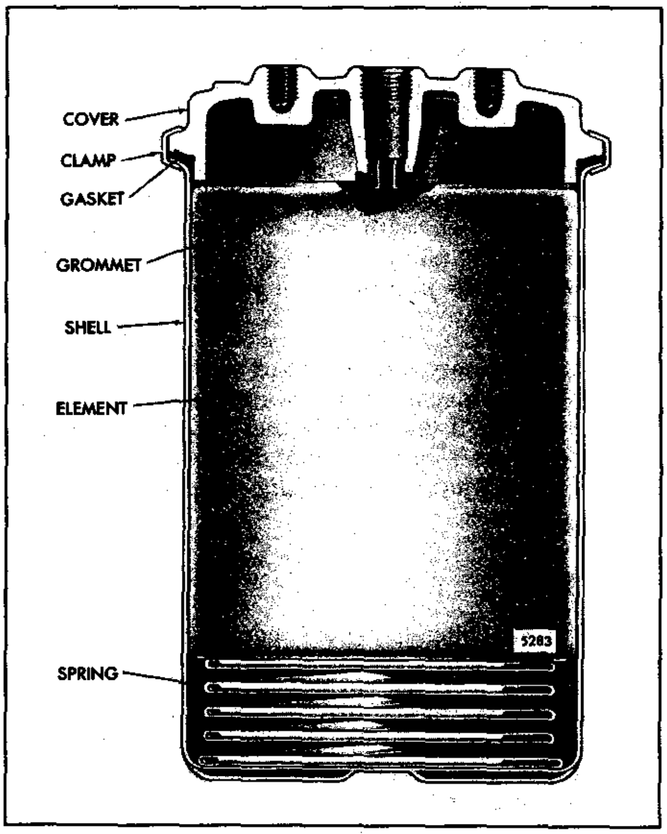


Fig. 3 – Coolant Filter and Conditioner (Clamp–On Type)

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

1. Close the filter inlet and outlet shutoff valves. If shutoff valves are not provided, vise grip pliers can be used to clamp each hose closed during the filter change. Use caution to avoid damaging the hoses with the vise grip pliers.

2. Remove and replace the element as follows:

Canister Type Element – Fig. 1:

a. Remove the drain plug in the bottom of the filter body and let drain.

b. Remove the filter cover–to–filter body bolts.

c. Remove and discard the element.

d. Remove and discard the corrosion resistor plates.

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

- **CAUTION: To prevent possible personal injury, wear adequate eye protection and do not exceed 40 psi (276 kPa) air pressure.**

f. Replace the drain plug in the bottom of the filter.

g. Insert the new element.

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

Spin–On Type Element – Fig. 2:

a. Remove and discard the element.

b. Clean the gasket seal on the filter cover.

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

- **CAUTION: To prevent possible personal injury, wear adequate eye protection and do not exceed 40 psi (276 kPa) air pressure.**

d. Apply clean engine oil to the filter element gasket and install the new element. A 2/3 turn after gasket contact assures a positive leakproof seal.

Clamp–On Type Element – Fig. 3:

a. Remove the retaining clamp.

b. Remove and discard the element.

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

- **CAUTION: To prevent possible personal injury, wear adequate eye protection and do not exceed 40 psi (276 kPa) air pressure.**

d. Insert the new element.

e. Secure the filter body in place with the clamp.

3. Open the inlet and outlet lines by opening the shutoff valves or removing the vise grip plier clamps.

4. 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

FAN HUB SPACER

The new fan hub spacers are similar to the former spacers except for the flange pilot radius and the width of the spacers (Fig. 1). The flange on the spacer serves as a pilot for the fan, as well as a pilot for the second spacer when two or more spacers are used together.

The former and new spacers are interchangeable on a former fan pulley hub assembly and only the new spacers are serviced.

The former .800" thick spacer must not be used with the current shaft type fan pulley hub assemblies, unless it is reworked (see Service Note).

NOTICE: Use of the former thick spacer will crush the fan hub cap causing the drive to bind.

The former .800" thick spacer can be reworked into the new .800" thick spacer by removing material at the radius (Fig. 1). A reworked spacer should be mated with the fan hub assembly. If a former thin spacer (.500" thick) is used in conjunction with the reworked thick spacer, it should be positioned against the fan.

The .500" thick spacer cannot be reworked into the new .560" thick spacer.

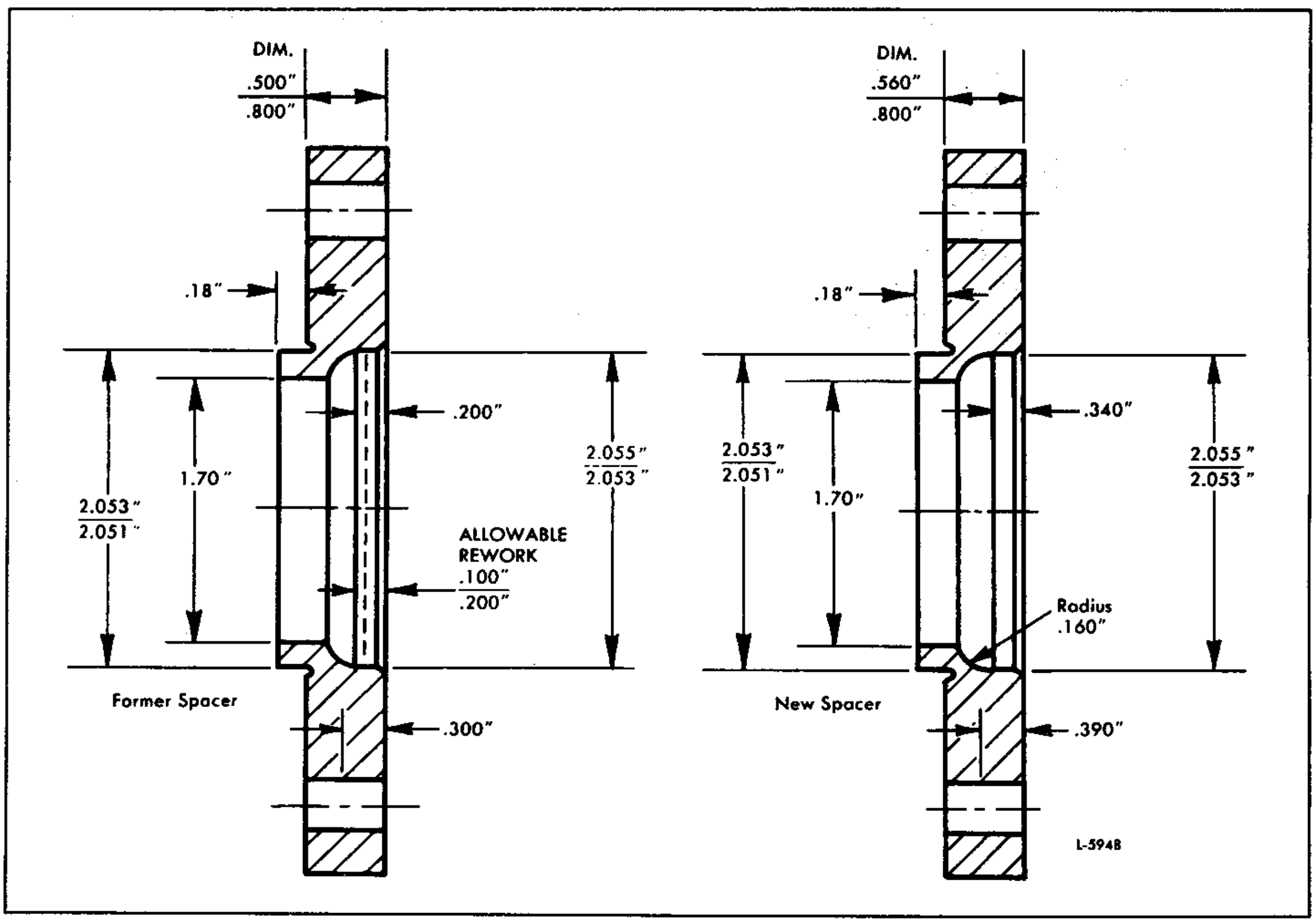


Fig. 1 – Former and New Spacers

FAN HUB GREASE FITTING

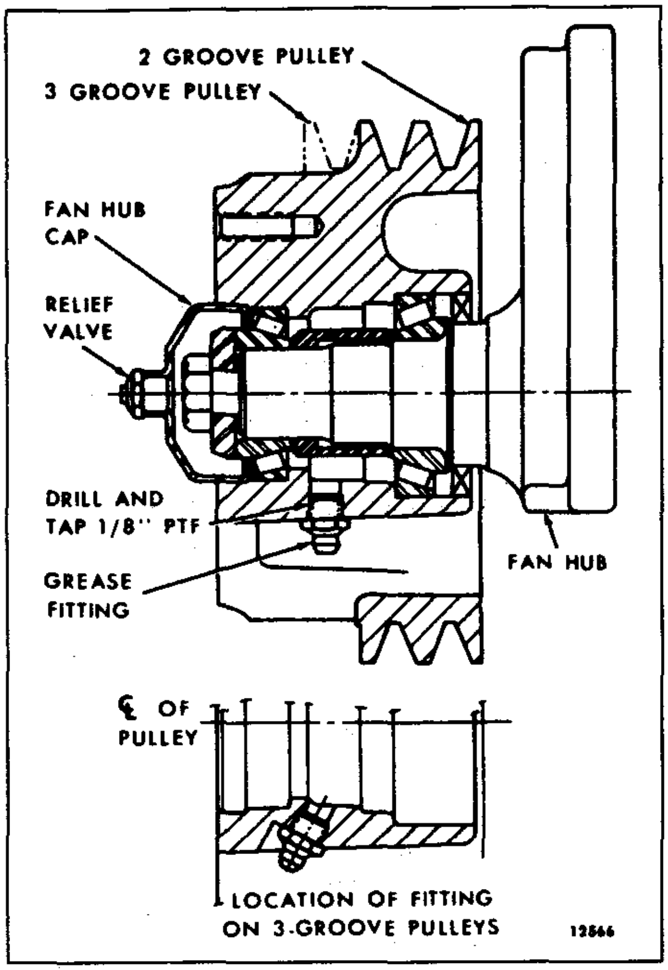


Fig. 2 – Location of Fan Hub Grease Fitting and Relief Valve

A grease fitting may be added to former fan hub assemblies used on vehicle engines to permit periodic lubrication of the bearings.

Rework the fan hub as follows:

1. Refer to Section 5.4 and disassemble the fan hub assembly and clean the parts throughly.
2. Drill and tap the fan hub, at the location shown in Fig. 2, to accept a 1/8" PTF x 11/16" threaded lubricator fitting. Clean the hub to remove any metal chips.
3. Refer to Section 5.4 and reassemble the fan hub. Discard the former grease retainer as it is not required when a grease fitting is used.
4. Install a *new* fan hub cap which is threaded for a relief valve (Fig. 2).
5. Install a grease fitting in the fan hub and a relief valve in the fan hub cap.

Refer to Section 15.1 for the maintenance schedule.

DRAINING JABSCO RAW WATER PUMP

Although all engine units are provided with draincocks for the purpose of draining the cooling system, a small amount of coolant may remain in the impeller housing of a Jabsco pump.

Under normal circumstances, there would be no need in completely draining the impeller housing of a raw water pump, therefore, no drain plug has been incorporated at this location. However, certain models employ a raw water pump in conjunction with a fresh water cooling system.

In the event the engine is to be stored in below freezing temperatures, it is suggested that, in addition to draining the cooling system of the engine unit, the impeller housing of the Jabsco pump (if so equipped) be completely drained. This may easily be accomplished by loosening the five fillister head screws which attach the end cover to the pump housing, at the impeller end of the pump, then pulling the end cover away from the pump body, while being careful to avoid damage to the gasket. The screws need only be loosened sufficiently to allow complete draining of the impeller housing, then retightened.

RAW WATER PUMP IMPELLERS

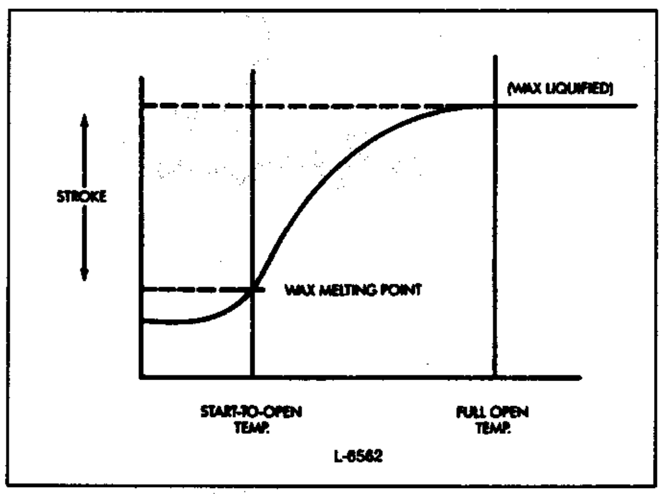
The Jabsco raw water pump is equipped with synthetic rubber impellers. Since the synthetic rubber begins to lose its elasticity at low temperatures, impellers made of natural rubber may be installed when it is necessary to pump raw water that has a temperature below 40°F (4°C). However, the standard impellers must be used when the pump operates in warmer water.

New service impellers of natural rubber are identified by a stripe of green paint.

• THERMOSTAT FUNCTION TESTING

Thermostat print specifications normally call for three specific operating conditions: namely, start–to–open temperature, full–open temperature, and full–open dimension. The most important of these is the *start–to–open* temperature. This is the temperature at which the motor mechanism (wax compound) experiences a change from a solid to a liquid, expanding and opening the thermostat to allow coolant flow. At full–open temperature, the liquid wax is fully expanded and the full–open dimension is reached, ensuring proper coolant flow to the radiator. The start–to–open temperature is normally stamped or printed on the thermostat.

A definite relationship exists between the start–to–open temperature and operating stroke (full–open travel) of the thermostat. This relationship may be seen in the illustration at right. The normal tolerance for the start–to–open temperature is +2°F or –3°F (+1.11°C or –1.67°C).



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To ensure that sufficiant coolant flows through the radiator to control engine temperature, the start–to–open temperature and the full–open dimension of the thermostat should be checked. Thermostats may be tested on the simple fixture shown (Fig. 5). This fixture can be made from readily available materials.

Materials

1 Stainless steel or non–ferrous metal vessel approximately 8" diameter by 6" deep

1 2000 watt immersion–type heating element

1 Thermostatic control having a 60°F to 230°F (15.6° to 110°C) temperature range and a capillary tube sensing device

1 12" length of 1/4" copper tubing

1 3/8" drain valve

1 7 1/2" diameter piece of 12–gague galvanized sheet steel or 1/8" aluminum (for bed plate)

1 Bulkhead fitting

1 Air control valve

1 Laboratory thermometer with a 60°F to 230°F (15.6°C to 110°C) range

1 Dial indicator having a one inch travel with a 3/8" gauge holding rod and swivel post lock screw

The thermostat test fixture consists of the test vessel with control (Fig. 4) and the test plate assembly (Fig. 3).

Making the Test Fixture

1. Drill a 1/8" hole in the side of the vessel and braze a bulkhead fitting to the vessel to accept an air control valve. Shop air will be used to agitate the water and relieve temperature stratification within the vessel.
2. Manufacture an aeration line from a 12" length of 1/4" copper tubing by drilling four equally spaced 1/8" holes in the tube and crimping or blocking one end. Attach the open end of the tube to the air valve and bend the tube to the inside contour of the vessel.
3. Install a 3/8" drain valve in the lower portion of the vessel.

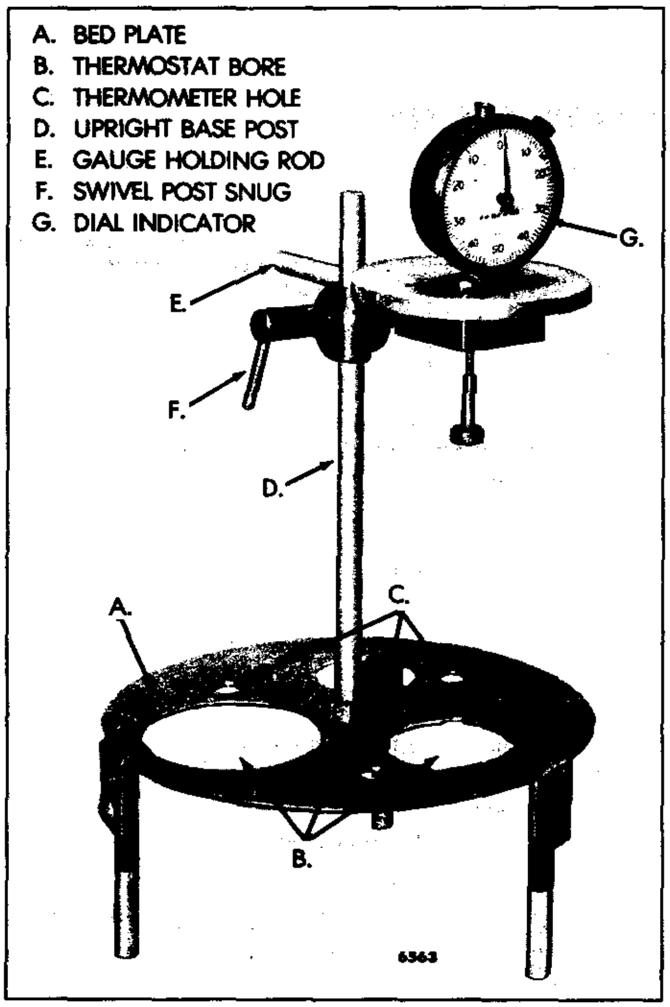

Fig. 3 – Test Plate Assembly

4. Fabricate the bed plate from 12–gauge galvanized steel or 1/8" aluminum sheet stock. The bed plate is used to suspend the thermostat at a mid–point in the vessel. This component must fit squarely in the vessel and have legs of sufficient length to ensure that stats won't contact the heating element and aeration line.

   Bore 1 9/16", 2", and 2 3/4" holes in the plate spaced 120° from each other to facilitate the installation of the variety of stats normally encountered. Drill three 7/16" holes at 60° from each thermostat mounting bore for conveniently locating a thermometer during testing.

   Install a 3/8" x 8" upright base post in the center of the plate to provide the mounting for a dial indicator.
5. Attach the dial indicator gauge to the upright center post of the plate to permit accurate thermostat travel measurement. The bed plate and dial indicator shown have components added to raise the indicator vertically above the gauge holding rod; however, the extra items are not required.

Thermostat Testing Procedure

NOTICE: This procedure will take time to do properly. Refer to Fig. 5.

Place the vessel on a level surface and lower the bed plate into position, being careful to avoid contact with the heating element.

Fully submerge the thermostat in warm water and place a laboratory thermometer in one of the 7/16" holes on the bed plate. Position the dial indicator over the thermostat, centering the contact point on the motor mechanism. Zero the dial. To ensure accurate test results, allow the thermostat to warm up to water temperature before testing. Then, turn on the heating element (if necessary) and bring water temperature to a few degrees below the start–to–open temperature of the thermostat being tested. Hold at this temperature for 2–3 minutes.

With the heating element on, adjust the air valve to sufficiently agitate the water for equal heat distribution. Bring bath temperature up to the maximum specified start–to–open temperature of the thermostat. Observe the dial indicator and note the temperature at which the needle just begins to move. This is referred to as the *start–to–open temperature.* The total indicator travel, from star–to–open to full–open is referred to as the *full open travel.*

For full–open temperature and travel, raise bath temperature a few degrees above the specified full–open temperature and hold at that temperature for 2 to 3 minutes.

To efficiently test a number of thermostats, simply add cold water to the vessel. This will reduce the water temperature to a level below the next thermostat opening temperature, thus saving time. Turn the heating element off after completing the tests.

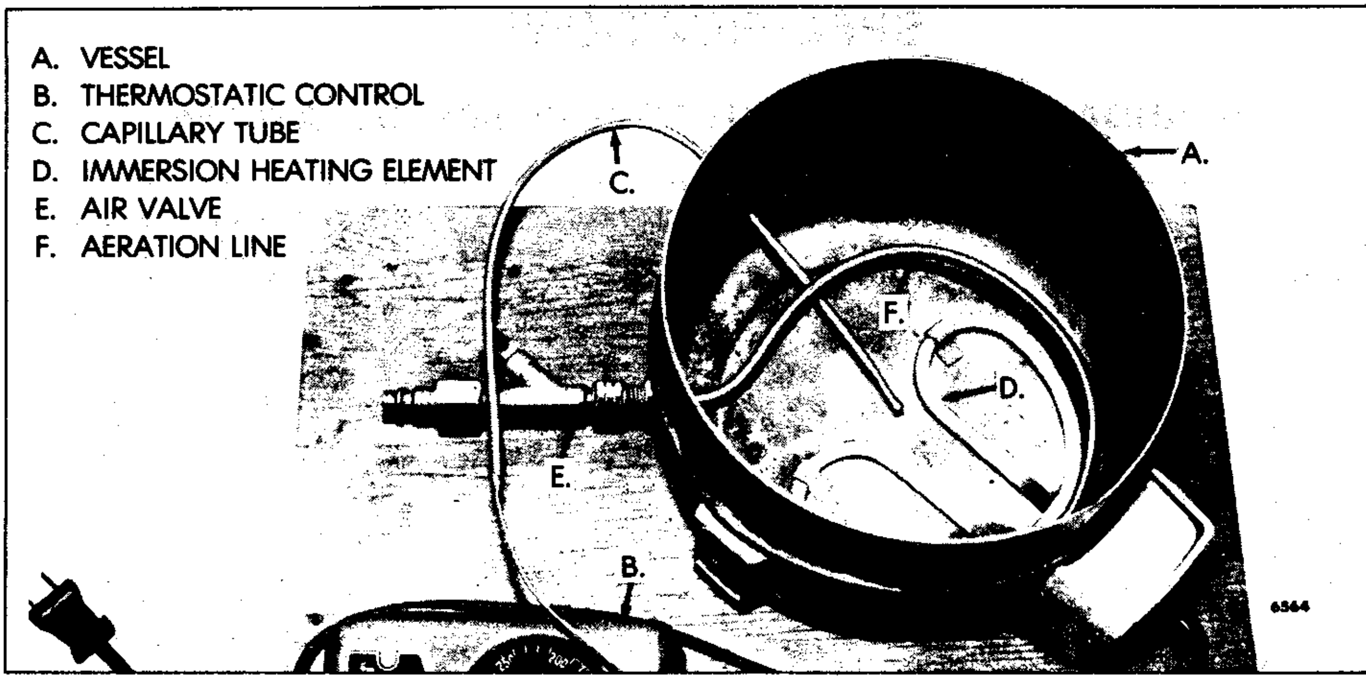

Fig. 4 – Test Vessel and Control

Fig. 5 – Testing a Thermostat in the Test Fixture

Conducting Cooling Tests

When conducting cooling tests on an engine, it is essential that maximum radiator/heat exchanger coolant flow be achieved. Coolant flow and, subsequently, the accuracy of cooling system test results depend to a large extent on the condition of the thermostat installation. If maximum flow does not occur, check for these causes:

1. Thermostat(s) not blocked open to correct dimension.
2. Thermostat housing seal(s) missing.
3. Thermostat housing seal(s) worn.
4. Thermostat housing cover bypass cavity sealing surface(s) not centered and/or worn.

• FIND COOLANT LEAKS WITH FLUORESCENT DYE, BLACK LIGHT

Finding the source of an engine coolant leak is often a time–consuming affair. To speed the process, a fluorescent dye such as *15174 Uranine* (or equivalent) may be added to the coolant. Under an ultraviolet "black light," the Uranine dye–treated coolant turns a highly visible, bright yellow–green color, making the leak path easy to trace.

15174 Uranine is manufactured by Chemcentral Corporation and is available through their distributor network. For further information contact:

CHEMCENTRAL CORPORATION
7050 West 71st Street
Chicago, Illinois 60638

SPECIFICATIONS

STANDARD BOLT AND NUT TORQUE SPECIFICATIONS

THREAD SIZE	260M BOLTS TORQUE (lb–ft)	260M BOLTS TORQUE N·m	THREAD SIZE	280M OR BETTER TORQUE (lb–ft)	280M OR BETTER TORQUE N·m
1/4–20	5–7	7–9	1/4–20	7–9	10–12
1/4–28	6–8	8–11	1/4–28	8–10	11–14
5/16–18	10–13	14–18	5/16–18	13–17	18–23
5/16–24	11–14	15–19	5/16–24	15–19	20–26
3/8–16	23–26	31–35	3/8–16	30–35	41–47
3/8–24	26–29	35–40	3/8–24	35–39	47–53
7/16–14	35–38	47–51	7/16–14	46–50	62–68
7/16–20	43–46	58–62	7/16–20	57–61	77–83
1/2–13	53–56	72–76	1/2–13	71–75	96–102
1/2–20	62–70	84–95	1/2–20	83–93	113–126
9/16–12	68–75	92–102	9/16–12	90–100	122–136
9/16–18	80–88	109–119	9/16–18	107–117	146–159
5/8–11	103–110	140–149	5/8–11	137–147	186–200
5/8–18	126–134	171–181	5/8–18	168–178	228–242
3/4–10	180–188	244–254	3/4–10	240–250	325–339
3/4–16	218–225	295–305	3/4–16	290–300	393–407
7/8–9	308–315	417–427	7/8–9	410–420	556–569
7/8–14	356–364	483–494	7/8–14	475–485	644–657
1–8	435–443	590–600	1–8	580–590	786–800
1–14	514–521	697–705	1–14	685–695	928–942

Grade identification markings are normally stamped on the heads of the bolts. To aid identification of the various bolts used in Detroit Diesel engines, refer to the following chart.

Grade Identification Marking on Bolt Head	GM Number	SAE Grade Designation	Nominal Size Diameter (inch)	Tensile Strength Min. (psi)
None	GM 255-M	1	No. 6 thru 1 1/2	60,000
None	GM 260-M	2	No. 6 thru 3/4 over 3/4 to 1 1/2	74,000 60,000
 Bolts and Screws	GM 280-M	5	No. 6 thru 1 over 1 to 1 1/2	120,000 105,000
 Hex Head Sems Only	GM 275-M	5.1	No. 6 thru 3/8	120,000
 Bolts and Screws	GM 290-M	7	1/4 thru 1 1/2	133,000
 Bolts and Screws	GM 300-M	8	1/4 thru 1 1/2	150,000
 Bolts and Screws	GM 455-M	None	No. 6 thru 1 1/2	55,000

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BOLT IDENTIFICATION CHART

EXCEPTIONS TO STANDARD BOLT AND NUT TORQUE SPECIFICATIONS

APPLICATION	THREAD	lb–ft	N·m
Water pump cover bolt	5/16–18	6–7	8.1–9.5
Fan hub retaining nut (6V engines)	1/2–20	35–40	47–54
Raw water pump drive gear retaining nut	5/8–18	30–35	41–47

SERVICE TOOLS

TOOL NAME	TOOL NO.
Handle, driver (1/2" diameter)	J 7079-2
Installer, thermostat housing seal (8V-53)	J 22091
Puller	J 24420-A
Radiator cap and cooling system tester	J 24460-01
Remover and installer, water pump coupling and oil seal (8V-53)	J 1930
Water pump impeller remover set	J 22488

SECTION 6

EXHAUST SYSTEM

CONTENTS

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 shutdown 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 shutdown valve adaptor and plug assembly.

Remove Exhaust Manifold

1. Allow the engine to cool. Then disconnect the exhaust pipe or muffler from the exhaust manifold flange.
2. If the engine is equipped with a mechanical automatic shutdown system, remove the two bolts and lock washers and withdraw the shutdown 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.

Replace broken or damaged exhaust manifold studs. Apply sealant to the threads and drive new studs to 25–40 lb-ft (34–54 N·m) 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). 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 (41–47 N·m) torque.

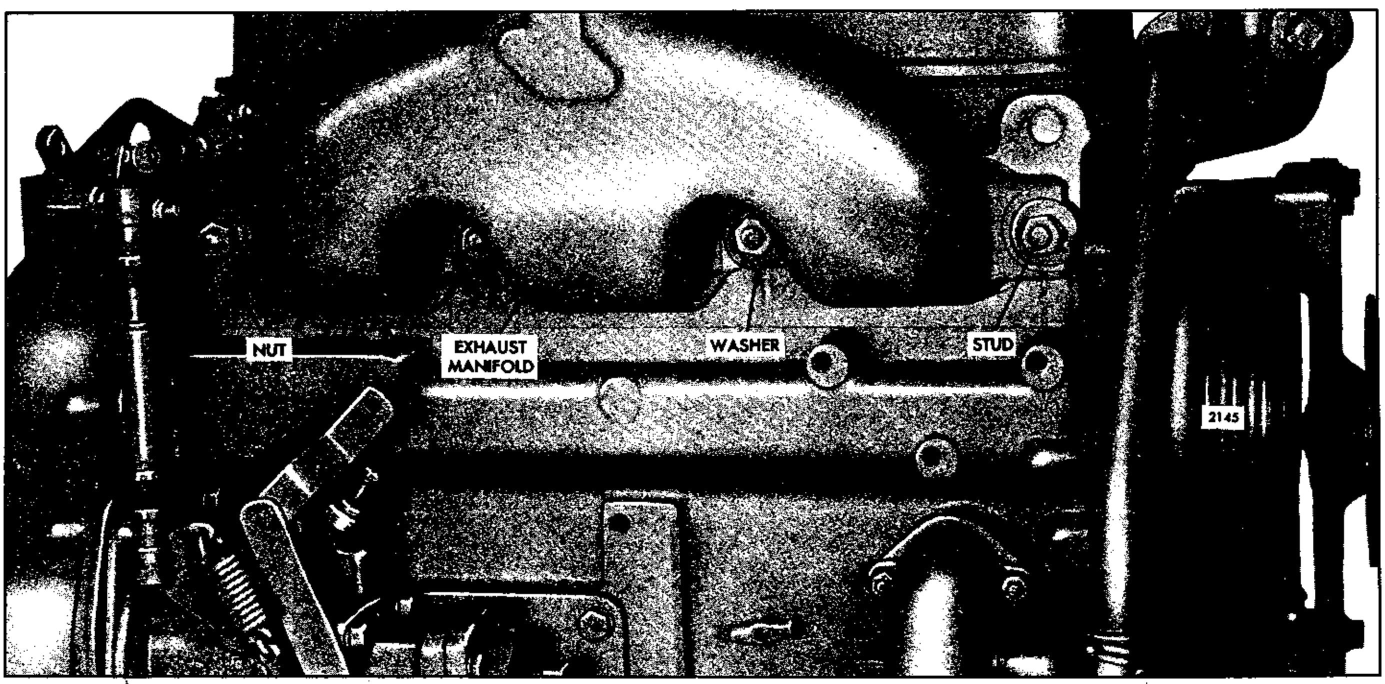


Fig. 1 – Typical Air-Cooled Exhaust Manifold (Square Flange) Mounting

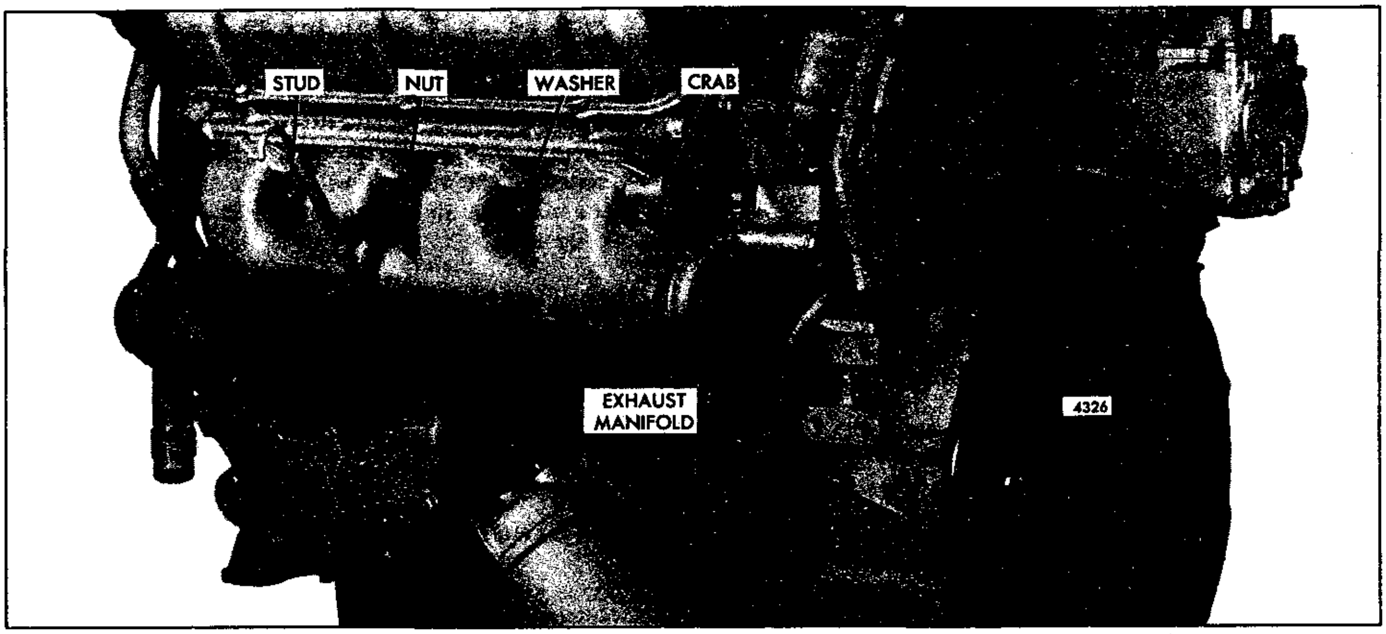


Fig. 2 – Exhaust Manifold with Marmon Flange

4. If the engine is equipped with a mechanical automatic shutdown assembly, install the shutdown 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.

NOTICE: To avoid turbocharger damage, do not allow exhaust piping to impose excessive loads on the turbocharger.

6. Inspect the exhaust outlet piping for dents, holes and potential sources of water infiltration such as loose clamps or deteriorated seals. Repair or replace, if necessary.

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 bypass tube to the water tank.

Remove Exhaust Manifold

1. Allow the engine to cool. Then remove the water tank filler cap and open the vent valve at the front end of the exhaust manifold.

- **CAUTION: Use extreme care when removing a coolant pressure control cap. The sudden release of pressure from a heated cooling system can result in loss of coolant and possible personal injury (scalding) from the hot liquid.**

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 bypass 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 (34–54 N·m) 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.

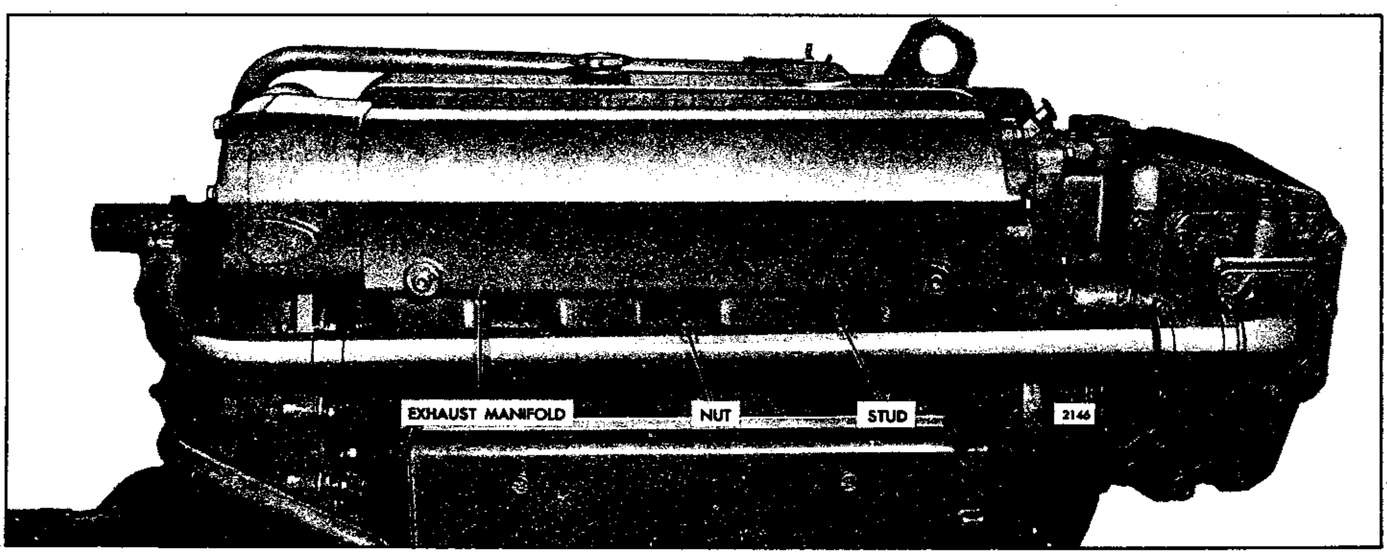
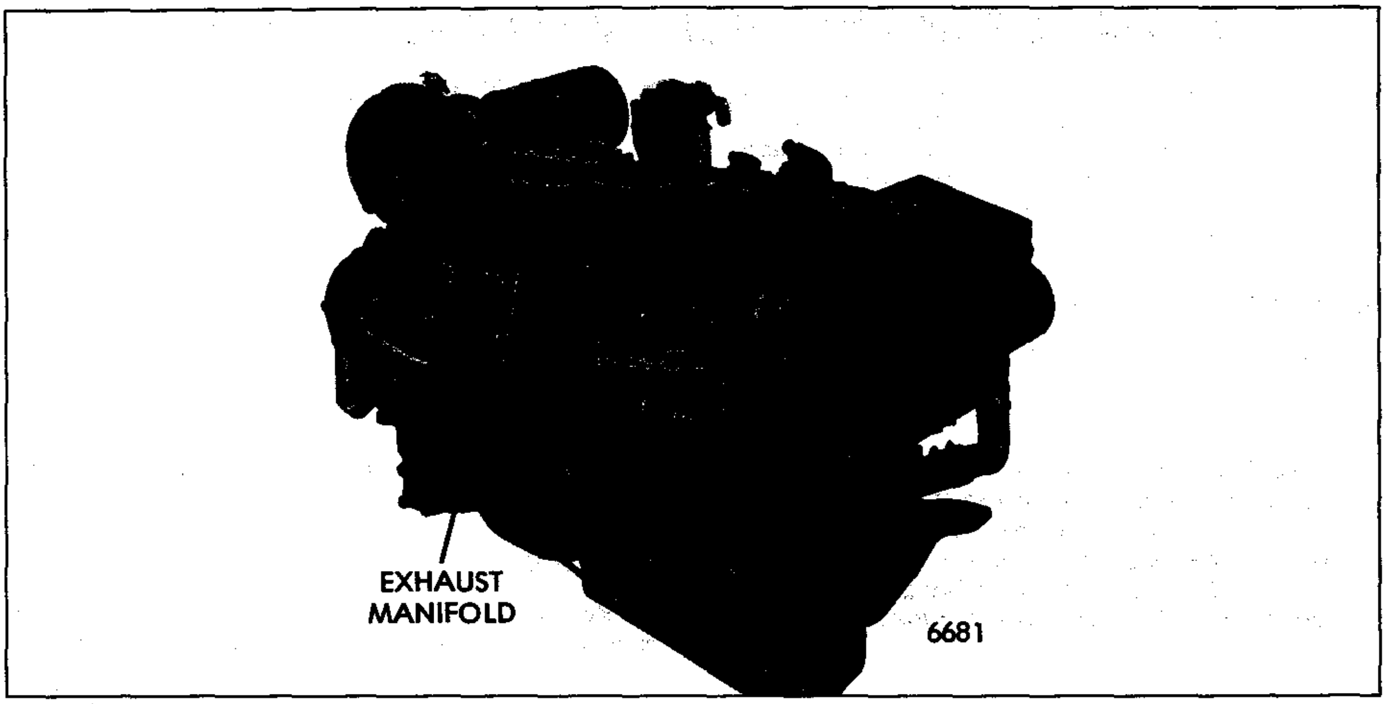


Fig. 1 – Typical Water-Cooled Exhaust Manifold Mounting (In-Line Engine)



● Fig. 2 – Typical Water-Cooled Exhaust Manifold Mounting (6V Engine)

3. Position the exhaust manifold over the studs and hold it against the cylinder head. Be sure the locating pads on the exhaust manifold rest on the cylinder block locating pads.

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 (41–47 N·m) torque.

5. Slide the hoses in place on the water bypass 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.

    NOTICE: To avoid turbocharger damage, do not allow exhaust piping to impose excessive loads on the turbocharger.

11. Inspect the exhaust outlet piping for dents, holes and potential sources of water infiltration such as loose clamps or deteriorated seals. Repair or replace, if necessary.

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

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

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

SECTION 7

ELECTRICAL EQUIPMENT, INSTRUMENTS AND PROTECTIVE SYSTEMS

CONTENTS

ELECTRICAL SYSTEM

A typical engine electrical system generally consists of the starting motor(s), a battery–charging alternator, storage batteries 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 service manuals. The manuals may be obtained from AC–Delco service outlets, 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 Corporation. For electrical equipment manufactured by Delco–Remy Division, repair service and parts are available through AC–Delco branches and repair stations.

- **CAUTION: To avoid possible personal injury and/or engine damage from accidental engine startup, always disconnect the battery before servicing the electrical system.**

BATTERY-CHARGING ALTERNATOR

The battery–charging circuit consists of an alternator, battery (Section 7.2), and the wiring. The battery–charging alternator (Figs. 1 and 2) 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 alternator.

- All In–line 53 engines and most 6V–53 engines use hinge–mounted (belt–driven) alternators. Certain 6V–53 models use flange–mounted (beltless) alternators.

• 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 alternator and the regulator. Never run an alternator on an open circuit.

Grounding an alternator'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.

Accidentally reversing the battery connections must be avoided.

Never disconnect the battery while an alternator is in operation. Disconnecting the battery will result in damage to the 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 alternator diodes.

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.

HINGE–MOUNTED ALTERNATOR (BELT–DRIVEN)

The hinge–mounted alternating current self–rectifying alternator, (Figs. 1 and 2) is belt–driven. The alternator drive pulley is keyed to a shaft which is coupled to the blower drive gear.

An adequate alternator drive ratio is necessary for an engine equipped 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 alternator, thereby eliminating the need for an external rectifier. The alternator is also available in various sizes and types, depending upon the specific application.

The SI series alternators have replaced the DN series alternator. With the new alternators, the need for a separately mounted voltage regulator is eliminated.

The 32 volt, 50 ampere 25SI alternator has been replaced by the 30SI alternator, rated at 60 amperes, for marine applications. When installing the 30SI alternator, a wire running from the alternator to the battery (insulated ground vs negative ground) must be installed.

The access hole permitting the external adjustment of the voltage regulator has been eliminated on current alternators. To adjust the voltage setting on the current alternators, remove the rectifier end plate. The voltage regulator adjustment is located on the voltage regulator circuit board. Refer to the pertinent Delco Service Bulletin for complete adjustment procedure.

The proper selection of an alternator 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 alternator troubles to a minimum. Since most alternators adhere to the same basic design, the maintenance, removal and installation procedures for all are similar.

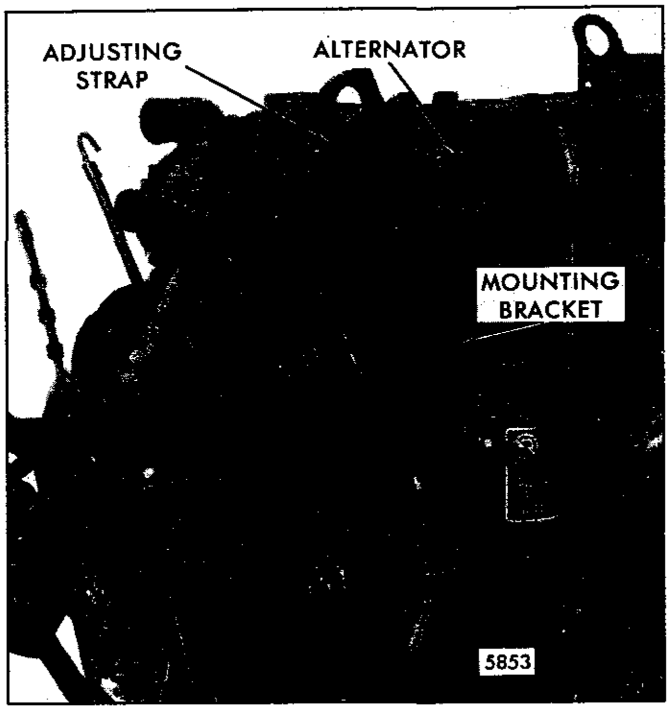


Fig. 1 – Typical Hinge–Mounted Alternator (In–line 53)

Alternator 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 alternator drive.

2. When installing or adjusting the drive belt, be sure the bolt at the pivot point is properly tightened, as well as the bolt in the adjusting slot.

3. Alternator bearings are permanently lubricated. There are no external oiler fittings.

Remove Alternator

1. Disconnect the cables at the battery supply.

   - **NOTICE:** To avoid alternator damage when removing battery connections, disconnect the negative (–) terminal first. When reinstalling connections, reconnect the negative terminal last.

   Disconnect all other leads from the alternator and tag each one to ensure correct reinstallation.

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

3. While supporting the alternator, remove the adjusting strap bolt and washers. Then remove the mounting bolts, washers and nuts. Remove the alternator carefully and protect it from costly physical damage.

4. Remove the pulley assembly if the alternator is to be replaced (Fig. 3).

Alternator Service

Repairs and overhaul work on alternators should be referred to an authorized repair station of the manufacturer of this equipment. Replacement parts for alternators should be ordered through the equipment manufacturer's outlets. For alternators manufactured by Delco–Remy Division, repair service and parts are available through AC Delco branches and repair stations.

Install Alternator

1. Install the drive pulley, if it was removed. Tighten the 5/8" – 18 pulley retaining nut to 70–80 lb–ft (95–108 N·m) torque (Fig. 3).

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

2. Position the alternator on the mounting brackets and start the bolts, with washers in place, through the bolt holes in the end frames. If nuts are used, insert the bolts through the bolt holes in the mounting bracket and end frame. Make sure that the washers and nuts are in their proper locations.

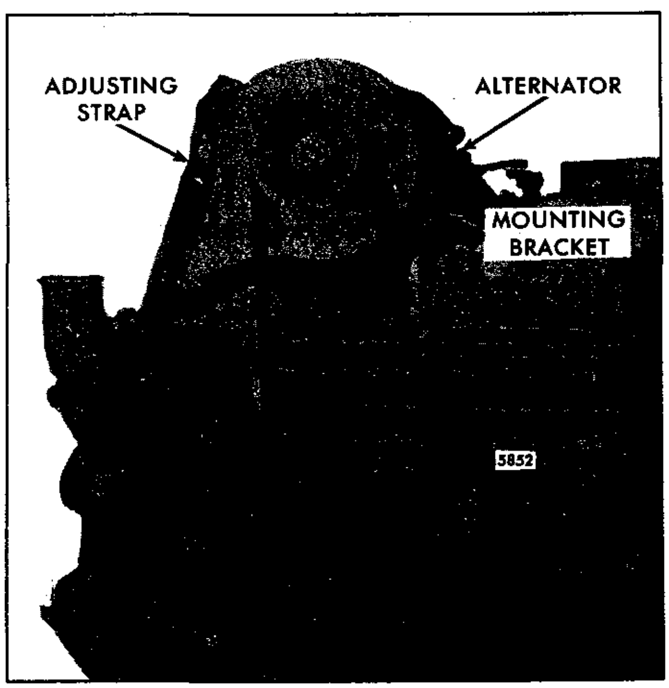


Fig. 2 – Typical Hinge–Mounted Alternator (V–53)

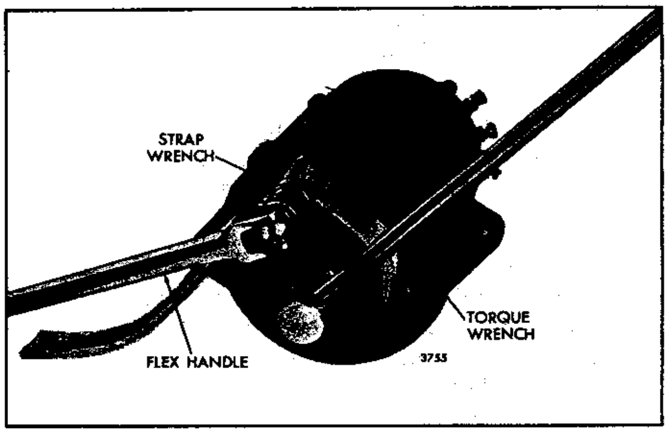


Fig. 3 – Tightening Alternator Pulley Retaining Nut

3. Align the threaded hole in the adjusting lug of the drive end frame with the slot in the adjusting strap. Start the bolt, with the washers, through the slot of the adjusting strap and into the threaded hole in the end frame.

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

5. Adjust the belt tension as outlined in Section 15.1. After the belt tightening is complete, tighten all mounting bolts.

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

• FLANGE–MOUNTED ALTERNATOR (BELTLESS)

The flange–mounted alternator is coupling–driven through a drive hub attached to the blower drive gear. It is a self load limiting alternator with a fully adjustable solid state integral regulator. It is designed with slow speed characteristics which allow lower rotational speed of the alternator without sacrificing any amperage output at idle or top speed. The alternator shaft may be rotated in either direction without affecting the output or cooling of the unit. Six silicon diodes mounted in heat sinks convert alternating current from the delta wound stator into direct current.

The brushes and integral voltage regulator are located in a waterproof housing that may be removed for replacement or inspection.

Alternator Maintenance

1. Keep the mounting bolts securely tightened to prevent vibration damage, which will occur if the mounting bolts loosen.

2. Be sure the plug that seals the integral regulator adjusting hole is in place.

Remove Alternator

1. Disconnect the cables at the battery supply. Disconnect the leads from the alternator and tag each one to ensure correct reinstallation.

2. Loosen the three alternator mounting bolts.

3. While supporting the alternator, remove the mounting bolts, hardened washers and lock washers and lift the alternator and fan guard as a unit from the mounting adaptor. Protect the alternator and fan guard assembly from physical damage following removal from the engine.

NOTICE: The fan guard, which includes an oil seal, should not be separated from the alternator until the alternator half of the coupling is removed. Any attempt to separate the fan guard from the alternator could damage the oil seal.

4. Loosen the retaining nut and remove the coupling hub keyed to the alternator shaft.

5. If the alternator is to be replaced, separate the fan guard from the alternator.

6. Remove the alternator flange mounting adaptor from the flywheel housing, if necessary.

Alternator Service

To service the alternator, contact the alternator manufacturer.

Inspection

Inspect the drive coupling and hub for wear at the seal surface and the drive tangs. If worn excessively, replace them with new parts.

Oil leaks indicate a worn or damaged oil seal. Replace the oil seal in the fan guard, if necessary.

Inspect the alternator housing and flange adaptor at the mounting bolt holes for cracks and the pilot diameters for damage, cracks or distortion. Replace if necessary.

Install Alternator

1. If removed, attach the alternator mounting adaptor, using a new gasket, to the flywheel housing. The adaptor is secured to the engine by two short bolts into

the flywheel housing and four long bolts through the flywheel housing, end plate and blower drive support.

Make sure the alternator is properly fitted to the adaptor before it is bolted in place. Improper installation of the alternator can disturb adaptor alignment and cause gear train damage. See Section 1.7.7 for alignment procedure.

NOTICE: Special hardened, plain washers seat in the six counterbored bolt holes in the adaptor. Also, the current gasket has a positioning identification tab.

2. If the fan guard and hub were removed, locate the fan guard on the alternator by engaging the mating pilot diameters. Lubricate the seal diameter on the coupling hub and the seal lip. Install the coupling hub on the shaft. Be careful not to damage the lip of the oil seal. Install the retaining nut on the shaft and tighten it to 70–80 lb–ft (95–108 N·m) torque. If the fan guard and hub were not removed, check the retaining nut for proper torque. *Do not support the alternator on the fan guard.*
3. Place the slotted drive coupling on the drive hub. *Align the slotted drive coupling with the blower drive coupling when attaching the alternator assembly.*
4. Align the bolt holes in the fan guard with the mounting holes in the alternator housing. Support the alternator assembly against the mounting flange adaptor, using a new gasket, and install the three 3/8"–16 x 3 1/2" bolts, lock washers and hardened washers through the alternator housing and fan guard mounting holes into the mounting adaptor. Tighten the bolts to 30–35 lb–ft (41–47 N·m) torque.
5. Attach the wires and cables. Be sure each one is correctly installed in accordance with its previous location on the alternator. Keep all connections clean and tight.

STORAGE BATTERY

The battery is a device for storing electrical energy and converting chemical energy into electrical energy.

The three basic types of batteries currently being marketed are:

Filler Cap Batteries

These are lead–acid batteries with a high degree of antimony in the grid alloy. They require frequent servicing, especially the need for adding water, as well as cleaning salts from the terminal posts.

Semi–Maintenance Free Batteries

These are conventional filler cap batteries with reduced amounts of antimony in the grid alloy and, consequently, servicing is somewhat reduced. Water must still be periodically added. Terminal posts tend to accumulate salts.

Maintenance–Free Batteries

These batteries use lead–calcium grid construction without antimony. They never need water, nor are provisions provided for adding water. As these batteries have no filler caps to leak acid fumes, terminal posts have less tendency to accumulate salts, and as a result require less frequent cable inspection and cleaning.

The chart below gives the minimum battery capacity recommended for acceptable engine cranking.

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 or alternator.

NOTICE: 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.

Install the battery as follows:

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 clamp. 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. On filler cap batteries or semi–maintenance free batteries, 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 terminal end 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.

ENGINE MODEL	SYSTEM VOLTAGE	MINIMUM BATTERY RATINGS SAE COLD CRANKING AMPS (CCA) @ 0°F (–17.8°C)
3–53 NA, T; 4–53 NA, T	12, 24, 32	625
6V–53 NA, T	12V	1250
	24V, 32V	625

• Fig. 1 – General Battery Recommendations

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

4. Use the standard battery test (below) 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.

Testing Batteries

CAUTION: Battery electrolyte is a solution of sulfuric acid. Avoid contact with clothing, skin, and eyes.

CAUTION: When batteries are being charged and tested, an explosive gas forms inside the battery. Some of this gas escapes through the holes in the vent plugs or vents in the battery cover and may form an explosive atmosphere around the battery itself if ventilation is poor. Sparks or flame can ignite this gas, causing an explosion which can shatter the battery. Flying pieces of the battery structure and splash of electrolyte can cause personal injury.

To avoid personal injury, observe these precautions before charging and/or testing a battery:

1. Wear face and eye protection.

2. Have a clean water supply available (to wash off any splashed electrolyte).

3. Provide proper ventilation.

4. Do not test near fire or flame.

Testing Maintenance-Free (Freedom) Batteries

Test each battery separately as follows:

1. Disconnect both terminals of each battery.

2. If battery has threaded stud terminals, use terminal adapters (AC-Delco #ST1201) when testing or charging.

3. Check each battery visually.

4. Examine the hydrometer "eye" (if no eye, proceed to Step 5).

   - Eye shows green – continue test.
   - Eye shows dark – recharge, then continue.
   - Eye shows yellow – replace battery.

5. Apply a 300 amp load for 15 seconds. Turn off load. Wait one minute.

6. If no hydrometer eye, measure terminal voltage (Fig. 2)

   - If 12.4 volts or more – continue.
   - If less than 12.4 volts – recharge, then repeat Steps 5 and 6.

7. Apply a test load of 1/2 CCA rating (in amps). After 15 seconds, with load still applied, measure the terminal voltage. Turn the load off.

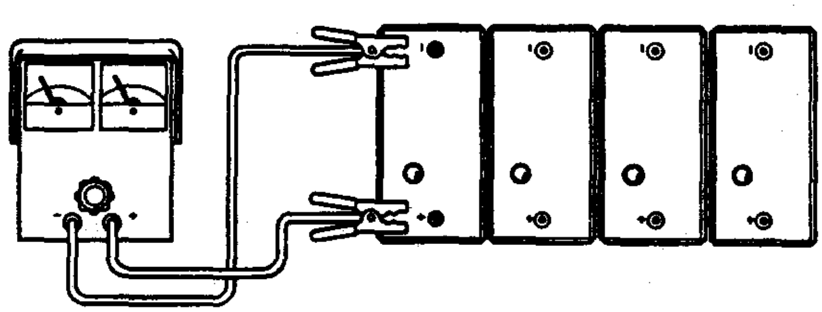


Fig. 2 – Battery Testing

8. Estimate the temperature of the battery. If measured voltage does not meet or exceed the values shown below, replace the battery.

TEMPERATURE	MIN. VOLTS
70°F (21.1°C)	9.6
50°F (10.0°C)	9.4
30°F (1.11°C)	9.1
15°F (-9.44°C)	8.8
0°F (-17.8°C)	8.5

9. Clean all cable ends and terminals of the battery with a wire brush.

10. Tighten the hold-down to specification.

Testing Filler Cap and Semi-Maintenance-Free Batteries

Test each battery separately as follows:

1. Disconnect both terminals of each battery.
2. If battery has threaded stud terminals, use terminal adapters (AC-Delco #ST1201) when testing or charging.
3. Check each battery visually.
4. Check electrolyte level.
   - If fluid is above the top of the plates in all cells, proceed to Step 5.
   - If not, add water, replace vent caps, and charge battery for 15 minutes at 15 to 25 amps to mix electrolyte. Proceed to Step 5.
5. Check specific gravity. If hydrometer readings for all cells are 1.230 or above and show less than 0.050 between high and low at electrolyte temperature of 80°F, proceed to Step 6.
   - If the readings show more than 0.050 difference – replace battery.
   - If the readings show less than 0.050 difference, but some cells read less than 1.230 – recharge battery.
   - If charging won't bring up the specific gravity – replace battery.
6. Remove vent caps and connect 300 amp load for 15 seconds.
   - If a blue haze or smoke is seen in any cell – replace battery.
   - If not, proceed to Step 7.
7. Measure electrolyte temperature and replace vent caps.
   - Connect voltmeter (Fig. 2) and a specific load of one-half the battery's rated CCA.
   - Read voltage after 15 seconds while load is still connected.
   - Disconnect load.
   - Compare voltage reading with the chart below.
   - If voltage is less than the chart, replace battery.
   - If voltage is equal or greater than the chart – the battery is good.

ELECTROLYTE TEMPERATURE	VOLTAGE
70°F (21.1°C)	9.6
60°F (15.6°C)	9.5
50°F (10.0°C)	9.4
40°F (4.44°C)	9.3
30°F (1.11°C)	9.1
20°F (-6.67°C)	8.9
10°F (-12.2°C)	8.7
0°F (-17.8°C)	8.5

8. Clean all cable ends and terminals of the battery with a wire brush.
9. Tighten the hold-down to specification.

•STARTING MOTOR

The starting motor (Fig. 1) is mounted on the flywheel housing. When the starting circuit is closed, a small drive pinion on the armature shaft engages with the teeth on the engine flywheel ring gear to crank the engine. When the engine starts, it is necessary to disengage the drive pinion to prevent the armature from overspeeding and damaging the starting motor.

See Section 7.0 for the mounting of a starter auxiliary magnetic switch.

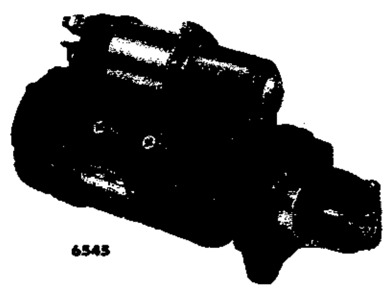


Fig. 1 – Typical Starting Motor

When repositioning of the solenoid is required on a service replacement starting motor, proceed as follows:

1. Remove the six socket head screws (1 short and 5 long) and six neoprene plugs, if a twelve hole starter mounting flange is used.
2. Turn the nose housing to the required position.

   NOTICE: 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 and six neoprene plugs, if a twelve hole starter mounting flange is used.
4. Tighten the screws to 13–17 lb–ft (18–23 N·m) torque.

Remove Starting Motor

Failure of the starting motor to crank the engine at normal cranking speed may be due to a defective battery, worn battery cables, poor connections in the cranking circuit, defective engine starting switch, low temperature, condition of the engine or a defective starting motor.

If the engine, battery and cranking circuit are in good condition, remove the starting motor as follows:

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 the starting motor cables and solenoid wiring. *Tag each lead to ensure correct connections when the starting motor is reinstalled.*
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 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 starter attaching bolts to 137–147 lb–ft (186–200 N·m) torque when a cast iron flywheel housing is used or to 95–105 lb–ft (129–143 N·m) torque when an aluminum flywheel housing is used.

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** (2–3 N·m) torque and the 1/2"–13 connections to 20–25 lb–ft (27–34 N·m) torque.

INSTRUMENTS AND TACHOMETER DRIVE

INSTRUMENTS

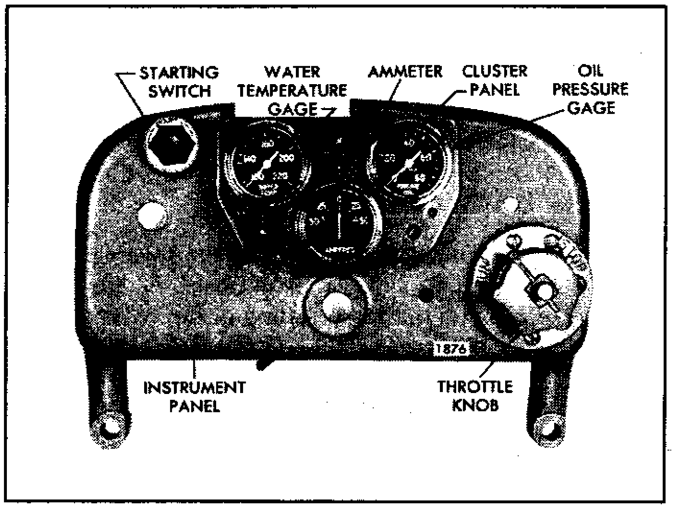


Fig. 1 – Typical Instrument Panel

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

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 engine.

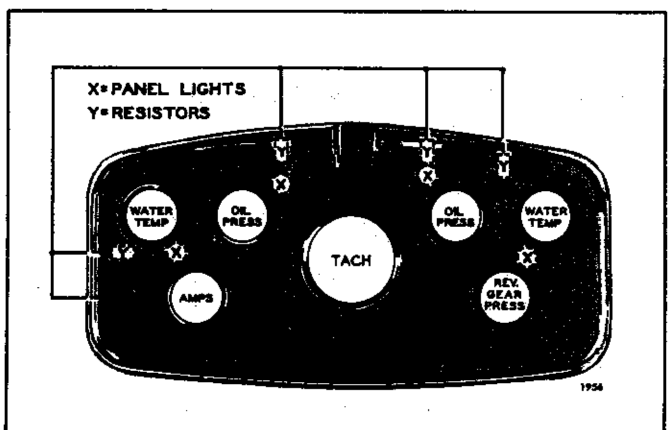


Fig. 2 – Installation of Resistors in Illuminated Instrument Panel

Marine propulsion engines 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 (Table 1) may be installed in the circuit to protect the instrument panel bulbs. As indicated in Fig. 2, one resistor is used in the lead for each instrument panel bulb.

Resistor Specifications		
Volts	Ohms	Watts
24	50	10
32	100	10

TABLE 1

Whenever performing service or preventive maintenance procedures on marine propulsion engine units which include a 24 or 32 volt electrical system, check the lighting circuit of the instrument panels 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 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 rubber mounts, care should be exercised, during removal and installation of the part, so twist is not imposed into the rubber mount diaphram. 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. Support the screw and tighten the nut only. If this screw turns, it will pre–load the rubber diaphragm in torsion and considerably shorten the life of the mount.

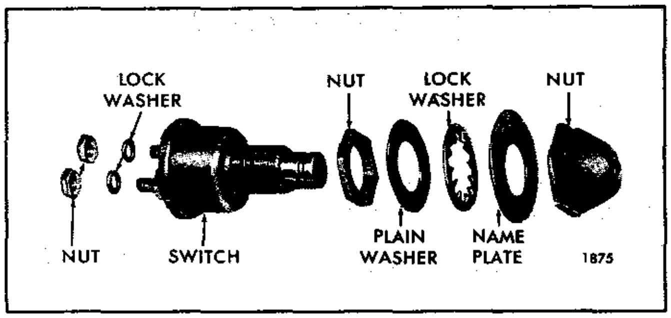


Fig. 3 – Typical Engine Starting Switch

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

Current oil pressure gages have male threads and require female fittings. When replacing a former gage with female threads, a new mounting clamp and connector must be used.

Water Temperature Gage

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

Incorrect coolant 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 ten 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 one 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 vibration.

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 alternator. 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).

Throttle Control

The engine throttle is connected to the governor speed 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. Starting switches may vary in design and their contacts must be rated sufficiently to carry the starter solenoid current. Tighten the starting switch mounting nut to 36–48 ***lb–in*** (4–5.5 N·m) torque.

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 and the engine allowed to operate at idle for a few minutes to permit the coolant to reduce the temperature of the engine's moving parts. Then pull the stop knob and hold it until the engine stops. Pulling on the stop knob manually places the injector racks in the no–fuel position. Return the stop knob to its original position after the engine stops.

> **NOTICE:** When an emergency shut down is necessary on a current engine with the spring loaded fuel injector control tubes, the stop knob should be pulled immediately and held until the engine stops.

Emergency Stop Knob (Engine with Air Shutoff Valve)

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 shutoff valve, located between the air intake and the blower, will trip and shut off the air supply to the engine. Lack 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 shutoff valve must be reset manually. The cause of the malfunction should be determined before the engine is started again.

TACHOMETER DRIVE

A 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.

When required, a tachometer drive cable adaptor is used to change speed or to change direction of rotation, depending upon the location of the tachometer drive. A special key is used to connect the drive shaft to the tachometer drive cable adaptor.

The cable connection at the current tachometer head is a 5/8" threaded connection in place of the former 7/8" connection. To eliminate possible misalignment, the current tachometer angle drive has a short flexible cable and incorporates an integral oil seal. The output shaft key size has been increased from 5/32" to SAE 3/16". New flexible drive cables are also required with the current tachometers and angle drives.

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 23907-1 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.

NOTICE: Use adequate protective measures to prevent 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 (Section 7.0).

ENGINE PROTECTIVE SYSTEMS

MANUAL SHUTDOWN

A manually operated emergency engine shutdown 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 shutdown device will prevent damage to the engine by cutting off the air supply and thus stopping the engine. The shutdown device consists of an air shutoff valve mounted in the air inlet housing and a suitable operating mechanism.

Operation

The manually operated shutdown device is operated by a knob located on the instrument panel and connected to the air shutoff 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 shutoff valve before starting the engine again.

Service

For disassembly and assembly of the shutdown device, refer to Section 3.3.

AUTOMATIC MECHANICAL SHUTDOWN

The automatic mechanical shutdown system is designed to stop the engine if an abnormal condition such as high engine coolant temperature, low engine oil pressure or engine overspeeding arises. The components of the shutdown 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 shutoff 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 shutoff 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 (34.5 to 172 kPa).

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 overspeed 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 shutdown mechanism and stopping the engine.

Operation

When starting the engine, it is necessary to first manually open the air shutoff valve and then press the engine starting switch, cranking the engine. As soon as the engine starts, the engine starting switch maybe released, but the air shutoff 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 shutoff 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 shutoff 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 shutoff valve to close, stopping the engine.

Should the engine lose 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 overspeed 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 shutoff valve to close, stopping the engine.

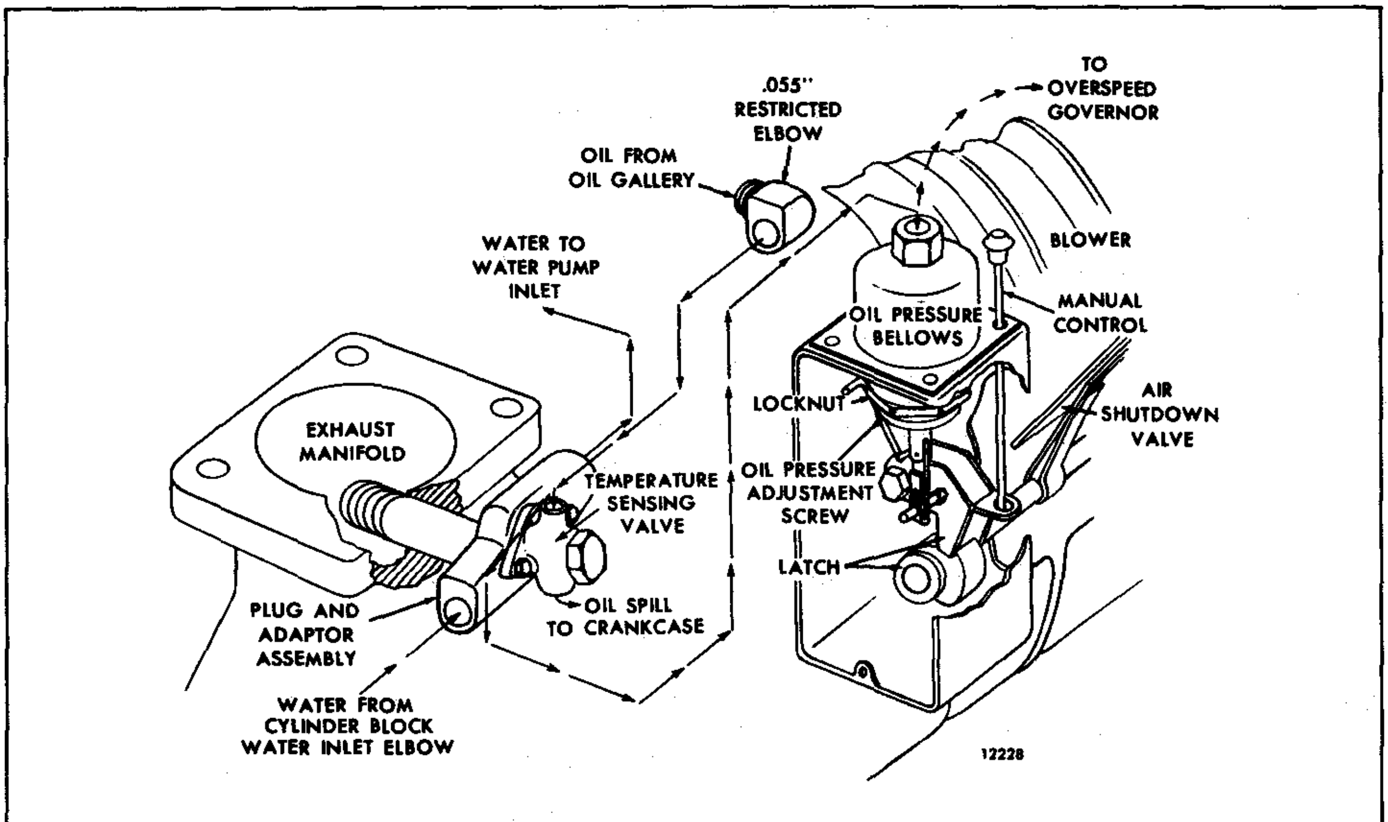


Fig. 1 – Mechanical Shutdown System Schematically Illustrated

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 shutdown 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 shutdown 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 has been reached and the oil pressure has stabilized. Then reduce the engine speed slowly until the bellows disengages the latch on the air shutoff valve and stops the engine. Note the oil pressure at which the shut down occurred. units having a minimum idle speed of 500 rpm it is 10 psi (69 kPa). If adjustment is necessary, loosen the locknut 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 locknut when the proper setting has been obtained.

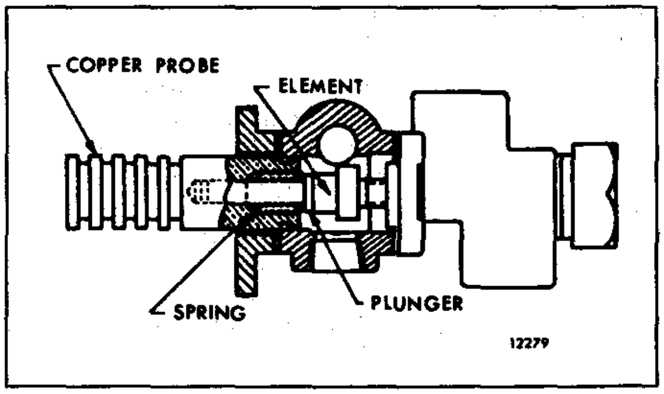


Fig. 2 – Temperature–Sensing Valve

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° to 210°F (93° to 99°C). If shut down does not occur, replace the coolant temperature–sensing valve assembly. If shut down occurs below 200°F (93°C), check the coolant flow through the plug and adaptor assembly. If circulation is satisfactory and shut down occurs below 200°F (93°C), replace the coolant temperature–sensing valve assembly. The coolant temperature–sensing valve cannot be adjusted.

NOTICE: If the temperature–sensing valve switch is removed, examine the temperature shutdown valve plunger in the copper probe (Fig. 2). If it is not free in the probe and adaptor, install a new plunger, spring and adaptor. Deposits from the engine coolant building up between the plunger, spring and plug can cause the plunger to stick in the probe.

The temperature–sensing valve can be bench tested by attaching an air hose (40 psi or 276 kPa air supply) to the oil inlet side and installing a tube from the outlet side to a can of water. Then, immerse the power element of the valve in a container of water that is heated and agitated.

- **CAUTION: To avoid personal injury when performing this test, wear adequate face and body protection (faceplate, gloves, boots, waterproof apron, etc.).**

Check the temperature of the water with a thermometer. Apply air to the valve. The valve should be open, as indicated by the flow of air, at a water temperature of 195°- 206°F (90°- 99°C).

Overspeed Shutdown Adjustment

1. Start the engine and bring it up to operating temperature.
2. Increase the engine speed to the specified overspeed shutdown speed. At this speed the bellows should disengage the air shutdown latch and stop the engine.
3. Adjust the overspeed governor setting, if necessary, by loosening the governor adjusting screw locknut (on the overspeed governor cap), then turning the adjusting screw clockwise to increase the speed at which the air shutdown mechanism is tripped. Turn counterclockwise to decrease the speed at which the latch will trip. Always tighten the locknut after each adjustment.
4. Stop the engine and replace the control shutdown housing cover.

AUTOMATIC ELECTRICAL SHUTDOWN

The automatic electrical shutdown 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 shutdown solenoid to release the air shutdown 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 (69 kPa) and the fuel oil pressure switch closes at approximately 20 psi (138 kPa) fuel pressure. The water temperature switch remains open.

If the oil pressure drops below 10 psi (69 kPa), the oil pressure switch will close the circuit and energize the shutdown solenoid. This will activate the shutdown mechanism and stop the engine.

A loss of coolant or an increase in coolant temperature to approximately 200°–210°F (93°–99°C) will close the contacts in the water temperature switch, thus closing the electrical circuit and activating the shutdown mechanism.

The water temperature switch 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 (94°C), the valve will close the contacts in the micro–switch and energize the shutdown 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 shutdown 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 shutdown mechanism.

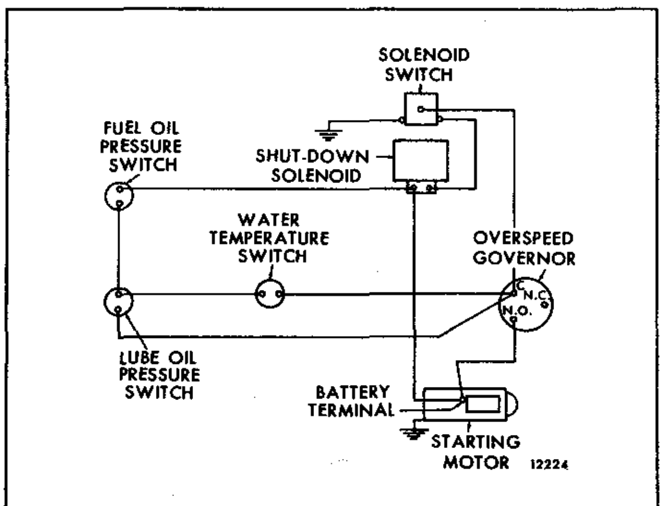
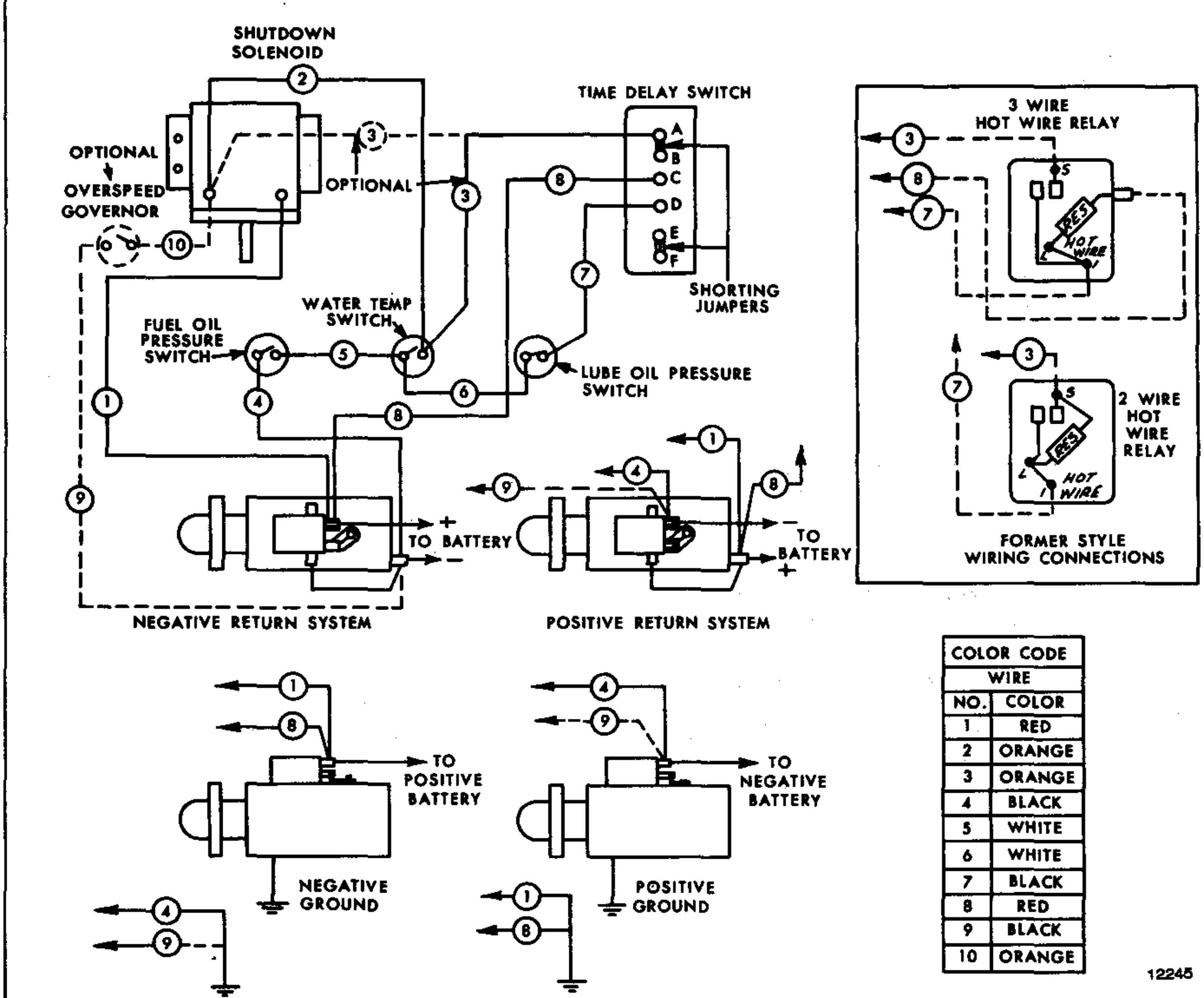


Fig. 3 – Automatic Electrical Shutdown System Diagram



COLOR CODE	
WIRE	
NO.	COLOR
1	RED
2	ORANGE
3	ORANGE
4	BLACK
5	WHITE
6	WHITE
7	BLACK
8	RED
9	BLACK
10	ORANGE

Fig. 4 – Automatic Electrical Shutdown System Incorporating Hot Wire Relay or Time Delay Switch

When the engine is shutdown, 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 shutoff valve must be manually reset in the open position before the engine can be started.

Some engines are equipped with an electrically operated automatic shutdown system which incorporates a hot wire relay or solid state time delay switch (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 shutdown of the engine. The hot wire relay or time delay switch, 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 or the time delay switch. The few seconds required to heat the hot wire relay provides sufficient delay to avoid an engine shutdown 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 (95°C).

Solid State Time Delay Switch

The current solid state time delay switch is designed as a direct replacement for the former hot wire relay (Fig. 4).

It is a solid–state time device which effectively withstands shock and vibrations. The switch is polarity–conscious. If a reverse polarity is applied the switch will not work.

The switch has two circuits: a time circuit and an electronic circuit which consists of a silicon control rectifier. The rectifier has sufficient capacity to handle standard loads such as the emergency shutdown solenoid. Abnormal load situations such as a collapsing magnetic field in a coil can damage the rectifier rendering it inoperative. To protect the rectifier a discharge diode is connected across the terminals B and C of the solid state time delay switch.

The time delay switch should be check periodically to be sure that it is operating properly (refer Section 7.0).

SHUTDOWN SYSTEM FOR DIRECT MOUNTED TURBOCHARGED ENGINES

With the use of a direct mounted turbocharger and the spring loaded fuel injector control racks, the air shutoff valve was eliminated from the air inlet housing. The spring loaded injector tube control rack enables the engine to come out of any advanced fuel position when an emergency situation arises.

When an engine is operating in an atmosphere subject to volatile fuel and is equipped with an air inlet housing without the air shutoff valve, a customer may request that the engine be equipped with an external or remote mounted emergency air shutdown assembly.

The remote mounted emergency air shutdown assembly that is equipped with the air shutoff valve can be installed upstream of the air inlet side of the turbocharger.

Care should be taken when installing the emergency air shutdown assembly between the turbocharger and the air cleaner. Because the engine shutdown system is activated, all of the piping between the shutdown system and the engine will be subjected to an abnormally high suction which may cause some of the piping components, i.e., rubber hoses and elbows to collapse. Therefore, it is recommended that all of these components be designed to withstand the maximum suction without a failure which would allow air to reach the engine air intake.

A 7 to 5 inch diameter reducing 90° rubber hose or a 7 to 5 inch diameter hump hose reducer can be used to adapt the shutdown to the turbocharger.

The rubber elbow can be obtained from the manufacturer; Griffin Rubber Mills in Portland, Oregon under their part number – 51759.

The customer is required to provide the mounting support brackets.

The emergency air shutdown assembly is manually operated. To be an automatic shutdown system, it will be necessary to install a solenoid.

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 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.

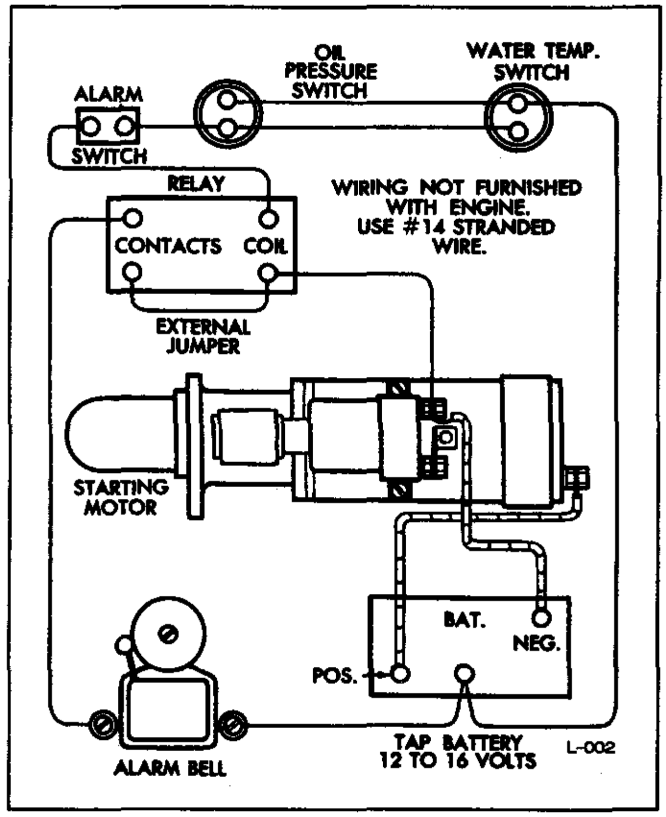


Fig. 1 – Alarm System Wiring Diagram

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

OVERSPEED GOVERNORS

ELECTRIC (TWO SWITCH)

The series GY–2 Synchro–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:
   a. Mark the position of the dust cover and remove both hold–down screws.

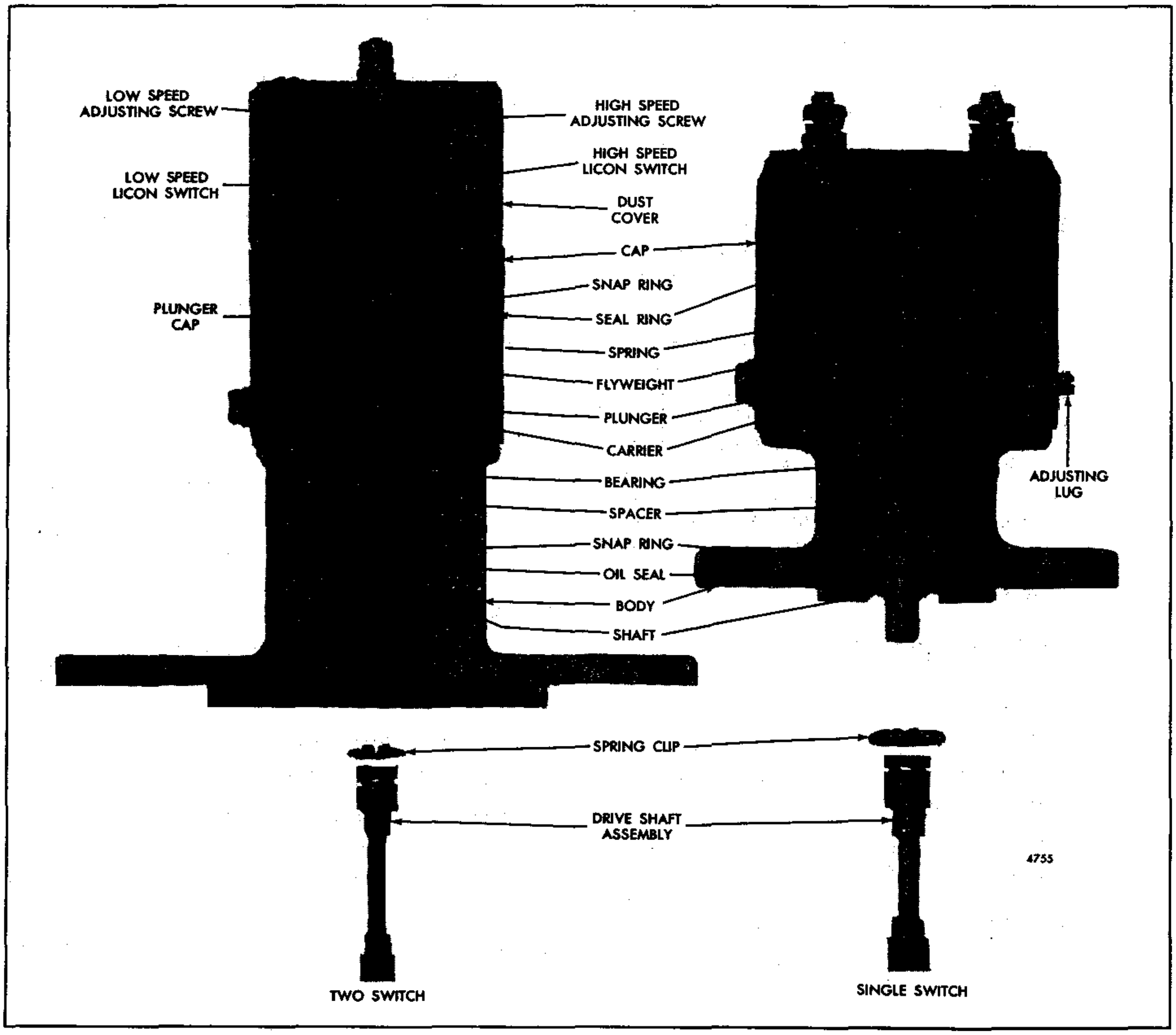


Fig. 1 – Electric Overspeed Governors

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. 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.

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.

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.

NOTICE: 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.

NOTICE: Under no circumstances should the governor switch be by–passed to prevent engine shut–down in the event of overspeed. Serious damage to the engine and the governor may result, 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.

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.

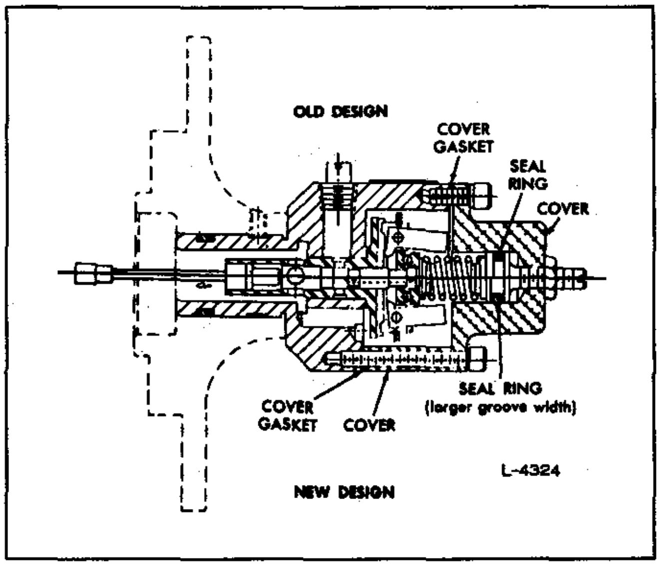


Fig. 2 – Hydraulic Overspeed Governor

SHOP NOTES - TROUBLESHOOTING SPECIFICATIONS - SERVICE TOOLS

SHOP NOTES

PROPER OPERATION OF THE SWITCHES OR ALARM SYSTEM FOR TESTING THE ELECTRICAL SHUTDOWN

The protective system is activated whenever low lubricating oil pressure, high coolant temperature, engine overspeed or any other abnormal condition develops that could damage the engine.

In a properly maintained installation, the shutdown system seldom has cause to function. Therefore, it is advisable to check the system periodically to be sure that it will function when needed.

Check each component of the shutdown system as outlined below. It is important to thoroughly warm-up the engine before any component of the shutdown system is checked.

Overspeed Governor

1. Remove the valve rocker cover. Discard the gasket.
2. Start the engine and move the speed control lever to the *full-speed* position.
3. While watching a tachometer, manually move the control tube slowly towards the *increased fuel* position until the air shutoff valve closes, stopping the engine. Do not exceed the engine no-load operating speed by more than 10%.
4. Note the speed at which the engine stops and adjust the overspeed governor, if necessary, as outlined in Section 7.4.3.
5. Using new gaskets reinstall the valve rocker cover.

Water Temperature Switch

The terminals of the water temperature switch are connected into the shutdown system and when the engine water temperature reaches 210°F (99°C), the switch closes and completes the circuit in the shutdown or alarm system.

1. Cover the radiator with a sheet of cardboard to prevent circulation of air.
2. Remove the radiator cap, if the engine is operating near sea level, and insert a steel jacketed thermometer.

The boiling point of water lowers approximately 2° for each 1000 foot rise in altitude. As an example, water boils at approximately 203°F (95°C) at 5000 feet and at 195°F (91°C) at 9000 feet altitude. It is necessary to retain the radiator pressure cap on engines which operate in excess of 1000 feet altitude to prevent the coolant from boiling while performing this test. The engine temperature gage, if it is found to be accurate, may be used when performing this test.

Do not exceed 210°F (99°C) when performing this test.

3. Start and run the engine at rated speed and with enough load to raise the water temperature gradually until the air shutoff valve closes. The water temperature switch will usually be set at 210°F (99°C).
4. Note the temperature at which the air shutoff valve closed.
5. Remove the radiator cover and start the engine without load immediately after the engine stops. This will permit the engine to cool down to normal operating temperature.

Fuel Oil Pressure Switch

The fuel oil pressure switch is set to make contact at an increasing fuel pressure of 20 psi (138 kPa). The phrase "20-MAKE" is stamped on the switch cover.

As the fuel pressure increases upon starting the engine, a diaphragm in the switch body expands and forces the plunger upwards (Fig. 1). Since the bottom of the adjusting screw bears against this plunger, the adjusting screw and the lower breaker point are also forced upwards. When the fuel pressure reaches 20 psi (138 kPa), the breaker points close and current flows to the terminals of the lubricating oil pressure switch and the water temperature switch.

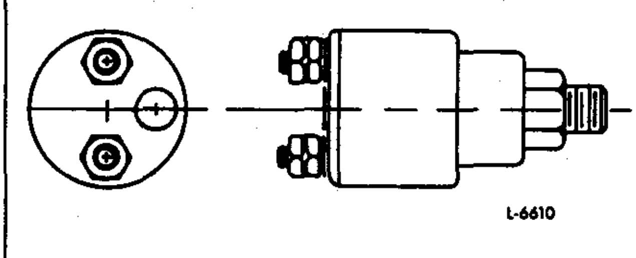


Fig. 1 - Fuel Oil Pressure Switch

When the engine is stopped, the fuel pressure decreases and the diaphragm in the switch body contracts. This action causes the plunger to lower and, when the fuel pressure decreases to 20 psi (138 kPa), permits the lower breaker point arm to lower and break the electrical circuit. The bracket to which the lower breaker point arm and the adjusting screw are attached is spring–loaded, which provides for positive breaking of the connection when the fuel pressure decreases sufficiently.

1. Insert a pressure gage on the discharge side of the fuel strainer.
2. Remove one of the leads from the lubricating oil pressure switch while this test is being performed, to prevent the engine from being shut down.
3. Start and run the engine at idle speed.
4. Slow the engine down by moving the speed control lever towards the *no–fuel* position until the fuel pressure is approximately 15 psi (103 kPa), with the engine barely turning over.
5. Place a jumper wire across the water temperature switch terminals.
6. Raise the engine speed slowly and watch the fuel oil pressure gage until the air shutoff valve closes.
7. Note the fuel pressure at which the air shutoff valve closed and, if necessary, replace the switch.
8. Remove the jumper wire from the water temperature switch and reconnect the lubricating oil pressure switch.

Lubricating Oil Pressure Switch

The construction of the lubricating oil pressure switch is very similar to that of the fuel oil pressure switch, except that the lubricating oil pressure switch is calibrated to break contact when the lubricating oil pressure increases to 10 psi (69 kPa). The phrase "10 BREAK" is stamped on the switch cover.

A 20 psi (138 kPa) break switch is used on some engines whose predominant operation is constant speed.

As the lubricating oil pressure increases upon starting, the diaphragm in the switch body expands and forces the plunger upwards (Fig. 2). Since the bottom of the adjusting screw bears against the plunger, and the adjusting screw is attached to the bracket which controls the upper breaker point arm, the arm is also forced upwards. When the lubricating oil pressure increases to 10 psi (69 kPa), the points separate. Current flows to the lubricating oil pressure switch only after the fuel oil pressure switch closes, at which time the points of the lubricating oil switch are open. Should the lubricating oil pressure decrease to 10 psi (69 kPa) during operation, the breaker point will close and either the alarm bell or shutdown solenoid will be energized.

1. Start and run the engine at idle speed.

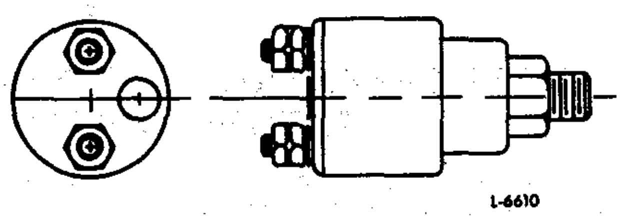


Fig. 2 – Lubricating Oil Pressure Switch

2. Place a jumper wire on the hot wire relay between the "1" and "S" terminals.
3. Place a jumper wire across the fuel oil pressure switch terminals.
4. Reduce the engine speed by moving the control lever towards the *no–fuel* position while watching the lubricating oil pressure gage.
5. Note the oil pressure at which the switch stops the engine and, if necessary, replace the switch.
6. Remove the jumper wire.

Hot Wire Relay

1. Start and operate the engine at idle speed.
2. Place the jumper wire across the terminals of the lubricating oil pressure switch while watching a second hand of a clock.
3. Not more than three (3) to ten (10) seconds should elapse between the time the jumper wire is placed across the terminals of the lubricating oil pressure switch and the air shutoff valve closes.

The above procedures completely test the normally open electrical shutdown system on an engine.

NOTICE: When the engine is operating at idle speed or above, the air shutoff valve will completely close off the air from the engine causing it to stop. However, when the engine is operating at the very low speeds that are necessary when performing the test on the fuel shutdown switch and the lubricating oil shutdown switch, the air damper solenoid will close the air shutoff valve, but the engine may continue to run very slowly. This may be due to insufficient force exerted by the low air flow on the back of the shutoff valve to completely close it.

Solid State Time Delay Switch 12, 24 or 32 Volts–Direct Current

A solid state time delay switch is used on current engines in place of the former hot wire relay.

A bench test procedure for the solid state time delay switch (Fig. 3) is as follows:

1. Remove the time delay switch from the engine.
2. Install the jumper straps on terminals "A" to "B" and "E" to "F", if they have been removed. Normally, the jumper straps are on the Time Delay Switches as supplied.
3. Install a positive battery lead to terminal "A".
4. Install a negative battery lead to one side of a 12 volt light which is a known good test lamp.
5. Install a lead from the opposite side of the light to terminal "D". A switch may be used in this lead, if desired.
6. After the negative lead is connected to "D" or the switch is closed, the lamp should light in eight (8) to ten (10) seconds. If not, the time delay switch must be replaced.

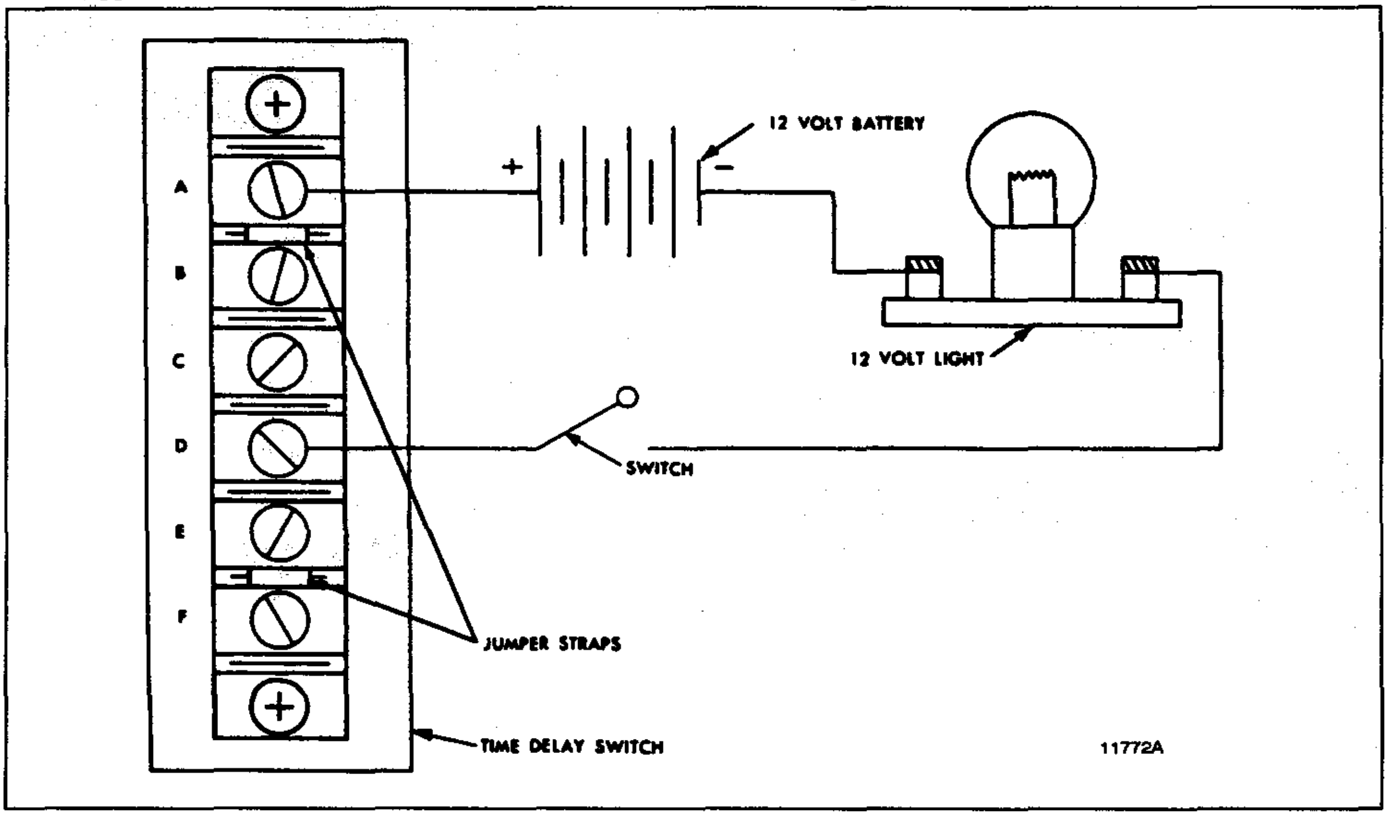


Fig. 3 – Time Delay Switch Testing Diagram

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 a 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.

Use one of three tools in set J 23068 to establish the proper alignment. Fig. 4 illustrates the use of the tools.

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.

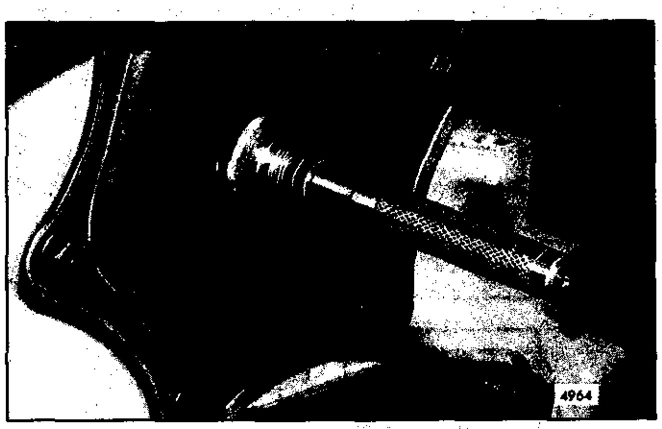


Fig. 4 – Checking Tachometer Drive Shaft Alignment

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.

MOUNTING THE STARTER AUXILIARY MAGNETIC SWITCH

On certain railcar and highway units equipped with Detroit Diesel engines and Delco–Remy starter auxiliary magnetic switches, no–start conditions may result from damage to the starter auxiliary magnetic switch caused by vibration. The vibration may result from improper mounting of the auxiliary magnetic switch.

The following guidelines should be followed when mounting a Delco–Remy starter auxiliary magnetic switch (Fig. 5):

1. Do not mount the switch on the engine.
2. Position the mounting pads of the switch vertically (one above the other).
3. Mount the switch on a rigid bracket, base rail or fire wall.

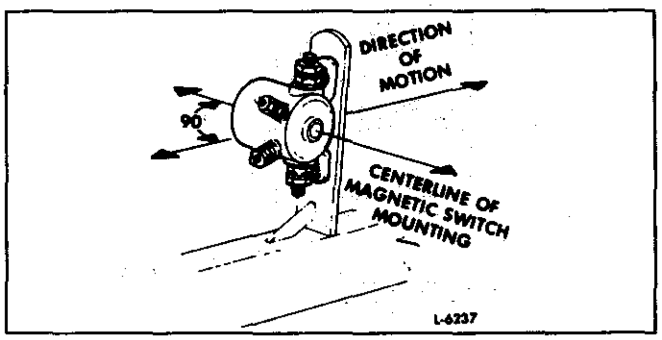


Fig. 5 – Starter Auxiliary Magnetic Switch Mounting

4. Mount the switch on a surface perpendicular (90°) to the forward motion of the vehicle so that contact disc movement is not in line with gravity or vehicle movement.

TROUBLESHOOTING

CHECKING ENGINE ELECTRICAL GENERATING SYSTEM

Whenever trouble is indicated in the electrical generating system, the following quick checks can be made to assist in localizing the cause.

A *fully charged battery and low charging rate* indicates normal alternator–regulator operation.

A *low battery and high charging rate* indicates normal alternator–regulator operation.

A *fully charged battery and high charging rate* condition usually indicates the voltage regulator is set too high or is not limiting the alternator output. A high charging rate to a fully charged battery will damage the battery and other electrical components.

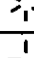
A *low battery and low or no charging rate* condition could be caused by: Loose connections or damaged wiring, defective battery or alternator and defective regulator or improper regulator setting.

SPECIFICATIONS

STANDARD BOLT AND NUT TORQUE SPECIFICATIONS

THREAD SIZE	260M BOLTS TORQUE (lb–ft)	260M BOLTS TORQUE N·m	THREAD SIZE	280M OR BETTER TORQUE (lb–ft)	280M OR BETTER TORQUE N·m
1/4–20	5–7	7–9	1/4–20	7–9	10–12
1/4–28	6–8	8–11	1/4–28	8–10	11–14
5/16–18	10–13	14–18	5/16–18	13–17	18–23
5/16–24	11–14	15–19	5/16–24	15–19	20–26
3/8–16	23–26	31–35	3/8–16	30–35	41–47
3/8–24	26–29	35–40	3/8–24	35–39	47–53
7/16–14	35–38	47–51	7/16–14	46–50	62–68
7/16–20	43–46	58–62	7/16–20	57–61	77–83
1/2–13	53–56	72–76	1/2–13	71–75	96–102
1/2–20	62–70	84–95	1/2–20	83–93	113–126
9/16–12	68–75	92–102	9/16–12	90–100	122–136
9/16–18	80–88	109–119	9/16–18	107–117	146–159
5/8–11	103–110	140–149	5/8–11	137–147	186–200
5/8–18	126–134	171–181	5/8–18	168–178	228–242
3/4–10	180–188	244–254	3/4–10	240–250	325–339
3/4–16	218–225	295–305	3/4–16	290–300	393–407
7/8–9	308–315	417–427	7/8–9	410–420	556–569
7/8–14	356–364	483–494	7/8–14	475–485	644–657
1–8	435–443	590–600	1–8	580–590	786–800
1–14	514–521	697–705	1–14	685–695	928–942

Grade identification markings are normally stamped on the heads of the bolts. To aid identification of the various bolts used in Detroit Diesel engines, refer to the following chart.

Grade Identification Marking on Bolt Head	GM Number	SAE Grade Designation	Nominal Size Diameter (inch)	Tensile Strength Min. (psi)
None	GM 255–M	1	No. 6 thru 1 1/2	60,000
None	GM 260–M	2	No. 6 thru 3/4 over 3/4 to 1 1/2	74,000 60,000
 Bolts and Screws	GM 280–M	5	No. 6 thru 1 over 1 to 1 1/2	120,000 105,000
 Hex Head Sems Only	GM 275–M	5.1	No. 6 thru 3/8	120,000
 Bolts and Screws	GM 290–M	7	1/4 thru 1 1/2	133,000
 Bolts and Screws	GM 300–M	8	1/4 thru 1 1/2	150,000
 Bolts and Screws	GM 455–M	None	No. 6 thru 1 1/2	55,000

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BOLT IDENTIFICATION CHART

EXCEPTIONS TO STANDARD BOLT AND NUT TORQUE SPECIFICATIONS

APPLICATION	THREAD SIZE	TORQUE (lb-ft)	TORQUE (lb-in)	TORQUE (N·m)
Tachometer drive cover bolt	7/16–14	30–35		41–47
Starting motor connector	1/2–13	20–25		27–34
Tachometer drive cover bolt	1/2–13	30–35		41–47
Starting motor connector	No. 10–32	—	16–30	2–3.5
Tachometer drive shaft (blower)	1/2–20	55–65		75–88
Starting motor attaching bolts (alum. flywheel hsg.)	5/8–11	95–105		129–143
Starting motor switch mounting nut	5/8–32	—	36–48	4–5.5

SERVICE TOOLS

TOOL NAME	TOOL NO.
Puller set	J 5901–01
Tachometer drive shaft remover	J 5901–3
Tachometer drive alignment tool set	J 23068